Monday August 18th

Time	
8:00	
8:20	**Plenary Session: Fisheries in Flux: How do we ensure our sustainable future?**
8:40	**William Gilly -** Change in the Gulf of California: what is the future of the aquarium to the world?
	AFS Awards
9:00	**Jake Rice -** Economic incentives can promote fisheries goals and reduce ecosystem impact
9:20	
9:40	
10:00	Break
10:20	**Plenary Session continued**
10:40	AFS Awards
11:00	**Sally Guynn - Taking the lead**
11:20	AFS Awards
11:40	
12:00	
12:20	
12:40	
1:00	

Venue	Westin Hotel									Ottawa Congress Centre								
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7	Poster Hall
1:20 1:40 2:00 2:20 2:40	S1 Evolving Fish Changing Fisheries	C4 Fish Conservation	S16 Fisheries Governance	S8 Tagging Use in Stock Assessment	S6 Atlantic Salmon Restoration	S33 Success Stories in Control of AIS	C2 Salmonids in Lakes	C1 Lake Communities	C21 Freshwater Fish Ecology	S17 Bycatch Reduction	S36 Best Student Paper	S28 Valley Rules the Stream	C5 Stats and Modeling 1	C6 Marine Fish Spatial Ecology	C7 Marine Fish Ecology 1	C9 Bio-engineering	C8 Human Dimensions	
3:00																		
3:20 3:40 4:00 4:20 4:40 5:00	S1 Evolving Fish Changing Fisheries	C4 Fish Conservation	S16 Fisheries Governance	S8 Tagging Use in Stock Assessment	S6 Atlantic Salmon Restoration	S33 Success Stories in Control of AIS	C2 Salmonids in Lakes	C1 Lake Communities	C21 Freshwater Fish Ecology	S17 Bycatch Reduction	S36 Best Student Paper	S28 Valley Rules the Stream	C5 Stats and Modeling 1	C6 Marine Fish Spatial Ecology	C7 Marine Fish Ecology 1	C9 Bio-engineering	C8 Human Dimensions	

Tuesday August 19th

Venue	Westin Hotel									Ottawa Congress Centre								
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
8:00 8:20 8:40 9:00 9:20 9:40	S1 Evolving Fish Changing Fisheries	S2 Community Ecology of Stream Fishes	C12 Habitat & Water Quality 1	S8 Tagging Use in Stock Assessment	S6 Atlantic Salmon Restoration	S33 Success Stories in Control of AIS	C10 Centrarchids 1	S10 Hydropower & Sustainable Fisheries	C22 Fish Culture	S22 Restless Lake Trout	S36 Best Student Paper	S32 Freshwater Fishes of Canada	C5 Stats and Modeling 2	S12 Highly Migratory Large Pelagics	C13 Marine Fish: Life History	S14 Squaloid Sharks	C4 Fish Conservation 2	
10:00																		
10:20 10:40 11:00 11:20 11:40	S1 Evolving Fish Changing Fisheries	S2 Community Ecology of Stream Fishes	C12 Habitat & Water Quality 1	S8 Tagging Use in Stock Assessment	S6 Atlantic Salmon Restoration	S33 Success Stories in Control of AIS	C10 Centrarchids 1	S10 Hydropower & Sustainable Fisheries	C22 Fish Culture removed	S22 Restless Lake Trout	C3 Sturgeon	S32 Freshwater Fishes of Canada	C5 Stats and Modeling 2	S12 Highly Migratory Large Pelagics	C13 Marine Fish: Life History	S14 Squaloid Sharks	C4 Fish Conservation 2	S35 Standard Methods for Sampling NA Freshwater Fish SPEED FORMAT
12:00																		
12:20																		
12:40																		
1:00																		
1:20 1:40 2:00 2:20 2:40	S1 Evolving Fish Changing Fisheries	S2 Community Ecology of Stream Fishes	C12 Habitat & Water Quality 1	S8 Tagging Use in Stock Assessment	S6 Atlantic Salmon Restoration	C11 Brook Trout	C10 Centrarchids 1	S10 Hydropower & Sustainable Fisheries		S22 Restless Lake Trout	C3 Sturgeon	S32 Freshwater Fishes of Canada	C5 Stats and Modeling 2	S12 Highly Migratory Large Pelagics	C15 Marine Fisheries Management	S14 Squaloid Sharks	C14 Contaminants and Toxicology	
3:00																		
3:20 3:40 4:00 4:20 4:40 5:00	**Business Meeting** Chateau Laurier Ballroom All AFS members are welcomed to attend																	

Wednesday August 20th

Venue	Westin Hotel									Ottawa Congress Centre								
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
8:00 8:20 8:40 9:00 9:20 9:40	S1 Evolving Fish Changing Fisheries	S2 Community Ecology of Stream Fishes	S7 Sustainable Sturgeon	S9 Model Selection in Fisheries Science	S3 Aquatic Habitat in Midwest Lakes	S24 Aboriginal Communities in Fisheries Management	C10 Centarchids 2	S10 Hydropower & Sustainable Fisheries		C11 Brook Trout	S27 Future is NOW for Distributed Data	S15 VHS in Great Lakes	S20 Cultured Aquatic Animals	S26 Fisheries Management for Ecosystem Health	C15 Marine Fisheries Management 2	C16 Sampling Techniques	S19 Government vs Third Party Certifiers	
10:00																		
10:20 10:40 11:00 11:20 11:40	S1 Evolving Fish Changing Fisheries	S2 Community Ecology of Stream Fishes	S7 Sustainable Sturgeon	S9 Model Selection in Fisheries Science	S3 Aquatic Habitat in Midwest Lakes	S24 Aboriginal Communities in Fisheries Management	C10 Centarchids 2	S10 Hydropower & Sustainable Fisheries		C11 Brook Trout	S27 Future is NOW for Distributed Data	S15 VHS in Great Lakes	S20 Cultured Aquatic Animals	S26 Fisheries Management for Ecosystem Health	C15 Marine Fisheries Management 2	C16 Sampling Techniques	S19 Government vs Third Party Certifiers	S31 Aquatic Habitat Restoration on the Toronto Waterfront SPEED FORMAT
12:00 12:20 12:40 1:00 1:20 1:40	**Poster Session**																	
2:00 2:20 2:40	S18 Well-managed Fisheries	C17 Percids 1	S7 Sustainable Sturgeon	S9 Model Selection in Fisheries Science	S3 Aquatic Habitat in Midwest Lakes	S24 Aboriginal Communities in Fisheries Management	C18 Salmonids in Streams	S10 Hydropower & Sustainable Fisheries	S5 Climate Related Drying Effects	S23 Parental Effects & Recruitment	S27 Future is NOW for Distributed Data	S15 VHS in Great Lakes	S20 Cultured Aquatic Animals	S26 Fisheries Managemen t for Ecosystem Health	C7 Marine Fish Ecology 2	S25 Social & Economics in Fisheries Mangement	S19 Government vs Third Party Certifiers	
3:00																		
3:20 3:40 4:00 4:20 4:40 5:00	S18 Well-managed Fisheries	C17 Percids 1	S7 Sustainable Sturgeon	S9 Model Selection in Fisheries Science	S3 Aquatic Habitat in Midwest Lakes	S24 Aboriginal Communities in Fisheries Management	C18 Salmonids in Streams		S5 Climate Related Drying Effects	S23 Parental Effects & Recruitment	S27 Future is NOW for Distributed Data	S15 VHS in Great Lakes	S20 Cultured Aquatic Animals	S26 Fisheries Managemen t for Ecosystem Health	C7 Marine Fish Ecology 2	S25 Social & Economics in Fisheries Mangement	S19 Government vs Third Party Certifiers	

Thursday August 21st

Venue	Westin Hotel									Ottawa Congress Centre								
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7	Poster Hall
8:00 8:20 8:40 9:00 9:20 9:40	S18 Well-managed Fisheries	S4 Sensitivity of Fish and Fisheries to Climate Change	S13 Genetics and Sustainable Fisheries	S7 Sustainable Sturgeon	S20 Cultured Aquatic Animals	S30 Managing Impacts to Fish and Fish Habitat	C18 Salmonids in Streams	S34 Native Species Restoration in Great Lakes		S23 Parental Effects & Recruitment	S29 Sampling for Understanding Headwater Systems and Fish Production	C19 Invasive Species	C17 Percids 2	C12 Habitat and Water Quality 2	C7 Marine Fish Ecology 3	C20 Stream and River Communities		
10:00																		
10:20 10:40 11:00 11:20 11:40	S11 Harvest Control Rules	S4 Sensitivity of Fish and Fisheries to Climate Change	S13 Genetics and Sustainable Fisheries	S7 Sustainable Sturgeon	S20 Cultured Aquatic Animals	S30 Managing Impacts to Fish and Fish Habitat	C18 Salmonids in Streams	S34 Native Species Restoration in Great Lakes		S23 Parental Effects & Recruitment	S29 Sampling for Understanding Headwater Systems and Fish Production	C19 Invasive Species	C17 Percids 2	C12 Habitat and Water Quality 2	C7 Marine Fish Ecology 3	C20 Stream and River Communities	S21 Barotrauma in Fish	
12:00																		
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1:20 1:40 2:00 2:20 2:40	S11 Harvest Control Rules	S4 Sensitivity of Fish and Fisheries to Climate Change	S13 Genetics and Sustainable Fisheries	S7 Sustainable Sturgeon		S30 Managing Impacts to Fish and Fish Habitat	C18 Salmonids in Streams	S34 Native Species Restoration in Great Lakes		S23 Parental Effects & Recruitment	S29 Sampling for Understanding Headwater Systems and Fish Production	C19 Invasive Species	C17 Percids 2	C12 Habitat and Water Quality 2	C7 Marine Fish Ecology 3	C20 Stream and River Communities	S21 Barotrauma in Fish	
3:00																		
3:20 3:40 4:00 4:20 4:40 5:00	S11 Harvest Control Rules	S4 Sensitivity of Fish and Fisheries to Climate Change	S13 Genetics and Sustainable Fisheries	Set up for Closing Social	Set up for Closing Social	S30 Managing Impacts to Fish and Fish Habitat	Set up for Closing Social	Set up for Closing Social		S1 Evolving Fish Changing Fisheries & S23 Parental Effects and Recruitment Discussion	S29 Sampling for Understanding Headwater Systems and Fish Production	C19 Invasive Species		C12 Habitat and Water Quality 2	C7 Marine Fish Ecology 3		S21 Barotrauma in Fish Discussion	

	Monday August 18th				
			Westin Hotel		
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S1 Evolving Fish Changing Fisheries	**C4 Fish Conservation**	**S16 Fisheries Governance**	**S8 Tagging Use in Stock Assessment**	**S6 Atlantic Salmon Restoration**
Moderator	Erin Dunlop	Karen Ralph	Rashid Sumaila	John Hoenig	Marion Daniels
1:20	Eco-genetic models of fisheries-induced evolution. **Ulf Dieckmann, Mikko Heino, Erin Dunlop, Katja Enberg**	Beyond exhibits: fisheries conservation in zoos & aquariums. **Cynthia Lee** C4.1-1	Are fisheries governable? A reality check. **Ratana Chuenpagdee, Svein Jentoft** S16-1	Using tagging data to inform stock assessments. **Paul Conn, Doug Vaughan, John Hoenig** S8-1	Opening remarks. **Eric Boysen and Terry Quinney**
1:40	S1-1	Are crayfish in a pinch: investigating the influence of multiple stressors on crayfish decline. **Brie Edwards*, Don Jackson, Keith Somers** C4.1-2	Slippery as fish: theoretical perspectives on systems-to-be-governed. **Maarten Bavinck** S16-2	Use of natural tags in capture-recapture models: modeling misidentification. **Ken Pollock, Jun Yoshizaki** S8-2	Atlantic salmon restoration solutions in Nova Scotia. **Bob Rutherford** S6-2
2:00	Fisheries-induced evolution of natural mortality rate. **Christian Jørgensen, Øyvind Fiksen** S1-2	Spatial patterns in the distribution and conservation of imperiled fishes in the Lower Colorado River Basin. **Joanna Whittier, Craig Paukert, Julian Olden** C4.1-3	The inverted pyramid: an alternative liege for the governance of fisheries and coastal systems. **Svein Jentoft, Ratana Chuenpagdee, Alida Bundy, Robin Mahon** S16-3	~~Population level tags and individual level tags to estimate survival and movement probabilities in multi-site capture-recapture models. **Zhi Wen, Ken Pollock, Cynthia Jones, James Nichols**~~ CANCELLED ~~S8-3~~	Eleven years of salmonid habitat restoration and monitoring in Brierly Brook, Nova Scotia. A success story. **Charles MacInnis** S6-3
2:20	Estimating selection strength on life-history traits in fish exploited by recreational fishing. **Robert Arlinghaus, Shuichi Matsumura, Ulf Dieckmann** S1-3	Assessing anthropogenic threats to fishes in the Lower Colorado River Basin. **Kristen Pitts*, Craig Paukert, Joanna Whittier** C4.1-4	Institutional adaptation as a governability problem in fisheries. **Derek Johnson, Jan Kooiman** S16-4	A method for estimating tag induced mortality and initial tag shedding rate of southern rock lobsters (*Jasus edwardsii*). **Matthew Smith** S8-4	Large woody debris structures and their influence on Atlantic salmon spawning in a stream in Nova Scotia, Canada. **Trevor Floyd** S6-4
2:40	The theory of harvesting generalist predators. **Peter Abrams** S1-4	Fish assemblages in Iowa's non-wadeable rivers: relationships with habitat and sampling methods. **Travis Neebling, Michael Quist** C4.1-4b	Alleviating poverty in small-scale fisheries: the governance perspective. **Paul Onyango*, Svein Jentoft** S16-5	A tagging model for estimating survival rates when tag fouling affects detectability: application to queen conch stock assessment. **Lynn Waterhouse*, Matthew Smith, Steven Newman, Kristene Parsons, Kathy Lockhart, John Hoenig** S8-5	The West River Sheet Harbour Acid Rain Mitigation Project: an NGO initiative. **George Ferguson, Lewis Hinks** S6-5
3:00					

Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S1 Evolving Fish Changing Fisheries	**C4 Fish Conservation**	**S16 Fisheries Governance**	**S8 Tagging Use in Stock Assessment**	**S6 Atlantic Salmon Restoration**
Moderator	Erin Dunlop	Karen Ralph	Derek Johnson	John Hoenig	Chris Robinson
3:20	Direct and indirect fisheries-induced evolution in a three-species community. **Anssi Vainikka, Åke Brännström, Anna Gårdmark, David Boukal, Ulf Dieckmann** S1-5	Restoring a rangeland watershed & its endemic rainbow trout: Pine Creek, California. **Lisa Thompson, David Lile, Peter Moyle, Kenneth Tate, Teresa Pustejovsky, Gerard Carmona Catot** C4.1-6	Discount factors as economic indicators of fisheries governance. **Ussif Rashid Sumaila, Marcos Dominguez-Torreiro** S16-6	Estimating rates of mortality and movement using single tag-recovery data unbiased by tag non-reporting and short-term tag losses. **Richard McGarvey, Janet Matthews** S8-6	Sonic tracking of Atlantic salmon smolts: opening the ocean black box. **Fred Whoriskey** S6-6
3:40	Ecology and evolution of female mating preferences under size-selective fishing. **Davnah Urbach, Erin S. Dunlop, Ulf Dieckmann** S1-6	Reconstructing sakhalin taimen (*Hucho perryi*) historical distribution and identifying causes for their local extinction. **Michio Fukushima, Hiroto Shimazaki, Pete Rand, Masahide Kaeriyama** C4.1-7	Exploring social networks in marine resource governance: the case of the Grenadine Islands. **Robin Mahon, Patrick McConney, Katherine Blackman, Rhonda Lee** S16-7	Sensitivity of tag-recovery mortality estimates to tag shedding, handling mortality, and reporting rate inaccuracies. **Travis Brenden, Michael Jones, Mark Ebener** S8-7	Genetic affinities of Lake Ontario Atlantic salmon assessed with ancient DNA. **Oliver Haddrath, Jerry Smitka, Jack Imhof, Allan Baker** S6-7
4:00	Eco-genetic models to explore the evolutionary consequences of size-selective harvest of Great Lakes fishes. **Hui-Yu Wang*, Tomas Hook** S1-7	Stocking with introduced silver carp as a tool for conserving native fishes in Ukraine. **Alexander Didenko, Igor Buzevich** C4.1-8	Governance potentials and limitations in inland fishery: a case of Lake Malawi. **Andrew Song*, Ratana Chuenpagdee** S16-8	Survival of yellowtail flounder (*Limanda ferruginea*) in the northwest Atlantic derived from tag-recapture data. **Anthony Wood, Steven Cadrin** S8-8	Quantifying the fluvial habitat needed for the re-introduction of Atlantic salmon in Lake Ontario. **Robert Randall** S6-8
4:20	Age, risk, and maternal investment: a state-dependent approach to the ecology and evolution of female life-histories. **Holly K. Kindsvater*, Suzanne H. Alonzo, Michael B. Bonsall** S1-8	Analysis of the saltmarsh topminnow (*Fundulus jenkinsi*) habitat and distribution along the northern Gulf of Mexico. **John Daniel Lopez*, Mark S. Peterson, Jake Walker, Gretchen W. Grammer, Mark S. Woodrey** C4.1-9	Sustainability of salmon aquaculture: governance systems, regulatory approaches and implementation challenges. **Yajie Liu*** S16-9	Estimates of fishing and natural mortality of black sea bass in the Mid-Atlantic based on a release-recapture experiment. **Gary Shepherd, Joshua Moser** S8-9	Survival, growth and emigration of stocked Atlantic salmon in Lake Ontario streams. **Russell Bobrowski*, Marc Desjardins, Chris Wilson, Nicholas Jones** S6-9
4:40	The effect of coastal marine reserves on fisheries-induced evolution in species of different ecological guilds. **Tanja Miethe*, Jon Pitchford, Calvin Dytham** S1-9	Habitat suitability of the Carolina madtom, an imperiled southeastern stream fish. **Steve Midway*, Thomas Kwak, D. Derek Aday** C4.1-10	Future of small-scale fisheries: Thailand's on-going governance experiment. **Kungwan Juntarashote** S16-10	Estimates of abundance from mark-recapture analysis of v-notched American lobster. **Talia Bigelow, Steven Cadrin, Bryan DeAngelis, John Catena** S8-10	The impacts of Atlantic salmon stocking on rainbow trout in Barnum House Creek, Lake Ontario. **Jason Dietrich, Jim Bowlby, Bruce Morrison, Nicholas Jones** S6-10
5:00		~~Distribution modeling to guide stream fish conservation: the mountain sucker and Black Hills National Forest. **Daniel Dauwalter, Frank Rahel**~~ CANCELLED ~~C4.1-11~~	How we fish matters: assessment and governance of ecosystem impacts of fishing in Canada. **Susanna Fuller, Ratana Chuenpagdee, Jennifer Ford, Candace Picco, Lance Morgan, Dorthea Hangaard, Fan Tsao** S16-11	Estimation of yellowtail flounder abundance using a Petersen mark-recapture experiment. **Jessica Melgey*, Steven X. Cadrin, Kevin Stokesbury, Christopher Legault** S8-11	

First author listed is presenting author and * indicate students requesting feedback

Monday August 18th

Westin Hotel

Room	Governor General 3	Provinces 1	Provinces 2	Quebec
	S33 Success Stories in Control of AIS	**C2 Salmonids in Lakes**	**C1 Lake Communities**	**C21 Freshwater Fish Ecology**
Moderator	Beth Brownson	Warren Dunlop	Dean Fitzgerald	Lynda Corkum
1:20	Forecasting invasion pathways: using gravity models to predict angler movement. **Andrew Drake*, Nicholas Mandrak, Harold Harvey** S33-1	Lipid mobilization and reproductive investment in lake trout, *Salvelinus namaycush*: stock specific patterns emerge from hatchery and field studies. **Cheryl Murphy, William Sloan, Yolanda Morbey, Tom Johnston, Brian Shuter** C2-1	Landscape scale management for lakes: connecting lake landscapes to water chemistry and fishes. **Mary Bremigan, Kendra Spence Cheruvelil, Tyler Wagner, Patricia Soranno, Katherine Webster, Brett Alger** C1-1	Demographics and seasonal habitat use of white catfish (*Ameiurus catus)* and channel catfish (*Ictalurus punctatus*) in the Delaware River estuary. **David Keller** C21-1
1:40	Introduced topmouth gudgeon in the UK: delayed management response results in expensive eradication strategies. **Gordon H. Copp, J. Robert Britton, Rodolphe E. Gozlan** S33-2	Hatchery and lake environments affect egg characteristics in lake trout *Salvelinus namaycush*. **Yolanda Morbey, Christopher Jastrebski** C2-2	Hydrogeomorphic and anthropogenic disturbance gradients in lakes: how have fish assemblages been altered? **Brett Alger*, Mary Bremigan, Kendra Spence Cheruvelil, Patricia Soranno, Katherine Webster** C1-2	Quantifying impacts of striped bass recovery on anadromous alosines in the Connecticut River. **Justin Davis, Eric Schultz** C21-2
2:00	Trying to get ahead of the curve: risk analysis of barramundi *Llates calcarifer* for Florida aquaculture. **Jeffrey Hill, Scott Hardin** S33-3	Feeding mechanisms of age-0 lean lake trout (*Salvelinus namaycush*). **Beth V. Holbrook*, Thomas R. Hrabik, Donn K. Branstrator, Allen F. Mensinger** C2-3	Building on existing models of reservoir function: balancing complexity with critical components and connections. **Joseph Conroy, Jonathan Denlinger, R. Scott Hale, Roy Stein** C1-3	Maternal and paternal influences on larval production characteristics of white bass. **S.E. Lochmann, K.J. Goodwin, M. McEntire, A. Fuller** C21-3
2:20	Early observations on an emerging Great Lakes invader, *Hemimysis anomala*, in Lake Ontario. **Maureen Walsh, Brian Lantry, Kelly Bowen, Joceyln Gerlofsma, Ted Schaner, Richard Back, Jennifer Questel, Roberta Cap, Garry Smythe, Michael Goehle, Bryan Young, Marc Chalupnicki, James Johnson, James McKenna** S33-4	The impact from dynamic postglacial events on regional lake trout population structure in Algonquin Park, Ontario. **Michael Halbisen*, Glenn Forward, Chris Wilson** C2-4	~~Relating species traits to habitat characteristics in coastal wetlands of the lower Great Lakes.~~ ~~**Lynn Bouvier, Karl Cottenie, Susan Doka**~~ Moved to Poster C12 C1-4	Regional and temporal variability in recruitment, growth, and mortality of river herring (*Alosa aestivalis* and *A. pseudoharengus*) larvae in Roanoke River, North Carolina. **Anthony Overton, Roger Rulifson, John Cooper** C21-4
2:40	Aquatic alien invasive species early detection network for the St. Lawrence River. **Geneviève Bourget** S33-5	Swimming speed and foraging behaviour of lake trout measured using multi-beam hydroacoustics. **Scott W. Milne, Erin S. Dunlop** C2-5	Spatial structure of coastal fish communities in Lake Huron. **Angela Strecker, Peter Abrams, John Casselman, Marie-Josee Fortin, Donald Jackson, Scott Milne, Mark Ridgway, Brian Shuter** C1-5	Natal homing in Lake Erie white bass: master navigators or lost wanderers? **Todd Hayden, Jeffrey Miner, John Farver** C21-5
3:00				
Room	Governor General 3	Provinces 1	Provinces 2	Quebec
	S33 Success Stories in Control of AIS	**C2 Salmonids in Lakes**	**C1 Lake Communities**	**C21 Freshwater Fish Ecology**
Moderator	Beth Brownson	Warren Dunlop	Dean Fitzgerald	Lynda Corkum
3:20	Early detection of invasive fish species at Great Lakes' Areas Of Concern. **Christine Brousseau, Robert Randall, Lisa O'Connor** S33-6	Habitat selection and the vertical distribution of cisco (*Coregonus artedi*) in Lake Opeongo, Ontario, Canada. **Jan Moryk*, Mark Ridgway** C2-6	Identifying energy sources supporting coastal fish: spatial differences revealed by stable isotope ratios. **Joel Hoffman, Greg Peterson, Anne Cotter, Jack Kelly** C1-6	Channel catfish population dynamics in the Platte River, Nebraska. **Tony Barada, Mark Pegg** C21-6
3:40	Residual ballast water and introduced aquatic species: from potential problem to policy in five years. **Sarah Bailey, Chris Wiley** S33-7	Status of lake whitefish (*Coregonus clupeaformis*) in Lake Champlain. **J. Ellen Marsden, Stephen J. Smith, Joanna Hatt** C2-7	Assessing nearshore small-fish community biodiversity in Lake Simcoe, Ontario, Canada. **Brent Metcalfe, Jake La Rose, Campbell Willox** C1-7	Migratory patterns of American shad transported above dams on the Roanoke River, NC. **Julianne Harris, Joseph Hightower** C21-7
4:00	Success of the Joint Ballast Water Inspection Program for ocean-going vessels entering the Great Lakes. **Chris Wiley, Sarah Bailey** S33-8	Relating feeding habits and trophic position to changes in condition of lake whitefish. **Kelly-Anne Fagan*, Marten Koops, Michael Arts, Trent Sutton, Michael Power** C2-8	Spatial and temporal patterns in the food web of Hamilton Harbour. **Jennie E Ryman*, Marten Koops, Michael Power** C1-8	Migratory energetics of American shad (*Alosa sapidissima*), an iteroparous anadromous fish. **Theodore Castro-Santos, Benjamin Letcher, Stephen McCormick** C21-8
4:20	Assessment and management of invasive spiny-rayed fishes in the Thompson River Watershed. **J. Bruce Runciman** S33-9	Characterizing basic movement and habitat use of lake whitefish (*Coregonus clupeaformis*) in Clear Lake, Maine. **Dimitry Gorsky*, Joseph Zydlewski, Dave Basely** C2-9	Fish community ecology of Cranberry Lake and Oswegatchie River, NY. **Emily Waldt*, Anthony Siniscal, Neil Ringler, Chris Van Maaran** C1-9	Blue sucker movements and resource selection in the Middle Missouri River. **Ben Neely, Mark Pegg, Gerald Mestl** C21-9
4:40	Fluridone eradication of the first Midwest hydrilla infestation, Lake Manitou, Rochester, Indiana. **Gwen White, Doug Keller, Jeremy Price** S33-10	Long-term variability of Arctic cisco growth rates: evidence of environmental controls **Vanessa von Biela, Christian E. Zimmerman, Larry Moulton** C2-10	Evaluating over-winter survival of gizzard shad (*Dorosoma cepedianum*) in Oneida Lake, NY. **William Fetzer*, Tom Brooking, John Forney, Randy Jackson, Lars Rudstam, Tony VanDeValk** C1-10	Wisconsin's contemporary muskellunge genetic resources and implications for management activities. **Brandon Spude*, Brian Sloss, Ed Murphy, Marty Jennings** C21-10
5:00	Alien aquatic species and eradication in NE Mexico: some cases & lessons. **Salvador Contreras-Balderas, Alberto Contreras-Arquieta** S33-11		Fish community composition in tussock-forming aquatic macrophytes at two south Florida Lakes. **Aaron Bunch, Mike Allen** C1-11	

First author listed is presenting author and * indicate students requesting feedback

	Monday August 18th			
	Ottawa Congress Centre			
Room	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3
	S17 Bycatch Reduction	**S36 Best Student Paper**	**S28 Valley Rules the Stream**	**C5 Stats and Modeling 1**
Moderator	Yonat Swimmer	Trent Sutton	Shawn Staton	Bruce Kilgour
1:20	Progress and effective strategies for reducing fisheries bycatch. **Yonat Swimmer** S17-1	Population genetic structure and invasion source of the exotic round goby. **Joshua Brown*, Carol Stepien** S36-1	Classification and modelling of stream temperatures in Ontario. **Cindy Chu, Nicholas Jones** S28-1	
1:40	Use of electropositive metals to reduce shark feeding behavior. **John Wang, Lianne McNaughton, Yonat Swimmer** S17-2	A genetic assessment of polyandry and breeding site fidelity in lemon sharks. **Joseph DiBattista*, Kevin Feldheim, Xavier Thibert-Plante, Samuel Gruber, Andrew Hendry** S36-2	Fish distribution in Wisconsin streams: estimating changes from the mid 1800's to the present with a GIS-based, watershed-scale, predictive model. **Jana Stewart, John Lyons** S28-2	The advantage of explicitly incorporating predation mortality into age-structured stock assessment models: an application to northwest Atlantic mackerel. **Hassan Moustahfid, William J. Overholtz, Jason S. Link, Megan C. Tyrrell** C5.1-1
2:00	Sensory-based approaches to sea turtle bycatch reduction in longline fisheries. **Amanda Southwood, Kerstin Fritsches, Richard Brill, Yonat Swimmer** S17-3	Limited access to cool-water refugia for adult up-river migrating sockeye salmon in the Fraser River mainstem, British Columbia, Canada. **Michael Donaldson*, Steven Cooke, David Patterson, David Robichaud, Glenn Crossin, Kyle Hanson, Ivan Olsson, Karl Eng** S36-3	Modeling fish assemblage responses to flow reduction in Michigan rivers. **Troy Zorn, Paul Seelbach, Edward Rutherford, Todd Wills, Michael Wiley, Su-Ting Chen** S28-3	Using linear models to validate recruitment indices. **Justine Woodward, Robert Latour, Mary Fabrizio, Christopher Bonzek** C5.1-3
2:20	Using field trials to examine sea turtle and target species CPUE in the presence of visual deterrents. **Cody Hooven, Adrian Alvarez, Khanh Chi Dam, Shara Fisler, Yaffet Mehari, Marlem Rivera, Ahiram Rodriguez, Yonat Swimmer, Edgar Trujillo, John Wang** S17-4	Ecological futures for stream fishes along an intermittent Great Plains riverscape affected by drought and groundwater withdrawal for irrigation. **Jeffrey Falke*, Kurt Fausch, Robin Magelky, Angela Squires, Deanna Durnford, Linda Riley, Ramchand Oad** S36-4	Examining the cumulative effects of headwater enclosures on downstream fish assemblages and water chemistry in stream agro-ecosystems. **Katie Stammler*, Robert Bailey, Nicholas Mandrak** S28-4	Comparing a multi-species to species-specific assessments of hammerhead sharks (*Sphyrna* spp.) using production models. **Christopher Hayes*, Yan Jiao, Enric Cortes** C5.1-4
2:40	Integrating people into fisheries management plans to reduce bycatch. **Martin Hall** S17-5	Using fish otoliths to explore mercury bioaccumulation patterns in coastal fish populations in the Mobile-Tensaw River Delta, Alabama. **Troy Farmer*, Dennis DeVries, Rusty Wright, Joel Gagnon, Brian Fryer** S36-5	Response of headwater fish communities to natural and stressor gradients in southwestern Ontario, Canada. **Adam G. Yates*, Robert C. Bailey** S28-5	From physics to fish to fishers: can the biology and people keep up with the computers? **Kenneth Rose, Enrique Curchitser, Shin-ichi Ito, Salvador Lluch-Cota, Takashi Setou** C5.1-5
3:00				
Room	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3
	S17 Bycatch Reduction	**S36 Best Student Paper**	**S28 Valley Rules the Stream**	**C5 Stats and Modeling 1**
Moderator	Yonat Swimmer	Amanda Rosenberger	Cindy Chu	Bruce Kilgour
3:20	Engaging community in developing strategies to reduce bycatch: a collaborative education and research effort. **Shara Fisler, Adrian Alvarez, Khanh Chi Dam, Cody Hooven, Yaffet Mehari, Marlem Rivera, Ahiram Rodriguez, Yonat Swimmer, Edgar Trujillo, John Wang** S17-6	Comparison of prepositioned areal electrofishers and two-way resistance board weirs for assessing migrating stream fish populations. **Scott Favrot*, Thomas Kwak** S36-6	Challenges and successes in recovering freshwater ecosystems in southern Ontario. **Shawn Staton, Nicholas Mandrak, Kari Killins** S28-6	Analysis of longline catch data from bycatch mitigation studies: a comparative study. **Marti McCracken** C5.1-6
3:40	Better marketing, less bycatch? **Douglas Meyer** S17-7	Intensive grass carp stocking effects on reservoir invasive plants and native fish populations. **Brad Garner*, Thomas Kwak, Kenneth Manuel, Hugh Barwick** S36-7	Hope for recovery or planned obsolescence: using relationship of stressor gradients and biota in agricultural streams to predict the recovery or demise of stream agroecosystems. **Robert Bailey, Adam Yates** S28-7	Can data collected during at-sea observer surveys be used to make general inferences about fishery discards? **Hugues Benoît, Jacques Allard** C5.1-7
4:00	Supporting effective bycatch reduction efforts with your seafood choices. **Jesse Marsh** S17-8	Parental care behaviour and muscle enzyme activities of nesting smallmouth bass across six lakes with a gradient of nest predator burdens. **Marie-Ange Gravel*, Steven J. Cooke, Patrice Couture** S36-8	It's a patchy world out there: how a multi-scaled approach can enhance recovery plans for endangered freshwater fishes. **Mark Poos*, Donald Jackson** S28-8	Estimating mortality rates from changes in mean lengths and catch rates in non equilibrium conditions. **Todd Gedamke, Clay E. Porch, John M. Hoenig** C5.1-8
4:20	Case studies of bycatch reduction strategies by Hawaii longline vessel operators. **Amy Gough, Stewart Allen, Yonat Swimmer** S17-9	The role of ecosystem size and disturbance in structuring stream food webs. **Phillip G. Jellyman*, Angus R. McIntosh** S36-9	Modeling habitat of the imperiled eastern sand darter (*Ammocrypta pellucida*) at multiple scales to help guide recovery and repatriation efforts. **Alan Dextrase, Nicholas Mandrak** S28-9	Model selection uncertainty: a comparison among age-structured models in assessing walleye (*Sander vitreus*) fishery in Lake Erie. **Yan Jiao, Kevin Reid** C5.1-9
4:40	Discussion	Dietary fatty acid composition differentially impacts white bass oocyte composition and larval quality. **Heidi Lewis*, Jesse Trushenski, Ryan Lane, Chris Kohler** S36-10	Population dynamics of eastern sand darter (*Ammocrypta pellucida*): a threatened species on the lower Thames River, Canada. **Mary Finch*, Michael Power, Susan Doka** S28-10	Development of a user-friendly stock assessment model for the American lobster. **Yuying Zhang*, Yong Chen, Carl Wilson, Minoru Kanaiwa** C5.1-10
5:00				~~Tools for implementing ecosystem-based fisheries management: development of a multispecies statistical catch-at-age model of the Georges Bank fish community.~~ ~~**Kiersten Curti, Jeremy Collie, Jason Link**~~ CANCELLED ~~C5.1-11~~

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	Monday August 18th			
	Ottawa Congress Centre			
Room	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	C6 Marine Fish Spatial Ecology	**C7 Marine Fish Ecology 1**	**C9 Bioengineering**	**C8 Human Dimensions**
Moderator	Vic Gillman	Cindy Hartmann	Doug Dixon	Christine Tu
1:20	Is biological sound production important in the Deep Sea? **Rodney Rountree, Cliff Goudey, Francis Juanes, Ken Ekstrom, Dave Mellinger** C6-1	An RNA:DNA-based index for estimating growth rate in juvenile Atlantic menhaden. **Jason Edwards*, Thomas Miller** C7.1-1		Shad memories, unforgotten spring on the Susquehanna River. **Amy Roe** C8-1
1:40	Fish Aggregating Device (FAD) effects of deepwater petroleum platforms in the northern Gulf of Mexico for yellowfin tuna, *Thunnus albacares*. **Michael Randall, Randy Edwards, Kenneth Sulak** C6-2	Exploiting tissue-specific isotopic turnover rates to characterize dietary habits of summer flounder (*Paralichthys dentatus*) in Chesapeake Bay. **Andre Buchheister*, Robert J. Latour** C7.1-2	Behavioural responses of sea lamprey to hydrodynamic conditions. **Greg Elliott*, Robert McLaughlin, Andrew Goodwin, John Nestler, George Constantinescu, Larry Weber, Jodi Benson** C9-1	Status of human dimensions information collection and utilization by fisheries management agencies. **Jody Simoes*, Frank Lupi, Dan Hayes, Aaron McCright** C8-2
2:00	Quantifying the timing and location of spawning activity for bonefish in Eleuthera, The Bahamas. **Andy Danylchuk, Aaron Adams, Steven Cooke, Cory Suski, Karen Murchie, Tony Goldberg, Jeff Koppleman, Aaron Shultz, Annabelle Oronti, Edd Brooks, David Philipp** C6-3	Among population differences in otolith chemistry has a genetic basis in *Menidia menidia*. **Lora Clarke, Simon Thorrold, David Conover** C7.1-3	Response of blueback herring with a radio tag and without one to high-frequency sound. **Dennis Dunning, Quentin Ross, Chris Frese** C9-3	What types of fishing opportunities are anglers looking for: can New York provide those opportunities? **Nancy Connelly, Shaun Keeler, Tommy Brown, Steve Hurst** C8-3
2:20	The spatial ecology of bonefish and lemon sharks in nearshore coastal flats and tidal creeks of Eleuthera, The Bahamas. **Karen Murchie*, Emily Schwager, Sascha Danylchuk, Steven Cooke, Andy Danylchuk, Tony Goldberg, Jeff Koppelman, Cory Suski, Dave Philipp** C6-4	Spatial variations in otolith microchemistry for *Tautoga onitis* in Narragansett Bay. **Ivan Mateo, David Bengtson, Edward Durbin** C7.1-4	An ultrasound barrier to prevent American shad (*Alosa sapidissima*) from entering the Des Prairies river powerhouse turbines – preliminary results. **Jean Caumartin, Denis Desrochers, Carl Schilt** C9-4	A comparison of anglers in urban communities: do urban fishing program anglers differ? **Clifford Hutt, Wes Neal** C8-4
2:40	Obtaining fine-scale movement and habitat data for spatial fisheries modelling. **Zy Biesinger*, George Niezgoda, Peter Anson, Mitch Sisak, Benjamin Bolker, William Lindberg** C6-5	Use of a geochemical signature in otoliths to evaluate age determination methods for American shad. **Sally A. Upton*, John E. Olney** C7.1-5	Site-specific assessment of cost-effectiveness of technologies for reducing impingement and entrainment of fish and shellfish on cooling water intake structures. **Erik Heinen, Mark Gerath** C9-5	Going beyond fishing clinics and developing aquatic stewards. **Steve Marshall, Rae Waddell, Tony Fedler** C8-5
3:00				
Room	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	C6 Marine Fish Spatial Ecology	**C7 Marine Fish Ecology 1**	**C9 Bioengineering**	**C8 Human Dimensions**
Moderator	Vic Gillman	Cindy Hartmann	Doug Dixon	Christine Tu
3:20	Spawning activity and migratory characteristics of American shad and striped bass in the Cape Fear River, NC. **Joseph Smith*, Joseph Hightower** C6-6	Can otolith microchemistry help elucidate the number of spawning grounds and population structure of South American hoki? **Pia Schuchert, Alexander Arkhipkin** C7.1-6	Evaluation of fine mesh panels as a means of reducing entrainment at cooling water intake structures. **Mark Gerath, Erik Heinen, Jonathan Black** C9-6	Marine ecosystem services in Clayoquot Sound, British Columbia. **Genevieve Layton-Cartier*, Kai Chan, Tania Weller** C7.3-11
3:40	Habitat use of the Snohomish River Estuary, Washington, by juvenile Pacific salmon: affects of several landscape scale factors. **Kurt Fresh, Mindy Rowse, Anna Kagley, Josh Chamberlin, Todd Zackey** C6-7	Characterization of spatial variability in age-0 menhaden chemical signatures in Chesapeake Bay and its implications for recruitment. **Jason Schaffler, Cynthia Jones** C7.1-7	A tale of two fishways: contrasting performance of nature-like fishway designs in coastal New England streams. **Abigail Franklin*, Alexander Haro, Theodore Castro-Santos** C9-7	Human dimensions of managing muskellunge in Minnesota. **Robert Dodd*, David Fulton, Sue Schroeder** C8-7
4:00	Patterns of movement in striped bass, *Morone saxatilis*, in the Penobscot River, Maine. **Joseph Zydlewski, John Kocik, Stephen Fernandes, James Hawkes** C6-8	Factors influencing growth and pigmentation in settling glass stage American Eels (*Anguilla rostrata*). **Daniel Luers** C7.1-8	Sound attenuation of harmful noise produced in water construction activities. **Hal Dreyer, John Micketts** C9-8	Partnering with stakeholders to ensure sustainable freshwater fisheries in Florida. **Dennis Renfro** C8-8
4:20	Tracking Atlantic croaker movement in the Gulf of Mexico: a shifting element mosaic in the "Dead Zone"? **Lance Sullivan*, Richard Strauss, Sandra Diamond** C6-9	Demographics and parasitism by *Anguillicola crassus* in Chesapeake Bay American eels. **Kari Fenske, Dave Secor, Mike Wilberg** C7.1-9	Meeting screening criteria - issues and solutions. **Edward Donahue, Michael McGowan, Fiona Goodson** C9-9	Coastal CURA: supporting maritimes fishing communities engaging in coastal management. **Anthony Charles** C8-9
4:40	Physiological and environmental influences on emigration timing in juvenile anadromous alewife. **Benjamin Gahagan*, Eric Schultz** C6-10	Exploring the ecological significance of color variation in Atlantic cod. **Graham Sherwood, Jonathan Grabowski** C7.1-10	A case study: improving the resilience of a watercourse to the stressors of increasing imperviousness of its drainage area and close proximity of municipal infrastructure using bioengineering and natural channel design techniques. **Samantha Mason** C9-10	Mercury contamination in the Adirondacks: science-based decision making about fish consumption. **Hannah Shayler*, Clifford Kraft** C8-10

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Tuesday August 19th

Westin Hotel

Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1
	S1 Evolving Fish Changing Fisheries	**S2 Community Ecology of Stream Fishes**	**C12 Habitat & Water Quality 1**	**S8 Tagging Use in Stock Assessment**
Moderator	Christian Jorgensen	Keith Gido	Jody Wingfield	Paul Conn
8:00	The role of experiments in understanding harvest-induced evolution. **David Conover** S1-10	Community ecology of stream fishes two decades later. **William Matthews** S2-1	Science and practice of aquatic ecosystem assessment, protection, and restoration. **Gordon Wichert** C12.1-1	Fishery management and tag-return estimates of fishing mortality: an example in the NC southern flounder fishery. **William Smith*, Fred Scharf, Joe Hightower, Kevin Craig** S8-12
8:20		Overview of methodological advances in stream fish community ecology. **Keith Gido and Don Jackson** ~~Community ecology of stream fish: a large scale perspective.~~ ~~**Bernard Hugueny, Pablo Tedesco, Thierry Oberdorff**~~ CANCELLED ~~S2-2~~	Strategy for avoiding impacts to aquatic habitat while temporarily discharging pumped groundwater to watercourses. **Robin McKillop** C12.1-2	Hierarchical Bayesian approach to age-structured tagging models. **Matthew Krachey*, Kenneth Pollock** S8-13
8:40	How and why fishing selects on life-history traits via fish behaviour. **Peter Biro** S1-11	Molecular approaches to stream fish ecology. **Marlis R Douglas, Michael E Douglas** S2-3	A stream sensitivity assessment tool developed for standardizing baseline condition reports. **Daniel Gibson, Gordon Wichert** C12.1-3	Tag-recapture data and spawning stock survey data indicate potential for a recreational fishery for mature male striped bass in the Delaware River and Bay. **Desmond Kahn** S8-14
9:00	Harvest induced life-history evolution: a common garden experiment. **Tom Cameron** S1-12	From metapopulations to metacommunities: linking theory with empirical observations of the spatial population dynamics of stream fishes. **Jeffrey Falke, Kurt Fausch** S2-4	Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes. **Larry Brown, Marissa Bauer** C12.1-4	~~A statistical catch-at-age model for Atlantic coast striped bass incorporating age-structured harvest and catch/release tag returns.~~ ~~**Gary Nelson**~~ ~~S8-15~~ CANCELLED
9:20	Physiological and nutritional consequences of selection for angling vulnerability in a recreational sportfish. **Tara Redpath*, David Wahl, David Philipp, Cory Suski, Patrice Couture, Robert Arlinghaus, Steven Cooke** S1-13	Fish ecology in the age of metacommunities: approaches, patterns and challenges. **Pedro Peres-Neto** S2-5	Using biology to establish sediment criteria in mountain streams. **Gregg Lomnicky, Sandra Bryce, Philip Kaufmann** C12.1-5	An integrated model using catch, catch-per-unit-effort, and tagging data to estimate mortality and abundance for the Aleutian Islands golden king crab (*Lithodes aequispinus*) stock. **Shareef Siddeek, Leslie Watson, David Barnard, Robert Gish** S8-16
9:40	Are Pacific salmon commercial fisheries selective for physiological and energetic traits? **Steven Cooke, Scott Hinch, Tony Farrell, Glen Van Der Kraak, Mark Shrimpton, Glenn Crossin, Mike Donaldson, Kyle Hanson, David Patterson, Karl English** S1-14	~~A genes-to-landscape perspective on stream fish community structure.~~ ~~**Michael Blum, David Heins**~~ CANCELLED ~~S2-6~~	~~Using nitrogen (δ15N) stable isotopes of the particulate organic matter as tracers of the anthropogenic impact in two contrasting riverine catchments of Eastern Cape Province-South Africa.~~ ~~**Kuriah F.K.*, Pakhomov E.A.**~~ CANCELLED	Using a combined telemetry-tag return method to aid the assessment of red drum in North Carolina. **Nathan Bacheler, Jeffrey Buckel, Joseph Hightower, Lee Paramore, Kenneth Pollock, Helen Takade, Summer Burdick** S8-17
10:00				
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1
	S1 Evolving Fish Changing Fisheries	**S2 Community Ecology of Stream Fishes**	**C12 Habitat & Water Quality 1**	**S8 Tagging Use in Stock Assessment**
Moderator	Christian Jorgensen	Don Jackson	Jody Wingfield	Paul Conn
10:20	Empirical evidence for fisheries-induced evolution in the wild. **Mikko Heino, Ulf Dieckmann** S1-15	A modelling framework for assessing the effects of long-distance dispersal and loss of connectivity in stream fish. **Marco A. Rodríguez** S2-7	Selenium influence on fish assemblages in the Arkansas River and selected tributaries, Colorado. **Lee Bergstedt, Lareina Wall, Steven Canton, James Chadwick** C12.1-7	Mark-recapture abundance estimates for 4 species of Pacific salmon returning to Upper Cook Inlet, Alaska using passive integrated transponder tags and radio telemetry. **Mark Willette, Robert DeCino, Timothy McKinley, Scott Raborn** S8-18
10:40		Homogenization, differentiation, and the widespread alteration of fish faunas. **Frank Rahel** S2-8	Patterns of fish assemblages in a long-term, watershed-scale study to address the effects of pulp and paper mill discharges in four U. S. receiving streams. **Camille Flinders, Timothy Hall, William Arthurs, Joan Ikoma, Renee Ragsdale** C12.1-8	Contributions of radio tagging to the assessment of Susitna River sockeye salmon productivity. **Richard Yanusz, Mark Willette, Ted Spencer** S8-19
11:00	What we know--and need to know--about fisheries-induced evolution in salmonids. **Jeffrey J. Hard, Mart R. Gross, Mikko Heino, Ray Hilborn, Robert G. Kope, Richard Law, John D. Reynolds** S1-16	Global changes and prediction of fish biodiversity using downscaling concept. **Clément Tisseuil, Gael Grenouillet, Muriel Gevrey, Sovan Lek** S2-9	A simulation model to evaluate common carp (*Cyprinus carpio*) removal as a tool to improve water quality. **Michael Colvin*, Clay Pierce, Tim Stewart** C12.1-9	The use of radio-telemetry and coded-wire tags in estimating stock parameters of wild Coho and Chinook salmon populations on the Kenai Peninsula, Alaska. **Timothy McKinley, Jamie Carlon, David Evans, Steve Fleischman, Robert Massengill, Adam Reimer** S8-20
11:20	Changes in selection and evolutionary responses in migratory brown trout following the construction of a fish ladder. **L. Asbjørn Vøllestad, Thrond O. Haugen, Per Aass, Nils Chr. Stenseth,** S1-17	~~Modelling the impact of landscape types on the distribution of stream fish species in the Adour-Garonne Basin, France.~~ ~~**Sovan Lek, Muriel Gevrey, Gael Grenouillet**~~ CANCELLED ~~S2-10~~	Effects of omnivorous fish biomanipulation on water quality and macrozooplankton at a subtropical lake. **Matthew Catalano*, David Buck, Micheal Allen, John Beaver** C12.1-10	Use of a collaborative, integrated acoustic telemetry network to monitor marine and anadromous fishes in the Puget Sound. **Fred Goetz, Barry Berejikian, Scott Steltzner, Correigh Greene, Ed Connor, John Payne, Thomas Quinn** S8-21
11:40	Life history variation in lake trout across North America: implications for exploitation management. **Brian Shuter** S1-18	Predicting the potential impacts of climate change on stream fish assemblages. **Laetitia Buisson, Nicolas Casajus, Sovan Lek, Gael Grenouillet** S2-11	Grand River structural enhancement project: restoring quality habitat in a dam controlled environment. **Al Murray, Jennifer Wright** C12.1-11	Conflicting results from a large multi-stratum PIT tag study and the Pacific halibut stock assessment. **Raymond Webster, William Clark** S8-22
12:00				
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		Tuesday August 19th		
		Westin Hotel		
Room	Governor General 2	Governor General 3	Provinces 1	Provinces 2
	S6 Atlantic Salmon Restoration	**S33 Success Stories in Control of AIS**	**C10 Centrarchids 1**	**S10 Hydropower & Sustainable Fisheries**
Moderator	Jack Imhof	Becky Cudmore	Terry Marshall	Mike Bradford
8:00				Community responses to flow regime: empirical tests, generality and predictability. **Nicolas Lamouroux** S10-1
8:20		Barriers and fishways as an ecologically sound tool for controlling invasive sea lampreys. **Lisa O'Connor, Thomas Pratt** S33-12		
8:40	Techniques used to maximize smolt production of landlocked Atlantic salmon for the Lake Champlain Fishing Restoration Program. **Kevin Kelsey** S6-11	Purple loosestrife biocontrol success in Ontario, 1992-2008: 16 years into the project. **Donna MacKenzie, Beth Brownson** S33-13		Effectiveness of instream flow mitigation: a review of biological monitoring to assess flow alteration. **Mark Bevelhimer** S10-2
9:00	A century of challenges and successes for landlocked Atlantic salmon in the company of hydropower on the Clyde River, a tributary to Lake Memphremagog on the Vermont / Quebec border. **Leonard Gerardi** S6-12	Specialty animal foods - new product made from invasive silver carp. **Duane Chapman, April Braddy, Andrew Clarke, Ellen Dierenfeld** S33-14	Comparison of population dynamics of largemouth bass at three reservoirs from La Plata River, Puerto Rico. **Marinelly Valentín** C10.1-2	Variation in large-bodied fish community structure and abundance in relation to water management regime in a large regulated river. **Tim Haxton, Scott Findlay** S10-3
9:20	Connecticut River Atlantic salmon restoration science and sociology. **Caleb Slater** S6-13	Management of the invasive European carp (*Cyprinus carpio*) through physical control at recruitment and migrational hotspots in the Murray-Darling Basin, Australia. **Dale McNeil, Anthony Connalin, Ivor Stuart, Dean Gilligan** S33-15	Effects of a summer high water event on young of the year largemouth bass in the Arkansas River. **Jeffrey Horne*, Steve Lochmann** C10.1-3	Spatial patterns of benthos in relation to natural and regulated flow regimes. **Nicholas Jones** S10-4
9:40	Community-based efforts for Atlantic salmon recovery in the Maritimes. **Todd Dupuis** S6-14	The history of freshwater fish introductions in Nova Scotia: balancing prevention and promotion. **Jason LeBlanc** S33-16	Trypsin activity as a measure of diet quality of age-0 largemouth bass in reservoirs with good and poor recruitment. **Bradley Ray, Brian Murphy** C10.1-4	Historic and current monitoring trends of resident sport-fish in the Columbia River and their relationship to flow regulation and other environmental factors. **Dana Schmidt, Dustin Ford, Robyn Irvine, Joseph Thorley, David DeRosa, Brent Mossop** S10-5
10:00				
Room	Governor General 2	Governor General 3	Provinces 1	Provinces 2
	S6 Atlantic Salmon Restoration	**S33 Success Stories in Control of AIS**	**C10 Centrarchids 1**	**S10 Hydropower & Sustainable Fisheries**
Moderator	Jack Imhof	Becky Cudmore	Terry Marshall	Mike Bradford
10:20	55 Years of community-based conservation on the Miramichi: experiences of the Miramichi Salmon Association. **Mark Hambrook** S6-15	Threats and stop aquatic hitchhikers! Campaigns work to prevent introduction of aquatic invasive species. **Douglas Grann, Douglas Jensen, Nick Schmal** S33-17	Energetic consequences of habitat loss to an apex predator. **Jakob Tetzlaff*, William Pine, Thomas Frazer** C10.1-5	Habitat and hydrodynamic assessment relating to flow releases below EB Campbell Hydroelectric Station on the Saskatchewan River. **Doug Watkinson, H. Ghamry, W. Franzin, M. Bast** S10-6
10:40	Restoring Atlantic Salmon stocks through community stewardship: experiences in Newfoundland. **T. Rex Porter** S6-16	Early successes in reducing the risks of schools, science curricula and biological supply houses as pathways for spreading aquatic invasive species. **Samuel Chan** S33-18	Temporal trends in largemouth bass mortality with fishery implications. Mike Allen, **Carl Walters, Randy Myers** C10.1-6	Effects of hourly variation in flow and density on spawning, incubation mortality, habitat use and survival of age-0 rainbow trout in the Colorado River below Glen Canyon Dam. **Josh Korman** S10-7
11:00	Lake Ontario Atlantic salmon restoration program and partnership. **Marion Daniels** S6-17	Some successes in aquatic invader prevention and containment: with special emphasis on the Great Lakes and Upper Mississippi River basins. **Michael Hoff** S33-19	The influence of selection for vulnerability to angling on foraging in largemouth bass. **Michael Nannini, David Wahl** C10.1-7	Suitability of flow regimes in sustaining unionids and fishes in North America. **Marguerite Xenopoulos, Daniel Spooner, Daelyn Woolnough** S10-8
11:20	Rags to riches of Northwest River Atlantic salmon: a tale from Sherwood Forest... **David Cote** S6-18	AIS information coordination: recent progress and promise using on-line technology. **Rochelle Sturtevant** S33-20	Effects of four deep hooked removal techniques on feeding, growth and survival of largemouth bass. **Corey DeBoom*, Matthew VanLandeghem, David Wahl** C10.1-8	~~Large scale hydroelectric development in northern ecosystems: an analysis of the potential effects of development of the proposed Lower Churchill Hydroelectric Generation Project, Labrador.~~ **~~David Scruton, Jim McCarthy, Bevin LeDrew~~** CANCELLED ~~S10-9~~
11:40	Partnerships in headwaters restoration for Atlantic salmon: Credit River, Ontario, Canada. **Mark Heaton** S6-19	Keeping our lakes great! Examples of cooperation to stop aquatic invasive species in Ontario. **Francine MacDonald** S33-21	Recovery profile and magnitude of physiological disturbance in two size classes of exercised largemouth bass. **Andrew Gingerich*, David Philipp, David Wahl, Cory Suski** C10.1-9	Walleye recruitment in the Peace-Athabasca Delta: can we use environmental correlates to assess instream flow needs? **Andrew Paul** S10-10
12:00				
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		Tuesday August 19th		
	Westin Hotel	Ottawa Congress Centre		
Room	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2
	C22 Fish Culture	**S22 Restless Lake Trout**	**S36 Best Student Paper**	**S32 Freshwater Fishes of Canada**
Moderator	Bruce Barton	Ken Mills	Trent Sutton	Tom Pratt
8:00	Tank culture of sunshine bass fingerlings without using rotifers. **Gerald Ludwig, Steve Lochmann** C22-1	Experiments in lake trout population dynamics. **Kenneth H. Mills, Sandra M. Chalanchuk, Douglas J. Allan** S22-1	Why saugeye are where they are. **Cassandra May*, Elizabeth Marschall, Derek Aday, R. Scott Hale** S36-11	Overview of the changes in the composition of the Canadian freshwater fish fauna since 1973. **Nicholas Mandrak** S32-1
8:20	Stocking density effects in phase one culture of hybrid striped bass (*Morone chrysops* ♀ x *M. saxatilis* ♂, Percichthyidae). **Erica Brumbaugh, David A. Culver** C22-2		Physiological and behavioural consequences of chronic stress during parental care in a wild teleost. **Constance O'Connor*, Kathleen Gilmour, Robert Arlinghaus, Glen Van der Kraak, Steven Cooke** S36-12	Changes in the taxonomy of Canadian fishes since 1973 and the "Common and scientific names of fishes from the United States, Canada, and Mexico". **Joseph Nelson, Héctor Espinosa-Pérez, Lloyd Findley, Carter Gilbert, Robert Lea, Nicholas Mandrak, Richard Mayden, Larry Page** S32-2
8:40	Biotechnological strategy to enhance human health beneficial omega-3 highly unsaturated fatty acids (HUFA) in fishes. **Shiva D. Singh, Garima Bajpai** C22-3	Taxonomy of *Salvelinus namaycush*. **Noel Alfonso** S22-2	The influence of feeding level on the metabolic rate of largemouth bass: evidence of a compensatory response. **Steven Ranney*, Steven Chipps, David Wahl** S36-13	Canadian fishes at risk: status assessment, legal listing, and the communication of science. **Jeffrey Hutchings** S32-3
9:00	Saturated lipid key to restoration of beneficial fatty acid profile in sunshine bass—a way out of the fish oil trap. **Jesse Trushenski, Heidi Lewis, Christopher Kohler** C22-4	Life history differentiation between deep-water and shallow-water forms of lake trout in large lakes of North America. **Nancy Nate, Michael Hansen, Charles Krueger, Mara Zimmerman, William Taylor** S22-3	Assessing genetic diversity and divergence levels of wild yellow perch and walleye populations and applications to improving broodstock. **Osvaldo Sepulveda-Villet*, Carol Stepien** S36-14	Identifying Canadian freshwater fishes through DNA barcodes. **Julien April*, Nicolas Hubert, Robert Hanner, Erling Holm, Nicholas Mandrak, Eric Taylor, Marry Burridge, Douglas Watkinson, Allen Curry, Paul Bentzen, Junbin Zhang, Louis Bernatchez** S32-4
9:20	Effect of dietary immunostimulants on immunity and disease resistance of channel catfish and Nile tilapia. **Thomas Welker, Chhorn Lim, Richard Shelby, Mediha Yildirim-Aksoy, Phillip Klesius** C22-5	Is assortative mating promoting the adaptive divergence in lake charr morphs in Great Bear Lake, NWT? **Craig Blackie, Paul Bentzen** S22-4	Density dependent growth and energy acquisition dynamics of central Appalachian brook trout. **Ryan Utz*, Kyle Hartman** S36-15	Phylogeographic influences of postglacial recolonization of freshwater fishes across dynamic spatiotemporal landscapes. **Chris Wilson** S32-5
9:40	Evaluation of a pilot recirculating aquaculture system for intensive culture of red drum *Sciaenops ocellatus* in Florida. **Micah Alo, Angela Dukeman, Kerry Mesner, Dan Roberts, Josh Taylor, Chad Young, Chris Young** C22-7	Genetic population structuring of lake trout in Great Bear Lake, Northwest Territories. **Kimberly Howland, Craig Blackie, Paul Bentzen, Melissa Lindsay, Ross Tallman** S22-5	Visual and chemical signaling in the round goby. **Stan Yavno*, Lynda Corkum** S36-16	Comparison of taxonomic and functional richness across Canadian freshwater ecoregions: a freshwater fish perspective. **Yorick Reyjol, Marco A. Rodríguez, Pierre Magnan, Nicholas E. Mandrak** S32-6
10:00				
Room	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2
	C22 Fish Culture removed	**S22 Restless Lake Trout**	**C3 Sturgeon**	**S32 Freshwater Fishes of Canada**
Moderator		Ken Mills	Greg Deyne	Nick Mandrak
10:20		Ontogenetic niche partitioning of lake trout morphotypes in Great Slave Lake. **Mara Zimmerman, Stephanie Schmidt, Charles Krueger, M. Jake Vander Zanden, Randy Eshenroder** S22-6	Age and growth of shovelnose sturgeon in the Missouri River. **Martin Hamel, Kirk Steffensen, Tyler Haddix, Ryan Wilson, Dane Shuman, Sam Stukel, Paul Horner, Wyatt Doyle** C3-1	Homogenization and differentiation of Canada's freshwater fish fauna: a comparison between 2000 and 2005 faunal surveys. **Eric Taylor** S32-7
10:40		The reproductive biology of siscowet lake trout and the role of genes and the environment in determining the siscowet phenotype. **Frederick Goetz, Shawn Sitar, Charles Bronte, Dan Rosauer** S22-7	Wrong place at the wrong time: incidental take of endangered pallid sturgeon in a commercial caviar fishery. **Phillip Bettoli, Michelle Casto-Yerty, George Scholten** C3-2	Morphological, genetic and life history variation in alternative ecotypes in Canadian Arctic fishes. **Ross Tallman, Kimberly Howland** S32-8
11:00		Vulnerable *Salvelinus*. **Ross Tallman, Kimberly Howland** S22-8	Spawning of pallid sturgeon in the Middle Missouri River. **Justin Haas, Dustin Everitt, David Adams, Aaron DeLonay, Gerald Mestl** C3-3	Changes in the Prairie provinces and northwestern Ontario fishes. **Doug Watkinson, Bill Franzin, Ken Stewart** S32-9
11:20		Climate-driven changes in seasonal habitat use by lake trout in a small boreal lake. **Paul Blanchfield** S22-9	Comparative examination of patterns of movement and spawning by pallid sturgeon and shovelnose sturgeon in the Lower Missouri River. **Aaron DeLonay, Kimberly Chojnacki, Sandra Clark-Kolaks, Emily Tracy-Smith, Diana Papoulias, Mark Wildhaber, Dustin Everitt, Gerald Mestl** C3-4	Fish populations and communities of Lake Ontario, Bay of Quinte, and Upper St. Lawrence River: 50 years of change. **John Casselman** S32-10
11:40		Lake trout past, present and future: prospects and adaptive potential for an Ice Age species in a warming world. **Chris Wilson, Jenni McDermid** S22-10	Fine-scale movement of Gulf of Mexico sturgeon relative to critical habitat within Escambia, East, Pensacola, and Choctawhatchee Bays, Florida, following Hurricanes Ivan (2004) and Dennis (2005). **Michelle Duncan, Lisa Hollensead, Lynne Carter-Gray, Frank Parauka, Stephania Bolden** C3-5	Lampreys in Canada: changes since 1973. **Claude Renaud, Margaret Docker, Nicholas Mandrak** S32-11
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		Tuesday August 19th	
		Ottawa Congress Centre	
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5
	C5 Stats and Modeling 2	**S12 Highly Migratory Large Pelagics**	**C13 Marine Fish: Life History**
Moderator	Brett van Poorten	Jon Brodziak	Anthony Overton
8:00	Learning from losers: investigating the sources and severity of mortality in freshwater fish during their early life stages. **Nicole McCasker*, Paul Humphries, Shaun Meredith, Nick Klomp** C5.2-1	Oceanography and reproductive strategies of tunas and mackerels. **Churchill Grimes, Edward Houde, Dan Margulies** S12-1	Growth and survival of rainbow smelt larvae in relation to zooplankton species assemblages and freshwater discharge in the Saguenay fjord, Canada. **Gabriel Diab*, Pascal Sirois, Stéphane Plourde** C13-1a
8:20	Estimating bioenergetics parameters using capture-recapture data from an unfished population. **Brett van Poorten*, Carl Walters** C5.2-2	Spatial perspectives of bycatch in fisheries targeting large pelagics: mapping the bycatch seascape. **Larry Crowder, Rebecca Lewison, Michelle Sims, Candan Soykan, Janet Franklin, Ramunas Zydelis** S12-2	Growth, mortality and abundance of young of the year winter flounder (*Pseudopleuronectes americanus*) in two Long Island environments. **Melissa Yencho*, Mike Frisk** C13-1
8:40	Time-trend models and tag-based survival estimates: a cautionary tale. **Stuart Welsh, John Hoenig** C5.2-3	Recent trends in the bluefin tuna (*Thunnus thynnus*) rod and reel fishery in the northeast United States. **Ronald Salz, John Foster** S12-3	~~Age, growth and reproduction of yellowedge grouper, *Epinephelus flavolimbatus*, in the northern Gulf of Mexico.~~ ~~**Melissa Cook, Nancy Brown-Peterson, Michael Hendon, Bruce Comyns**~~ CANCELLED ~~C13-2~~
9:00	Identifying critical habitat across multiple scales for estuarine-dependent fishes with a landscape modelling approach. **Richard Fulford, Mark Peterson, Paul Grammer** C5.2-4	Resolving population boundaries in a mixed stock with Exon-Primed Intron-Crossing nuclear genetic markers (EPICs) using High-Resolution Melting Analysis (HRMA). **Brad Smith, Jaime Alvarado-Bremer** S12-4	Age composition, growth and density-dependent mortality in juvenile red snapper estimated from observer data from the Gulf of Mexico penaeid shrimp fishery. **William Gazey, Benny Gallaway, John Cole, David Fournier** C13-3
9:20	Stock assessment of chambo (*Oreochromis* sp.) in the southeast arm of Lake Malawi. **Richard Bell*, Jeremy Collie** C5.2-5	Bycatch and incidental catches of sharks in the Hawaii-based pelagic longline fishery for swordfish, *Xiphias gladius*, in 2004–2006. **William Walsh** S12-5	Intracohort variation in growth and mortality of age-0 red drum (*Sciaenops ocellatus*) with evidence for demographic restructuring during the overwinter period. **Cassie Martin*, Fred Scharf** C13-4
9:40	A simulation study to evaluate uncertainties of the simple yield analysis for the Taitung lobster fishery. **Yi-Jay Chang*, Chi-Lu Sun, Yong Chen, Su-Zan Yeh** C5.2-6	Application of a Bayesian hierarchal meta-analysis in the assessment of pelagic sharks: a case study using the night shark, *Carcharhinus signatus*. **John Carlson, Kate Siegfried, Enric Cortés, Aaron MacNeil** S12-6	~~Age and growth of crimson sea bream *Paragyrops edita* Tanaka in Beibu Gulf, China.~~ ~~**Huoshong Lu, Yunrong Yan, Bo Feng, Gang Hou**~~ CANCELLED ~~C13-5~~
10:00			
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5
	C5 Stats and Modeling 2	**S12 Highly Migratory Large Pelagics**	**C13 Marine Fish: Life History**
Moderator	Brett van Poorten	Jon Brodziak	Anthony Overton
10:20	Assessing impingement and entrainment impacts using population dynamic models with limited data. **Matthew Bingham, Jason Kinnell, Grant Crownfield** C5.2-7	Using historical data to estimate movement and fishing mortality rates of the blue shark (*Prionace glauca*) in the North Atlantic Ocean. **Alexandre Silva, Mark Maunder, Vincent Gallucci, Nancy Kohler, John Hoey** S12-7	C13-6 removed
10:40	Methodology for estimating entrainment under alternative cooling water intake screen configurations. **John A. D. Burnett, Alan W. Wells, Thomas L. Englert** C5.2-8	Tales of the demise of large pelagic fishes: where's the truth? **Pierre Kleiber** S12-8	Age, growth, and mortality of sheepshead in Chesapeake Bay, Virginia. **Joseph Ballenger*, Hongsheng Liao, Cynthia Jones** C13-7
11:00	Considerations regarding production foregone as a tool for evaluating losses of organisms at power plants. **Thomas Englert, Alan Wells, John Burnett, Robert Norris** C5.2-9	Population structure, spawning fidelity and contributions of western and eastern origin populations to North American fisheries for bluefin tuna (*Thunnus thynnus*): evidence from otolith stable isotope analysis. **David Secor, Jay Rooker, Ryan Schloess** S12-9	Aspects of the biology of large monkfish in the northwest Atlantic Ocean. **Andrea Johnson, Anne Richards, Daniel Cullen, Belita Nguluwe, Kathy Lang** C13-8
11:20	Bias studies to test assumptions in NOAA's recreational fisheries surveys. **Linda Barker** C5.2-10	Age & growth and other life history aspects of swordfish in the central Pacific. **Robert L. Humphreys, Jr., Edward E. DeMartini** S12-10	Relative contribution of spring- and summer-spawned bluefish to North Carolina. **James Morley, Jeffrey Buckel, Thomas Lankford** C13-9
11:40	Commercial mark-recapture: new methodology for studying large valuable fish. **Nuno Prista*, José Lino, Costa Maria, José Costa, Cynthia Jones** C5.2-11	Efficient single-tube characterization of genetic polymorphisms in fishes: the use of high-resolution-melting analysis as a breakthrough to study the genetic population structure of the swordfish (*Xiphias gladius*). **Jaime Alvarado Bremer, Mike Hint** S12-11	Estimating true growth and body condition in coastal bluefish. **Kyle Hartman, Beth Phalen** C13-10
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		Tuesday August 19th	
		Ottawa Congress Centre	
Room	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
	S14 Squaloid Sharks	**C4 Fish Conservation 2**	
Moderator	Roger Rulifson	Melissa Robillard	
8:00		Prioritizing areas for the conservation of stream biodiversity in Maryland. **Scott Stranko, Ronald Klauda, Patrick Ciccotto** C4.2-1	
8:20	Rulifson/ Cudney – Opening remarks	Predicting future changes in Muskegon River watershed (Michigan, USA) game fish under land use alteration and climate change scenarios. **Paul Steen, Michael Wiley, Jeffrey Schaeffer** C4.2-2	
8:40	Spatial analysis of North Carolina spiny dogfish (*Squalus acanthias*) population movements. **Jennifer Cudney*, Roger Rulifson** S14-2	Sculpin reintroductions in Minnesota's driftless region: growth and survival vary among habitats and source populations. **David Huff*, Loren Miller** C4.2-3	
9:00	Integrating microsatellites and pop-up satellite tags to study population structure of dogfish, *Squalus acanthias*, in the western North Atlantic. **Walter Bubley*, James Sulikowski, Paul Tsang** S14-3	Vulnerability of freshwater fish communities to human mediated impacts. **Jenni McDermid, David Browne** C4.2-4	
9:20	~~Fishery closed areas for deepwater dogfishes off southern Australia – design, monitoring and evaluation.~~ ~~**Ross Daley**~~ Moved to Poster C15 S14-4	Inbreeding depression in the endangered Aurora brook trout (*Salvelinus fontinalis timagamiensis*): assessment and conservation options. **Jenny Lynn Fortier*, Chris Wilson** C4.2-5	
9:40	~~Adult, juvenile and neonate habitat preferences of spiny dogfish, *Squalus acanthias*: density, temperature and neonate range expansion in the western Atlantic.~~ ~~**Kathy Sosebee, Michael Frisk, Thomas Miller, Jack Musick**~~ CANCELLED ~~S14-5~~	Landscape mosaics and the aquatic ecosystem: improving fisheries management strategies for Species at Risk (SAR) in an urbanizing catchment. **David Lawrie, Christine Tu, Mark Poos** C4.2-6	
10:00			
Room	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
	S14 Squaloid Sharks	**C4 Fish Conservation 2**	**S35 Standard Methods for Sampling NA Freshwater Fish**
Moderator	Jennifer Cudney	Melissa Robillard	Scott Bonar
10:20	Population structure of the spiny dogfish in Atlantic waters inferred from nuclear microsatellites. **Ana Verissimo*, Jan McDowell, John Graves** S14-6	Declining abundance and recruitment of American eels at the extremities of the range. **John Casselman, Lucian Marcogliese, Rob MacGregor, Peter Thompson** C4.2-10 ~~Using meta-population dynamics to quantify extinction risks to the endangered fish the redside dace (*Clinostomus elongatus*).~~ ~~**Mark Poos*, Christine Tu, Donald Jackson**~~ Moved to 11:20 am, same session ~~C4.2-7~~	**SPEED FORMAT** **S35-SP-1:** Standard methods for sampling North American freshwater fishes. **Scott Bonar, Wayne Hubert, David Willis** **S35-SP-2:** Standardized sampling of warmwater fish in small standing waters **Kevin Pope, Robert Neumann, Scott Bryan** **S35-SP-3:** Sampling coldwater fish in small standing waters of North America. **Paul Bailey, Nigel Lester, Wayne Hubert** **S35-SP-4:** Sampling coldwater fish in large lakes. **Donna Parrish, David Beauchamp, Roy Whaley** **S35-SP-5:** Sampling coldwater fish in rivers. **Robert M. Hughes, R. Allen Curry, Mark McMaster, David J. Zafft** **S35-SP-6**: Sampling warmwater and coldwater fish in two-story standing waters. **Phaedra Budy, Gary Thiede, Chris Luecke, Roger Schneidervin** S35-SP-7: Converting non-standard fish sampling data to standardized data. **Jim Peterson, Craig Paukert** **S35-SP-8:** Efficacy of the proposed North American gill net standard for monitoring fish communities in Ontario, Canada. **Steve Sandstrom, Nigel Lester, George Morgan, Tim Haxton**
10:40	~~Sex-specific spatial and temporal distribution patterns of spiny dogfish, *Squalus acanthias* in the northwest Atlantic Ocean.~~ ~~**Katherine Sosebee, Paul Rago**~~ CANCELLED ~~S14-7~~	From theory to the river: the supportive breeding program of an endangered Catostomid fish, the Copper redhorse (*Moxostoma hubbsi*). **Nathalie Vachon, Pierre Dumont, Jean Leclerc, Francis Bouchard, Catherine Lippé, Louis Bernatchez, Paul Grondin, Michel Legault, Julie Brassard, Pascal Sirois** C4.2-8	
11:00	Cooperative winter tagging of spiny dogfish in North Carolina waters: 10 years of data. **Roger Rulifson, Jennifer Cudney, Wilson Laney** S14-8	Tailored conservation scenarios for American eel in the major basins of New York State. **Dawn Dittman, Leonard Machut, James Johnson** C4.2-9	
11:20	Management of spiny dogfish (*Squalus acanthias*) and a demographic risk analysis for the Gulf of Alaska. **Cindy Tribuzio*** S14-9	Using meta-population dynamics to quantify extinction risks to the endangered fish the redside dace (*Clinostomus elongatus*). **Mark Poos*, Christine Tu, Donald Jackson** C4.2-7 ~~Declining abundance and recruitment of American eels at the extremities of the range.~~ ~~**John Casselman, Lucian Marcogliese, Rob MacGregor, Peter Thompson**~~ Moved to 10:20 am, same session ~~C4.2-10~~	
11:40	The possible role of spiny dogfish in the Strait of Georgia ecosystem. **Richard Beamish, Ruston Sweeting, Chrys Neville** S14-10	Estimation of age-based biomass of American eel in relation to temporal variation of recruitment in Lake Ontario systems. **Xinhua Zhu, Yingming Zhao, Timothy Johnson, Alastair Mathers** C4.2-11	
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		Tuesday August 19th		
		Westin Hotel		
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1
	S1 Evolving Fish Changing Fisheries	**S2 Community Ecology of Stream Fishes**	**C12 Habitat & Water Quality 1**	**S8 Tagging Use in Stock Assessment**
Moderator	Katja Enberg	Keith Gido	Samantha Mason	Doug Vaughan
1:20	Arctic charr life history under differing harvest regimes. **Raul Primicerio, Per-Arne Amundsen, Rune Knudsen, Anders Klemetsen, Mikko Heino** S1-19	Interactions of introduced pumpkinseed *Lepomis gibbosus* and native brown trout *Salmo trutta* in small streams of southern England. **Gordon Copp, Julien Cucherousset, Saulius Stakenas, J. Robert Britton, Lorenzo Vilizzi, Michael G. Fox, François Villeneuve** S2-12	Challenges of sustained blue crab fisheries in pollution-impacted Chesapeake Bay waters. **Cynthia McOliver*, Thaddeus Graczyk** C12.1-12	A finite-state continuous-time approach to estimating abundance and instantaneous migration and mortality rates for mixing stocks from tagging and catch data. **Tim Miller** S8-23
1:40	A meta-analysis of life history changes in exploited fish populations. **Diana Sharpe*, Andrew Hendry** S1-20	The response of stream fish assemblages to local-scale habitat as influenced by landscape: a mechanistic investigation of stream fish assemblages. **Dana M. Infante, J. David Allan** S2-13	Ecological restoration of fish habitat at the watershed scale. **Carole Godin** C12.1-13	Consideration of spatial patterns in modeling and managing spawning groups of cod. **Jon Loehrke*, David Martins, Steven X. Cadrin** S8-24
2:00	The study of ecological speciation and its implications for fisheries. **Ross Tallman, Kimberly Howland** S1-21	Comparing stochastic properties of stream hydrographs and the resilience of fish assemblages. **Gary Grossman, John Sabo** S2-14	Assessing ecological risk in an increasingly complex world: proposed model for fish habitat managers. **Sophie Bastien-Daigle, Matthew Hardy, Guy Robichaud** C12.1-14	Improvement of a spatial age-structured model with mark-recapture data. **Terrance Quinn, Sara Miller, Peter-John Hulson** S8-25
2:20	Patterns of evolution in a polymorphic fish: a challenge for conservation and management. **Pamela Woods*, Skúli Skúlason, Sigurdur Snorrason** S1-22	Persistence of longitudinal structure in stream fish communities. **James Roberts, Nathaniel Hitt** S2-15	~~Watershed condition assessments for George Washington Birthplace National Monument and Thomas Stone National Historic Site.~~ ~~**Ernie Hain*, Stacy Nelson, Halil Cakir**~~ CANCELLED ~~C12.1-15~~	A spatially explicit model of yellowtail flounder. **Daniel Goethel, Christopher Legault, Steven Cadrin** S8-26
2:40	Population divergence in reproductive traits of a protandrous pandalid shrimp caused by size-selective fishing. **Susumu Chiba** S1-23	Reproductive timing and the assembly larval fish communities in a highly variable river system, the Rio Grande in New Mexico. **Thomas Turner, Trevor Krabbenhoft, Ayesha Burdett** S2-16	Impacts of human use of water drive need for improved and increasing use of incremental impact assessment tools. **William Werner** C12.1-16	A simulation-based approach for assessing the performance of a yellowtail flounder (*Limanda ferruginea*) movement-mortality mode. **Larry Alade, Steven Cadrin, Thomas Miller, Eric May** S8-27
3:00				
4:00		**Business Meeting** Chateau Laurier Ballroom All AFS members are welcomed to attend		
5:00				

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		Tuesday August 19th		
		Westin Hotel		
Room	Governor General 2	Governor General 3	Provinces 1	Provinces 2
	S6 Atlantic Salmon Restoration	**C11 Brook Trout**	**C10 Centrarchids 1**	**S10 Hydropower & Sustainable Fisheries**
Moderator	Marion Daniels	Kelly Eggers	Marie-Ann Gravel	Mike Bradford
1:20	Classrooms, graduate students, government, conservation agencies and Atlantic salmon: a winning combination in re-introduction initiatives. **Shidan Murphy*, Michael Rennie, Mark Heaton, Chris Robinson** S6-20	Age and size structure of coaster brook trout in Pictured Rocks National Lakeshore, Michigan, USA. **Jill Leonard, Paul Kusnierz** C11-1	Introgression and genetic structure among Florida's largemouth bass. **Dijar Lutz-Carrillo** C10.1-10	Monitoring salmon smolt outmigration to evaluate the response of fish populations to flow manipulations. **Brent Mossop, Caroline Melville, Don McCubbing, Scott Decker, Josh Korman, Simon Bonner, Paul Higgins** S10-11
1:40	What do children have to do with fish restoration? **Pamela Gibson** S6-21	Growth in coaster brook trout: seasonal and hormonal effects. **Carla Serfas*, Rachel Holman, Lindsey Watch, Jesse Karner, Jill Leonard** C11-2	Genetic mark and recapture of stocked Florida largemouth bass. **Michael Tringali, Wes Porak, Rick Stout, Pamela Bellotti, Nick Trippel, Mike Matthews** C10.1-11	Understanding the natural flow regime, a key component in instream flow studies. **Daniel Caissie** S10-12
2:00	Corporate conservation – the Banrock Station Experience. **Tony Sharley** S6-22	Alternative growth rates in populations of Lake Superior brook trout: a critical test for partial migration. **Melissa Robillard, Rob McLaughlin, John M Casselman, Rob Mackereth** C11-3	Investigating interactions between largemouth and spotted bass, Lake Norman, North Carolina. **Jason Godbout, Jim Rice, Derek Aday** C10.1-12	Year 12 of an adaptive management experiment for instream flows in the Bridge River, British Columbia. **Mike Bradford, Paul Higgins, Josh Korman, Chris Perrin** S10-13
2:20		Effects of summer temperature conditions on brook trout in a thermally marginal lake. **Jason Robinson*, Daniel Josephson, Cliff Kraft** C11-4	Inter-specific relationship between largemouth bass and armored catfish at Lucchetti Reservoir, Puerto Rico. **Darien López** C10.1-13	Examination of the efficacy of controlled flows from a reservoir for the purpose of moderating migration temperatures for Pacific salmon: a case study in the Nechako Watershed. **Steve Macdonald, John Morrison, David Patterson** S10-14
2:40		Brook trout heaven and hell: life in a small Shield lake impacted by beaver dam activity. **John Parks, Derek Parks, Wayne Groom** C11-5		The effect of ramping rates and other environmental parameters on the stranding rates of fish below hydro-electric dams in British Columbia, Canada. **Robyn Irvine, Trevor Oussoren, James Baxter, Dana Schmidt** S10-15
3:00				
4:00		**Business Meeting** Chateau Laurier Ballroom All AFS members are welcomed to attend		
5:00				

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		Tuesday August 19th		
		Ottawa Congress Centre		
Room	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2	Congress Centre 3
	S22 Restless Lake Trout	**C3 Sturgeon**	**S32 Freshwater Fishes of Canada**	**C5 Stats and Modeling 2**
Moderator	Ross Tallman	Greg Deyne	Eric Taylor	Nathan Richer
1:20	Effects of climate and temperature on life history characteristics of lake trout. **Jenni McDermid, Brian Shuter, Bill Sloan, Nigel Lester** S22-11	Status of gulf sturgeon in Florida waters: using age-structured population modeling techniques to reconstruct and project population trends and evaluate conservation targets. **H. Jared Flowers*, William Pine, Steven Martell** C3-6	The continuing loss of cisco diversity in the Laurentian Great Lakes. **Tom Pratt, Nick Mandrak** S32-12	Designing marine reserve networks for species that move within a home range and the effects on persistence and yield. **Elizabeth A. Moffitt*, Louis W. Botsford, David M. Kaplan, Michael R. O'Farrell** C5.2-12
1:40	Life history variation among lake trout ecotypes in Great Bear Lake, Northwest Territories: implications for stock assessment and management. **Kimberly Howland, Louise Chaverie, Ross Tallman, William Tonn** S22-12	Effects of environmental factors and parental reproductive characteristics on dispersal time of larval lake sturgeon (*Acipenser fulvescens*). **Yen Duong*, Kim Scribner, James Crossman, Patrick Forsythe, Edward Baker** C3-7	Diversity and taxonomic uncertainty in the cisco complexes of Canadian lakes. **Nicholas Mandrak, Scott Reid, Mark Ridgway, Jim Reist** S32-13	Environmental modeling of a remote Arctic longline fishery. **Susan Dennard*, Aaron MacNeil, Margaret Treble, Steven Campana, Aaron Fisk** C5.2-13
2:00	Restless indeed: seasonal migrations of lake trout (*Salvelinus namaycush*) to brackish-water environments of coastal Nunavut. **Heidi Swanson*, Karen Kidd** S22-13	Genetic diversity implications of lake sturgeon stream-side rearing. **Luke Roffler*, Brian Sloss, Brad Eggold, Tom Burzynski, Ron Bruch** C3-8	~~Progress in Char (*Salvelinus*) Taxonomy since 1973.~~ ~~**Jim Reist**~~ CANCELLED ~~S32-14~~	When it rains, it pours: effects of freshwater influx on spatial dynamics of blue crabs and implications for fisheries management. **Christina Durham*, David Eggleston** C5.2-14
2:20	Molecular genetic characterization and comparison of lake trout from Yellowstone and Lewis Lakes, Wyoming. **Wendylee Stott, Todd Koel, Kim Scribner, Philip Doepke** S22-14	The St. Lawrence estuary Atlantic sturgeon (*Acipenser oxyrinchus*) fishery: managing a valuable resource towards a sustainable fishery. **Guy Verreault, Guy Trencia** C3-9	Diversity of the mottled sculpin species complex (Teleostei: Cottidae): How many species are there and where do we go from here? **David Neely, Michael Blum** S32-15	Metapopulation dynamics of oyster reserves in Pamlico Sound, NC. **Brandon Puckett*, David Eggleston** C5.2-15
2:40	Collapse and recovery: a history of lake trout dynamics in Great Slave Lake. **Ross Tallman, Chris Day, Kimberly Howland, George Low** S22-15	Bycatch mortality of sturgeon in the Northwest Atlantic Ocean. **Tim Miller, Gary Shepherd, David Secor** C3-10		An analysis of current and alternate management strategies for summer flounder (*Paralychthys dentatus*) along the U.S. Atlantic coast. **Robert Latour, James Gartland, Christopher Bonzek** C5.2-16
3:00				
		Business Meeting Chateau Laurier Ballroom All AFS members are welcomed to attend		
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		Tuesday August 19th		
		Ottawa Congress Centre		
Room	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	S12 Highly Migratory Large Pelagics	**C15 Marine Fisheries Management**	**S14 Squaloid Sharks**	**C14 Contaminants and Toxicology**
Moderator	Churchill Grimes	Tim Haxton	Roger Rulifson and Jennifer Cudney	Shannon LeBlond
1:20	Sustainability of the Hawaii-based pelagic longline fishery for swordfish: a case study of successful collaboration among fishery stakeholders. **Russell Ito** S12-12	~~Performance of a fish descender in the Gulf of Mexico red snapper fishery.~~ ~~**Matthew Campbell*, Sandy Diamond**~~ Moved to poster S21 ~~C15.1-1~~	Phylogeography of two wide ranging, deep-sea squaliform sharks *Centroscymnus coelolepis* and *Centrophorus squamosus* – inferences from mitochondrial DNA control region. **Ana Verissimo*, Jan McDowell, John Graves** S14-11	~~Olfactory impairment by copper affects juvenile salmon behaviour and survival with cutthroat trout predators.~~ ~~**Jenifer McIntyre*, David Baldwin, David Beauchamp, Nathaniel Scholz**~~ CANCELLED
1:40	Biological reference points and status of north Pacific striped marlin, *Tetrapturus audax*. **Jon Brodziak, Kevin Piner** S12-13	An analysis of individual transferable quotas for both the commercial and recreational fishing sector. **Ming Ng*, Jesse Patterson, Steve Choy** C15.1-2	Trophic structure of a nearshore marine fish assemblage off Assateague Island, MD. **Ryan Woodland*, David Secor** S14-12	Analysis of an alternative method for measuring methyl mercury in fish. **Toby Stover, William G. Hagar** C14-2
2:00	Reducing pelagic bycatch: an analysis of two approaches to capture swordfish in Canadian waters. **Susanna Fuller, Gretchen Fitzgerald, Jen Ford, Scott Wallace** S12-14	Development of a monitoring tool for fish populations of the St. Lawrence estuary using the bycatch from the commercial eel fishery. **Pierre Pettigrew, Andrée-Anne Vézina, Serge Perron, René Richard** C15.1-3	Discussion	Bacteriological, light, and scanning electron microscopical studies on vibrio spp. in *Penaeus indicus*. **Salah Afifi** C14-3
2:20	Biomass-based reference points for north Pacific albacore, *Thunnus alalunga*. **Ray Conser, Yukio Takeuchi, Paul Crone, Koji Uosaki** S12-15	~~Managing variability in New Zealand's northern scallop fisheries. Murray Bruges C15.1-4 Moved to Poster C15~~ CANCELLED ~~C15.1-4~~	Discussion	Species-specific differences in mercury concentration and trophic position of planktivorous fish from Caddo Lake, Texas. **Matthew Chumchal, Ray Drenner, K. David Hambright** C14-4
2:40	Are there sustainable fisheries for ICCAT species? **Gerald Scott** S12-16	~~Gear switching as a means to reduce bycatch and habitat impacts.~~ ~~**Lokelia Jenkins, Karen Garrison**~~ **CANCELLED** ~~C15.1-5~~	Discussion	Mercury, cadmium, lead and arsenic in muscle tissue of striped marlin and Indo-Pacific sailfish from the southwestern Gulf of California. **Felipe Amezcua, Martin Soto** C14-5
3:00				
4:00		**Business Meeting** Chateau Laurier Ballroom All AFS members are welcomed to attend		
5:00				

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		Wednesday August 20th			
			Westin Hotel		
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S1 Evolving Fish Changing Fisheries	**S2 Community Ecology of Stream Fishes**	**S7 Sustainable Sturgeon**	**S9 Model Selection in Fisheries Science**	**S3 Aquatic Habitat in Midwest Lakes**
Moderator	Katja Enberg	Don Jackson	Peter Allen	David Hewitt	Mark Ermer
8:00	Harvest-induced evolution; using the Pacific oyster in France as a model system. **Ane T. Laugen, Pierre Boudry, Bruno Ernande** S1-24	Traits-based approaches in stream fish community analysis. **Emmanuel Frimpong, Paul Angermeier** S2-17	Genetic assessment of population fragmentation of lake sturgeon (*Acipenser fulvescens*) in the Ottawa River. **Kristyne Wozney, Chris Wilson, Tim Haxton, Shawna Kjartanson** S7-1	Model based inferences in the aquatic sciences: the concepts of information and evidence. **David Anderson** S9-1	The Midwest Glacial Lakes Partnership: protecting and restoring aquatic habitats in glacial lakes in the Upper Midwest. **Patrick Rivers** S3-1
8:20	Developing an eco-genetic model of Caspian Sea sturgeon stocks. **Rebecca Whitlock, Ulf Dieckmann** S1-25	Fish assemblage stability in a prairie-margin stream: do droughts matter? **Edie Marsh-Matthews, William Matthews** S2-18	Genetic evaluation of lake sturgeon (*Acipenser fulvescens*) designatable units in Canada. **Shawna Kjartanson*, Chris Wilson, Nathan Lovejoy** S7-2		Impacts of residential lakeshore development on habitat of Michigan lakes. **Kevin Wehrly, Lizhu Wang, James Breck** S3-2
8:40	Changes in maturation reaction norms in Flemish Cap cod. **Alfonso Pérez-Rodríguez*, Joanne Morgan, Fran Saborido-Rey** S1-26	Fish species traits and communities in relation to a habitat template for Arctic rivers and streams. **Nicholas Jones, Garry Scrimgeour, William Tonn** S2-19	Hydropower facilities & sustainable sturgeon: a conservation genetic approach. **Amy Welsh, Melinda Baerwald, Mike Friday, Bernie May** S7-3	Evaluating the Use of Akaike's Information Criterion (AIC) in American Fisheries Society publications. **Steven Ranney*, Brian Graeb, Steven Chipps** S9-2	Lake shoreline coarse wood and riparian forest research in central Ontario. **William Cole, Elaine Mallory, Karen Smokorowski** S3-3
9:00	Fisheries-induced evolution in maturation of Icelandic cod and the influence of structure in the stock. **Heidi Pardoe*, Anssi Vainikka, Erin Dunlop, Gudmundur Thordarson, Mikko Heino, Ulf Dieckmann, Gudrun Marteinsdottir** S1-27	Multivariate analysis of stream fish communities: What might we be missing in our approaches? **Donald Jackson, Steven Walker, Mark Poos** S2-20	Identifying the fundamental unit of management in U.S. Atlantic coast sturgeons: a genetic-based approach. **Tim King, Barbara Lubinski, Anne Henderson, Doug Peterson** S7-4	Model selection uncertainty with measurement error models: a simulation study. **Yan Jiao** S9-3	Experimental test of the importance of habitat on the productivity of inland lakes. **Karen Smokorowski, Thomas Pratt, William Cole** S3-4
9:20	Management implications of fisheries-induced evolution. **Jeffrey Hutchings** S1-28	Stream fish in communities revisited: consequences of reciprocal land-water linkages and organism movement for community theory. **Colden Baxter** S2-21	Drift dynamics and abundance of larval lake sturgeon in the Peshtigo River, Wisconsin, USA. **David Caroffino*, Trent Sutton, Dan Daugherty** S7-5	Model selection and estimate precision for length-selective field samples: a shark simulation study. **James Thorson*, Colin Simpfendorfer** S9-4	Quantifying the spatial extent of dock structures in the littoral zones of central Minnesota lakes. **Lyn Bergquist, Michael Duval, Paul Radomski, Andrew Williquett** S3-5
9:40		Migratory fishes as key subsidies in stream ecosystems. **Alexander Flecker, Peter McIntyre, Jonathan Moore** S2-22	Tracking temporal trends in female effective population size for white sturgeon in the Lower Columbia River. **Andrea Drauch*, Tucker Jones, Colin Chapman, Bernie May** S7-6	Evaluation of alternative model structures for Bayesian mark-recapture models. **Rebecca Whitlock, Murdoch McAllister** S9-5	A 72-Year analysis of Lake Koshkonong water levels and corresponding riparian wetland losses. **Paul Cunningham, Jeff Kraemer, Paul Rasmussen** S3-6
10:00					
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S1 Evolving Fish Changing Fisheries	**S2 Community Ecology of Stream Fishes**	**S7 Sustainable Sturgeon**	**S9 Model Selection in Fisheries Science**	**S3 Aquatic Habitat in Midwest Lakes**
Moderator	Mikko Heino	Keith Gido	Peter Allen	Yan Jiao	Mark Ermer
10:20	Minimum selection harvest strategies. **Stephan Munch** S1-29	Ecological stoichiometry as a synthetic framework in stream fish ecology. **Peter McIntyre, Alex Flecker** S2-23	Effect of rearing temperature on the onset and duration of dispersal of early life stages of shortnose sturgeon. **Erika Parker, Boyd Kynard** S7-7	Information-theoretic modeling of capture-recapture data to assess population dynamics and status of two endangered sucker populations in the Upper Klamath Basin, Oregon. **Eric Janney** S9-6	Framework for classification of Michigan lakes. **James Breck, Lizhu Wang, Kevin Wehrly** S3-7
10:40	Evolutionary impact assessment: a framework for managing evolving resources. **Katja Enberg** S1-30	Disturbance mediated effects of stream fishes on ecosystem processes. **Keith Gido, Katie Bertrand, Justin Murdock, Walter Dodds, Matt Whiles** S2-24	Dispersal and behaviour of early life stages of Kootenai white sturgeon: a laboratory study. **Boyd Kynard, Erika Parker, Brian Kynard, Timothy Parker** S7-8	An information-theoretic assessment of juvenile salmonid passage and survival at McNary Dam on the Lower Columbia River. **John Plumb, Chris Holbrook, Noah Adams** S9-7	Water quality and fisheries in Iowa – development of the State Lakes Classification Project. **Joe Larscheid** S3-8
11:00	Evolutionary impact assessment for different management strategies in the North Sea flatfish fishery. **Fabian Mollet, Jan Jaap Poos, Laurence Kell, Adriaan Rijnsdorp, Ulf Dieckmann** S1-31	Direct and indirect effects of predation on stream fish communities. **David Hoeinghaus, Fernando Pelicice, Alexandre Garcia** S2-25	Spatial distribution and movement of juvenile lake sturgeon in an impounded reach of the Winnipeg River. **Cameron Barth, Stephan Peake, Mark Abrahams, W. Gary Anderson** S7-9	Disentangling patterns of trout survival and movement before and after logging using model based inferences. **Aaron Berger*, Robert Gresswell, Douglas Bateman** S9-8	Landscape based identification of human disturbance gradients and reference condition for inland lakes in Michigan. **Lizhu Wang, James Breck, Kevin Wehrly** S3-9
11:20	The economic repercussions of fisheries-induced evolution. **Anne Maria Eikeset*, Erin S. Dunlop, Eric Nævdal, Ulf Dieckmann, Nils Chr. Stenseth** S1-32	Discussion	Juvenile Gulf sturgeon winter habitat use patterns in the Suwannee River estuary and in Apalachicola Bay as defined by automated acoustic listening post telemetry. **Kenneth Sulak, Michael Randall, April Norem, J Travis Smith, Kirsten Luke, William Harden** S7-10	A retrospective evaluation of sockeye salmon management adjustment models for the Fraser River, British Columbia. **Jonathan Cummings*, Merran Hague, David Patterson, Randall Peterman** S9-9	Application in benefit-cost analysis: improving water quality in Iowa's lakes. **Kevin J. Egan, Catherine Kling, Joseph Herriges, John Downing** **Poster presentation S3-10
11:40	Can marine protected areas mitigate the evolutionary impact of fishing on a migratory species? **Erin S. Dunlop, Marissa L. Baskett, Mikko Heino, Ulf Dieckmann** S1-33	Discussion	SPEED FORMAT: S7-SP-1: Results of a formal review of recruitment failure hypotheses for white sturgeon (*Acipenser transmontanus*) from the upper Columbia River. **Gary Birch, Paul Higgins, Robin Gregory, Graham Long** S7-SP-2: Long-term field evaluation of external and internal telemetry-tagged shortnose sturgeon. **Micah Kieffer, Boyd Kynard** S7-SP-3: Determining the timing of seawater migration in juvenile green sturgeon through LA-ICP-MS of pectoral fin rays. **Peter Allen, James Hobbs, Joseph Cech, Joel Van Eenennaam, Serge Doroshov**	Evaluating mercury dynamics and methylmercury accumulation in aquatic systems: a multi-model approach. **Dana Sackett, D. Derek Aday, James A. Rice** S9-10	~~Testing a methodology for assessing plant communities in temperate inland lakes: building a framework to detect human impacts to lake ecosystems.~~ ~~**Jennifer Hauxwell, Alison Mikulyuk, Paul Rasmussen, Susan Knight, Kelly Wagner, Michelle Nault, Daryl Ridge**~~ **CANCELLED** ~~S3-11~~
12:00					
12:20					
12:40			**Poster Session**		
1:00					
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		Wednesday August 20th			
		Westin Hotel		Ottawa Congress Centre	
Room	Governor General 3	Provinces 1	Provinces 2	Congress Centre Colonel By	Congress Centre 1
	S24 Aboriginal Communities in Fisheries Management	**C10 Centarchids 2**	**S10 Hydropower & Sustainable Fisheries**	**C11 Brook Trout**	**S27 Future is NOW for Distributed Data**
Moderator	Perry McLeod-Shabogesic	Helen Ball	Mike Bradford	Rob Mackareth	Robin Bruckner
8:00	Sunrise ceremony Introduction by Chief Madahbee				National Fisheries Data Summit: the next steps. **William Fisher** S27-1
8:20	~~Akwesasne, aboriginal knowledge and problems with fisheries management, a First Nations view.~~ ~~**Henry Lickers**~~ CANCELLED	Evaluating interactions between channel catfish and other sportfishes in Alabama's state public fishing lakes. **Mike Leonard*, Dennis DeVries, Russell Wright** C10.2-1	Fish and invertebrate response to 3 years of experimental unlimited ramping rates on a river regulated by a peaking hydroelectric generating facility. **Karen Smokorowski** S10-16	Effects of stripping gametes on return visits to the spawning grounds of lake-spawning brook trout. **Glenn Forward, Viren Bharti** C11-6	Managing water information in a distributed and diverse organizational environment: lessons from Ontario's Water Resources Information Program. **James Britton** S27-2
8:40	Building capacity through education for resource management. **Dan Longboat** S24-5	Movement and habitat use of smallmouth bass (*Micropterus dolomieu*) within the Beaver Archipelago, northern Lake Michigan. **Mark Kaemingk*, Tracy Galarowicz, David Clapp, John Clevenger** C10.2-2	The responses of the food-web to hydropeaking: an experimental approach based on stable isotopes. **Jerome Marty, Michael Power, Karen Smokorowski** S10-17	Brook trout survival during summer: effects of fish size, water temperature and stream flow. **Cailin Xu, Ben Letcher, Keith Nislow** C11-7	Great Lakes Habitat Initiative – a web-based tool for planning and implementing restoration and conservation projects. **Frank Veraldi** S27-3
9:00	Community based fish habitat assessments: challenges and benefits from the perspective of a First Nation empowered research institution. **Jennifer Simard, Alexandre Litvinov** S24-3	Nutritional condition and physiology of paternal care in smallmouth bass (*Micropterus dolomieu*) relative to stage of offspring development. **Kyle Hanson*, Steven Cooke** C10.2-3	Influence of hydropeaking on sediment suspension. **Colin Rennie, Robert Metcalfe** S10-18	Biological relevance of summer stream temperatures on brook trout in Vermont. **Ryan S Butryn*, Donna L Parrish, Donna M Rizzo, Beverley C Wemple** C11-8	The Conservation Success Index: a web-based tool to help protect, reconnect, and restore coldwater fisheries habitats. **Jack Williams, Amy Haak** S27-4
9:20	~~Walpole Island First Nation fisheries management initiatives.~~ ~~**Dean Jacobs**~~ CANCELLED	The physiological impacts of decompression and fizzing on smallmouth bass during live-release tournaments. **Matthew DeMille*, Bruce Tufts** C10.2-4	Improving downstream passage of juvenile salmonids in the Federal Columbia River Power System – what has worked at dams and what has not over the last 14 years. **John Beeman, Noah Adams** S10-19	Riparian vegetation and stream temperature relationships; opportunities for trout management. **Benjamin Cross*, Michael Bozek, Matthew Mitro** C11-9	National Estuaries Restoration Inventory – establishing data partnerships to enhance project tracking. **Marti McGuire** S27-5
9:40	Community fisheries in the Maritimes: Mi'kmaq First Nations and fishery management. **Tony Charles** S24-6	Life history variability of non-native centrarchids in the lower Guadiana drainage, Iberian Peninsula. **Filipe Ribeiro, Maria João Collares-Pereira** C10.2-5	An overview of studies to test the efficiency of a retrofitted bypass system for downstream migrating Atlantic salmon at Bishop's Falls, Exploit's River, Newfoundland Canada. **Keith Clarke, David Scruton, Curtis Pennell, Chuck Bourgeois, Rick Goosney** S10-20	~~Use of small tributaries by resident brook trout.~~ ~~**Todd Dubeuil, Matthew O'Donnell, Jason Coombs, Ben Letcher**~~ **CANCELLED** ~~C11-10~~	The Conservation Registry: promoting strategic conservation. **Gina LaRocco** S27-6
10:00					
Room	Governor General 3	Provinces 1	Provinces 2	Congress Centre Colonel By	Congress Centre 1
	S24 Aboriginal Communities in Fisheries Management	**C10 Centarchids 2**	**S10 Hydropower & Sustainable Fisheries**	**C11 Brook Trout**	**S27 Future is NOW for Distributed Data**
Moderator	Perry McLeod-Shabogesic	Helen Ball	Mike Bradford	Rob Mackareth	Marti McGuire
10:20	Synopsis of a thirteen year community based harvest monitoring program in the Mackenzie Delta, Northwest Territories; management of a dolly varden (*Salvelinus malma*) fishery in a changing environment. **Steve Sandstrom, Robert Charlie, John Carmichael, Lois Hardwood** S24-10	Site fidelity in *Lepomis macrochirus*: do males benefit from consistency? **Jennifer Bartlett*, John Epifanio** C10.2-6	Effects of trashrack geometry on flow patterns and hydraulic head loss in an attempt to reduce hydro turbine mortality for fish. **Chris Katopodis, J. M. Tsikata, M. F. Tachie, D. Lemke, H. Ghamry** S10-21	~~Characterizing brook trout movements in a small coastal Maine stream.~~ ~~**Matthew O'Donnell, Benjamin Letcher, Bruce Connery, Joseph Zydlewski**~~ **CANCELLED** ~~C11-11~~	Fish Passage Decision Support System - a tool for decision making. **Jose Barrios, Leslie Hartsell** S27-7
10:40	Aboriginal fisheries management in PEI, Canada: a tale of two regimes. **Randy Angus** S24-7	Ecological specialization in the introduced pumpkinseed in Iberian reservoirs. **Yakuta Bhagat*, Michael G. Fox, Maria Teresa, Ferreira** C10.2-7	Survival capacity of spring-summer chinook salmon in the Federal Columbia River Power System. **Jennifer L. Tran*, James J. Anderson** S10-22	Factors influencing brook trout distribution in the Mill Creek drainage, Utah. **Benjamin Nadolski*, Phaedra Budy** C11-12	SPEED FORMAT **S27-SP-1** The U.S. Fish and Wildlife Service (FWS) and the Fisheries Information System (FIS). **Susan Wells** **S27-SP-2** National Oceanic and Atmospheric Administration (NOAA) Restoration Portal. **David Landsman, Karla Trampus** **S27-SP-3 removed** **S27-SP-4** ConserveOnline: an online community for conservation science and practice. **Jonathan Adams** **S27-SP-5** The Federal Fish Passage Action Plan Community of Practice. **Andrea Ostroff, Robin Schrock, Robin Bruckner, Leslie Hartsell** **S27-SP-6** Clearinghouse for dam removal information: a network approach to project data collection and dissemination. **Paul Atwood, Robin Bruckner**
11:00	Distinguishing between owners and users: social identity in Kwakwaka'wakw clam management. **Robyn Heaslip, Evelyn Pinkerton** S24-8	Changes in the Onondaga Lake macroinvertebrate community and shifts in pumpkinseed (*Lepomis Gibbosus*) diet. **Stephanie Johnson*, Lucas Kirby, Neil Ringler** C10.2-8	Expanding the 'toolbox' for measuring the impacts of hydropower on fish and fish habitat using individual-based techniques: a case study from the Puntledge River, British Columbia. **Caleb Hasler, Rana Sunder, Michael Donaldson, Ester Guidmond, David Patterson, Brent Mossop, Scott Hinch, Steven Cooke** S10-23	Accurate model prediction of potential stream brook trout abundance. **James E. McKenna Jr., James H. Johnson, Marc Chalupnicki, Christopher Nack, Timothy Wallbridge** C11-13	
11:20	Changing skies: tribal governments, collaborative agreements and climate change. **Linda Moon Stumpff** S24-9		Biological knowledge, engineering expertise, and money: the key ingredients for effective fish passage facilities at hydropower dams. **John Williams** S10-24	~~Modeling eastern brook trout status using remote sensing.~~ ~~**Joan Louie*, Stacy Nelson, Halil Cakir, Ernie Hain, Christopher DeRolph**~~ CANCELLED ~~C11-14~~	
11:40	Anishinabek/Ontario Fisheries Resource Centre; a cooperative model for fisheries information. **Tom Whillans, Ed Desson** S24-2				
12:00					
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12:40			**Poster Session**		
1:00					
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	Wednesday August 20th			
		Ottawa Congress Centre		
Room	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5
	S15 VHS in Great Lakes	**S20 Cultured Aquatic Animals**	**S26 Fisheries Management for Ecosystem Health**	**C15 Marine Fisheries Management 2**
Moderator	Steve Kerr	Jesse Trushenski	Bob Hecky	Peter Haulsman
8:00	An introduction to the Viral Hemorrhagic Septicemia (VHS) virus in the Great Lakes Basin: what have we learned? **Elizabeth Wright** S15-1		Metrics of ecosystem health: comparing the African and Laurentian Great Lakes. **Norine Dobiesz, Robert Hecky** S26-1	Improvements in data collection spark new ideas in reporting compliance and overall data quality. **Julie Defilippi, Geoffrey White** C15.2-1
8:20	Emergence of Viral Hemorrhagic Septicemia virus among populations of wild fish in the Great Lakes region of the United States and Canada. **James Winton** S15-2		The small scale perspective: value, resilience, fishing patterns, and the need for open access. **Jeppe Kolding, Paul van Zwieten** S26-2	Developing standardized survey abundance indices for groundfish species in the inshore Gulf of Mane. **Keri Stepanek, Yong Chen, Sally Sherman** C15.2-2
8:40	Viral Hemorrhagic Septicemia Virus (VHSV): development of improved detection methodologies and viral stability at various environmental conditions. **Kyle Garver, Laura Hawley, Sandra Edes** S15-3	Hatchery reform in the Columbia River. Application of biological principles to hatchery programs and the impact on large scale harvest and conservation goals. **John Barr, Peter Paquet, Andy Appleby, Lee Blankenship, Donald E. Campton, Mike Delarm, Trevor Evelyn, Dave Fast, Tom Flagg, Jeff Gislason, Paul Kline, Conrad VW Mahnken, Desmond Maynard, Lars Mobrand, George Nandor, Lisa W. Seeb, Paul R. Seidel, William Smoker, Stephen H. Smith** S20-1		Determining recreational summer flounder management options in Maryland using a volunteer based angler survey. **Allison Luettel, Angel Bolinger, Michael Luisi, Steven Doctor, Gary Tyler** C15.2-3
9:00	Stability and abundance of VHSV In Great Lakes diagnostic submissions. **Rodman Getchell, Ashleigh Walker, Geoffrey Groocock, Rufina Casey, Stephen Frattini, Paul Bowser** S15-4		Managing the fisheries of Lake Victoria: how successful are the initiatives undertaken by LVFO. **Oliva Mkumbo, Brian Marshall, Fiona Nunan, Levi Muhoozi, Taabu Munyaho, Robert Kayanda, Rhoda Tumwebaze, Albert Getabu** S26-3	Estimating virgin catch rate for thorny skate on Georges Bank: a possible method for setting restoration targets. **Lynn Waterhouse*, Mathew Smith, John Hoenig, Todd Gedamke** C15.2-4
9:20	Viral hemorrhagic septicemia virus IVb sensitivity to UVC and viability at 4°C and -20°C. **John S. Lumsden, Paul Huber, Brian Petri** S15-5	Impacts of supplementation: genetic diversity in supplemented and unsupplemented populations of summer chum salmon in Puget Sound. **Maureen Small, Ken Currens, Thom Johnson, Alice Frye, Jennifer Von Bargen** S20-3	How relevant is the resilient concept to the management of fisheries resources in Malawi Lakes? **Daniel Jamu, Friday Njaya** S26-4	Mississippi rigs to reef program: retaining valuable hard bottom habitat in the northern Gulf of Mexico. **Kerwin Cuevas, Eric Broussard, William Perret** C15.2-5
9:40	Emergence of Viral Hemorrhagic Septicemia in the Great Lakes basin: lessons learned and effectiveness of surveillance strategies. **Mohamed Faisal, Robert Kim** S15-6	Genetic evaluations of Great Lakes hatchery programs: concepts and case studies of domestic broodstocks and andromous salmonids. **Kim Scribner, Meredith Bartron, Kevin Page** S20-4	Fisheries management in ecosystem restoration – experiences from stocking and intensified fishing in Finnish lakes. **Jouko Sarvala** S26-5	To Stock or Not to Stock? How have stock enhancement programs affected the striped bass population in the Southeastern United States. **Jennifer Woodroffe*, Roger Rulifson** C15.2-6
10:00				
Room	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5
	S15 VHS in Great Lakes	**S20 Cultured Aquatic Animals**	**S26 Fisheries Management for Ecosystem Health**	**C15 Marine Fisheries Management 2**
Moderator	Steve Kerr	Kim Scribner	Norine Dobiesz	Peter Haulsman
10:20	Response of freshwater drum to outbreak of Viral Hemorrhagic Septicemia (VHS) in Lake Ontario. **Gavin Christie, Jim Hoyle, Jim Bowlby, Bruce Morrison, Beth Wright** S15-7	Development of a captive broodstock management plan for upper Missouri River pallid sturgeon. **Edward Heist, Melody Saltzgiver, Josh Geltz, Phil Hedrick** S20-5	Fisheries management in the Great Lakes – what is it that we manage? **Tim Johnson, David Bunnell** S26-6	Coupling, signals, and responses in commercial fisheries. **Bonnie McCay** C15.2-7
10:40	Effects of VHS on the muskellunge population in Lake St. Clair. **Geoff Yunker, Megan Belore, Mike Thomas, Mohamed Faisal** S15-8	Environmental factors affecting hatching, and larval survival of rainbow smelt: implications for possible stock enhancement. **Lauren Wyatt*, David Berlinksy** S20-6	Managing Lake Ontario fish communities and fisheries in a changing ecosystem: lessons learned and new challenges. **Tom Stewart, Steve Lapan, Gavin Christie** S26-7	Implications of quota allocation from a dynamic economic-biological model. **John Ward, Christopher Hayes** C15.2-8
11:00	Die-off of Muskellunge (*Esox masquinongy*) in the Upper St. Lawrence River Caused by Viral Haemorrhagic Septicaemia, 2005-2007: impacts and consequences. **John Casselman, Tom Lusk, John Farrell, Colin Lake** S15-9	Managing integrated hatchery programs with the Proportionate Natural Influence (PNI) concept. **Craig Busack** S20-7	Percid management in Lake Erie: successes and the future. **Jeffrey Tyson, Roger Knight** S26-8	Comparative dynamics of commercial and recreational sectors of marine fisheries **Thomas Ihde, Thomas Miller, Michael Wilberg** C15.2-9
11:20	Round goby mediated viral distribution and impacts to smallmouth bass in the St Lawrence River. **Geoffrey Eckerlin*, John Farrell, Paul Bowser, Geoffrey Groocock** S15-10	A State's perspective on making optimal stocking decisions: reducing uncertainty by asking questions about ecological aspects of species leads to reduced potential for negative impact. **Jeffrey Koppelman** S20-8	Exploring fishery management adaptations to a changing food web: the case of yellow perch in Lake Michigan. **John Dettmers, Brian Breidert, David Clapp, Pradeep Hirethota, Dan Makauskas** S26-9	Changes in species catch composition from artisanal fisheries in San José Island, Baja California Sur, Mexico. **Mauricio Ramirez-Rodriguez, Mauricio Montoya-Campos** C15.2-10
11:40	Fisheries management responses to the detection of VHS in Ontario. **Brenda Koenig, Steve Kerr, Chris Brousseau, Elizabeth Wright** S15-11	Relatedness estimates, effective population sizes, and spawning guidelines in hatchery management: evaluation using case studies. **Meredith Bartron, Gregory Moyer** S20-9	Walleye recovery in Saginaw Bay, Lake Huron as a function of ecosystem level changes. **David Fielder, Michael Thomas, Jeffery Schaeffer, James Baker** S26-10	
12:00				
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12:40		**Poster Session**		
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	Wednesday August 20th		
	Ottawa Congress Centre		
Room	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
	C16 Sampling Techniques	**S19 Government vs Third Party Certifiers**	
Moderator	Bill Gardner	Peter Fricke	
8:00			
8:20	An empirical study of angling assessment methods: catch and harvest rate comparisons from complete and incomplete trip data. **Scott D. Krueger, James R. Jackson, Anthony J. VanDeValk** C16-1		
8:40	Evaluation of finrays as a non-lethal aging method for protected goliath grouper in Florida. **Debra Murie, Daryl Parkyn, Christopher Koenig, Felicia Coleman, Jennifer Schull, Sarah Frias-Torres** C16-2		
9:00	Comparison of aging methods and structures for bighead and silver carp. **Duane Chapman, Joseph Deters** C16-3	Ecolabelling of fisheries: Canadian government response. **Nadia Bouffard** S19-1	
9:20	Advances in coded wire tag technology: meeting changing fish management objectives. **Geraldine Vander Haegen, Lee Blankenship** C16-4	Effectiveness of the MSC in promoting sustainable fisheries: role of corporate social responsibility. **Cathy Roheim** S19-4	
9:40	Comparative survival and behavior of acoustic and pit-tagged yearling Chinook salmon in the Snake and Columbia rivers. **M. Brad Eppard, A. Michelle Wargo Rub, Rich Brown, Katherine Deters, Lyle Gilbreath, Lynn McComas, Benjamin Sandford, Jessica Vucelick, Eric Hockersmith, Geoff McMichael, Ryan Harnish** C16-5	Confusing the public: current seafood certification methods. **David Beutel** S19-5	
10:00			
Room	Congress Centre 6	Congress Centre 7	Poster Hall Speed Stage
	C16 Sampling Techniques	**S19 Government vs Third Party Certifiers**	**S31 Aquatic Habitat Restoration on the Toronto Waterfront**
Moderator	Bill Gardner	Madeleine Hall-Arber	Ed DeBruyn
10:20	Comparative performance of acoustic and PIT-tagged juvenile subyearling Chinook salmon in the Snake and Columbia rivers. Michelle Wargo Rub, Brad Eppard, Rich Brown, Katherine Deters, Lyle Gilbreath, Lynn McComas, Benjamin Sandford, Jessica Vucelick, Eric Hockersmith, Geoff McMichael, Ryan Harnish C16-6	The intersection of the sustainable fisheries and the demands of the marketplace and where certification programs play. **Philip Fitzpatrick** S19-6	**S31-SP-1:** Great Lakes Areas of Concern – limits to restoration. **Kelly Montgomery** **S31-SP-2:** Restoring wetlands in the Hamilton Area of Concern. **Tys Theysmeyer** **S31-SP-3:** Baseline environmental monitoring in support of aquatic habitat Toronto. **Rick Portiss** **S31-SP-4:** The fish communities of the Toronto Waterfront: summary and assessment,1989 – 2005. **Jason Dietrich** **S31-SP-5:** Variation in thermal habitat characteristics in 18 small coastal embayments of Lake Ontario: effects of basin morphometry, connectivity with the open lake, and weather. **Shidan Murphy*, Nicholas Collins, Susan Doka** **S31-SP-6:** Factors affecting northern pike (*Esox Lucius*) home range, size and habitat use in perturbed environments. **Ian Barrett** **S31-SP-7:** Effects of land based storm water controls on waterfront aquatic habitat. **Bill Snodgrass** **S31-SP-8:** Assessment of urban fish habitat renewal, the Lake Ontario experience. **Susan Doka** **S31-SP-9:** Waterfront Toronto's commitment to revitalizing fish habitat in Toronto's Inner Harbour **Pina Mallozzi** **S31-SP-10:** Nearshore fish habitat creation at Tommy Thompson Park **Ralph Toninger** **S31-SP-11:** Toronto Waterfront Aquatic Habitat Restoration Strategy – a strategic and integrated approach to managing the aquatic habitat in a large urbanized centre. **Warren May, Laud Matos**
10:40	Effects of incision location on wound healing and suture retention on juvenile Chinook salmon. **Katherine A. Deters, Richard S. Brown, Jennifer L. Panther, M. Brad Eppard** C16-7	The BC Sockeye salmon experience. **Christina Burridge** S19-7	
11:00	Survival and behaviour of river-run juvenile chinook salmon after surgical implantation of acoustic transmitters: what role does the physical condition of fish play? **Jennifer L. Panther*, Richard S. Brown, M. Brad Eppard, Michelle Rub, Lyle Gilbreath** C16-8	Teaching the trendsetters: a chef-based sustainable seafood initiative. **Megan Westmeyer** S19-8	
11:20	Use of a flat-bed antenna grid for continuous monitoring of wild juvenile Atlantic salmon (*Salmo salar*) movements in a natural stream. **Patricia Johnston, Francis Bérubé, Normand Bergeron** C16-9	Legal aspects of seafood certification. **Stephanie Showalter** S19-9	
11:40	Using hydroacoustics to enumerate and identify Atlantic salmon smolts in the Sheepscot River: is it feasible? **Christine Lipsky, Brandon Kulik, Anna-Maria Mueller** C16-10	Economic factors affecting eco-label success at achieving sustainable fisheries goals. **Kevin Athearn** S19-10	
12:00			
12:20			
12:40			
1:00		**Poster Session**	
1:20			
1:40			

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Wednesday August 20th

Westin Hotel

Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3
	S18 Well-managed Fisheries	**C17 Percids 1**	**S7 Sustainable Sturgeon**	**S9 Model Selection in Fisheries Science**	**S3 Aquatic Habitat in Midwest Lakes**	**S24 Aboriginal Communities in Fisheries Management**
Moderator	L. Scott Parsons	Dave Brown	Ron Bruch	Summer Burdick	James Breck	Caroline Deary
2:00	Well managed fisheries: what do we mean and what are some candidates? **Ray Hilborn** S18-1	Blue walleye of Canada – an overview. **Wayne Schaefer, Mark Schmitz** C17.1-1	Habitat selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone. **Daniel Hatin, Jean Munro, François Caron, Rachel Simons** S7-11	Modeling the feeding ecology of Atlantic menhaden to address water quality concerns in Chesapeake Bay. **Patrick Lynch*, Mark Brush, Elizabeth Condon, Robert Latour** S9-11	Paleolimnological diatom communities and their use in establishing reference conditions for lake assessments. **Paul Garrison** **Poster presentation S3-12	"Better off if they never saw a fish": the treatment of Aboriginal People in the development of Canadian fishery policy in the Great Lakes. **Victor Lytwyn** S24-11
2:20		Genetic variation in walleye populations. **Neil Billington** C17.1-2	Evidence of behavioural habitat selection in juvenile Atlantic and shortnose sturgeons. **Edwin Niklitschek, David Secor** S7-12	Population dynamics of juvenile American shad and blueback herring in lower Chesapeake Bay nurseries. **Troy Tuckey** S9-12	The role of land trusts in lake conservation and protection: the Nature Conservancy in the Upper Midwest. **Kristen Blann, Meredith Cornett, Matt Dallman, Patrick Doran** S3-13	
2:40	Best practices in fisheries management: a literature review. **Howard Powles** S18-2	Population genetic structure of naturally recruiting walleye populations in Wisconsin. **Jeremy Hammen*, Brian Sloss, Michael Bozek** C17.1-3	World Sturgeon Conservation Society: North American Chapter? **Harald Rosenthal**	The role of spatial dynamics in the stability, resilience, and productivity of fish populations: An evaluation based on white perch in the Chesapeake Bay. **Lisa Kerr, Steven Cadrin, David Secor** S9-13	Lake sensitivity using the MINLEAP model, Itasca County, Minnesota. **Rian Reed, Noel Griese, Paul Radomski, William W. Walker** S3-14	Strategic directions for a rights based fishery. **Chief Isadore Day** S24-12
3:00						
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2	Governor General 3
	S18 Well-managed Fisheries	**C17 Percids 1**	**S7 Sustainable Sturgeon**	**S9 Model Selection in Fisheries Science**	**S3 Aquatic Habitat in Midwest Lakes**	**S24 Aboriginal Communities in Fisheries Management**
Moderator	L. Scott Parsons	Dave Brown	Ron Bruch	Eric Janney	James Breck	Caroline Deary
3:20	85 years of Pacific halibut management – NOW we're talking sustainable! **Bruce Leaman** S18-3	Exploring adaptive and plastic variation in egg size of Great Lakes walleye (*Sander vitreus*). **Hui-Yu Wang, Tomas Höök, Donald Einhouse, David Fielder, Lars Rudstam, Christopher Vandergoot, Anthony VanDeValk, Troy Zorn** C17.1-4	Circadian or diel depth changes in shortnose (*Acipenser brevirostrum*) and Atlantic sturgeon (*A. oxyrinchus*) in Connecticut waters. **Tom Savoy, Jacqueline Benway, Kevin Friedland** S7-14	A simple binomial likelihood model to estimate the probability of habitat use: a case study of lotic fishes from the Apalachicola River, Florida USA. **Oliver Burgess*, Aaron Bunch, Dan Gwinn, William Pine, Michael Allen** S9-15	Minnesota's sensitive shoreland designation project. **Paul Radomski, Donna Perleberg, Pam Perry, Kristin Thompson, Kevin Woizeschke** S3-15	The Saugeen-Ojibway commercial fishing agreement – history & challenges. **David Latremouille** S24-13
3:40	Pacific herring stock assessment and management, a successful partnership. **Jake Schweigert, Dennis Chalmers, Lorena Hamer** S18-4	Habitat selection and spawning success of walleye in a tributary to Owasco Lake. **Marc Chalupnicki, Jim Johnson, Jim McKenna Jr., Dawn Dittman** C17.1-5	Growth variation among juvenile lake sturgeon: a consequence of competitive interactions or an adaptive strategy? **Cheryl Klassen, Mark Abrahams, Steve Peake** S7-15	Application of occupancy models to compare summer habitat use of age-0 and age-1 endangered Lost River and shortnose suckers in Upper Klamath Lake, Oregon. **Summer Burdick, Scott VanderKooi** S9-16	The Indiana Lake and River enhancement program. **James Ray, Angela Sturdevant, Gwen White** S3-16	Nipissing First Nation and Lake Nipissing: building and managing a modern commercial fishery. **Richard Rowe** S24-14
4:00	An analysis of factors controlling the sustainability of fisheries for sockeye salmon over the past century on the west coast of Vancouver Island, British Columbia. **Kim Hyatt** S18-5	Consistent walleye recruitment failure: where is the bottleneck? **Jordan Wise*, Jeffrey Miner, Freeman Jones, Matthew Wolfe** C17.1-6	A GIS-based niche model for mapping and monitoring white sturgeon habitat in the Lower Columbia River, USA. **Michael Parsley, James Hatten** S7-16	Habitat selection by juvenile striped bass in lower Chesapeake Bay tributaries: inferences from occupancy models. **David Hewitt, Mary Fabrizio, Amanda Hewitt, Julia Ellis** S9-17	Measuring the value of wildlife habitat restoration on northern Wisconsin Lakes – the Wisconsin Lakeshore Restoration Project. **Michael Meyer, Dan Haskell** **Poster presentation S3-17	Update on Wisconsin 1837 and 1842 ceded territory inland fisheries. **Mark Luehring, Neil Kmiecik, Joe Dan Rose** S24-15
4:20	The Marine Stewardship Council Fisheries Certification Program. **Jim Humphreys** S18-6	Survival and stock-recruitment of walleye in Lake Ontario in response to dreissenid invasion. **James Bowlby, James Hoyle, Bruce Morrison** C17.1-7	Evidence of fall spawning in Gulf of Mexico sturgeon, Acipenser oxyrinchus desotoi, in the Suwannee River, FL. **Michael Randall, Kenneth Sulak** S7-17	An evaluation of the influence of streamflows and species traits on meta-demographic parameters of stream-dwelling fishes. **James Peterson, Colin Shea** S9-18	Minimizing human development impacts to aquatic habitat: lessons learned in running the shoreland habitat. **John Hiebert, Grant Program** S3-18	Tribal Nmé (sturgeon) Stewardship in the Big Manistee River, MI and the establishment of streamside rearing for lake sturgeon. **J. Marty Holtgren, Stephanie Ogren** S24-16
4:40	The importance of scientific knowledge in securing long-term utilization of fish resources. **Jóhann Sigurjónsson, Sigurdsson Thorsteinn** S18-7	High mortality on walleye and yellow perch larvae in clupeid lakes: Evidence from comparisons among ten New York lakes. **Thomas Brooking, John Forney, Anthony VanDeValk, Lars Rudstam** C17.1-8	Use of pop-up satellite archival tags and GIS to estimate movements, habitat use, and threats for adult Atlantic sturgeon in the ocean. **Daniel Erickson, Andy Kahnle, Michael Millard, Gosia Bryja, Amanda Higgs, Jerre Mohler, John Sweka, Gregg Kenney, Mark Dufour, Ellen Pikitch** S7-18		Synthesis and future directions. **Michael Duval**	Knowledge acquisition about mature lake sturgeon (*Acipenser fulvescens*) ecology on Kitigan Zibi Anishinabeg First Nation community. **Andre Dumont, Linda Dwyer** S24-17

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Wednesday August 20th

	Westin Hotel			Ottawa Congress Centre		
Room	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2
	C18 Salmonids in Streams	**S10 Hydropower & Sustainable Fisheries**	**S5 Climate Related Drying Effects**	**S23 Parental Effects & Recruitment**	**S27 Future is NOW for Distributed Data**	**S15 VHS in Great Lakes**
Moderator	Kyle Hartman	Mike Bradford	Joe Margraf	Paul Venturelli	Leslie Hartsell	Steve Kerr
2:00	Development of an integrated salmonid population and habitat study model on Sakhalin island, Russia, for the detection of population status and trends. **Vladimir Samarskiy, Alexander Kaev, Anatoly Semenchenko, Nicole Portley, Gordon Reeves** C18.1-1	Species-specific attraction efficiency and passage efficiency of fish passage structures and instream barriers to fish migration. **Christopher Bunt** S10-25	Heterogeneity in climate warming effects on aquatic habitats. **Jennifer Roach, Brad Griffith** S5-1	Measuring maternal effects and their population dynamic consequences in a model system: implications for fisheries management. **Stewart Plaistow, Tim Benton**	Finding, sharing and using distributed data – Northwest Environmental Data-network portal development. **Thomas Pansky, Eric Lowrance** S27-8	So how do fisheries agencies respond when a new virulent pathogen such as VHSv shows up in their waters: a case study from the Great Lakes. **Gary Whelan** S15-12
2:20	~~Chum salmon from the Sacramento to the Columbia River – How climate and development have changed the population and genetic structure of a species at the edge of its range.~~ ~~**Orlay Johnson, Anna Elz, Joffery Hard**~~ CANCELLED ~~C18.1-2~~	Fishway passage, water diversion and warming temperatures: factors limiting successful spawning migration of Seton-Anderson watershed salmon. **David Roscoe*, Scott Hinch, Steven Cooke, Lucas Pon, David Patterson, Andrew Lotto** S10-26	Effects of water loss on Fish communities in the Arctic – landscape perspectives and future research directions. **Amanda Rosenberger, Stan Triebenbach, Anupma Prakash, Terry Chapin, Joseph Margraf** S5-2	S23-1	Implementation of a spatial catalog to characterize and identify habitats in the Gulf of Mexico (Gulf GAME). **Cristina Carollo, Dave Reed** S27-9	Evolution of VHS regulations in the Great Lakes: the importance of harmonizing rules to effectively manage human and fish populations. **Jill Finster, John Dettmers, Roger Knight, Rob MacGregor** S15-13
2:40	Pacific salmon in hot water: using aerobic scope and physiological characteristics to predict the success of spawning migrations during climate warming. **Scott Hinch, Tony Farrell Steve Cooke, Dave Patterson, Glenn Crossin, Todd Mathes, Stefan Larsson, Mike Lapointe** C18.1-3	The influence of acclimation pressure and exposure pressure on barotrauma driven mortal injury to juvenile salmonids exposed to rapid decompression during hydroturbine passage. **Richard Brown, Thomas Carlson, John Stephenson, Abby Welch, Craig McKinst** S10-27	The role of seasonal drying in structuring Australian floodplain fish assemblages. **Dale McNeil** S5-3	Maternal effects, age structure and population resiliency: managing for diversity in the face of uncertainty. **Selina Heppell, Wade Smith** S23-2	Managing observation and model data to support ecosystem science and management in the Chesapeake Bay. **Howard Townsend, Doug Wilson** S27-10	From risk assessment to disease control measures: VHSV case study. **Grace Karreman, Kim Klotins, Brian Peart, Lori Gustafson, Rod Penney** S15-14
3:00						
Room	Provinces 1	Provinces 2	Quebec	Congress Centre Colonel By	Congress Centre 1	Congress Centre 2
	C18 Salmonids in Streams		**S5 Climate Related Drying Effects**	**S23 Parental Effects & Recruitment**	**S27 Future is NOW for Distributed Data**	**S15 VHS in Great Lakes**
Moderator	Kyle Hartman		Joe Margraf	Susan Sogard	Marti McGuire	Steve Kerr
3:20	Effects of summer flow variability on juvenile salmonid survival in coastal California streams, **Ted Grantham*, Adina Merenlender, David Newburn** C18.1-4		Are fish assemblages ultimately maintained by booms or busts in an Australian arid-zone river? **Stephen Balcombe, Angela Arthington, Stuart Bunn** S5-4	Maternal effects in pike (*Esox lucius*) and their relation to the efficiency of harvest regulations: a modelling approach. **Robert Arlinghaus, Shuichi Matsumura, Ulf Dieckmann** S23-3	Ontario's Fish Web Collaborative – enabling the discovery of fish distribution data over the Internet using metadata, standard protocols, and web mapping services. **Craig Onafrychuk, Silvia Strobl** S27-11	The role of risk assessments in guiding management and response decisions: Viral Hemorrhagic Septicemia Virus case study. **Kim Klotins, Carol Tinga, Pascale Nérette, Grace Karreman** S15-15
3:40	Spatial analysis of beach susceptibility for stranding juvenile salmonids by ship wakes in the Lower Columbia River. **William Fleece, Walter Pearson, Kevin Gabel, Sarah Jenniges, John Skalski** C18.1-5		Climate change implications for drought, refugia, and population and community persistence in streams. **Nick Bond, Paul Reich, Sam Lake** S5-5	Larger females yield larger and more robust offspring in European lobster (*Homarus gammarus*): implications for fisheries management. **Even Moland*, Esben M Olsen** S23-4	Discussion ~~Toward Science 2.0. Using Wikis and Portals to facilitate radical collaboration in natural resource science.~~ ~~**Michael J. Furniss**~~ ~~S27-12~~ CANCELLED	Modeling expert opinion to guide VHS surveillance in the US and Canada. **Lori Gustafson, Sarah Tomlinson, Amber Barker, Kim Klotins, Grace Karreman** S15-16
4:00	Modelling stranding of juvenile salmonids by wakes from increased deep-draft vessel traffic in the Lower Columbia River. **Walter Pearson, John Skalski, Kathryn Sobocinski, William Fleece** C18.1-6		Effects of stream drying on fish refuge use and species persistence: forecasting effects of global climate change. **Dan Magoulick, Gary Huxel, Matt Dekar, Shawn Hodges, Chris Bare** S5-6	~~Maternal effects in brown trout (*Salmo trutta*): a combined laboratory and field study on the impact of female size on egg and larval traits.~~ ~~**Markus Faller, Robert Arlinghaus, Christian Wolter**~~ CANCELLED	Discussion	Fish health and ecosystem dysfunction in the Great Lakes. **Stephen Riley, Kelly Munkittrick, Allison Evans, Charles Krueger, John Dettmers** S15-17
4:20	Timing, abundance, and population characteristics of hatchery and natural origin Chinook salmon on the spawning grounds in the Cedar-Sammamish Watershed, Washington. **Hans Berge, Steve Foley, Mistie Hammer** C18.1-7		Forecasting the combined effects of urbanization and climate change on stream ecosystems: from impacts to management options. **P.L. Angermeier, K.C. Nelson, M.A. Palmer, J.E. Pizzuto, G.E. Moglen, R.H. Hilderbrand, M. Dettinger, K. Hayhoe** S5-7	Maternal effects on timing of parturition in rockfishes. **Susan Sogard, Stephen Ralston, David Stafford** S23-6	Discussion	Predicting and detecting VHS impacts on populations using modelling results: is VHS mortality separable from M? **Kevin A. Kayle, M. Elizabeth Wright** S15-18
4:40	~~Individual-based model simulation of effects of fishery management activities on Chinook (*Oncorhynchus tshawytscha*) recruitment in a large Lake Michigan tributary.~~ ~~**Damon Krueger*, Jeffrey Tyler, Edward Rutherford, Michael Wiley, Doran Mason**~~ CANCELLED ~~C18.1-8~~		Discussion	Artificial selection overriding natural selection: unlikely role of an annual fish in a complex play with a gigantic audience. **William Bennett, James Hobbs, Swee The** S23-7	Discussion	

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			Wednesday August 20th		
			Ottawa Congress Centre		
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	S20 Cultured Aquatic Animals	**S26 Fisheries Management for Ecosystem Health**	**C7 Marine Fish Ecology 2**	**S25 Social & Economics in Fisheries Mangement**	**S19 Government vs Third Party Certifiers**
Moderator	Kim Scribner	Norine Dobiesz	Fred Genthner	Eric May	Peter Fricke
2:00	Effects of broodstock management practices on effective population sizes of hatchery strains in Ontario. **Chris Wilson, Gord Durant** S20-10	A perspective on lake trout in oligotrophic lakes of North America: restoration in the Laurentian Great Lakes versus suppression in western lakes. **Michael Hansen, Ned Horner** S26-11	A genetic assessment of the potential for local depletion of Atlantic menhaden (*Brevoortia tyrannus*) within Chesapeake Bay. **Abigail Lynch*, Jan McDowell, John Graves** C7.2-1	Social science and ecosystem based fisheries management at NOAA: what have we done, where are we going? **Kristy Wallmo** S25-1	Consumer preferences for seafood information attributes. **Robert Fonner*, Gil Sylvia** S19-11
2:20	Genetic marker-assisted restoration of the presumptive native walleye fishery in the New River, Virginia and West Virginia. **Eric Hallerman, George Palmer, Joe Williams, Mark Scott, Katherine Finne, Nathan Johnson, Daniel Dutton, Brian Murphy** S20-11	The impact of sea lamprey (*Petromyzon marinus*) management on the structure of the Great Lakes fish community. **Robert Young, Paul Sullivan, Dennis Lavis, Terry Morse, Todd Steeves** S26-12	Saltwater intrusion impacts fish diversity and distribution in the Blackwater River drainage (Chesapeake Bay watershed): Effects on freshwater fish populations. **Joseph Love, John Gill Joshua Newhard** C7.2-2	Incorporating the increasingly important artisanal fishery sector into fishery management. **Ayeisha Brinson, David Die** S25-2	~~Using market initiatives to facilitate improvement in problem fisheries: the Gulf of Mexico experience. **Howard Johnson**~~ CANCELLED ~~S19-12~~
2:40	The genetic architecture of fitness-related traits in salmonid fishes: implications for stock enhancement. **Moira Ferguson, Roy Danzmann** S20-12	Magnitude of biomass response to experimental cormorant control versus regime shift in coastal fish of Lake Huron. **Mark Ridgway, Scott Milne, John Casselman** S26-13	The effects of winter temperature and flow on a summer-fall nursery fish assemblage in the Chesapeake Bay, Maryland. **Rebecca Wingate, David Secor** C7.2-3	New directions in the management of commercial fisheries: changes occurring in the NE USA. **Barbara Rountree** S25-3	Understanding consumer trends when cultivating new seafood markets: a workshop for seafood producers. **M. Scott Baker Jr., Barry Nash, Brian Efland, Sara Mirabilio** S19-13
3:00					
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	S20 Cultured Aquatic Animals	**S26 Fisheries Management for Ecosystem Health**	**C7 Marine Fish Ecology 2**	**S25 Social & Economics in Fisheries Mangement**	**S19 Government vs Third Party Certifiers**
Moderator	Kim Scribner	Tim Johnson	Fred Genther	Eric May	Palma Ingles
3:20	Research results from an integrated spring Chinook hatchery on the Yakima River, Washington. **David Fast, William Bosch, Mark Johnston, David Lind, Curtis Knudsen, Douglas Neeley, Steve Schroder** S20-13	When habitat improvement, fisheries management and infrastructure collide: challenges to Great Lakes ecosystem protection. **Phil Moy** S26-14	Coral reef fish community shifts and declines in species richness and abundance in the upper FL Keys, USA. **Todd Kellison, Vanessa McDonough, Doug Harper, James Tilmant** C7.2-4	Recreational fishing and tourism a changing landscape. **Eric May** S25-4	"Local Catch": wallet-size cards inform or misinform consumers about North Carolina seafood choices? **Sara Mirabilio** S19-14
3:40	Conservation aquaculture of northern leatherside chub. **Eric Wagner** S20-14	Risk assessment in the management of Species at Risk. **Marten Koops, Antonio Vélez-Espino** S26-15	Using biological and habitat data to identify strategic habitat areas for juvenile fish in Albemarle Sound, North Carolina. **Timothy Ellis, Scott Chappell, Michael Loeffler, Anne Deaton, Jeffrey Buckel** C7.2-5	Facing the climate future in Arctic Alaskan fisheries. **David Fluharty** S25-5	Discussion
4:00	A conservation hatchery for the marine rearing of anadromous salmonids. **Desmond Maynard, Carlin McAuley, Mike Wastel, Deborah Frost, Bryon Kluver, Greg Baesler, Jeffrey Gislason, Jeff Hiendel, Paul Kline, Thomas Flagg** S20-15	Connections between fisheries management and lower trophic levels in the North American Great Lakes: a review of the evidence. **Lars Rudstam** S26-16	White perch bioenergetic responses to temperature, salinity and dissolved oxygen. **Deanna McQuarrie*, Dave Secor** C7.2-6	The role of fisheries heritage in historical ecology: a case study from the Albemarle Sound Region, North Carolina. **Anne Garland** S25-6	Discussion
4:20	Use of multiple spawning techniques to increase genetic diversity in a Coho Salmon broodstock program. **Erick Sturm, R. Bruce MacFarlane** S20-16	Metrics for ecosystem health: are subsidized fisheries healthy? **Robert Hecky** S26-17	A history of the Pacific Biological Station. **Richard Beamish** C7.2-7	The evolution of fisheries values from marine ecosystems of the U.S. **Ussif Rashid Sumaila, Jackie Alder, Gakushi Ishimura, William Cheung, Lisa Dropkin** S25-7	Decades of fisheries involvement - a tribute to Ralph Rayburn. **Gary Graham** S19-15
4:40	Los Lunas silvery minnow refugium: an endangered species breeding facility designed to minimize genetic changes during propagation. **Kenneth Ferjancic, Douglas Tave** S20-17		A history of the St. Andrews (Atlantic) Biological Station. **Robert Stephenson** C7.2-8	Discussion	

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			Thursday August 21st		
			Westin Hotel		
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S18 Well-managed Fisheries	**S4 Sensitivity of Fish and Fisheries to Climate Change**	**S13 Genetics and Sustainable Fisheries**	**S7 Sustainable Sturgeon**	**S20 Cultured Aquatic Animals**
Moderator	Howard Powles	John Casselman	Kim Scribner	Cheryl Klassen	Jesse Trushenski
8:00		Introduction **Brian Shuter and John Casselman**	Canada's Wild Salmon Policy: Conservation planning for an uncertain future. **Brian Riddell, Blair Holtby** S13-1	Movement patterns and habitat use of adult lake sturgeon in an impounded river system. **Holly Labadie*, Steve Peake** S7-19	
8:20	New Zealand lobster fisheries. **Paul Breen** S18-8	Opening remarks. **Henry Lickers**	Sexual selection and breeding programs: the importance of genetic quality. **Bryan Neff, Trevor Pitcher** S13-2	Using telemetry to evaluate modification in the spatial distribution of the Eastmain River lake sturgeon (*Acipenser fulvescens*) after dam construction and reservoir impoundment in James Bay territory (Québec). **Frederic Burton, Marc Gendron Michel** S7-20	Ignorance is not bliss: hatchery rearing influences on salmonid stocking success force rapport between fisheries managers and hatchery staff in South Dakota. **Michael Barnes** S20-18
8:40	The restoration of Atlantic striped bass: the convergence of fisheries management, policy and science. **Gary Shepherd, Gary Nelson, Nichola Meserve** S18-9	Potential effects of climate change on stream flows and water levels in Mississippi Valley Watershed. **Sobhalatha Kunjikutty, Paul Lehman, Bahram Gharabaghi** S4-2	Not long ago, in a galaxy not so far away: Marker wars and the on-going campaign for standardized and shared inter-laboratory genetic databases. **Paul Moran** S13-3	Fine-scale movement patterns of adult lake sturgeon during spawning. **Stephan Peake** S7-21	Fitness of hatchery Coho in the wild: discerning the effect of alternate captive breeding histories. **Veronique Theriault, Gregory Moyer, Laura Jackson, Gregory Huchko, Michael Banks** S20-19
9:00	Georges Bank: an integrated fisheries management approach. **Nadia Bouffard, Chris Annand, Lisa Setterington** S18-10	Intra-specific differences in preferred temperatures shape regional differences in sensitivity of lake trout to climate change. **Brian Shuter, Ken Minns** S4-3	Differentiating salmon populations at broad and fine geographic scales with microsatellites and SNPs. **Shawn Narum** S13-4	Balancing mineral resource extraction and protection of a lake sturgeon population in a northern Ontario River. **Rob Mellow, Chris Pullen, John Seyler, Dana Schmidt** S7-22	Commercial channel catfish fry production: hatchery spawning replace natural pond spawning? **Nagaraj Chatakondi** S20-20
9:20	Discussion	The response of shallow lake fish to climate change: the case of the three-spined stickleback. **Rebecca Moran*, Ian Harvey, Heidrun Feuchtmayr, Brian Moss, Keith Hatton, Tom Heyes, David Atkinson** S4-5	Conservation genetics of brook trout (*Salvelinus fontinalis*): phylogeography, population structure, and assessing the adaptive significance of observed differentiation. **Tim King, Barbara Lubinski, Raymond Morgan II, Diane Pavek** S13-5	Understanding lake sturgeon spawning demographics in a northern Ontario River. **Chris Pullen, Robert Mellow, John Seyler, Dana Shmidt** S7-23	Use of recirculating aquaculture systems to increase production and quality of hatchery reared juvenile red drum for marine stock enhancement. **Paul Wills, Timothy Pfeiffer, Megan Davis** S20-21
9:40	Discussion	Sensitivity of fish and fisheries to a changing climate: response and adaptation. **John Casselman** S4-6	A transcriptomic view on whitefish population genetics. **Arne Nolte, Louis Bernatchez** S13-6	Lake sturgeon reintroduction in the Coosa River System, Georgia, United States. **Justin Bezold, Douglas Peterson** S7-34 ~~Combining new technologies with traditional mark-recapture methods to estimate the number of green sturgeon that spawn in the Rogue River, Oregon.~~ ~~**Daniel Erickson, Steven Lindley Ethan Mora John Weber Todd Confer Blair Krohn Phaedra Doukakis**~~ CANCELLED	Production of juvenile and sub-adult cobia in recirculating aquaculture systems. **Charles Weirich, Paul Wills, Richard Baptiste, Marty Riche** S20-22
10:00					
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 2
	S11 Harvest Control Rules	**S4 Sensitivity of Fish and Fisheries to Climate Change**	**S13 Genetics and Sustainable Fisheries**	**S7 Sustainable Sturgeon**	**S20 Cultured Aquatic Animals**
Moderator	Dorothy Dankel	John Casselman	Kim Scribner	Stephan Peake	Jesse Trushenski
10:20	HCR's - is backwards the best way forwards? - South African experiences. **Doug Butterworth**	The effects of climate change and invasion of centrarchids on northern fish communities. **Sapna Sharma, Donald Jackson** S4-7	Identification of lake trout morphotypes in large, deep lakes: a comparison of unexploited and exploited communities. **Mara Zimmerman, Charles Krueger, Randy Eshenroder** S13-7	Indirect measures of reproductive state in lake sturgeon. **Peter Allen, W. Gary Anderson, Stephan Peake** S7-25	Development of genetic identification tools to refine striped bass *Morone saxatilis* release strategies and improve hatchery contribution. **Michael Denson, Wallace Jenkins, Tanya Darden, Jen Fountain, Forrest Sessions, Justin Yost** S20-23
10:40	S11-1	Partitioning the influence of climate variation from the effects of other concurrent stressors on the habitat and recruitment success of lake trout in Lake Simcoe. **David Evans, Audie Skinner, Jennifer Winter, Jake La Rose** S4-8	Major histocompatibility genes can define populations of multiple species of fish: African and Arctic experiences. **Brian Dixon** S13-8	Shortnose sturgeon in the Ogeechee River, Georgia. **Daniel Farrae*, Douglas Peterson** S7-26	Evaluation of recruitment bottlenecks using cultured red drum (*Sciaenops ocellatus*). **Wallace Jenkins, Theodore Smith, Karl Brenkert, Justin Yost, Tanya Darden, Michael Denson** S20-24
11:00	The evolution of HCRs in Europe. **Laurence Kell, Martin Pastoors Beatriz Roel**	North Atlantic Oscillation variability influences latitudinal trends in marine fish species richness. **Jonathan Fisher, Kenneth Frank, William Leggett, Nancy Shackell, Brian Petrie** S4-9	Genomic analysis of morphological and physiological indices of alternative migratory and non-migratory life history strategies in *Oncorhynchus mykiss.* **Krista Nichols, John Colletti, Alicia Felip, Paul Wheeler, Gary Thorgaard** S13-9	Use of fishery independent surveys to determine abundance, habitat, distribution and age class structure of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) within the Atlantic Ocean. **Keith Dunton*, Adrian Jordaan, Michael Frisk, David Conover** S7-27	Cannibalism in size-structured populations of common snook *Centropomus undecimalis*. **Nathan Brennan** S20-25
11:20	S11-2	Atlantic salmon at the southern limit of their range are faced with high temperatures during spawning: can they adapt? **Edward Beall, David Grimardias, Michel Parade** S4-10	Is size-selective fishing responsible for the declining size of Yukon River Chinook salmon? **Jeffrey Hard, Jeffrey F. Bromaghin, Ryan Nielson** S13-10	Predicting local extinction of pallid sturgeon in the Mississippi River. **James Garvey, Steven Bartell, Thomas Keevin** S7-28	Florida's Bass Conservation Center: past, present, and future. **Nick Trippel, Wes Porak, Rick Stout, Mike Matthews** S20-26
11:40	Precautionary harvest policies and the uncertainty paradox. **Steve Cadrin, Martin Pastoors** S11-3	From local to global climate change effects on southern European Atlantic salmon. **Eva Garcia-Vazquez, America Valiente, Francis Juanes, Steve Gephard** S4-11	Why both within- and between-population diversity are essential to conserve fitness in the wild: a lesson from Alaskan steelhead. **Frank Thrower, Jeff Hard** S13-11	Validation of true age of lake sturgeon and implications for population and harvest management. **Ronald Bruch, Shannon Davis-Foust, Michael Hansen, Steven Campana** S7-29	Evaluation of pre-release feed weaning on performance of juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). **Andrew Lazur, Erin Markin** S20-27
12:00					
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First author listed is presenting author and * indicate students requesting feedback

	Thursday August 21st				
		Westin Hotel		Ottawa Congress Centre	
Room	Governor General 3	Provinces 1	Provinces 2	Congress Centre Colonel By	Congress Centre 1
	S30 Managing Impacts to Fish andFish Habitat	**C18 Salmonids in Streams**	**S34 Native Species Restoration in Great Lakes**	**S23 Parental Effects & Recruitment**	**S29 Sampling for Understanding Headwater Systems and Fish Production**
Moderator	Barry Sadler	Ben Letcher	Jason Borwick	Steve Munch	Michael Kaller
8:00	Choosing our legacy—fisheries sustainability or ultimate collapse. **William Taylor, Kerry Waco, Nancy Leonard, Michael Schechter, C. Paola Ferreri** S30-1		Lake trout recovery in Lake Superior: a success of coordinated management. **Steve Chong, Shawn Sitar, Mark Ebener, Michael Hansen, Bill Mattes, Steve Schram, Don Schreiner** S34-1		From habitat units to landscapes: sampling headwater streams in western Oregon. **Robert Gresswell, Douglas Bateman, Christian Torgersen, David Hockman-Wert** S29-1
8:20			Assessing potential spawning habitat to assist lake trout restoration in Lake Erie. **Patrick Kocovsky, Ann Marie Gorman, Tom MacDougall, Scudder Mackey, James Markham** S34-2	The influences of maternal age of spawning, recruitment variability, and life-history pattern upon harvest reference points and fishery management. **Paul Spencer** S23-8	The production potential of stream fishes as affected by changes in water temperature driven by climate and land-use in the Delaware River basin. **Jerry Mead, Fredrick Scatena, Richard Horwitz, Yude Pan, Richard Birdsey** S29-2
8:40	Canada's legal, program and policy frameworks for managing impacts to fish and fish habitat. **Patrice LeBlanc** S30-2	Movement and fate of non-migratory subyearling Chinook salmon detected on autonomous acoustic receivers in a hydropower reservoir. **Ian Welch, Geoff McMichael, Jessica Vucelick, Eric Hockersmith, Ben Sandford, John Skalski, Rebecca Buchanan, Ann Setter** C18.2-1	~~Lake trout restoration in the Canadian waters of Lake Huron – successes and challenges.~~ ~~**David Anderson, Adam Cottrill, Yolanda Morbey, David Reid**~~ CANCELLED ~~S34-3~~	Size-dependent reproductive success in wild zebrafish (*Danio rerio*). **Silva Uusi-Heikkilä*, Christian Wolter, Thomas Meinelt, Robert Arlinghaus** S23-9	A preliminary investigation of exported materials from headwater drainage features in forty sites located within Southern Ontario. **Odum Idika*, David Barton** S29-3
9:00	U.S. experience since 1996 implementing the "Essential Fish Habitat" program to conserve fish habitat. **Thomas Bigford** S30-3	A cross-continental, bioenergetic comparison of factors limiting the endemic and exotic distribution of brown trout under current and future environmental conditions. **Phaedra Budy, Javier Lobon-Cervia, Gustavo Ganzalez, Leif Asbjorn, Vollestad, Eloy Becares** C18.2-2	Historical trends and current status of the coldwater fish community of Lake Simcoe, Ontario, Canada. **Jake La Rose, Brent Metcalfe, Campbell Willox** S34-4	Population level expression of maternal effects depends on life-history context. **Yasmin Lucero** S23-10	Abiotic constraints to sampling and evaluating macroinvertebrate communities in headwater streams. **Robert Danehy, Russell Langshaw, Robert Bilby** S29-4
9:20	The Mexican experience in implementing norms to regulate impacts to fish habitat. **Felipe Amezcua** S30-4	Bioenergetic evaluation of food supply and consumption demand by brown and rainbow trout in catch-and-release areas of Arkansas tailwaters. **Jon Flinders, Dan Magoulick** C18.2-3	Lessons learned from 35 Years of lake trout restoration in Lake Ontario. **Brian Lantry, Ted Schaner, Jana Lantry** S34-5	Variation in maternal investment when juvenile survival is density dependent. **Stephan Munch** S23-11	Ecological linkages between fishless headwaters and downstream fish communities. **Elizabeth Green*, Mark Wipfli, Karl Polivka** S29-5
9:40	Fish resource protection mechanisms, their application and their effectiveness in Vermont, a small, rural state in the northeast US with an outsize reputation for environmental quality. **Leonard Gerardi** S30-5	Spawning ecology and early life history of Bonneville cutthroat trout in northern Utah. **Sara Seidel*, Phaedra Budy, Stephen Bennett, Brett Roper** C18.2-5	Movement of individual brook trout within and between tributaries to Lake Superior. **Marilee Chase, Thomas Pratt, Lisa O'Connor** S34-6	Redtail surfperch reproduction in heated water. **Karl Brookins, Howard Horton** S23-12	How important are fishless headwaters to downstream fishes and food webs? **Mark Wipfli** S29-6
10:00					
Room	Governor General 3	Provinces 1	Provinces 2	Congress Centre Colonel By	Congress Centre 1
	S30 Managing Impacts to Fish and Fish Habitat	**C18 Salmonids in Streams**	**S34 Native Species Restoration in Great Lakes**	**S23 Parental Effects & Recruitment**	**S29 Sampling for Understanding Headwater Systems and Fish Production**
Moderator	Barry Sadler	Lynn Bouvier	Arunas Liskauskas	Paul Venturelli	Michael Kaller
10:20	What should science be providing to support policy and regulation of fish habitat, and how well prepared are we to provide it? **Jake Rice** S30-6	Effects of a long-term elevation of perceived predation risk on individual behaviour and population density in wild juvenile Atlantic salmon. **Jae-woo Kim*, James Grant, Grant Brown** C18.2-6	Opportunities for lake herring recovery in Lake Huron. **David Fielder, Lloyd Mohr, Richard Barbiero, Jeffery Schaeffer** S34-7	Warming rivers, migratory stress, and parental effects: the influence of changing adult salmon migratory conditions on offspring fitness. **David Patterson, Anthony Farrell Steve Macdonald, Scott Hinch** S23-13	Possible controls on the production and flux of invertebrates from headwater streams. **John Richardson** S29-7
10:40	A better way to think about aquatic habitat: the science foundation for the National Fish Habitat Action Plan. **Gary Whelan** S30-7	Impact of environmental variation on Atlantic Salmon freshwater growth rates. **R. Scott Davidson, Ben Letcher, Keith H. Nislow** C18.2-7	Resurgence of emerald shiners *Notropis atherinoides* in Lake Huron's main basin. **Jeffrey Schaeffer, David Warner, Timothy O'Brien** S34-8	~~Implications of spawning habitat choice on recruitment and population dynamics in exploited salmon populations.~~ ~~**Keith Nislow, Darren Ward, Sigurd Einum**~~ CANCELLED ~~S23-14~~	Influence of riparian forest cover manipulations on terrestrial invertebrate inputs into headwater streams. **Jered Studinski*, Kyle Hartman** S29-8
11:00	Overview talk on the proposed DFO Centre of Expertise on habitat research. **Robert Gregory** S30-8	Long-term seawater performance of Atlantic salmon smolts. **Gayle Zydlewski, Joseph Zydlewski** C18.2-8	Use of decision analysis in the development of an action plan for restoration of Lawrence eel in the Upper St. Lawrence river and Lake Ontario. **Alastair Mathers, Rob MacGregor, Lorne Greg** S34-9	The influence of paternal traits on offspring survival and recruitment in a nest-guarding fish, the smallmouth bass. **Brandon Barthel*, David Philipp** S23-15	Cattle grazing regimes influence terrestrial and aquatic invertebrate prey that support trout populations in western rangeland headwaters streams: conceptual model, initial results, and challenges of sampling. **Kurt Fausch, W. Carl Saunders** S29-9
11:20	Assessing net change of productive capacity: moving from suitability to fish. **Charles K Minns** S30-9	Density-dependent growth in juvenile Atlantic salmon: mechanisms of competition. **Istvan Imre, James W.A. Grant, Richard A. Cunjak** C18.2-9	Recovery of burbot *Lota lota* in Lake Erie. **Martin Stapanian, Larry Witzel, Andy Cook** S34-10	Parental behaviour and offspring recruitment: implications for exploitation. **Joseph Parkos III, David Wahl, Jeff Stein, David Philipp** S23-16	Appalachian brook trout dietary analysis and their linkage to riparian zone manipulation. **Jonathan Niles*, Kyle Hartman, Brandon Keplinger** S29-10
11:40	Implications of cumulative impacts to estuarine marsh habitat quality and fish and invertebrates resources. **Mark Peterson, Michael Lowe** S30-10	Habitat-dependent growth and survival of brook trout and Atlantic salmon in a small stream – everybody in the pool? **Ben Letcher, Keith Nislow, Jason Coombs, Matthew O'Donnell, Todd Durbeuil** C18.2-10	The Black Sturgeon River Dam: A barrier to the rehabilitation of Black Bay walleye in Lake Superior. **Pat Furlong, Rob Foster, Peter Colby** S34-11	Evolutionary impacts of angling nesting bass. **David Philipp, Julie Claussen, Cory Suski, Steven Cooke, Brandon Barthel, Aaron Shultz, Jeff Stein, Joe Parkos, Frank Phelan, David Wahl** S23-17	Quantifying the factors that influence flow response to storm events in headwater streams. **Les Stanfield, Don Jackson** S29-11
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			Thursday August 21st			
			Ottawa Congress Centre			
Room	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	C19 Invasive Species	**C17 Percids 2**	**C12 Habitat and Water Quality 2**	**C7 Marine Fish Ecology 3**	**C20 Stream and River Communities**	
Moderator	Marten Koops	Bob Bergmann	Steven Woolfenden	Kurt Fresh	Lynn Bouvier	
8:00			Hydro-climate and Atmosphere Indexed Runoff Prediction (HARP) Tool. **Michael McMahon, John Henz, William Badini, Steve Anderson** C12.2-1		Longitudinal variability in rivers: implications for survey design. **Robert M Hughes, Alan T. Herlihy** C20-1	
8:20	Rapid response: yhe tunicate's tale…and then there were four. **Andrea Locke, J. Mark Hanson, Renee Bernier** C19-1		Actogram and Habitat Meter: tools for real time assessment of the fish habitat status in streams. **Piotr Parasiewicz, Thomas Seager, Thomas Meyer, Ed Edelson** C12.2-2	Comparing striped bass prey size-predator size relationships across the species range. **Francis Juanes** C7.3-1a	Can less stream distance be sampled in depauperate regions when estimating fish species richness? **Yoichiro Kanno*, Jason Vokoun** C20-2	
8:40	New names, evolutionary resolution, and founding sources for exotic Great Lakes gobies. **Carol Stepien, Matthew Neilson, Joshua Brown** C19-2		Short-term effects of drain maintenance on fish assemblages inhabiting agricultural drains in southwestern Ontario. **Belinda Ward-Campbell, Robert L. McLaughlin, Nicholas E. Mandrak** C12.2-3	Predatory impact on yoy winter flounder, *Pseudopleuronectes americanus*: comparative dietary analysis of common fish species in Long Island waters. **Skyler Sagarese*, Michael Frisk** C7.3-1	Detection and occupancy probabilities for monitoring Missouri River fishes. **Joshua Schloesser*, Craig Paukert, Wyatt Doyle, Tracy Hill, Gerald Mestl, Vince Travnichek** C20-3	
9:00	Fish assemblages and environmental factors associated with gobiids in the Lower Great Lakes. **Lynda Corkum, Silvia Dopazo, Nicholas Mandrak** C19-3	Predicting walleye and yellow perch recruitment with the addition of a top predator. **Robin DeBruyne*, Lars Rudstam, Travis DeVault, James R. Jackson, Anthony VanDeValk** C17.2-1	The role of habitat patterns in controlling the impact of predatory trout on non-migratory galaxiid distributions across New Zealand riverscapes. **Darragh Woodford*, Angus McIntosh** C12.2-4	Variability in the diet of Atlantic croaker and its consequences to the Chesapeake Bay fisheries ecosystem. **Janet Nye, Thomas Miller** C7.3-2	Ecology of South American migratory fish: a perspective from the rithron. **Claudio Baigun, Juan Neiff, Marta Cannon, Veron Roberto Salazar** C20-4	
9:20	Monitoring the expansion of round goby (*Neogobius melanostomus*) into Great Lake tributaries; closing the knowledge gap for fisheries managers. **Jason Barnucz, Jeff McNeice** C19-4	Alberta's small walleyes: diagnosis and correction of a stunting or an overfishing problem? **Stephen Spencer*, Michael Sullivan, Lee Foote** C17.2-2	Response of fish assemblages to natural-channel-design restoration in streams of New York. **Barry Baldigo** C12.2-5	Role of trophic processes in structuring nursery habitats. **Cynthia Jones, Jacques van Montfrans, Stacy Beharry, Renne Reilly** C7.3-3	Factors influencing the distribution and density of Puerto Rico stream fishes. **Patrick B. Cooney, Thomas J. Kwak, Christin H. Brown, Craig G. Lilyestrom** C20-5	
9:40	Population dynamics of an invasive fish in its expansion phase: the round goby in an Ontario river. **Lee Gutowsky*, Michael Fox** C19-5	Mark-recapture analysis on walleye (*Sander vitreus*) spawning populations in eastern Lake Erie. **Yingming Zhao, Brian Shuter, Don Einhouse** C17.2-3	Road crossing designs and their impact on movement and diversity of Great Plains stream fishes. **Wesley Bouska*, Craig Paukert** C12.2-6	Current and historic states of the trophic structure of Great South Bay, New York. **Matthew Nuttall*, Michael Frisk** C7.3-4	~~Fish distribution in Wisconsin streams: estimating changes from the mid 1800's to the present with a GIS-based, watershed-scale, predictive model. **Jana Stewart, John Lyons** C20-6~~ Moved to: S28, 1:40 pm, Mon Aug 18, Congress Centre 2	
10:00						
Room	Congress Centre 2	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	C19 Invasive Species	**C17 Percids 2**	**C12 Habitat and Water Quality 2**	**C7 Marine Fish Ecology 3**	**C20 Stream and River Communities**	**S21 Barotrauma in Fish**
Moderator	Duane Chapman	Bob Bergmann	Steven Woolfenden	Kurt Fresh	Anthony Overton	Chuck Adams
10:20	Invasion dynamics of round goby (*Neogobius melanostomus*) in Hamilton Harbour, Lake Ontario. **Luis A. Velez-Espino, Marten A. Koops** C19-6	Bioeconomic risk assessment of the Lake Erie walleye commercial fishery. **Kate Tsiplova, Natalya Obushenko, Kevin Reid, Wanhong Yang, Tom Nudds** C17.2-4	Effects of a low-head dam on the fish community of a Large Great Plains River. **Joe Gerken, Craig Paukert** C12.2-8	Essential nutrient contribution by heterotrophic protists in the marine pelagic food webs and its ecological implications. **Fu-Lin Chu, Eric Lund, Paul Littreal, Kate Ruck** C7.3-5	The structure and function of riverine fish assemblages: natural and anthropogenic effects. **Jonathan A. Freedman*, Timothy D. Stecko, Robert F. Carline, Jay R. Stauffer Jr.** C20-7	Management implications of minimizing bycatch and reducing release mortality in the Gulf of Mexico reef fish fishery **Andrew Strelcheck, Clay Porch, William Patterson, III** S21-1
10:40	Urine pulses as a male-female signal during mating period in round goby *Apollonia melanostoma*. **Benjamin Meunier*, Lynda Corkum** C19-7	Evaluation of a 14 to 18 inch protected slot for walleye in 12 northern Wisconsin waters. **John Kubisiak, Steve Gilbert** C17.2-5	A multi-disciplinary dam removal feasibility study on the Mill River, Hatfield, Massachusetts. **Jeffrey Legros*, Piotr Parasiewicz, Jim MacBroom, David Ahlfeld, Bradley Compton, Scott Jackson, Diane Mas, Miira Wirth, Jeffrey Legros** C12.2-9	Impacts of fishing and striped bass predation on Atlantic menhaden. **Jim Uphoff** C7.3-6	Long-term surveys of fish populations in two estuaries – are the changes substantial and consistent or transient and random? **Stephanie Wilson, Mark Gerath, Kurtis Schlicht, William Stephens, Jessica Stephens, Breck Sacra, Sandra Davidson** C20-8	Laboratory and field studies on the effects and survival of red grouper and red snapper following rapid decompression from depth **Karen Burns*, Nancy Brown-Peterson**
11:00	Longitudinal variation of fish assemblages in Canadaway Creek: focus on invasive species. **Alicia Fahrner*, Timothy Strakosh** C19-8	A patch occupancy model to assess importance of habitats for walleye. **Dustin Martin*, Kevin Pope** C17.2-6	What can clinical medicine teach fisheries science? A systematic review on the effectiveness of placing large wood in streams. **Kelly Burnett, Guillermo Giannico, Jeff Behan** C12.2-10	Copepod nauplius production drives recruitment in a marine fish Martin Castonguay. **Stéphane Plourde, Dominique Robert, Jeffrey Runge, Louis Fortier** C7.3-7	Abiotic conditions in contrasting environments: an examination of Canadian Precambrian Shield lotic communities. **Margaret Neff*, Donald Jackson** C20-9	S21-2
11:20	Seasonally extended effects of the invasive round goby (*Apollonia melanostoma*) on young-of-the-year smallmouth bass (*Micropterus dolomieu*): eviction from winter refuges. **Christopher Winslow*, Jeffrey Miner, Daniel Wiegmann** C19-9	Walleye spawning habitat use: development of statistical models to guide restoration. **Brian F Kelder, John M Farrell** C17.2-7	Identification and assessment of lake trout spawning habitat through underwater surveys using volunteer scuba divers. **Barry Corbett, Laureen Parsons** C12-.2-11	Identifying links between habitat and fisheries production of white shrimp *Litopenaeus setiferus*: life stage and habitat-related mortality. **Ronald Baker, Tom Minello, Phil Levin** C7.3-8	Dynamics of fish diversity in the Tonawanda Creek Watershed of western New York State. **Scott Wells, James Haynes** C20-10	Sink or swim indicators – which factors can best predict survival or mortality of discarded red snapper? **Matthew Campbell, Sandra Diamond** S21-3
11:40	What the way for sustainable fisheries development in Ulungur Lake of China? **Jianzhong Shen** C19-10	Response of yellow perch to hypoxia in Lake Erie's central basin: spatial patterns. **James J Roberts*, Tomas O Höök, Stuart A Ludsin, Steven A Pothoven, Henry A Vanderploeg** S3-19		Fisheries-independent measures of variation in American lobster abundance and distribution in Northumberland Strait. **John Mark Hanson** C7.3-9	Fish assemblages on gravel bars in the Arkansas river. **Lael A. Will*, Steve E. Lochmann** C20-11	Releasing gravid female rockfish. Is it an effective management tool? Developing a collaborative barotrauma research project with the fishers of Port Orford. **Stephen Theberge Jr, Selina Heppell, Jennifer Bloeser** S21-4
12:00						
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			Thursday August 21st		
			Westin Hotel		
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 3
	S11 Harvest Control Rules	**S4 Sensitivity of Fish and Fisheries to Climate Change**	**S13 Genetics and Sustainable Fisheries**	**S7 Sustainable Sturgeon**	**S30 Managing Impacts to Fish and Fish Habitat**
Moderator	Steve Cadrin	Brian Shuter	Chris Wilson	Cam Barth	Barry Sadler
1:20	General properties of harvest rules: the theoretical approach. **Dorothy Jane Dankel** S11-4	Unconfounding the effects of climate and density dependence on spiny dogfish using 60 years of demographic data. **Ian Taylor, Vincent Gallucci** S4-12	Genetic assignment of lake sturgeon in Lakes Superior and Huron. **Amy Welsh, Henry Quinlan, Lloyd Mohr, Bernie May** S13-12	Evaluation of recovery goals for endangered white sturgeon in the Kootenai River, Idaho USA. **Vaughn Paragamian, Michael Hansen** S7-30	Basin scale monitoring of river restoration: guide-lines and case studies from the Western United States. **Phil Roni, George Pess, Tim Beechie, Chris Jordan, Martin Liermann** S30-11
1:40	Evaluating harvest control rules when life history varies: the case of lake whitefish in the Great Lakes. **Jonathan Deroba*, James Bence** S11-5	Climate warming implications for fisheries and fish communities of the African Great Lakes. **Robert Hecky, Piet Verburg** S4-13	Relative importance of environmental and ecological variables to the comparative genetic structure among Great Lakes forage species. **Wendylee Stott, Kim T. Scribner, Kristi Bennett, Owen Gorman, Scott Libants, Chuck Madenjian, Jeffery Schaeffer** S13-13	Stock-recruit dynamics of Atlantic Sturgeon in the Altamaha River, Georgia: A baseline for evaluating species recovery. **Paul Schueller*, Douglas Peterson** S7-31	Involvement of the Department of Fisheries and Oceans, Quebec Region in the analysis, mitigation and monitoring of a major highway construction project in the Réserve faunique des Laurentides, Québec. **Alain Guitard, France Pouliot, Simon Blais** S30-12
2:00	Are threshold harvesting strategies evolutionarily sustainable? **Katja Enberg, Erin S. Dunlop, Mikko Heino, Ulf Dieckmann** S11-6	Long-term climatic forcing of north Pacific salmon populations: Understanding future fisheries production in context of natural variability. **Daniel Selbie, Bruce Finney, Peter Leavitt, Daniel Schindler, John Smol, Irene Gregory-Eaves** S4-14	Review of the population connectivity of various invertebrate and vertebrate species of the St. Lawrence system and the northwest Atlantic. **Jean-Marie Sévigny, André Talbot, Alexandra Valentin** S13-14	Lake sturgeon (*Acipenser fulvescens*) artificial fertilisation, rearing and propagation at the Eastmain-1 hydroelectric development (Québec): a conservation program in collaboration with the Cree. **Jerome Gingras, Frederic Burton, Marc Gendron** S7-32	Effects of habitat change on fishes – a review and meta-analysis. **Tom Pratt, Karen Smokorowski** S30-13
2:20	Development, evaluation and implementation of harvest control rules for Northeast Arctic cod, haddock and saithe. **Bjarte Bogstad, Harald Gjøsæter, Asgeir Aglen, Sigbjørn Mehl** S11-7	Are recent historic high catches of pink and chum salmon an indication of a climate related change in the capacity of the subarctic Pacific to produce Pacific salmon? **Richard Beamish** S4-15	Adaptive variation in larval lake sturgeon phenotypic traits to environmental conditions during spawning. **James Crossman*, Patrick Forsythe, Kim Scribner, Edward Baker** S13-15	Status of stocked lake sturgeon in targeted restoration waters of New York. **Dawn Dittman** S7-33	Exploring how low-resolution data can work in high-resolution mapping tools – lessons learned from NOAA's Essential Fish Habitat Mapper. **Michael Peccini** S30-14
2:40	Integrating stakeholder perspectives with management objectives: a modeling approach for recreational fisheries. **Fiona Johnston*, Robert Arlinghaus, Ulf Dieckmann** S11-8	Management implications of climate change impacts on life history events of salmonids in British Columbia's southern interior. **Kim Hyatt, Margot Stockwell, Clint Alexander** S4-16	Landscape genetics and hierarchical genetic structure in Atlantic salmon: the interaction of gene flow and local adaptation. **Melanie Dionne*, François Caron, Julian Dodson, Louis Bernatchez** S13-16	Lake sturgeon spawning habitat enhancement through flow manipulation. **Mike Friday** S7-P-1 ~~Lake sturgeon reintroduction in the Coosa River System, Georgia, United States. **Justin Bezold, Douglas Peterson** S7-34~~ Moved to 9:40 a.m., same room	Evaluating the stability and performance of engineered fluvial habitat as a method to achieve 'no net loss' over the past 20 years in Seal Cove River, Newfoundland, Canada. **Keith Clarke, David Scruton, Curtis Pennell** S30-15
3:00					
Room	Confederation 1	Confederation 2	Confederation 3	Governor General 1	Governor General 3
	S11 Harvest Control Rules	**S4 Sensitivity of Fish and Fisheries to Climate Change**	**S13 Genetics and Sustainable Fisheries**		**S30 Managing Impacts to Fish and Fish Habitat**
Moderator	Steve Cadrin	Brian Shuter	Chris Wilson		Barry Sadler
3:20	Harvest control rules and user-group agendas: making the two compatible. **Joseph Powers, Elizabeth Brooks** S11-9	Impacts, adaptive capacity, and socioeconomic consequences of climate change on fish resource use and management in Ontario--a survey of resource users, businesses, and professionals. **Lucian A. Marcogliese, John M. Casselman** S4-17	Analysis of sub-population origin and run timing of Atlantic salmon in mixed stock fishery of the lower main stem of a large subarctic river. **Juha-Pekka Vähä, Jaakko Erkinaro, Eero Niemelä, Sturla Brørs** S13-17		Getting beyond the leap of faith: translating habitat science into management advice. **John Boreman** S30-16
3:40	Influence of sources of variation on the performance of a harvest control rule. **James Bence, Jonathan Deroba, Weihai Liu** S11-10	What has the IPCC said about fish and fisheries? **John J. Magnuson** S4-18	Fitness consequences to wild Atlantic salmon from interbreeding with escaped farmed salmon in the Northwest Atlantic. **Dylan Fraser, Jeffrey Hutchings** S13-18		The National Fish Habitat Action Plan – a national partnership to protect and restore fish habitat. **Susan-Marie Stedman, Thomas Busiahn, Christopher Estes, Janet Cushing** S30-17
4:00	Long term agreed management plan for western horse mackerel; "If history repeats itself, and the unexpected always happens, how incapable must Man be of learning from experience." **Ciaran Kelly** S11-11	Closing remarks. **Henry Lickers** ~~Miller - Environmental Commissioner's perspective~~ CANCELLED	Temporal changes in Atlantic bluefin tuna (*Thunnus thynnus*) genetic variation. **Giulia Riccioni, Monica Landi, Giorgia Ferrara, Fausto Tinti, Guido Barbujani** S13-19		An integrated regulatory review process for regulating impacts to fish and fish habitat from Placer Mining in the Yukon. **Steve Gotch** S30-18
4:20	Discussion		Managing the gag (*Mycteroperca microlepis*) fishery in the southeastern United States: is there a genetic basis for the current separation between Gulf and Atlantic stocks? **Elizabeth Cushman*, Nate Jue, Allan Strand, Erik Sotka** S13-20		Risk characterization and assessment of cumulative impacts on aquatic ecosystems. **Roland Cormier** S30-19
4:40	Discussion		Genetic stock identification determines inter-annual variation in stock composition for legal and sub-legal Chinook captured in the Washington Area – 2 non-treaty troll fishery. **Scott Blankenship, Kenneth Warheit, Doug Milward** S13-21		Toronto Waterfront Aquatic Habitat Restoration Strategy – a strategic and integrated approach to managing the aquatic habitat in a large urbanized centre. **Cassandra Bach** S30-20
5:00					Discussion

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	C18 Salmonids in Streams	**S34 Native Species Restoration in Great Lakes**	**S23 Parental Effects & Recruitment**	**S29 Sampling for Understanding Headwater Systems and Fish Production**	**C19 Invasive Species**
Moderator	Andy Todd	Brad Allan	Paul Venturelli	Les Stanfield	Christine Brousseau
1:20	Competition between Atlantic salmon and smallmouth bass; experiments in an artificial stream. **Gus Wathen*, Stephen Coghlan, Joseph Zydlewski** C18.2-11	Walleye restoration on the Moon River, Georgian Bay: striking a balance. **David Gonder, Harry Taylor, Scott Finucan** S34-12		Check Your Watershed Day: a community-based survey quantifying flow and fish barriers in headwater streams. **Sarah Hogg, Joyce Chau, Les W. Stanfield** S29-12	Food web effects of a nonnative fish: initial results of a large-scale field experiment. **Joseph Benjamin*, Fabio Lepori, Colden Baxter, Kurt Fausch** C19-11
1:40	Planting Atlantic salmon eggs with a new hydraulic planter. **Paul Christman, Daniel McCaw, Jason Overlock** C18.2-12	Efforts to restore muskellunge to the Spanish River delta, Lake Huron, Ontario, Canada. **Arunas Liskauskas, Christine Selinger, Wayne Selinger, Seija Deschenes** S34-13	Taking the next step: Examining recruitment and population variation in largemouth bass when catch and release angling disrupts parental care. **Jeffrey Stein*, David Philipp** S23-18	Quantification of processes within a headwater channel network. **John Parish, Shelley Gorenc, Mike Tilston, Jackie Thomas** S29-13	Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River. **Kevin Irons, Greg Sass, Michael McClelland, Joshua Stafford** C19-12
2:00	Effects of fish size, habitat, flow, and density on capture probabilities of age-0 rainbow trout estimated from electrofishing at discrete sites in a large river. **Josh Korman, Mike Yard, Carl Walters, Lewis Coggins** C18.2-13	The development of muskellunge rearing techniques for fisheries restoration projects in Ontario. **Allan Chamberlain, Sasha Fernando** S34-14	Genetic links between adult size and larval quality in a marine fish: effects of parent phenotype on population replenishment. **Darren Johnson*, Jessica Moye, Mark Christie, Mark Hixon** S23-19	The consequences of habitat sampling choice on benthic macroinvertebrate metric and index estimation in coastal Louisiana streams. **Michael Kaller, William Kelso** S29-14	Is the impact of an invasive species on ecosystem properties altered by differences in native fish diversity? **Michael Carey*, David Wahl** C19-13
2:20	Effects of urban development in the Muskegon River watershed on growth, survival and potential recruitment of a Lake Michigan steelhead population: results of a multi-modeling approach. **Jeffrey Tyler, Edward Rutherford, Mike Wiley, Catherine Riseng, David Hyndman, Bryan Pijanowski** C18.2-14	An overview of the Lake Simcoe Muskellunge Restoration Project. **Jason Borwick, Brad Allan** S34-15	Maternal influences as a mechanism of population regulation in exploited marine stocks. **Paul Venturelli, Brian Shuter** S23-20	Fishless streams: natural and anthropogenic causes. **Richard Horwitz, Paul Overbeck, David Keller, Shane Moser, Thomas Belton** S29-15	Effect of the invasive predator, *Bythotrephes longimanus*, on growth of fishes in Ontario lakes. **Leah James*, Shelley Arnott, John Casselman** C19-14
2:40	Changes in suitable habitat for salmonids in the Muskegon River resulting from different paths of urban development. **Edward Rutherford, Jeffrey Tyler, Mike Wiley, Catherine Riseng, David Hyndman, Bryan Pijanowski** C18.2-15	Parking on the water: evaluating the management and conservation of Great Lakes fishes through Aquatic Protected Areas. **Kevin Hedges, Nicholas Mandrak, Marten Koops, Ora Johannsson** S34-16	Parental effects on stock rebuilding rates. **Tara Marshall** S23-21	Spatial variance of headwater stream environments and fish assemblages. **Beth Sparks-Jackson*, Michael Wiley, Paul Seelbach** S29-16	Natural history of introduced northern snakehead in the Potomac River catchment: implications for control. **Nicolas W. R. Lapointe*, Paul L. Angermeier** C19-15
3:00					

Room			Congress Centre Colonel By	Congress Centre 1	Congress Centre 2
			S23 Parental Effects and Recruitment	**S29 Sampling for Understanding Headwater Systems and Fish Production**	**C19 Invasive Species**
Moderator			Paul Venturelli	Michael Kaller	Christine Brousseau
3:20			Discussion	SPEED FORMAT: **S29-SP-17:** Ready, set, check your watershed day: a unique community-based approach to assess stream conditions. **Joyce Chau, Sarah Hogg, Les W. Stanfield** **S29-SP-18:** A comparison of crest stage gauges and pressure transducer as tools for assessing stage response in headwater streams. **Les Stanfield** **S29-SP-19:** A management tool for maintaining headwater functions in an urban setting. **Shelley Gorenc, John Parish** **S29-SP-20:** Landscape models to prioritize headwater restoration for watershed recovery. **George Merovich, J. Todd Petty** **S29-SP-21**: Reference conditions for mid-Atlantic headwater streams. **Camille Flinders, Richard Horwitz, Paul Overbeck, Amanda Fierro, David Keller, Thomas Belton**	Combining habitat suitability and introduction risk to predict the invasion of smallmouth bass. **Sapna Sharma, Leif-Matthias Herborg** C19-16
3:40			Discussion		Effects of nonnative species on food web structure and variability in the Gila River drainage, New Mexico. **Tyler Pilger, Keith Gido, David Propst** C19-17
4:00			Discussion		The behavior of spawning phase sea lampreys from Middle River, WI in their relation to a low-head barrier. **Sara Ruiter*, Jill Leonard** C19-18
4:20					Field trials for the use of sea lamprey migratory pheromone as an attractant within tributary systems. **Wayne Bouffard*, J. Ellen Marsden, Donna Parrish** C19-19
4:40					Young of year planktivore dynamics: distributions of native rainbow smelt in relation to non-native alewife in Lake Champlain. **Paul W. Simonin*, Donna L. Parrish, Lars G. Rudstam, Bernard Pientka, Patrick J. Sulivan** C19-20

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			Thursday August 21st		
			Ottawa Congress Centre		
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
	C17 Percids 2	**C12 Habitat and Water Quality 2**	**C7 Marine Fish Ecology 3**	**C20 Stream and River Communities**	**S21 Barotrauma in Fish**
Moderator	Derek Parks	Deb Martin-Downs	Karen Murchie	Joe deLaronde	Chuck Adams
1:20	Distribution of egg strands of European perch (*Perca fluviatilis*, L.) with respect to depth and spawning substrate. **Martin Cech, Jiri Peterka, Milan Riha, Tomas Juza, Jan Kubecka** C17.2-8	Prediction of young of the year muskellunge nursery habitat to guide protection and restoration efforts in the Upper St. Lawrence River. **Katie Woodside*, John Farrell** C12.2-12	Impacts of fishing on the ecosystem of the east China Sea shelf off the coast of China. **Yunkai Li*, Yong Chen, Liqiao Chen** C7.3-10	Ecosystem effects of fish diversity and food web structure interact with habitat heterogeneity in experimental streams. **David Hoeinghaus, Keith Gido, Michelle Evans-White, Walter Dodds** C20-12	Developing practical and effective release methods for releasing □arotraumas-impacted fish. **Stephen F Theberge Jr.** S21-5
1:40	Predictions of year class strength of yellow perch in central basin Lake Erie based on projected spawning dates and winter severity indices. **Carey Knight, Ann Marie Gorman** C17.2-9	Fish community and habitat assessment of a recovering urban lake in anticipation of habitat remediation. **Lucas Kirby*, Anthony Siniscal, Neil Ringler** C12.2-13	~~Marine ecosystem services in Clayoquot Sound, British Columbia.~~ ~~**Genevieve Layton-Cartier*, Kai Chan, Tania Weller**~~ Moved to: C8 Human Dimensions, 3:20pm Mon, Congress Centre 7 ~~C7.3-11~~	Young-of-year fish community structure and habitat use along the upper channelized reach of the Missouri River. **Mark Pegg, Benjamin Neely, Kirk Steffensen** C20-14	Discussion
2:00	Variation in early growth, condition and size of age-0 yellow perch in Lake Erie. **Alex Johnson, Paris Collingsworth, Elizabeth Marschall** C17.2-10	Use of an artificial reef as habitat compensation in an Arctic lake. **John Fitzsimons, Hilary Machtans, Sheena Majewski** C12.2-14	Ontogenetic, seasonal, and annual variation in lipid content and composition of Atlantic herring (*Clupea harengus*) from the Bay of Fundy, Canada. **Hillary Lane*, Heather Koopman** C7.3-12	Where is everybody? Evaluating floodplain-dependent fish reproduction in a subtropical river system. **B. Thorpe Halloran*, D. Allen Rutherford Michael D. Kaller William E. Kelso** C20-15	The potential for recovery in black rockfish (*Sebastes melanops*) following recompression. **Alena Pribyl*, Steve Parker, Carl Schreck** S21-7
2:20	Impact of forest harvesting on growth of yellow perch larvae: an example of a bottom-up effect. **Véronique Leclerc*, Pascal Sirois, Pierre Bérubé** C17.2-11	Wetland loss in coastal areas: bucking the national "net gain" trend. **Susan-Marie Stedman, Thomas Dahl** C12.2-16	Evaluation of closed areas: cashes Ledge as juvenile cod habitat. **Jonathan Grabowski, Julien Gaudette, Tom Weber, Christopher McGonigle, Robert Steneck** C7.3-13		Field evaluations of □arotraumas incidences and treatment at a smallmouth bass tournament in northwestern Ontario. **Vivian Nguyen, Marie-Ange Gravel, Steven Cooke** S21-8
2:40	~~Linking yellow perch movements to nearshore bottom substrate.~~ ~~**Karen Stainbrook, Sergiusz Czesny, John Dettmers, Daniel Makauskas**~~ CANCELLED ~~C17.2-12~~		Stable isotopes and gut content analysis reveal contributions of riverine invertebrates and organic matter in two Caribbean island riverine estuaries. **Katherine Smith, Zoe Rodriguez, del Rey Merryl Alber, Cathy Pringle** C7.3-14		Post-release survival RD&E in Australia, with particular reference to □arotraumas issues. Kane Moyle, **Ian Brown** S21-9
3:00					
Room	Congress Centre 3	Congress Centre 4	Congress Centre 5	Congress Centre 6	Congress Centre 7
		C12 Habitat and Water Quality 2	**C7 Marine Fish Ecology 3**		**S21 Barotrauma in Fish**
Moderator		Deb Martin-Downs	Karen Murchie		Steven Theberge
3:20		Evaluating the effects of nutrient enrichment due to land use activities in PEI estuaries using the estuarine fish, *Fundulus heteroclitus*. **Megan Finley*, Michael van den Heuvel, Simon Courtenay, Kevin Teather** C12.2-17	The lionfish invasion: biological and ecological profiles of a successful marine invader in the Atlantic. **James A. Morris, Jr.** C7.3-15		Will anglers adopt fish venting practices? **John Stevely, Charles Adams** S21-10
3:40		Determining coastal restoration success: indicators of nekton functional support. **Megan La Peyre, Bryan Piazza, Bryan Gossman, Christopher Llewellyn, John Gordon** C12.2-18	Catch of red grouper (*Epinephelus mori*) from the bottom longline fishery in waters off the coast of Florida. **Loraine Hale*, Lisa Hollensead, John Carlson** C7.3-16		Barotrauma Panel Discussion
4:00		Tidal and wave energy projects – assessment and monitoring of the biological and physical environment. **Michael Burger, James Dawson** C12.2-19	~~Study on light-induced retina injury of juvenile mullet (*Mugil cephalus*) exposed to different intensity light.~~ ~~**Yunrong Yan, Huosheng Lu, Bo Feng, Yiyao Wang**~~ CANCELLED ~~C7.3-17~~		Barotrauma Panel Discussion
4:20		An analysis of habitat and benthic community effects of scallop dredging on Georges Bank using video photography data. **Danielle Brzezinski*, Yong Chen, James Wilson** C12.2-20			Barotrauma Panel Discussion
4:40					

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POSTERS

S4 Sensitivity of Fish and Fisheries to Climate Change	
S4-P-1	Air temperature, groundwater discharge and climate change influences on the thermal diversity of stream fishes in southern Ontario. **Cindy Chu, Nicholas Jones, Nicholas Mandrak, Andrew Piggott, Ken Minns**
S5 Climate Related Drying Effects	
S5-P-1	Dynamics of peripheral aquatic habitats in the Yukon River Drainage. **Stan Triebenbach, Amanda Rosenberger**
S7 Sustainable Sturgeon	
~~S7-P-1~~	~~Lake sturgeon spawning habitat enhancement through flow manipulation.~~ ~~**Mike Friday**~~ Moved to Oral presentation S7 2:40 p.m. Thu Aug 21 Governor General 1
S21 Barotrauma in Fish	
S21-P-1	Performance of a fish descender hook in the Gulf of Mexico red snapper fishery. **Matthew Campbell, Tiffany Hedrick, Sandra Diamond**
S22 Restless Lake Trout	
S22-P-1	Supplemental stocking has variable impact on regional patterns of native genetic diversity in lake trout populations. **Michael Halbisen, Chris Wilson**
S26 Fisheries Management for Ecosystem Health	
S26-P-1	Implications of *Clarias gariepinus* (African Catfish) propagation in Cuban waters. **Daniel De La Rosa Medero**
S28 Valley Rules the Stream	
S28-P-1	Productive capacity of semi-alluvial streams in Ontario: the importance of alluvial material for fish, benthic invertebrates, periphyton and organic matter. **Sarah Quesnelle, Nicholas Jones**
S28-P-2	Approaches to identifying critical habitat for northern madtom (*Noturus stigmosus*) in Canada. **Amy Edwards, Nicholas E. Mandrak, Shawn Staton**
S30 Managing Impacts to Fish and Fish Habitat	
S30-P-2	Nutrients in the Upper Athabasca River monitoring to fit the need. **Mark Spafford, Preston McEachern**
S30-P-3	Potential benefits of regional fish habitat compensation planning. **M. Kerry Brewin, Julie Dahl**
S30-P-4	The will to protect: an evaluation of fish habitat management and policy in Canada **John Werring, Jeffery Young**
S30-P-5	Fish habitat management at Canadian Forces Base Gagetown. **Andy Smith, Shane Heartz, Steve Falconer**
S30-P-6	Canada's approach to addressing the impacts of fishing on the ecosystem, including fish and fish habitat. **Nadia Bouffard, Lisa Setterington, Brett Gilchrist**
S30-P-7	Evaluating the origin of spawners utilizing an engineered stream at the Granite Canal Hydroelectric Project: what is the spatial influence of the new habitat within the reservoir system? **Curtis Pennell, Brent Sellars, Keith Clarke, David Scruton**
S30-P-8	The Saskatchewan Protocol Agreement: a cooperative approach to prioritizing and managing fisheries issues at power-generating facilities. **Jackie Lukey, Vincent Harper, Debbie Nielsen, Robert Wallace, Michael Pollock**
S30-P-9	Protecting fish and fish habitat on provincial transportation undertakings in Ontario. **Cynthia Mitton-Wilkie, Jamie Dougall, Gareth Goodchild, Stuart Niven, Stephen Casselman, Bob Bergmann**
S30-P-10	Perspective on a habitat area-production approach for assessing the productive capacity of fish habitat. **Robert Randall**
S30-P-11	The application of a risk based approach to the management of development impacts on fish and fish habitat in Canada. **Nicholas Winfield, Abdelhafid Chalabi, Lonnie King**
S30-P-12	Green shores: a voluntary rating and certification program for sustainable shore development. **Brian Emmett, John Readshaw, Harriet Rueggeberg, John Harper, Gretchen Harlow**
S30-P-13	Cottages impact fish habitat in the Canadian Shield. **James Atkinson, Tracy Allison**
S30-P-14	The development of a Replacement Class Screening as a regulatory and planning tool to guide the sustainable development of oyster aquaculture in New Brunswick, Canada. **Sophie Bastien-Daigle**
~~S30-P-15~~	~~A method of conducting fisheries studies in a small watershed. **Jeff Anderson**~~ CANCELLED
S30-P-16	A user based methodology for assessing stream crossing barriers to fish passage: a path to prioritize mitigation efforts. **Simon J. Mitchell, George Peabody**
S35 Standard Methods for Sampling North American Freshwater Fishes	
S35-P-1	Sampling warmwater fish in large standing waters **Steve Miranda, Jeff Boxrucker, John Ney**
S35-P-2	Sampling warmwater fish in rivers C**hristopher Guy, Scott Rogers, Patrick Braaten, Johannus Pitlo, David Herzog**
S35-P-4	Controlling the spread of invasive species while sampling **Stewart Jacks, Roger Sorensen, Doug Jensen, Scott Smith, Steve Sharon, Ron Kinnunen, David Britton**
S35-P-5	Length frequency, condition, growth, and catch per effort indices of common North American fishes **Mark Brouder, Scott Nonar, Alison Iles**
S36 Best Student Symposium	
S36-P-1	Age and growth of the threatened spotted gar (*Lepisosteus oculatus*) from Rondeau Bay, southwestern Ontario. **William Glass, Lynda Corkum, Nicholas Mandrak**
S36-P-2	Development, regulations, and outcomes of the Georges Bank Closed Area II scallop access fisheries, with reference to yellowtail flounder bycatch. **Michelle S. Bachman, Daniel Georgianna, Kevin D. E. Stokesbury**
S36-P-3	Variation in ecosystem sensitivity to watershed urbanization between physiographic ecoregions in the southeastern United States. **Ryan Utz, Robert Hilderbrand**
C2 Salmonids in Lakes	
C2-P-1	A model for the evolution of river-spawning behavior in lake trout. **Michael Halbisen*, Stephen Chong, Chris Wilson, Cheryl Murphy**
C2-P-2	Egg quality variation in wild and hatchery stocks of lake trout. **Tom Johnston**
C3 Sturgeon	
C3-P-1	A comparison of two transmitter implantation techniques in shovelnose sturgeon. **Ben Neely, Kirk Steffensen, Mark Pegg**
C3-P-2	Population parameters and potential management scenarios of shovelnose sturgeon in the Upper Mississippi River. **Jeff Koch*, Michael Quist, Clay Pierce, Michael Steuck, Kirk Hansen, Gene Jones**
C3-P-3	Diet composition of juvenile shovelnose sturgeon in the Middle Mississippi River. **Dawn Sechler*, James Garvey, Quinton Phelps**
C3-P-4	Development and application of a spatially explicit habitat model for juvenile pallid sturgeon. **Bryan Spindler, Steven Chipps, Robert Klumb**

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C3-P-5	Efforts to document spawning of shortnose sturgeon in the Penobscot River System, ME. **Phillip Dionne*, Gayle Zydlewski, Michael Kinnison, James Wilson**
C3-P-6	Assessing the spatial distribution of pallid and shovelnose sturgeon capture sites in the Lower Missouri River using geospatially enabled relational data. **Aaron DeLonay , Kimberly Chojnacki, Sandra Clark-Kolaks, Emily Tracy-Smith**
C3-P-7	Movement of lake sturgeon in the Namakan River, Ontario. **Darryl McLeod**
C4 Fish Conservation	
C4-P-1	Fishes of Canada's National Capital Region. **Noel Alfonso, Brian Coad**
C4-P-2	Movement and habitat associations of native and introduced catostomids in the Big Sandy River of Wyoming. **Diana Sweet, Wayne Hubert**
C4-P-3	A demographic based strategy for prioritizing juvenile salmon habitat restoration across a stream network. **Michael Colvin*, Joe Ebersole, Jim Wigington**
C4-P-4	Conservation of American eel in tributaries of the Upper Delaware River. **Mari-Beth DeLucia, Barry Baldigo, George Schuler**
C4-P-5	Detection of chemical alarm cues and learning capability in an endangered lake sucker. **Stephanie Kraft***
C4-P-8	Artificial propagation of Danube salmon in Ukraine. **Antonina Mruk, Vasyl Ustych, Anna Zakharenko**
C4-P-9	Ecological characteristics of Maryland's stream fishes and connections with abiotic variables for imperiled species management. **Patrick Ciccotto, Scott Stranko, Ronald Klauda**
C4-P-10	Application of forensic techniques to fish conservation and management: injury detection using presumptive tests for blood. **Alison Colotelo, Steven Cooke, Karen Smokorowski, Tim Haxton**
C4-P-11	Management of anthropogenically derived hybrid populations: explicit recognition of assumptions. **Matthew Corsi*, Paul Spruell**
C4-P-12	Protecting species at risk fishes through a community based management plan. **Kari Killins, Mari Veliz**
C5 Statistics and Modeling	
C5-P-1	A simple model of Lake Ontario circulation and larval invertebrate transport. **James E. McKenna Jr., Marc Chalupnicki, Dawn Dittman**
C5-P-2	Ten years after - a decade of Atlantic salmon smolt trapping in Maine. **John Kocik, Graham Goulette, James Hawkes, Christine Lipsky, Paul Music, Timothy Sheehan**
C5-P-3	A bioenergetics approach to explaining variation in yellow perch (*Perca flavescens*) growth and size structure: the role of prey composition. **Kristi Arend**
C5-P-4	A comparative study of inshore and offshore survey programs in quantifying groundfish population dynamics. **Keri Stepanek, Yong Chen, Sally Sherman**
C5-P-5	Spatial analyses of Lake Erie walleye distributions, 1989 - 2003. **Andreas Winter, Yan Jiao**
C5-P-6	Impacts of seasonality in recruitment and growth on stock-recruitment analysis for American lobster. **Jui-Han Chang*, Yong Chen**
C5-P-7	Building predictive species models in the Delaware River basin. **Cara Campbell, Lori Redell**
~~C5-P-8~~	~~Population dynamics of rainbow smelt in U.S. waters of Lake Ontario, 1978-2007.~~ ~~**Maureen Walsh, Randall Owens**~~ CANCELLED
C6 Marine Fish Spatial Ecology	
~~C6-P-1~~	~~Estuarine-scale movements of spotted seatrout (*Cynoscion nebulosus*) in Louisiana determined by acoustic telemetry.~~ ~~**Jody Callihan*, James H. Cowan, Jr.**~~ CANCELLED
C6-P-2	A summary of acoustic tagging programs for migratory and resident Chinook salmon in Puget Sound. **Anna Kagley, Fred Goetz, Correigh Greene, Tom Quinn, Joshua Chamberlin, Kurt Fresh**
C6-P-3	Interannual variability in mixing between Atlantic Ocean and Gulf of Mexico king mackerel stocks estimated with otolith chemistry. **Will Patterson, Kate Shepard, Todd Clardy**
C7 Marine Fish Ecology	
C7-P-2	Spatial variations in elemental otolith elemental fingerprints for two reef fish species in nearshore nursery habitats in St. Croix (USVI) and Puerto Rico. **Ivan Mateo, Edward Durbin, Richard Appeldoorn, Aaron Adams**
C7-P-3	A trophic analysis for hairtail, *Trichiurus japonicus*, during feeding migration in the East-China Sea. **Yong Liu, Jiahua Cheng, Yong Chen**
C7-P-4	Differential niche utilization and ontogenetic shifts in the feeding habits of the barndoor skate on Georges Bank. **Todd Gedamke, William D. DuPaul, John A. Musick, Joseph D. Schmitt**
C7-P-5	Predation by sub-adult red drum (*Sciaenops ocellatus*) on juvenile blue crabs (*Callinectes sapidus*): estimation of daily ration and seasonal variation in the contribution of blue crab to the diet. **Joseph Facendola*, Frederick Scharf**
C7-P-6	Development of coring methods to extract nursery signatures from red snapper otoliths. **Beverly Barnett*, William Patterson III**
C7-P-7	Strong pulses production of Catarina scallop (*Argopecten ventricosus*) fishery, under numerical modelling scenarios in a coastal lagoon system. **Veronica Morales-Zarate, Salvador Lluch-Cota, Alfonso Maeda-Martinez, Francisco Werner**
C7-P-8	Recruitment dynamics of gray snapper (*Lutjanus griseus*) among west Florida estuaries. **Cecelia Lounder*, William F. Patterson, III, Robert J. Allman**
C7-P-9	Improving the accuracy of maturity staging in black sea bass (*Centropristis striata*). **Nikolai Klibansky*, Frederick S. Scharf, David M. Wyanski, M. Scott Baker**
C7-P-10	Preliminary analysis on feeding habits of lancelet at Naozhou Island Sea Area of Zhanjiang, China. **Yunrong Yan, Huosheng Lu, Bo Feng, Haobo Zhao, Huimin Zhan, Chuanyi Liao**
~~C7-P-11~~	~~Genetic isolation by distance and localized fjord population structure in Pacific cod (*Gadus macrochephalus*) indicate limited effective dispersal in the northeastern Pacific Ocean.~~ ~~**Michael Canino, Kathryn Cunningham, Ingrid Spies, Lorenz Hauser**~~ CANCELLED
C8 Human Dimensions	
C8-P-1	Fostering communication and relationships with key organizations yields positive results for fisheries projects. **Brian Dresser**
C8-P-2	Behaviours and knowledge regarding aquatic invasive species: lessons from Lake Champlain boaters and tournament anglers. **Mark Malchoff, Meg Modley**
C8-P-3	Evaluation of consumer choices on spinner dolphin excursions and the implications on spinner dolphin conservation. **Minling Pan*, Katya Boehle, Linda Cox, Wuyang Hu**
C8-P-4	Predicting angler behaviours with an agent-based model: a case of the landscape fisheries model. **Len Hunt, Rob Kushneriuk, Nigel Lester**
C8-P-5	The challenges of developing a CARICOM fisheries agreement. **John Duff, Tricia Lovell**
C8-P-6	Does herring fishing affect whale-watching in the Gulf of Maine? **Min-Yang Lee**
C8-P-7	Learning inquiry-based teaching. **Jim Winter, Janet Lanza**
C8-P-8	How to keep your favorite fishing hole from being Posted --- NO Trespassing! **Scott Wels**

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C8-P-9	Testing adaptation strategies of Baja California (Mexico) coastal fishing communities to climate change. **Salvador Lluch-Cota, Veronica Morales-Zarate, Elisa Serviere-Zaragoza, Sergio Guzman-del-Proo**
C8-P-10	Estimating water, land, and other resources used to produce beef and trout for human consumption. **Lubia Cajas Cano*, Christine Moffitt**
C8-P-11	Empowering recreational fishers to value each fish they release. **Kane Moyle, Frank Prokop, Bill Sawynok**
C9 Bioengineering	
C9-P-1	Simplifying barrier culvert determinations on large scale transportation projects. **Bill Mavros, Matthew Gray**
C9-P-2	Reinitiating fluvial processes and improving salmon habitat at a flood control dam through use of gravel nourishment and large wood transport. **Fred Goetz, Scott Pozarycki, Eric Jeanes, Zachary Corum**
C9-P-3	Entrainment exclusion by an aquatic filter barrier system - design, installation and exclusion and operational performance four seasons of Operations. **Andrew McCusker, Melissa Hamlin, Christian Guelke, Jim Campbell**
C9-P-4	Success of engineered fishway at Arborg Dam. **Maureen Forster, Jonathan Stephens**
C9-P-5	Diversion structure consolidation: more water for fish? **Bill Mavros, Michael C. Garello**
C10 Centrarchids	
C10-P-1	Effects of brood size, offspring age, and parent age on nest abandonment by smallmouth bass. **Geoffrey Steinhart, Brianne Lunn**
C10-P-2	Longitudinal movement of smallmouth bass within tributaries of Lake Erie. **Holly Kaas*, Timothy Strakosh**
C10-P-3	Early life history characteristics of tributary vs. lake spawned age-0 smallmouth bass. **Scott Sullivan*, Timothy Strakosh, Donald Einhouse**
C11 Brook Trout	
C11-P-1	Brook trout distribution in Lake Superior South shore tributary streams. **Martin Jennings, Gene Hatzenbeler, Jeffrey Kampa**
C11-P-2	Current status of the New York State Heritage Brook Trout Program. **Chris VanMaaren, Tim King**
C11-P-3	Diel and seasonal variations in stream habitat use of brook trout. **James Johnson, Robert Ross, David Dropkin, Lori Redell**
C11-P-4	Assessing interactions between walleye and smallmouth bass in South Dakota waters. **Melissa Wuellner*, Brian Graeb, David Willis, John Lott**
C11-P-5	Aberrant growth in brook charr in small Canadian Shield lakes. **William Gardner, Tom Pratt, Karen Smokorowski**
C11-P-6	Behavioural and genetic assessment of mate choice in brook trout. **Terin Robinson*, Joanna Freeland, Chris Wilson**
C11-P-7	Population status and life history characteristics of coaster brook trout in Tobin Harbor, Michigan. **Henry Quinlan**
C11-P-8	Effects of population density on feeding behavior by brook and cutthroat trout in an Idaho stream. **David Owens*, Joe Benjamin, Colden Baxter, Kurt Fausch, Fabio Lepori**
C12 Habitat and Water Quality	
C12-P-1	Effects of road salt on urban fish assemblages. **Ray Morgan**
C12-P-3	Assessing habitat quality for silverside spawning via biochemical analysis of zooplankton. **Barry Volson*, David Bengtson**
C12-P-4	Effects of recreational-flow releases on thermal refuges and their use by brown trout in two Adirondack rivers of northern New York, USA. **Beth Boisvert, Barry Baldigo, Anne Ernst, Clifford Kraft**
C12-P-5	Does hypoxia directly or indirectly effect juvenile fish in the Neuse River estuary, NC? **Lindsay Glass*, James Rice**
C12-P-6	Effects of natural-channel-design restoration on habitat quality in streams of the Catskill Mountains, New York, USA. **Anne Ernst*, Barry Baldigo, Christiane Mulvihill**
C12-P-7	Dissolved oxygen dynamics in tussock-forming aquatic macrophytes. **Aaron Bunch, Mike Allen**
~~C12-P-8~~	~~At what scale are watershed land-use practices useful for determining Ohio River water quality?~~ ~~**Jamie K. Lau*, Erich Emery, Thomas E. Lauer**~~ CANCELLED
C12-P-9	The importance of scale and resolution of field data collection for fish habitat management in the land-use planning process**.** **Jennifer Haslett, Paul Villard**
C12-P-10	Fisheries ecosystem model in Chesapeake Bay and its coupling with a hydrographic model. **Hongguang Ma, Howard Townsend, Villy Christensen**
C12-P-11	Fish passage and fish habitat enhancement of the Blue Note Caribou Mines Diversion Channel near Bathurst, NB. **Ed Torenvliet, Peter Pheeney, Eric Arseneau, John Middlemiss**
C12-P-13	Protection measures to minimize entrainment and impingement of fish at a desalination plant within the Taunton River Estuary, Massachusetts. **Nathan Henderson, Beysy Shreve-Gibb**
C12-P-14	GIS applications for protecting aquatic values. **Darren McCormick, Rob Mackereth**
C12-P-15	An assessment of natural channel designs within the Greater Toronto Area, Ontario, Canada. **Paul Villard, Ryan Ness, Jennifer Haslett, Bradley Wright**
C12-P-16	A comparison between field assessed and photo-interpreted macro habitat values of pallid sturgeon capture sites in the Lower Missouri River. **Aaron DeLonay, Kimberly Chojnacki, Sandra Clark-Kolaks, Emily Tracy-Smith**
C12-P-17	Fishery conservation leaders within the Great Lakes Basin join forces to establish a new National Fish Habitat Partnership. **Mark Brouder**
C12-P-18	Effect of an oil spill on northern pike incubation in a freshwater lake. **Corey Stefura, Barbara Wernick, Luanne Patterson**
C12-P-19	How did the cable get to the other side? Marine resource monitoring requirements and results at submarine cable crossings. **Sarah Zappala, John Duschang**
C12-P-20	Assessing the Index of Biotic Integrity as a measure of remedial action plan status in Areas of Concern. **Monica Granados*, Nicholas Mandrak, Donald Jackson**
C12-P-21	Pearl dace (*Margariscus margarita*): Bioindicator for mining effluent in small headwater systems within boreal ecosystems. **Derek Parks, Joe Tetrault, Dean Fitzgerald**
C12-P-22	Application of North American environmental best management practices for pipeline stream crossings in the Russian Far East. **David Hamilton, Curtiss McLeod, Koen Broker, Malcolm Lowings**
C12-P-23	Using carbon stable isotopes of the particulate organic matter as tracers of the anthropogenic impact in two contrasting riverine catchments of Eastern Cape Province-South Africa**. Pakhomov E.A., Kuriah F.K.**
C12-P-24	Examination of metal contamination within the Rideau River Waterway. **Shannon LeBlond*, Kathleen Hamilton, Allison Rutter, Linda Campbell**
C1-4	Relating species traits to habitat characteristics in coastal wetlands of the lower Great Lakes. **Lynn Bouvier, Karl Cottenie, Susan Doka**

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C14 Contaminants and Toxicology	
C14-P-1	Value chains and health standards in shrimp export from Bangladesh to the world's market. **Mohammad Taj Uddin**
C14-P-2	Fatty acid profile of freshwater sardine *Mirogrex terraesanctae* from the Sea of Galilee. **Valery Dembitsky, Lumir Hanus, Tomas Rezanka**
C14-P-3	Physiological disturbances in largemouth bass: consequences of temperature and oxygen shock. **Matthew VanLandeghem, Cory Suski, David Wahl**
C14-P-4	Ecophysiology of the gray snapper (*Lutjanus griseus*): salinity challenges and choices in the laboratory. **Xaymara Serrano*, Joseph Serafy, David Die, Martin Grosell**
C14-P-5	Housatonic river remediation and aquatic community response. **J. Dana DeGraaf, John P. Lortie, Susan Svirsky**
C14-P-6	Incidence of barotraumas in fish in the St. Lawrence River. **Jason Gokey*, Jason Schreer**
C14-P-7	Aquatic risk assessments for regulation of pesticides in Canada. **Brigitte Lavallée, Scott R. Kirby, Lizanne Avon, Ian Kennedy**
C14-P-8	Sex-based divergence in mercury bioaccumulation by northern fishes. **Kyla Standeven*, Tom Johnston**
~~C14-P-9~~	~~Altered dietary essential fatty acid composition, immune function, mycobacteriosis progression in striped bass, *Morone saxatilis*; is there a link?~~ ~~**Lonnie Gonsalves*, John Jacobs, Matt Rhodes, Eric May**~~ CANCELLED
C14-P-10	Impacts of disturbance on mercury levels and bioaccumulation in small stream environments of northwestern Ontario. **Eric Misener*, Rob Mackereth**
C14-P-11	Habitat relationships with fish assemblages in minimally disturbed Great Plains regions. **Jesse Fischer*, Craig Paukert**
C14-P-12	Patterns of dam building over time in New York State: implications for migratory fish. **Dawn Dittman, Leonard Machut, James Johnson**
C14-P-13	Fish assemblages in an urbanizing basin. **Teresa Wilson, Mark Scott, William English**
C14-P-14	Monitoring changes in resident and anadromous fish communities in Sedgeunkedunk Stream (Penobscot Co., Maine) after low-head dam removal. **Cory T. Gardner*, Stephen M. Coghlan, Joseph D. Zydlewski**
C15 Marine Fisheries Management	
C15-P-1	Management recommendation for *Paragyrops edita* in Beibu Gulf based on per-recruit analysis. **Huosheng Lu, Bo Feng, Gang Hou, Yunrong Yan**
C15-P-3	The importance and consequences of striped bass maternal condition on reproductive potential. **Adam Peer*, Thomas Miller**
C15-P-4	The influence of temperature on monkfish (*Lophius americanus V.*): historical distribution based on bottom trawl survey data. **Daniel Cullen*, Anne Richards, Andrea K. Johnson**
C15-P-5	A comparison of the starfish (*Pisaster ochraceus*) population dynamics in two fishing grounds exposed to different fishing intensities in Baja California. **Gabriela Montaño-Moctezuma*, Elizabeth Romero-Hernandez, Guillermina Chi-Barragán, Fernando García Pámanes**
C15-P-6	Testing the effects of sea turtle bycatch reduction techniques on catch rates in existing gillnet fisheries in Baja California. **Cody Hooven*, Adrian Alvarez, Khahn Chi Dam, Shara Fisler, Yaffet Mehari, Marlem Rivera, Ahiram Rodriguez, Yonat Swimmer, Edgar Trujillo, John Wang**
C15-P-7	Coastal mangrove ecosystems: co-management with social communities. **Rita Singh***
C15-P-8	Project FishSmart: harnessing the knowledge and insights of fishery stakeholders. **Thomas Ihde, Thomas Miller, Michael Wilberg, Michael Nussman**
C15-P-9	Cost-time efficiency of aging menhaden (*Brevortia tyrannus*): scales versus otoliths. **Billy Culver*, Jason Shaffler, Cynthia Jones**
C15-P-10	Efficacy of venting protocol on juvenile red snapper exposed to rapid decompression. **Karon Radzik*, Wayne Bennett**
C15-P-11	Providing quantitative metrics for Marginal Increment Analysis (MIA) to validate annulus formation. **Christina Morgan, Nuno Prista, Cynthia Jones, Hongsheng Liao, James Davies**
C15-P-12	Mind the gap: the state of knowledge of ecosystem impacts of fisheries in Canada. **Jennifer Ford, Candace Picco, Susanna Fuller, Dorthea Haangard, Fan Tsao, Lance Morgan, Ratana Chuenpagdee**
C15-P-13	Steelhead pre-screen loss in Clifton Court Forebay, CA, USA. **Mark Bowen, Kevin Clark, Katherine Zehfuss, Ryan Mayfield**
C15-P-14	Reproductive potential of Pacific cod in Alaska. **Olav A. Ormseth*, Brenda L. Norcross**
C15-P-15	Temporal characterization of the surf zone macrofauna at Folly beach, South Carolina. **Jacquelyn Wilkie***
C15-P-16	Location choice and expected catch: determining causal structures in fisherman travel behaviour. **Michael Robinson*, Kostas Goulias**
C15-P-17	Reproductive biology and fishery of the blue lobster *Panulirus inflatus* in the central Mexican Pacific. **Eduardo Rios-Jara*, Eduardo Juarez-Carrillo, Ernesto Lopez-Uriarte, Jose Luis Gomez-Marquez, Elaine Espino-Barr**
~~C15.1-4~~	~~Managing variability in New Zealand's northern scallop fisheries.~~ ~~**Murray Bruges**~~ CANCELLED
S14-4	Fishery closed areas for deepwater dogfishes off southern Australia - design, monitoring and evaluation. **Ross Daley**
C16 Sampling Techniques	
C16-P-1	The differentiation of Chinook Salmon, natal streams in Lake Huron, Laurentian Great Lakes: the use of otolith microchemistry as a natural tag. **Stephen Marklevitz*, Yolanda Morbey, Brian Fryer**
C16-P-2	Standardized removal and sectioning locations for shovelnose sturgeon fin rays**.** **Jeff Koch*, William Schreck, Michael Quist**
C16-P-3	Otolith chemistry as an indicator of fish environmental history in the Upper Illinois River system and Lake Michigan. **Gregory Whitledge**
C16-P-4	Using visible implant elastomer to tag rare species. **Geraldine Vander Haegen, Lee Blankenship**
C16-P-5	Preservz-It is a suitable alternative to formalin. **Caitlin O'Brien*, Patrick Kovocsky, Michael Porta, William Edwards**
C16-P-6	Analysis of age with different methods for five species of minnows from streams across Ontario: implications for assessment and management. **Dean Fitzgerald, Derek Parks, Joseph Tetreault, Nardia Ali**
C16-P-7	A comparison of nearshore fish sampling gears in Oneida Lake, New York. **Sarah McConnachie*, J. Randy Jackson, Tom Brooking**
C16-P-8	Assessing length-related bias and the potential for standardization in the development of standard weight (Ws) equations. **Mark Fincel*, Steve Ranney, Melissa Wuellner, Justin VanDeHey**
C16-P-9	Development and efficacy of an electrified trawl for sampling benthic fishes. **Timothy D. Stecko*, Jonathan A. Freedman, Richard B. Taylor, Jay R. Stauffer Jr.**
C16-P-10	Comparison of channel catfish age estimates and resulting population demographics using two common structures. **Quinton Phelps*, Robert Colombo, James Garvey, Roy Heidinger**
C16-P-11	Documenting taxonomic data quality for field fish identifications: a proposal for national surveys. **Joseph Flotemersch, James Stribling, Robert Hughes, Louis Reynolds, Treda Smith, Blaine Snyder, Ellen Tarquinio, Christopher Yoder**
C17 Percids	
C17-P-1	Hydroacoustic monitoring of the bathypelagic layer of European perch (*Perca fluviatilis* L.) fry in reservoirs: from raw ecological characteristics to particular features of fish behaviour. **Martin Cech, Jan Kubecka, Vladislav Drastik, Jaroslava Frouzova, Michal Kratochvil, Josef Matena, Jiri Jarosik, Josef Hejzlar**

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C17-P-2	Diet overlap between native yellow perch and invasive white perch in Lake Champlain, Vermont, U.S.A. **Jeffrey White*, Douglas Facey**
C17-P-3	Evaluation of shifts in yellow perch sub-population dynamics in response to habitat changes associated with the introduction of zebra mussels. **William Fetzer*, Katie White, John Forney, Randy Jackson, Lars Rudstam, Tom Brooking, Tony VanDeValk**
C17-P-4	Do freshwater habitats enhance growth of juvenile white perch (*Morone americana*)? **Joshua Newhard***
C17-P-5	Inter-reservoir variation in walleye isotope signatures: implications for food web analysis. **Mark Fincel*, Blake Davis Steve Chipps**
C17-P-6	Timing of walleye spawning runs as an indicator of climate change. **Kristal N. Schneider*, Don L. Pereira, Virginia Card, Raymond M. Newman**
C18 Salmonids in Streams	
C18-P-1	Intraspecific variation in habitat use of juvenile Atlantic salmon in a Lake Ontario tributary. **James Johnson**
C18-P-2	Habitat dependent superimposition of Pacific salmon redds by brown trout in the Salmon River (New York) drainage and implications to Atlantic salmon restoration. **John Fitzsimons, Karala Passow, Fran Verdoliva, Chris Wilson, Dustin Everitt**
C19 Inasive Species	
C19-P-1	Aquatic invasive species: watercraft inspection at international borders in NW Ontario. **Laurie Wesson, Alyson Rob, Vuong Pham**
C19-P-2	Growth responses of fish species of multiple trophic levels to a zebra mussel (*Dreissena polymorpha*) invasion in a shallow, eutrophic lake. **Eric Katzenmeyer*, Clay Pierce, Mike Colvin**
C20 Stream and River Communities	
C20-P-1	Spatial and temporal variation of intermittent stream food webs derived from stable isotopes. **Matthew Dekar, Daniel Magoulick, Gary Huxel**
C20-P-2	Predictive models for fish assemblages of eastern USA streams: implications for species loss. **Michael Meador, Daren Carlisle**
C20-P-3	Benthic macroinvertebrate communities in relation to reach contributing area in small streams in the boreal forest of northwestern Ontario. **Robin LeCraw*, Robert Mackereth**
C20-P-4	Evaluating hydrological connections between aquatic and terrestrial systems in Northwestern Ontario streams. **Lisa McKee*, Robert Mackereth**
C20-P-5	Diet shift of double-crested cormorants in the Upper St. Lawrence River over the past decade. **James Johnson, Rodger Klindt, Anne Bendig**
C20-P-6	Sustainability of a multi-species fishery in the Kafue River, Zambia. **Andrew Deines*, Jeppe Kolding David Lodge, Patrick Ngalande**
~~C-20-P-7~~	~~Reference conditions for mid-Atlantic headwater streams. **Camille Flinders, Richard Horwitz, Paul Overbeck, Amanda Fierro, David Keller, Thomas Belton**~~ Moved to S29 (Speed), 3:20 pm Thu Aug 21, Congress Centre 1
C21 Freshwater Fish Ecology	
C21-P-1	They were everywhere! Estimates of historic eel distribution during the early 20th century in New York State. **Leonard Machut, Dawn Dittman, James Johnson**
C21-P-2	Where are they now? Current observations of American eel in New York State. **Dawn Dittman, Leonard Machut, James Johnson**
C21-P-3	Influence of drought, temperature and didymosphenia geminata on brown trout size structures in the Black Hills, South Dakota. **Daniel James*, Steven Chipps**
C21-P-4	Analysis of Rio Grande silvery minnow nursery habitat utilization for habitat restoration projects. **Michael Porter**
C21-P-5	Feeding ecology of lake whitefish larvae in eastern Lake Ontario. **James Johnson, James McKenna, Timothy Wallbridge, Marc Chalupnicki**
C21-P-6	Survival and growth of brook trout stocked as eggs and fry. **James Johnson, Timothy Wallbridge**
C21-P-7	Lateral distribution of fishes in the main-channel trough of a large floodplain river. **Steve Gutreuter, Jon Vallazza, Brent Knights**
C21-P-8	A proposed monitoring framework for bull trout wildlife habitat areas in the Peace Region of British Columbia. **Nick Baccante**
C21-P-9	Assessing changes in the inland lake fish communities in Bruce Peninsula National Park, Ontario. **Cavan Harpur*, Harold Harvey, Nicholas Mandrak, Scott Parker**
C21-P-10	Analysis of measured and GAP-predicted abundances of American eel in the upper Delaware River. **Leonard Machut, Barry Baldigo, James McKenna, Mari-beth DeLucia, Dawn Dittman, George Schuler**
C21-P-11	Reproductive life history variation in Great Lakes naturalized rainbow trout populations. **Micale Prévost*, Tom Johnston, Lee Haslam, Peter Addison**
C21-P-12	Willingness to pay: an essential component of a cost-benefit analysis to support regulatory decisions. **May Raad-Young**
C21-P-13	Use of chemical signatures of otoliths of St. Lawrence River-Lake Ontario corridor (SLRLO) American eel to determine habitat use and migratory behaviour. **John Fitzsimons, Brian Fryer, Guy Verrault, Remi Tardif**
C21-P-14	Movement patterns and fish passage of redband trout in the Donner and Blitzen River, Oregon, U.S.A. **Matthew Anderson*, Guillermo Giannico, Steve Jacobs**
C22 Fish Culture	
C22-P-1	Ammonia, organics, metals, and P: monitoring hatchery water quality. **Cathleen Doyle, Ruth Briland, Kristina Carlson, David Culver**
C22-P-2	Improving juvenile percid size at harvest. **Ruth Briland*, David Culver**
C22-P-3	Alternative lipids do not affect production performance of Nile tilapia—fatty acid metabolism similar among lean-fleshed fishes? **Jesse Trushenski, John Boesenberg, Christopher Kohler**
C22-P-4	Comparison of a new alternative fish tank material. **Daniel Miller*, Gerard D'Souza**
C22-P-5	Effect of plant material dietary supplement on growth, food consumption and hematoloy in rainbow trout. **Tedra Booker*, Paulinus Chigbu, Eric May**
C22-P-6	EcoLE-FisH: modeling the impacts of lower trophic level-fish-human interactions on Lake Erie walleye. **Jonathan Horn*, Aparna Sathyanarayan, Hongyan Zhang, David Culver**
C22-P-7	Intraspecific competition in larval lake whitefish: the interactive effect of food availability and fish density on growth rates in a laboratory setting. **Dimitry Gorsky*, Joseph Zydlewski, Linda Kling**
C22-P-8	Assessment of fish yield in Patagonian lakes (Argentina): development and application of empirical models. **Claudio Baigun, Norberto Oldani, Adrian Madirolas, Gustavo Colombo**
C22-P-9	Controlling fungus during jar incubation of rosy red fathead minnow eggs. **Ashlee N. Paver and Nathan Stone**
C23 Genetics	
C23-P-1	Reproductive success of reconditioned steelhead kelt. **Jeff Stephenson, Shawn Narum, Douglas Hatch, Rhonda Dasher**
C23-P-2	Pumpkinseed habitat morphs in freshwater reservoirs of Portugal: a result of sympatric divergence? **Yakuta Bhagat*, Chris Wilson, Michael G. Fox, Maria Teresa Ferreira**
C23-P-3	Genetic identification of Lake Erie smallmouth bass tributary stocks and their contribution to the Lake Erie population. **Timothy Strakosh, Theodore Lee, Nicholas Sard, Cassidy Hahns**
C23-P-4	Genetic relationships of Suwannee bass *Micropterus notius* populations in six Florida rivers. **Wesley Porak, Brandon Barthel, Thomas Near, Rich Cailteux, David Philipp**

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S1. Evolving Fish, Changing Fisheries

S1-1

Eco-genetic models of fisheries-induced evolution

Ulf Dieckmann[1] (presenting), Mikko Heino[3], Erin Dunlop[2], Katja Enberg[3]. [1]Evolution and Ecology Program, International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria, [2]Institute of Marine Research, N-5817 Bergen, Norway, [3]Department of Biology, University of Bergen, N-5020 Bergen, Norway

Fisheries-induced evolution is increasingly recognized as a force to be reckoned with in the sustainable management of living aquatic resources: fishing is not only changing population abundance, but also heritable traits. The majority of existing evolutionary models, however, have not been designed to match the specific and rather complex needs of studying fisheries-induced evolution. This is because such studies routinely require accounting for (a) the physiological structure of fish populations in terms of age, size, and maturation status; (b) trade-offs between the fitness consequences of changes in salient life-history traits; (c) the considerable degree of phenotypic plasticity typically underlying the population dynamics of fish populations; (d) frequency-dependent selection pressures resulting, e.g. from density-dependent growth and recruitment; and (e) the amount and distribution of additive genetic variance harbored by fish populations. Earlier modeling approaches based on life-history optimization methods or on quantitative genetics theory succeeded in addressing requirements (a) and (b), but rarely incorporated (c), and typically fall short of reflecting (d) and (e). More recent models, based on adaptive dynamics theory, can take care of (a) to (d), but fail to do justice to (e). This situation sets the stage for the development of a new generation of models of fisheries-induced evolution capable of addressing (a) to (e) simultaneously. These new models are called 'eco-genetic' to reflect that they are specifically geared to incorporate a sufficient amount of ecological detail, thus tackling requirements (a) to (d), in addition to a suitable rendering of genetic detail, thus tackling requirement (e). Eco-genetic models help[1] evaluate hypotheses advanced for explaining observed data;[2] understand and quantify fisheries-induced selection pressures;[3] forecast the direction, speed, and outcome of evolutionary changes; and[4] investigate the consequences of alternative management scenarios.

S1-2

Fisheries-induced evolution of natural mortality rate

Christian Jørgensen[1] (presenting), Øyvind Fiksen[1]. [1]Department of Biology, University of Bergen, Bergen, Norway

Predation is a fundamental process that influences behavioural and life history trade-offs in nature. Therefore, when a system shaped by natural selection is perturbed by human activities, one would logically expect that these trade-offs might change, with consequences for natural predation rates. With a life history model, we show that harvesting a fish population leads to life history evolution towards smaller body size and more risk-taking to increase foraging rates. These evolved life histories increase natural predation rates by nearly as much as the fishing mortality itself. Based on these findings, we recommend increased effort to monitor natural mortality rates, and that modellers of fisheries-induced evolution investigate mortality rates in addition to other phenotypic trait changes.

S1-3

Estimating selection strength on life-history traits in fish exploited by recreational fishing

Robert Arlinghaus[1] (presenting), Shuichi Matsumura[2], Ulf Dieckmann[1]. [1]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany, [2]International Institute of Applied Systems Analysis, Laxenburg, Austria

Despite mounting recognition of the significance of fishing-induced evolution, methods for quantifying selection pressures on adaptive traits affected by size-selective harvesting are still scarce, and none have as yet been developed specifically for recreational fishing. This is a major shortcoming in the current debate about the potential of fishing to act as an evolutionary force. The purpose of the present study is to develop a simple, but ecologically realistic age-structured population model that accounts for the eco-evolutionary feedback arising from density-dependent and frequency-dependent selection and specific patterns of recreational fishing. Using a highly demanded recreational fish species, northern pike (*Esox lucius* L.), we study selection differentials on three life-history traits – reproductive investment, age at maturation, and growth capacity – under size-selective exploitation. We find that size-selective fishing mortality exerts positive selection differentials on annual reproductive investment and negative ones on age at maturation. We find that selection differentials on growth capacity are often positive, but much more difficult to predict in general than those for age at maturation and reproductive investment. A general procedure using a mean-standardized selection differential is developed for comparison of selection strength among different traits. The general methods introduced here allow evaluating and comparing selection pressures on different adaptive traits in different populations and species, and thus have the potential of becoming an important tool for evolutionary impact assessment of recreational fishing-induced evolution.

S1-4

The theory of harvesting generalist predators

Peter Abrams[1] (presenting). [1]University of Toronto, Toronto, ON, Canada

Generalist predators consume a large number of prey species. A large fraction of severely over-fished species are generalist predators. The impact of increased or decreased harvesting of such species on their population size is largely dependent on the form of density dependence in population growth that characterizes these species. Changes in harvesting rate of the predators is likely to result in changes in the prey community, as well as within-species evolutionary changes in prey traits related to defense against, or avoidance of predators. The impact of such changes on predator population growth is analyzed using a range of models of one-predator-multiple-prey systems. In many cases such changes can exacerbate the negative impact of harvesting on the predator's population size.

S1-5

Direct and indirect fisheries-induced evolution in a three-species community

Anssi Vainikka[1] (presenting), Åke Brännström[2], Anna Gårdmark[1], David Boukal[3], Ulf Dieckmann[4]. [1]Institute of Coastal Reseach, Swedish Board of Fisheries, Öregrund, Sweden, [2]Department of Mathematics and Mathematical Statistics, Umeå University, Umeå, Sweden, [3]Institute of Marine Research, Bergen, Norway, [4]Evolution and Ecology Program, International Institute of Applied System Analysis, Laxenburg, Austria

The potential of industrial fishing to cause evolution in exploited stocks has only recently gained attention from managers. Further, fisheries management traditionally relies on single-species models and stocks are managed as independent units. However, in nature species are connected through trophic interactions. Any mortality – originating from fishing, predation, or resource competition – causes selective pressures that potentially translate to adaptive changes in the life-history traits of affected species. Here we report evolutionary predictions from a dynamic model of one predator and two prey species. In addition to causing evolution in the target species, fishing changes the functional structure of the community and leads to indirect evolution in non-target species. Our preliminary results suggest that, assuming constant primary production, high total fisheries yields might be maintained by sustaining natural predator-to-prey ratios, and thereby avoiding starvation mortality in any of the species. Since positively size-selective fishing targeting the top predator may lead to a long-term decrease in yield, it would turn out advantageous to favour late maturation in the predator by targeting small and/or mature fish. We compare fisheries yields in the absence and presence of fisheries-induced evolution resulting from different management scenarios, seeking to maximize yields in the presence of fisheries-induced evolution without sacrificing catches on time scales relevant for fisheries. These results demonstrate the importance of an ecosystem approach to fisheries also in the study and management of fisheries-induced evolution.

S1-6

Ecology and evolution of female mating preferences under size-selective fishing

Davnah Urbach[1] (presenting), Erin S. Dunlop[2], Ulf Dieckmann[1]. [1]International Institute for Applied Systems Analysis, Laxenburg, Austria, [2]University of Bergen, Bergen, Norway

Harvesting is increasingly recognized as a major selective force driving the evolution of life history traits. Yet, little attention has been paid to the effect of fishing on sexual selection and, in particular, on female mate choice. However, by acting on life history traits such as growth, upon which sexual selection ultimately relies, harvesting might induce the evolution of alternative mating preferences. To investigate the effects and implications of harvesting on female mate preferences, we developed an individual-based eco-genetic model and asked i. how different mating preferences affect the demographic response of populations at the onset of fishing, and ii. how the outcomes and the evolutionary trajectories of female preference evolution depend on harvesting regimes, natural ecological conditions, life history traits and the initial female preference.

S1-7

Eco-genetic models to explore the evolutionary consequences of size-selective harvest of Great Lakes fishes

Tomas Hook[1], Hui-Yu Wang[1] (presenting). [1]University of Michigan, CILER, Ann Arbor, MI, United States

Since the early 1800s, fish stocks in the Laurentian Great Lakes have been commercially and recreationally harvested with size-selective gear. This harvest is partially responsible for precipitous declines and even extirpation of some fish stocks. While it is highly likely that intense harvest activities have also impacted adaptive life history traits of Great Lakes fish species, such phenomena are difficult to evaluate due to 1) a multitude of concurrent ecosystem level stressors, 2) somewhat erratic fisheries effort and 3) temporally limited assessment data. However, based on maturation reaction norm analyses, there is evidence of intra-specific spatial variation in adaptive maturation schedules of Great Lakes fishes. We develop and apply an eco-genetic individual based model parameterized for two Great Lakes periodic fish species, walleye and lake whitefish. We use this model to explore interactions of genetic and plastic variation in growth and maturation traits and how size-selective fisheries induced evolutionary impacts may influence stock productivity. Our model is flexible and allows for exploration of the effects of heritable growth rates (based on von Bertalanffy growth patterns), heritable maturation schedules (based on maturation reaction norm concepts), or both. With rather simple ecological tradeoffs and over a relatively short time period (less than 200 simulation years), simulated male and female fish evolve differential genetic growth and maturation. Simulations demonstrate the potential influence of not only size-selective fisheries harvest, but also ecological factors (natural mortality rate, density-dependent growth) and the interactive effects of growth and maturation on the inheritance of these two life-history traits.

S1-8

Age, risk, and maternal investment: a state-dependent approach to the ecology and evolution of female life-histories

Holly K. Kindsvater[1] (presenting), Suzanne H. Alonzo[1], Michael B. Bonsall[2]. [1]Yale University, New Haven, CT, United States, [2]University of Oxford, Oxford, United Kingdom

Recent empirical evidence for age-dependent and state-dependent variation in fish life-history traits motivates the question of how plasticity in individual life-history strategies affects population growth, demography, and the evolution of life-history traits. We use a dynamic state variable model to understand how age and state influence allocation to reproduction and lifespan. We then extend this model to an evolutionary game that incorporates the demographic consequences of life-history allocation patterns into the fitness landscape. This modelling framework allows us to examine how variation in extrinsic mortality (e.g. fishing pressure) can interact with intrinsic factors and shape the reproductive strategy of females.

S1-9

The effect of coastal marine reserves on fisheries-induced evolution in species of different ecological guilds

Tanja Miethe[1] (presenting), Jon Pitchford[1], Calvin Dytham[1]. [1]University of York, York, United Kingdom

Changes in size and age at maturation have been observed in commercially important marine fish stocks and have been partly attributed to highly size-selective fishing mortality. Several fish stocks undertake annual migrations. These need to be considered when implementing a marine reserve as a precautionary approach to manage stocks in an ecologically and evolutionarily sustainable way. Coastal areas often play an important role in the life history of marine fish and have been chosen for protection by marine reserves. We explore the effect of marine reserve implementation on the evolution of size at maturation depending on the migratory pattern of fish stocks. For our analysis, we compare five identified ecological guilds. Individual fish caught in a coastal area are either a resident, belong to an anadromous species, or use the area as a spawning ground, feeding ground, or a nursery ground. We use individual-based models to investigate if a coastal marine reserve can be expected to mitigate the evolutionary impacts of fishing on stocks belonging to different ecological guilds.

S1-10

The role of experiments in understanding harvest-induced evolution

David Conover[1] (presenting). [1]Stony Brook University, Stony Brook, United States

The most difficult challenge in detecting harvest-induced evolution is disentangling the genetic and environmental components of phenotypic change. Likewise, a difficult problem in predicting evolutionary change is the tangled web of genetic covariances among traits that may constrain evolutionary change. Finally, there is the question of the rate of evolutionary reversal, if any, were fishery-induced selection to cease as in a moratorium. Unambiguous evidence of the rate of recovery from evolutionary change, sometimes referred to as the “Darwinian debt”, is nonexistent. In my laboratory, we have used an experimental approach to shed light on each of these issues. We experimentally subjected six captive populations of silverside fish (*Menidia menidia*) to three forms of size-selective fishing for five generations thereby generating two-fold differences among populations in mean weight and yield (biomass) at harvest. This caused rapid evolutionary divergence in body size, growth rate, harvestable biomass, and a suite of other physiological, behavioral, and morphological traits. This was followed by an additional five generations during which size-selective harvest was halted. We found that detrimental evolutionary changes were reversible. Populations evolving smaller body size when subjected to size-selective fishing displayed a slow but significant increase in size when fishing ceased. In contrast, populations that in the first five generations evolved larger size and yield retained these characteristics. Even though the pace of reversal may be very slow, these results offer hope that harmful evolutionary changes caused by fishing are reversible and that management procedures accounting for the evolutionary consequences of size-selectivity of harvest can be successfully implemented. Moreover, our findings illustrate the power of selection experiments in revealing evolutionary dynamics that would be very difficult to measure in most wild populations of harvested species.

S1-11

How and why fishing selects on life-history traits via fish behaviour

Peter Biro[1] (presenting). [1]Univ of Technology, Sydney (UTS), Sydney, Australia

Fish behaviour has long been known to affect catchability as most anglers know well; some are easily caught, others never. What determines their vulnerability? I will suggest, based on experiments and literature review, that (1) fish behaviour varies among individuals, is consistent within individuals, and can and does affect vulnerability to harvest (2) behaviour is tightly linked to underlying life history productivity whereby more productive individuals express behaviours that help secure food resources at a high rate (3) behaviours that facilitate higher productivity also increase vulnerability to harvest and (4) evolution of LH traits is likely due to points 1- 3 given the genetic correlations between behaviours likely to affect catchability and LH trait variation.

S1-12

Harvest induced life-history evolution: a common garden experiment

Tom Cameron[1,2] (presenting), [1]University of Leeds, Leeds, West Yorks., United Kingdom,[2]University of Aberdeen, Aberdeen, Aberdeenshire, United Kingdom

The causes, consequences and occurrence of induced life-history evolution in animal populations which are exploited for human resources, or are of conservation concern, are creating intense international debate at the present time. Much of the reason for the debate is the ambiguity in predictions of what life-historical responses should we expect as a result of a given manipulation on organism survival and over what time-scale should these responses be observed. Life-history theory predicts that reducing adult survival can select for earlier maturation. And while some tests of this theory have been confirmatory, more recent theoretical developments on the response of life-histories to increased adult mortality has predicted many responses in growth rate, maturation, and adult size should be expected dependent on how the manipulation on adult survival is applied, and the strength of the trade-offs between growth, survival and reproduction. Here we test some of these predictions in a common garden experiment controlling for parental effects, differences between environment's and food availability. We show that in populations of the Soil mite, *Sancassania berlesei* (Michael) maintained in either constant or periodic environments', the response of the life-history, as measured by the age and size at maturity and survival schedules, to state-dependent manipulation on adult survival is dependent on current and historical competitive environments.

S1-13

Physiological and nutritional consequences of selection for angling vulnerability in a recreational sportfish

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Commercial marine fisheries can exert selective pressures on the life history characteristics of fish, although little research has examined the selective basis of recreational fisheries and the potential consequences on sportfish. Beyond documenting selectivity associated with recreational fishing, there is an interest in understanding the mechanistic basis for differential angling vulnerability. We evaluated the physiological and nutritional consequences of selection for angling vulnerability using the popular sportfish, the largemouth bass (*Micropterus salmoides*). Over 30 years, fish were subjected to four generations of artificial truncation selection for vulnerability to angling by selecting for high (HVF) and low (LVF) vulnerability fish. A series of studies evaluated the physiological response to exercise as a stressor, metabolic rate, and patterns of energy storage. General trends in the exercise recovery profiles revealed that HVF experienced more severe physiological disturbance than LVF immediately following exercise, but these differences became less apparent over the subsequent recovery period. Using intermittent flow respirometry to quantify oxygen consumption, it was revealed that HVF tended to have a larger metabolic scope than LVF. Standard metabolic rates were reasonably similar between the two groups. We also evaluated the body constituents (lipid, water, protein and ash) of fish in the two groups although data and these results are forthcoming.

S1-14

Are Pacific salmon commercial fisheries selective for physiological and energetic traits?

Steven Cooke[1] (presenting), Scott Hinch[2], Tony Farrell[2], Glen Van Der Kraak[2], Mark Shrimpton[2], Glenn Crossin[2], Mike Donaldson[2], Kyle Hanson[2], David Patterson[2], Karl English[2]. [1]Carleton University, Ottawa, ON, Canada, [2]Sockeye Salmon Research Team, Vancouver, Canada

There is extensive evidence that fishing is often selective for specific phenotypic characteristics, and that selective harvest can thus result in genotypic change. To date, however, there are no studies that evaluate whether fishing is selective for certain physiological or energetic characteristics. Here, adult sockeye salmon (*Oncorhynchus nerka*) were used as a model to test the null hypothesis that fishing is not selective for specific physiological or energetic traits. Fish were intercepted in the Pacific Ocean or in the lower Fraser River during spawning migrations and implanted with a gastric radio transmitter. Fish were also biopsied before release which included drawing a blood sample, collecting a gill biopsy, and quantifying energetic status with a micro-wave energy meter. We paired the individual fish that were harvested with another fish of the same genetic stock. The paired fish were also released on the same date and exhibited similar migration behaviour, except that they successfully evaded capture and reached natal spawning grounds rather than being harvested. We then conducted statistical analyses to determine whether commercial fisheries are selective for physiological and energetic traits.

S1-15

Empirical evidence for fisheries-induced evolution in the wild

Mikko Heino[1] (presenting), Ulf Dieckmann[2]. [1]University of Bergen & Institute of Marine Research, Bergen, Norway, [2]International

Institute for Applied Systems Analysis, Laxenburg, Austria

Today, fishing is the dominant source of mortality in most commercially exploited fish stocks. Life-history theory predicts that changes in mortality regime cause selection on life-history traits. In particular, increased mortality can strongly favour earlier maturation. Indeed, commercially exploited fish stocks often show trends towards earlier maturation. However, earlier maturation may also simply reflect phenotypic plasticity - triggered, for example, by improved individual growth when stock abundance is diminished. Until recently, the difficulties involved in disentangling plastic and evolutionary components of life-history changes have hindered understanding the nature of phenotypic maturity changes. Introduction of probabilistic reaction norms for age and size at maturation have helped to combat this problem: by estimating maturation reaction norms, one can control for growth-related phenotypic plasticity and changes in mortality. A suite of methods for estimating these reaction norms is now available. Addressing different types of data, these methods have been applied to more than 20 stocks, re(presenting) 10 different species of marine and freshwater fish. All but three of these studies suggest that a significant evolutionary component has contributed to the observed trends in age and size at maturation. Remarkably, this component is often detectable at time scales as short as a couple of decades. However, for other life history traits, the evidence is still more scattered. Nevertheless, observations are suggesting that growth has decreased and fecundity has increased in a number of stocks and species.

S1-16

What we know--and need to know--about fisheries-induced evolution in salmonids

Jeffrey J. Hard[1] (presenting), Mart R. Gross[2], Mikko Heino[3], Ray Hilborn[4], Robert G. Kope[1], Richard Law[5], John D. Reynolds[6]. [1]National Marine Fisheries Service, Northwest Fisheries Science Center, Conservation Biology Division, Seattle, WA, United States, [2]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, Ontario, Canada, [3]Department of Biology, University of Bergen, Bergen, Norway, [4]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, United States, [5]Department of Biology, University of York, York, United Kingdom, [6]Department of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada

We review the evidence for fisheries-induced evolution in anadromous salmonids. Salmon are exposed to a variety of fishing gears and intensities as immature or maturing individuals. We evaluate the evidence that fishing is causing evolutionary changes to traits including body size, migration timing and age of maturation, and we discuss the implications for fisheries and conservation. Few studies have fully evaluated the ingredients of fisheries-induced evolution: selection intensity, genetic variability, correlation among traits under selection, and response to selection. Most studies are limited in their ability to separate genetic responses from phenotypic plasticity, and environmental change complicates interpretation. However, evidence for selection intensity and for genetic variability in salmon fitness traits indicates that fishing can cause detectable evolution over ecological time frames. Evolutionary issues are therefore important considerations in salmon fishery management. Despite the lack of conclusive evidence in any specific case to identify fishing as a cause of evolution or decline in salmon, we argue that the collective weight of evidence for fisheries-induced evolution in these and other fishes is strong enough—and the potential consequences serious enough—to justify reassessing current approaches to managing these fisheries. Future research must more directly evaluate the potential long-term effects of fishing. We recommend that managers alter fishing policy to a) allow experimental testing and monitoring of evolutionary responses to exploitation and b) improve the long-term sustainability of the fishery by mitigating unfavorable evolutionary responses to fishing.

S1-17

Changes in selection and evolutionary responses in migratory brown trout following the construction of a fish ladder

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Brown trout (*Salmo trutta*) are extensively harvested and its habitat highly influenced by human encroachments. Using a 40-year time series of mark-recapture data we estimate vital rates for a piscivorous trout population. This population spawns upstream of a waterfall, which historically acted as a migration barrier for smaller trout. In 1966, the waterfall was dammed and a fish ladder constructed. All fish ascending the fish ladder were individually tagged and measured for a variety of traits. The fish ladder overall favoured access to upstream spawning areas for middlesized trout, resulting in stabilizing selection acting on size at spawning. Over time, natural and fishing mortality have varied, with fishing mortality generally decreasing and natural mortality increasing. The average and particularly variance in size-at-spawning, and growth rates during the first years of lake residence have decreased. These changes are all consistent with a shift from directional to stabilizing selection on age and size at spawning. Estimated rates of phenotypic change are relatively high, adding further support for the growing notion that human interference may lead to rapid life-history trait evolution.

S1-18

Life history variation in lake trout across North America: implications for exploitation management

Brian Shuter[1] (presenting). [1]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

Life history characteristics for lake trout vary systematically across the zoogeographic range of the species in North American. Region-specific, sustainable exploitation strategies are derived assuming that this pattern of life history variation is immutable. These strategies are compared with a parallel set of strategies derived assuming that life history characters can shift when subjected to the new selective forces created by exploitation.

S1-19

Arctic charr life history under differing harvest regimes

Raul Primicerio[1] (presenting), Per-Arne Amundsen[1], Rune Knudsen[1], Anders Klemetsen[1], Mikko Heino[2]. [1]University of Tromso, Tromso, Norway, [2]University of Bergen, Bergen, Norway

Landlocked salmonid populations that have been exposed to heavy, selective harvesting, tend to become overcrowded. Harvesting imposes selective mortality on adults in the salmonids that shift habitat at maturation, moving to the littoral zone where they can be captured by gillnets. The expected evolutionary implications of such selective mortality promote bistability and overcrowding in structured population models. Overcrowded Arctic charr populations represent a problem for inland fishery management. Our long term, manipulative study in lake Takvatn (Northern Norway) has confirmed the bistable nature of an Arctic charr population subject to intensive harvesting. Life history data from lakes Takvatn and Fjellfrosvatn, inhabited by Arctic charr populations of common origin but exposed to differing harvest regimes, document the direction and speed of fishery induced evolution, and the potential for recovery during twenty years of suspended harvest.

S1-20

A meta-analysis of life history changes in exploited fish populations

Diana Sharpe[1] (presenting), Andrew Hendry[1]. [1]McGill University, Montreal, QC, Canada

Age and size at maturity have declined dramatically in many commercial fish stocks over the past few decades - changes that have been widely attributed to human fishing pressure. We performed a meta-analysis of all available data on this topic, to test for the consistency of phenotypic changes under fishing, and for their association with the intensity of exploitation (fishing mortality) and the selection regime (harvesting of adults, juveniles, or both). Rates of phenotypic change were calculated for two traditional maturation indices (length and age at maturity), as well as for probabilistic maturation reaction norms (PMRNs). PMRNs are particularly interesting because they partition out some of the plastic variation that can confound apparent changes in age and size at maturity. Age at maturity declined in almost all fished populations (as predicted by theory), but the rate of change did not depend on the intensity of fishing. Length at maturity did not always decrease under fishing, but the rate of change was correlated with the intensity of fishing. PMRNs usually declined in heavily exploited populations (as predicted by theory), and at a rate that depended on the intensity of fishing. These results suggest that fishing is playing a very general role in the dramatic changes in maturation observed in commercial fish stocks. Most interestingly, the rapid rates of change in PMRNs provide compelling evidence that fishing-induced phenotypic changes often have a genetic basis.

S1-21

The study of ecological speciation and its implications for fisheries.

Ross Tallman[1] (presenting), Kimberly Howland[1]. [1]Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada

The term ecological speciation has been used to describe a process of intra-specific differentiation in the absence of geographical barriers. The micro-evolution that occurs has significant implications for the management of fisheries in that production parameters such as growth and reproductive output of populations are often linked to the changes in the populations. We outline the importance of considering whether ecological speciation processes are occurring in harvested species. Using examples from the Canadian Arctic and elsewhere we demonstrate how fisheries management decisions should take these processes into account and the potential consequences to conservation of resources when these principles are ignored.

S1-22

Patterns of evolution in a polymorphic fish: a challenge for conservation and management.

Pamela Woods[1] (presenting), Skúli Skúlason[1], Sigurdur Snorrason[2]. [1]Hólar University College, Sauðarkrókur, Iceland, [2]University of Iceland, Reykjavik, Iceland

Despite heavy emphasis placed on the maintenance of biodiversity in conservation efforts, anthropogenic evolutionary effects are rarely considered. The purpose of this project is to elucidate the ecological conditions under which a species diverges and subsequently, anthropogenic threats to it. This study focuses on Icelandic Arctic charr for three main reasons: 1) it exhibits rapid and repeated phenotypic divergence within lakes over short geological time scales, and some populations have been fished selectively; 2) large ecological database of Icelandic lakes exists and was collected mostly from the Ecological Survey of Icelandic

Lakes Project from 1992 to 2004. These ecological data, including chemical data, invertebrate assemblage, and gut content data, were analyzed for correlations with the presence of Arctic charr and its divergence into multiple morphs. The effect that such morphological divergence has on food webs of these systems, as well as how size-selective fishing can affect them, are discussed.

S1-23
Population divergence in reproductive traits of a protandrous pandalid shrimp caused by size-selective fishing
Susumu Chiba[1] (presenting). [1]Tokyo Univ. of Agriculture, Hokkaido, Japan

Evolutionary changes in the characteristics of a population by size-selective fishing are often less apparent because they are generally processes occurring over an extended period of time. To clarify changes with relatively short period data, this study compared the reproductive traits among populations of protandrous (male first) hermaphroditic pandalid shrimp *Pandalus latirostris* exploited by size-selective cage traps. Shrimps were investigated in six populations with similar environmental conditions at the same latitude (ca 44ºN) in Japan. Multi-year (≤17 years) data showed that the mean body size of each population decreased with the fishing pressure in these populations. While the number of eggs and egg size both increased with female body size in each population, females subjected to high fishing pressure had fewer and/or smaller eggs than females exposed to low fishing pressure in general. Comparisons of the starvation period of laboratory-hatched larvae of females from two adjacent populations subjected to different fishing pressure revealed that larvae from populations subjected to relatively higher fishing pressure died sooner than larvae subjected to lower fishing pressure. These results suggest that the reproductive traits of this shrimp shift with successive generation in response to differences in the selective pressure.

S1-24
Harvest-induced evolution; using the Pacific oyster in France as a model system
Ane T. Laugen[1] (presenting), Pierre Boudry[2], Bruno Ernande[1]. [1]Ifremer, Port-en-Bessin, France, [2]Ifremer, Brest, France
In recent years, accumulating evidence has shown that commercial exploitation of living resources may induce changes in life history traits because of selective harvesting. The nature of such changes may be plastic due to changed environmental conditions or genetic due to altered genetic composition of the population. The Pacific oyster (*Crassostrea gigas*), farmed on the French Atlantic coast, is a commercially important species, heavily exploited, and subject to strong size-selective harvesting. We therefore expect to observe harvest-induced evolutionary change in life-history traits such as growth, reproductive effort and timing of spawning. Thus, by using this species as a model system we aim to investigate the prevalence and causes of harvest-induced changes. By using time series of environmental parameters (biotic and abiotic) to remove noise due to phenotypic plasticity, and statistical techniques to remove co-linearity between variables, we may observe temporal trends in time-series of life-history traits and thereby separate the effects of plastic and evolutionary components. Whereas plastic responses can be reversed within a generation, reversing undesirable evolutionary changes generally requires several generations. Investigating the causes of life-history changes is therefore crucial for the selection of optimal management strategies to obtain long-term sustainable yields in this species.

S1-25
Developing an eco-genetic model of Caspian Sea sturgeon stocks
Rebecca Whitlock[1] (presenting), Ulf Dieckmann[1]. [1]International Institute for Applied Systems Analysis, Laxenburg, Niederoesterreich, Austria

The Caspian Sea has undergone major anthropogenic environmental changes, with large impacts on its ecology and fish population dynamics. Understanding the selective forces such changes imply for key life-history traits is a prerequisite for formulating management strategies that aim to minimise potentially negative evolutionary changes in exploited fish stocks. An individual-based sex-structured eco-genetic model was developed to investigate fishery- and environment-induced demographic and evolutionary changes for late-maturing anadromous fish populations, and applied to sturgeon stocks in the Caspian Sea. This presentation describes a model that considers evolution in five life-history traits: spawning periodicity, spawning migration distance, probability of maturing as a function of age and size, somatic growth rate, and reproductive investment. Preliminary results and findings are presented.

S1-26
Changes in maturation reaction norms in Flemish Cap cod
Alfonso Pérez-Rodríguez[1] (presenting), Joanne Morgan[2], Fran Saborido-Rey[1]. [1]Institute of Marine Research, Vigo, Spain, [2]Department of Fisheries and Oceans, St. John's, Canada

As many other fish populations subjected to high fishing rates, an important decreased in size and age at maturation has been described in Flemish Cap cod. Since 1992 to 1995, size and age at maturation decreased in parallel reaching the lowest values ever observed, and coinciding with the highest fishing pressure observed in all the study period. After a period of relatively stability in both parameters, age at maturation has further decreased, particularly from 2001 to 2005; while size at maturation remained stable at the lower values previously observed. Although initially, compensatory response was supposed to be the main factor responsible of this change, analysis of reaction norms shows how evolution is important in fisheries science and also how changes in maturation could have a more complicated origin than the simple assumption of one of this changing forces (evolution opposite compensatory response) as the unique responsible of the observed changes in maturation. The knowledge of changes in the ecosystem has to be also considered to hypothesize over causes of change and to forecast trends in maturation.

S1-27

Fisheries-induced evolution in maturation of Icelandic cod, and the influence of structure in the stock

Heidi Pardoe[1] (presenting), Anssi Vainikka[2], Erin Dunlop[3], Gudmundur Thordarson[1], Mikko Heino[3], Ulf Dieckmann[4], Gudrun Marteinsdottir[5]. [1]Marine Research Institute, Reykjavik, Iceland, [2]Swedish Board of Fisheries, Oregrund, Sweden, [3]Institute of Marine Research, Bergen, Norway, [4]International Institute of Applied Systems Analysis, Laxenburg, Austria,[5]University of Iceland, Reykjavik, Iceland

Fishing is known to exert novel selection pressures, and fishing-induced changes in maturation schedules have been observed in several exploited fish stocks. Also for Atlantic cod (*Gadus morhua*) in Icelandic waters, declines in age and length at maturation have been detected. Here we present results of a retrospective evolutionary impact assessment in which we analysed temporal trends in probabilistic maturation reaction norms (PMRNs) of Icelandic cod. Another common theme for many fish stocks is that of population structure. Within the Icelandic cod stock, there is evidence of phenotypic and genetic complexity, and the stock has been subject to spatially varying exploitation pressure. The influence of such structure on fisheries-induced evolution in life-history traits – including its rate, magnitude, and detection – will be investigated through the development of an individual-based eco-genetic model, on which preliminary findings will be presented.

S1-28

Management implications of fisheries-induced evolution

Jeffrey Hutchings[1] (presenting). [1]Dalhousie University, Halifax, NS, Canada

Resource managers and decision-makers should seek to avoid the use of harvesting techniques and practices likely to lead to strong, fisheries-induced, directional selection. One means by which this could be achieved is by reducing fishing mortality on larger, older individuals. There also appears to be considerable utility in maintaining and/or rebuilding a breadth of variability in body sizes and age classes within exploited populations. These management objectives could potentially be achieved by a number of measures, including[1] maximum harvestable size limits,[2] marine reserves, or[3] fishing gear-related measures that would distribute fishing mortality more equitably among age and size classes. Depleted populations would benefit from the proposed management actions by reducing or eliminating directional selection intensities, allowing for the potential reversal of fishing-induced genetic changes to life-history traits. Newly exploited species would also benefit by the inclusion of specific management measures designed to minimize the probability of fishing-induced evolutionary change as these new fisheries develop. One means of assessing the strengths and weaknesses of potential management measures is to explore how strategies to reduce the probability of fisheries-induced evolution affect maximum population growth rate, the parameter on which sustainable harvesting rates and population recovery depend.

S1-29

Minimum selection harvest strategies

Stephan Munch[1] (presenting). [1]Stony Brook University, Stony Brook, NY, United States

Evidence from wild and experimental populations indicates that exploited populations may evolve in response to harvest selection and that many traits may be involved in the response. Although in principal it may be possible to manage the evolutionary response to harvest, deducing such strategies requires knowledge of the genetic architecture of the traits involved. When such information is absent, as is the case for most harvested species, it may be better simply to reduce harvest selection the minimum possible. Several strategies for mitigating selection are evaluated including size and age dependent harvest limits and closed-area management.

S1-30

Evolutionary impact assessment: a framework for managing evolving resources

Katja Enberg[1] (presenting). [1]University of Bergen, Bergen, Norway

Evidence is accumulating that the increased mortality levels caused by fisheries are causing evolutionary changes in harvested fish stocks. This is not surprising, as fishing mortality in some cases exceeds natural mortality by more that 400%. Fisheries-induced changes may occur in just a few decades, but be difficult to reverse. Moreover, such life-history changes are likely to have far-reaching ecological and economic consequences, some of which might be difficult to predict. The need for evolutionary enlightened management is thus compelling. Fish stocks and other marine resources provide a number of ecological services of direct and indirect utility to the society. These services may be affected by fisheries-induced evolution: for example, decreased age and size at maturation may decrease the recovery potential, fisheries yield and its stability, influence trophic interactions, geographical distributions, pest and invasion control, and the intrinsic value of species and ecosystems. Acknowledging and understanding the variety of such ecological services will facilitate discussions among stakeholders with different backgrounds and assist in the prioritization of objectives and actions. Evolutionary impact assessment (EvoIA) aims at evaluating the evolutionary influences of human actions. The first step of an EvoIA relies on existing time series data to investigate how fishing has lead to trait changes. The second step involves evolutionary modelling and addresses how these fisheries-induced trait changes influence the stock's utility to society. Employing EvoIA and taking into account the evolutionary enlightened management perspective will (i) support the ecosystem approach to fisheries management by considering how evolution alters ecological relations and management reference points, (ii) comply with the precautionary approach by accounting for uncertainty and risk, and (iii) respect the Johannesburg summit's commitment to the restoration of sustainable fisheries.

S1-31

Evolutionary impact assessment for different management strategies in the North Sea flatfish fishery

Fabian Mollet[1] (presenting), Jan Jaap Poos[1], Laurence Kell[2], Adriaan Rijnsdorp[1], Ulf Dieckmann[3]. [1]IMARES, IJmuiden, Noord-Holland, Netherlands, [2]CEFAS, Lowestoft, Suffolk, United Kingdom, [3]IIASA, Laxenburg, Vienna, Austria

There is growing evidence that fishing will cause evolution in traits that affect the productivity of a fish stock. The impact of evolution on flatfish management is explored using eco-genetic individual based population models and stock assessment tools. We explore the performance of different management strategies in achieving sustainable exploitation including or excluding the evolutionary response. The different management options are tested to find the combination of management options for which the evolutionary impact is lowest. In order to minimize the cost of not considering evolution in fisheries management, we discuss the development of potential assessment tools to account for the evolutionary effect.

S1-32

The economic repercussions of fisheries-induced evolution

Anne Maria Eikeset[1] (presenting), Erin S. Dunlop[2], Eric Nævdal[5], Ulf Dieckmann[2], Nils Chr. Stenseth[1]. [1]Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biology, University of Oslo, Oslo, Norway, [2]Evolution and Ecology Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, [4]Population Genetics and Ecology, Institute of Marine Research (IMR), Bergen, Norway, [5]Department of Biology, University of Bergen, Bergen, Norway, [6]Department of Economics, University of Oslo, Oslo, Norway

Despite growing evidence that harvest can cause rapid evolution of key yield-determining life-history traits, the economic effects of fisheries-induced evolution have yet to be formally investigated. The world's largest stock of Atlantic cod, the Northeast Arctic cod, experienced an intensification of fishing pressure in the 1930s to 1950s, when open-ocean trawling was introduced in the stock's Barents Sea feeding grounds. Since this increase in exploitation, the stock exhibited a pronounced reduction in the mean age and size at maturation, a trend paralleled by observations in many other commercially harvested species. Evidence suggests that these life-history changes have a genetic basis and that they could diminish the stock's productivity and sustainable yield by reducing the mean body size of fish in the population. Considering that, in addition, large fish are disproportionately more valuable than smaller fish, the removal of late-maturing or large-sized genotypes from exploited populations could lead to considerable economic losses. Here, we merge ecology, evolution, and economy by evaluating the economic cost of fisheries-induced evolution in Northeast Arctic cod under realistic assumptions about the behaviour of fishermen. We demonstrate that, within a few decades, the evolution of life-history traits induced by fishing significantly reduces the economic returns generated by the stock's feeding-ground fishery. This shows how disregard for evolutionary change can be economically costly over a relatively short time horizon. Our results therefore caution against ignoring the consequences of fisheries-induced evolution.

S1-33

Can marine protected areas mitigate the evolutionary impact of fishing on a migratory species?

Erin S. Dunlop[1] (presenting), Marissa L. Baskett[2], Mikko Heino[3], Ulf Dieckmann[4]. [1]Institute of Marine Research, Bergen, Norway, [2]National Center for Ecological Analysis and Synthesis, Santa Barbara, United States, [3]University of Bergen, Bergen, Norway, [4]International Institute for Applied Systems Analysis, Laxenburg, Austria

There is mounting evidence that fishing is capable of inducing evolutionary changes in key life-history traits. These evolutionary changes can have unwanted consequences that reduce the quality of a fishery. Therefore, fisheries managers need viable options for mitigating the evolutionary consequences of fishing. Here we explore one important class of potential management strategies by developing an eco-genetic model to predict the effects of marine reserves on fisheries-induced evolution in a species such as Atlantic cod. Our model advances previous studies by including multiple evolving traits, density-dependent growth, and an annual migration between feeding and spawning grounds. We find that in such a setting the success of a marine reserve in countering fisheries-induced evolution crucially depends on the reserve's location. A reserve placed in the feeding grounds slows evolution, even though there is mixing on the spawning grounds. However, a reserve placed in the spawning grounds has little mitigating effects on evolution, and may even exacerbate its rate. Our results underscore the importance of including an evolutionary perspective when devising management strategies for the protection of commercially important migratory fish stocks.

S2. Community Ecology of Stream Fishes: Concepts, Approaches and Techniques

S2-1

Community ecology of stream fishes two decades later

William Matthews[1] (presenting). [1]University of Oklahoma, Norman, OK, United States

In 1985 at the annual meeting of the American Society of Ichthyologists in Knoxville, a symposium on "Community and Evolutionary Ecology of North American Stream Fishes" was organized by W. J. Matthews and D. C. Heins, resulting in the 1987 publication of a 30-paper volume. Published papers were on: conceptual models of life history, zoogeography, or community dynamics(4); habitat use(5); responses to stress or to flooding(5); predator effects(1); effects of grazing fishes(1); ecomorphology, morphological plasticity, niche packing, or rarity(4); anthropogenic changes in fish faunas(5); life history variation or tactics (3); and genetic variation or divergence (2). Influential papers from the volume were: Schlosser's conceptual framework on fish distribution in small streams, Moyle's comparison of fish life history in North America and Europe, Frank Cross's assessment of changes in fishes in streams of the Great Plains, and Mayden's phylogenetic analysis of historical ecology of fishes of the Central Highlands. As of 1985, gene sequencing, GIS, GPS units, GoogleEarth, or the internet were not used; "landscape ecology", "metapopulation", "macroecology", and "riverscapes" were unknown; and global warming was not a household word. Since the 1985 symposium, there have been two important international meetings of fish ecologists in Spain, organized by Javier Lobon-Cervia. However, there has not in this interval been another symposium providing an overview of ecology of North American stream fishes. Since the 1985 symposium, fish ecologists have adopted many new methods or conceptual approaches. Large-scale and long-term surveys of stream fish provide data for assessment of ecological patterns. Gene sequences offer opportunities from determination of paternity to robust phylogenies for comparative ecological studies. Stable isotopes and concepts like ecological stoichiometry provide new inroads. Linkages among habitat patches, fish effects in streams ecosystems, and climate change are a major focus. The 2008 symposium will provide 24 papers on: macroecology; landscapes and connectivity; conservation challenges; community structure and dynamics; and fish effects in stream ecosystems. These papers will provide a broad view of progress, using new approaches to confront new theory with empirical data, and address questions that were unanswerable or unasked two decades ago.

S2-3

Molecular approaches to stream fish ecology

Marlis R Douglas[1] (presenting), Michael E Douglas[1]. [1]Illinois Natural History Survey, Champaign, IL, United States

Molecular genetic approaches have expanded our capabilities to address questions in stream fish ecology, such as population connectivity, biotic homogenization, species invasions, introgression and effects of habitat alterations on population structure and demography. A broad spectrum of molecular markers can now be tailored to address specific questions, while newer statistical approaches accommodate larger data sets and permit the test of alternative hypotheses. Furthermore, molecular approaches facilitate evaluation of ecological processes across both spatial and temporal scales. Population expansions, declines, and movements can now be examined from recent to deep history and scaled from local drainages to continents. The intrinsic properties of stream ecosystems also make them particular amenable to molecular approaches. Their hierarchical order translates directly into an expanding spatial scale, from headwaters through entire basins. Additionally, stream habitats are often linear and consequently fish populations are distributed sequentially, with interactions constrained to neighboring populations. Finally, stream landscapes often form vicariant barriers, isolating populations and promoting local adaptation. Molecular markers have also contributed to the resolution of conservation issues and to guide appropriate stream management. A comprehensive review of molecular approaches in stream fish ecology is too diffuse so we illustrate their facility by instead emphasizing particular case studies that demonstrate broad utility, such as a molecular phylogeny of Speckled Dace (*Rhinichthys osculus*) as a means of testing hydrographic evolution in western North America and range-wide diversity in Flannelmouth Sucker (*Catostomus latipinnis*), pointing to a basin-wide population bottleneck likely induced by severe post-Pleistocene drought.

S2-4

From metapopulations to metacommunities: linking theory with empirical observations of the spatial population dynamics of stream fishes

Jeffrey Falke[1] (presenting), Kurt Fausch[1]. [1]Colorado State University, Fort Collins, CO, United States

Due to the linear and hierarchical nature of stream ecosystems, stream fishes carry out their life histories across multiple spatial and temporal scales, leading to spatially structured populations. Over the past several decades, metapopulation theory has provided a strong conceptualization of how populations are segregated across space, and stream fish ecologists have explored how this concept applies to stream fishes. Our first objective was to review and synthesize empirical research on metapopulation dynamics in stream fish populations. Recent work builds on three decades of metapopulation theory to bridge the gap between spatial population structure and spatial community dynamics. These "metacommunity" models assume that dispersal is a key factor in structuring communities, and that processes that structure communities (e.g. biotic interactions) occur over large spatial and temporal scales.

To date, little empirical work has focused on investigating metacommunity dynamics. Therefore, our second objective was to review metacommunity theory, and evaluate how four proposed metacommunity paradigms might apply to stream fish communities. Finally, we use data from our research in Great Plains streams to test the utility of these paradigms in explaining variation in stream fish community dynamics.

S2-5

Fish ecology in the age of metacommunities: approaches, patterns and challenges

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Understanding how natural and human-induced processes control fish distribution and biodiversity is a central goal in aquatic ecology. Species assemblages are considered to be regulated by both local and large-scale (geographic) processes. Although this view is widespread in modern ecology, most studies have failed to tackle the relevant geographic scales at which fish communities are organized. Local and regional habitat, as well as the dynamics of dispersal and local colonization-extinction, are well recognized key processes structuring freshwater fish metacommunities, yet we have little knowledge of how these processes interact. Further, habitat geometry and connectivity seem to be more severe for fishes than terrestrial species, as movement is restricted to one-dimension whereas terrestrial animals can disperse within two dimensions. Estimating movement and local extinction for many species for which distributions encompass several spatial scales provide a major challenge in understanding how local and regional processes affect the distribution of fish metacommunities. One potential solution is the use of quantitative tools that can address these questions using multiple scale snapshot data. The modelling of dispersing populations can be accomplished by a variety of metapopulation statistical and stochastic patch occupancy models. Nevertheless, these frameworks are designed to model single species in the landscape, precluding the analysis of metacommunities. The goal of this study is to introduce a quantitative framework that considers local environmental factors, spatial processes and patch isolation to estimate the relative importance of these factors and to describe patterns in the distribution of fish metacommunities.

S2-7

A modelling framework for assessing the effects of long-distance dispersal and loss of connectivity in stream fish

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Long-distance dispersal (LDD) and habitat connectivity influence many important ecological processes, such as population spread and redistribution, regulation of local and regional population dynamics, colonization of newly available habitats, maintenance of diversity in variable environments, and transfer of energy and nutrients. Field studies have shown that both LDD and instream barriers can have marked effects on the distribution patterns and demographic isolation of stream fishes at various spatial scales. Traditional summary measures of movement, such as mean displacement and home range, have limited utility for examining the effects of connectivity in the presence of LDD or instream barriers; however, simple models can be tailored to extract and synthesize this information efficiently. This study presents a modelling framework for quantifying LDD of marked fish as well as their movements in the presence of barriers of differing permeability and directionality. Simulations are used to illustrate the feasibility of the modelling approach and explore sample size requirements. Comparison of model parameters across systems, species, and time periods, should provide insights into the contribution of movement to structuring fish communities in riverine landscapes. The proposed framework can help improve on methods currently used, e.g. to quantify characteristic scales of habitat use (by appropriate combinations of model parameters instead of home ranges) and relate fish movements to environmental or individual predictors (by robust, instead of ordinary least-squares, regression). Management applications follow naturally.

S2-8

Homogenization, differentiation, and the widespread alteration of fish faunas

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Widespread introduction of common species coupled with extirpation of endemic species can cause fish assemblages to lose much of their regional uniqueness. This process of biotic homogenization contrasts with biotic differentiation, whereby initially similar fish faunas diverge due to introductions of different species. The relative importance of homogenization and differentiation in altering fish faunas has been examined in dozens of studies across the world. Synthesis of these studies indicates that homogenization of fish faunas has been widespread and that introductions, especially of sport fishes, have played a bigger role in altering fish faunas than extirpations. In the United States, pairs of states now average 15.4 more species in common than before European settlement. Additionally, the 89 pairs of states that formerly had no species in common now share an average of 25.2 species. Whereas homogenization is prevalent at large spatial scales, differentiation of fish faunas is evident at smaller spatial scales, such as among watersheds within an ecoregion. This differentiation is largely the result of the haphazard nature of fish introductions among individual lakes and streams. Habitat homogenization is a major driver of biotic homogenization because altered habitats create conditions that favor a few cosmopolitan species at the expense of local endemic species.

S2-9

Global changes and prediction of fish biodiversity using downscaling concept

Clément Tisseuil[1] (presenting), Gael Grenouillet[1], Muriel Gevrey[1], Sovan Lek[1]. [1]University Toulouse III, Toulouse, France

Freshwater ecosystems are highly sensitive to local environmental conditions, especially river flow that is a critical component to water supply and water quality. Climate changes can create shifts in the timing and magnitude of high or low flow events, or change the magnitude of river flow at monthly, seasonal, or yearly time scales. Such events may result in dramatically altered river systems or processes, especially freshwater fish biodiversity whose dispersal is limited within hydrographic networks. For catchment scale assessment, fish are particularly well suited as their response time to environmental changes is generally longer/greater than that of other organisms, being most probably the best indicators to register long-term patterns of climate impacts. We applied a two step downscaling approach on 70 river stations widespread over SW of France using four combined statistical methods (Boosted Tree, GAM, GLM and Artificial Neural Networks). We started by predicting local hydrological daily time series from large scale NCEP (National Centers for Environmental Prediction) Reanalysis data. Then, built upon previous results and combined with geographical variables, we predicted local fish biodiversity in terms of species richness and species occurrence for the most common native fish species in France.

S2-11

Predicting the potential impacts of climate change on stream fish assemblages

Laetitia Buisson[1] (presenting), Nicolas Casajus[1], Sovan Lek[1], Gael Grenouillet[1]. [1]University Toulouse III, Toulouse, France

Stream fish are expected to be significantly influenced by climate change as they are ectothermic animals whose dispersal is limited within hydrographic networks. Using stream fish presence-absence records in more than 1100 sites widespread within 9 large French river units, our study aimed at (i) modelling the current spatial distribution of the most common fish species in France (36 species), (ii) comparing the future fish species distribution predicted by several Climate General Circulation Models x future climate scenarios x Species Distribution Models combinations, and (iii) assessing the potential impacts on fish assemblages' structure and diversity. Overall, only the scarce cold-water species (e.g. *Salmo trutta* fario, *Cottus gobio*) were predicted to experience a strong reduction in their distributional area whereas most cool- and warm-water fish species (e.g. *Barbus barbus, Leuciscus cephalus*) were predicted to colonize many newly suitable sites. Our results thus suggested that headwater species would undergo a deleterious effect of climate change whereas downstream species would expand their range by migrating to sites located in intermediate streams or upstream. As a result, local species richness was forecasted to increase greatly and high turnover rates indicated future fundamental changes in assemblages' structure. Nevertheless, predicted future species distributions were highly variable depending on the statistical methods and future socio-economic scenarios considered. Thus, these results may be viewed as a first estimation of climate change impacts on European freshwater fish biodiversity. Moreover, they illustrate the need to account for different sources of uncertainty when addressing the potential impacts of climate change on species distribution modifications.

S2-12

Interactions of introduced pumpkinseed *Lepomis gibbosus* and native brown trout *Salmo trutta* in small streams of southern England

Gordon Copp[1] (presenting), Julien Cucherousset[2], Saulius Stakenas[3], J. Robert Britton[4], Lorenzo Vilizzi[5], Michael G. Fox[6], François Villeneuve[6], Michael Godard[1], Rodolphe E. Gozlan[4]. [1]Cefas, Lowestoft, Suffolk, United Kingdom, [2]Université Paul Sabatier, Toulouse, France, [3]Institute of Ecology of Vilnius University, Vilnius, Lithuania, [4]Bournemouth University, Bournemouth, Dorset, United Kingdom, [5]Murray-Darling Freshwater Research Centre, Mildura, Victoria, Australia, [6]Trent University, Peterborough, Ontario, Canada

The pumpkinseed (*Lepomis gibbosus*), was introduced into the UK more than 100 years ago, but little is known of the ecological impacts on native fishes and ecosystems where not present. The pumpkinseed is established in on-line still waters of the River Ouse (Sussex, southern England), and escapee pumpkinseed are found in some of the Ouse's small tributaries, which contain native species of conservation interest (brown trout *Salmo trutta*, brook lamprey *Lampetra planeri*, European eel *Anguilla anguilla*). We examined the interactions between pumpkinseed and these species, though especially brown trout, using electrofishing surveys and telemetry (coded-wire, passive integrated transponder, radio tags) to assess microhabitat preferences, microhabitat fidelity, home range, and microhabitat overlap/repartition. We also conducted a preliminary study of pumpkinseed impacts on trout growth and stream food web structure (primary and secondary producers, fish, riparian spiders) in stretches with and without pumpkinseed using back-calculated growth techniques and stable isotope analyses (δ13C and δ15N), respectively. The ecological and management implications of the results will be discussed.

S2-13

The response of stream fish assemblages to local-scale habitat as influenced by landscape: A mechanistic investigation of stream fish assemblages

Dana M. Infante[1] (presenting), J. David Allan[2]. [1]Michigan State University, Department of Fisheries and Wildlife, East Lansing, Michigan, United States, [2]University of Michigan, School of Natural Resources and Environment, Ann Arbor, Michigan, United States

Stream fish assemblages are indirectly influenced by natural and anthropogenic landscape features acting through intermediate factors like flow regime, water quality, and physical habitat. These relationships affect distributions and abundances of individual species and also define potential interactions among different groups of fishes. Although the hierarchical influence of environmental factors is a widely accepted view of fluvial systems, few studies have attempted to quantify the complex mechanistic relationships among landscape variables, intermediate factors, and fish. This gap is due in part to limitations of traditional analytical techniques for devolving such relationships. Using covariance structure analysis (CSA), we attempt to quantify the influence of natural and anthropogenic land uses on stream fish assemblages through indirect effects on fluvial physical habitat, including descriptors of flow regimes, habitat complexity, substrate, and channel morphology, for 46 streams of southeastern Michigan. CSA was selected for this investigation because of its ability to quantify indirect effects of variables through intermediate factors and to account for inter-correlations among related measures. For analysis, fish assemblages were summarized by their richness and diversity and also according to functional groups such as trophic guilds, habitat preferences, and tolerances to stressors. Our analysis showed that – when acting through habitat – assemblages were more strongly influenced by natural landscape features including catchment area and geology than by anthropogenic land uses of our study region. Further, the analyses revealed that different aspects of fish assemblages varied with different habitat variables. While diversity and richness increased with habitat complexity and channel size, numbers of tolerant fish species increased with flow stability. These results emphasize the complex effects of natural and anthropogenic landscape features on stream fish through effects on habitat and suggest the importance of understanding the varied response of different aspects of assemblages to environmental controls for improved management and restoration opportunities.

S2-14

Comparing stochastic properties of stream hydrographs and the resilience of fish assemblages

Gary Grossman[1] (presenting), John Sabo[2]. [1]University of Georgia, Athens, GA United States, [2]Arizona State University, Tempe AZ, United States

Stochastic dynamics are central to theory, data analysis and understanding in the fields of hydrology and population ecology. More importantly, hydrology has a clear effect on ecological processes in streams at the community level. Unfortunately, ecologists have rarely linked key components of stochastic descriptions of discharge and stream communities. Here we apply several time series tools to analyze several classic questions in ecology, and in particular stream fish ecology. Specifically, we use a adaptation of Fourier analysis of daily discharge data coupled with multivariate autoregressive (MAR) models describing the relative abundance of species in stream fish assemblages to quantify the resilience of fish assemblages from Coweeta and Ball Creeks, NC We further use these time series tools to link stream hydrology more mechanistically to measures of community resilience. Thus, stochastic hydrology is used to inform a broader theory of community dynamics-one that embraces environmentally driven variability in community structure. We conclude by suggesting possible ways in which this combination of time series tools could be used to forecast changes in stream fish assemblages as a result of changes in environmental conditions or assemblage structure resulting from global climate change and species invasions.

S2-15

Persistence of longitudinal structure in stream fish communities

James Roberts[1] (presenting), Nathaniel Hitt[1]. [1]Virginia Tech, Blacksburg, Virginia, United States

Longitudinal structure in stream fish communities is thought to result from environmental "filters" (e.g. niche diversity and extinction-colonization dynamics) that tend to vary predictably from upstream to downstream locations. Within a given stream's species pool (gamma diversity), environmental filters have predictable effects on longitudinal patterns of nestedness and local species richness (alpha diversity), but their effects on spatial species turnover (beta diversity) and temporal persistence remain largely unexplored. Herein, we develop sets of predictions for the effects of filtering processes on the form and persistence of longitudinal fish community structure. In light of these predictions, we examine published and original fish community data collected over multiple time periods at longitudinal series of sites in four streams (three in Virginia and one in Illinois). We observed similarities among streams, including a) spatial nestedness and a decrease of alpha with increasing distance from stream mouth, b) weak relationships between beta and distance from stream mouth, and c) an overall decrease in beta over time. However, streams varied widely in the temporal persistence of gamma and alpha, as well as in the persistence of longitudinal trends in alpha and beta. Overall, observed patterns indicate the importance of immigrants from outside the stream in determining the regional species pool, though this interacted in complex, idiosyncratic ways with local extinctions, instream permeability, and potentially, changes in niche diversity, to produce longitudinal community structure that varied strongly over space and time. Longitudinal structure is a fundamental component of stream fish community diversity, but our work reveals an underappreciated lack of persistence to this structure. This instability merits greater consideration in biological assessments and conservation planning.

S2-16

Reproductive timing and the assembly larval fish communities in a highly variable river system, the Rio Grande in New

Mexico

Thomas Turner[1] (presenting), Trevor Krabbenhoft[1], Ayesha Burdett[1]. [1]University of New Mexico, Albuquerque, New Mexico, United States

Larval fish community composition in temperate floodplain rivers is determined almost entirely by the phenology of reproduction, and so understanding the cues and conditions necessary for spawning would provide considerable insight into how larval fish communities are assembled. Habitat requirements and feeding ecologies in larvae differ from adults and therefore larvae comprise a unique part of the river fish community. Larvae also make up a significant portion of river biomass in the growing season and are likely to have strong effects on the entire river food web as predators and prey. We studied the timing of reproduction of the fish community of the Rio Grande in New Mexico with a data set that spanned five spawning seasons from 2003 – 2007. We reasoned that if a fixed cue like day length was the primary determinant then the onset of spawning should be invariant among years. Timing of spawning varied considerably with first larvae appearing in April in 2003 and not until June in 2007. We next evaluated whether the rank order of appearance of larvae for each species was invariant across years. Some species (carp, fathead minnow, buffalo) consistently spawned earlier than others (mosquitofish), but two species varied considerably in the order that they appeared in the larval fish community (Rio Grande silvery minnow, red shiner). These observations suggest that while cues like day length are probably very important for spawning readiness, the actual act of spawning is probably cued by other environmental stimuli. We outline a research program that seeks to understand proximate mechanisms of spawning through comparative analysis of reproductive physiology among Rio Grande species. We also present data on ultimate causes of differences in timing of spawning as it relates to seasonal availability of critical resources, and predation and competition risk for larval fish. In a highly variable system like the Rio Grande, plasticity in the timing of spawning may be critical to surmount unpredictable fluctuations in abiotic conditions, but differences in spawning time among species may be maintained by biotic interactions like competition and predation in the early life history of these species.

S2-17

Traits-based approaches in stream fish community analysis

Emmanuel Frimpong[1] (presenting), Paul Angermeier[2]. [1]Virginia Polytechnic Institute and State University, Blacksburg, VA, United States, [2]U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, irginia Polytechnic Institute and State University, Blacksburg, VA, United States

Species traits are used to study the functional organization of fish communities for a range of reasons, from simply reducing data dimensionality to providing mechanistic explanations for observed variation in communities. Ecological and life-history traits in particular have been used in attempts to understand the basic ecology of fishes and predict species and community responses to contemporary environmental challenges, including habitat alteration and biological assessments, non-native invasions and community homogenizations, consequences of climate change, and species extirpations and extinctions. The pace at which traits-based approaches are being used by stream fish ecologists requires related terminology to be streamlined and standardized, traits data to be consistently reported, and methodological limitations to be highlighted and addressed. In this paper, we review the literature on traits-based approaches to stream fish ecology, identifying and defining common terms such as species, trait, tactic, trait-state, guild, functional group, and strategy, and their relationships. We also classify ecological and life-history traits of fishes according to their demonstrated or potential utility in addressing selected ecological hypotheses. We discuss conceptual problems and propose solutions for issues related to a) species as the unit for trait coding, b) intraspecific variability in traits, c) coding for phenotypic plasticity, d) accessing fish traits literature and databases, e) traits data formats and inter-conversion, f) selecting statistical models for different data formats, and g) dealing with phylogenetic and statistical constraints in traits data. Conceptual models and empirical examples are introduced wherever appropriate.

S2-18

Fish assemblage stability in a prairie-margin stream: do droughts matter?

Edie Marsh-Matthews[1] (presenting), William Matthews[1]. [1]University of Oklahoma, Norman, United States

Brier Creek (Marshall Co. Oklahoma, USA) is a 24-km, low gradient, riffle-pool stream, that is a direct tributary of the Red River arm of Lake Texoma. Flow varies seasonally, with drying of riffles in late summer in most years, but extreme dry periods can result in complete drying of headwaters, and formation of small, isolated pools in lower reaches. In 1998, and again in 2000, severe drying occurred in the creek during the two worst regional droughts on record. Fish assemblages in the creek have been sampled for over three decades, with systematic seining of six stations along the length of the creek from 1976-2006, and snorkelling surveys of 14 pools in a 1-km reach (1982-2004). Samples in 1999 and 2001 followed the two recent drought events. We also made collections in several drying pools during the drought of 2000. Using these long-term data, we examined fish assemblage composition in Brier Creek at different spatial scales, to ask if severe drying affected assemblage composition. We used Non-metric Multidimensional Scaling to examine distribution of fish assemblage samples in multivariate space. Long-term seine samples for the entire creek (six sites pooled) show substantial temporal variation in assemblage composition. However, samples in years following severe droughts were not notably more extreme in multivariate space than those in non-drought years. Overall variation in multivariate space was greater for upstream than for downstream sites. Snorkelling data showed a similar pattern at a smaller spatial scale, with temporal variation, but no clear drought effect on assemblage composition. Drying pools sampled during September 2000 had approximately the same number of species as found in non-drought samples, and contained large numbers of young-of-year minnows, topminnows and sunfishes. Two of those pools were also sampled in October 2000 (at which time they were about 2/3 surface area as in September). In the later samples, those pools contained fewer minnows, but were not otherwise significantly different in composition. Our previous studies have shown that fish in drying pools in Brier Creek are in poor condition, but our analyses of long-term assemblage variation suggest that severe drying does not result in predictable or persistent change in fish communities in this system.

S2-19

Fish species traits and communities in relation to a habitat template for Arctic rivers and streams

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We classify and describe rivers and streams in the Arctic ecoregions of North America to develop a habitat template for fishes and fish communities. We provide a brief review of the work that has been done on arctic stream fishes. We describe the Arctic environment: climate, landscape characteristics, and drainages and the streams including spring, tundra lake-chain and wetland, tundra, mountain, and glacier in relation to sediment dynamics, hydrology and thermal regimes, with particular emphasis on the ecological effects of freezing and scouring. Are some streams more environmentally stable than others and why? We describe the distribution of fishes, richness of species, and general life history characteristics. What traits do arctic stream fishes have? Lastly, we develop a conceptual model (hypothesis) linking the habitat template (arctic stream environments described above) with the arctic stream fishes and fish assemblages.

S2-20

Multivariate analysis of stream fish communities: What might we be missing in our approaches?

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Stream fish communities often represent systems varying in their environmental conditions and species composition, frequently with many species involved. Given the inherent complexities of the data, fish community ecologists often rely on multivariate approaches, such as analysis and ordination analysis, to summarize patterns within the communities and to test relationships between community composition and environmental conditions. Although often applied, standard multivariate statistical methods may not adequately capture underlying ecological relationships due to the characteristics of the data involved. Although other methods have been developed in different research fields, including other areas of community ecology, their implementation within studies of fish communities has been slow or non-existent. We examine modifications and alternatives to our standard approaches in order to show how greater insight into community patterns and associations may be achieved through these alternatives. We demonstrate these methods with simple examples and stream fish community data to show potential advantages in these alternative methods. We show how our interpretation of how these communities are structured and classified may be quite different relative to standard methods.

S2-21

Stream fish in communities revisited: consequences of reciprocal land-water linkages and organism movement for community theory

Colden Baxter[1] (presenting). [1]Idaho State University, Pocatello, ID, United States

Ecologists have long acknowledged the complexity of real communities (even the difficulty of defining them), but historically sought to build understanding through work on simplified or experimentally tractable sub-systems. A more recent trend affecting stream fish ecology has been to embrace, and even focus on, the very complexity that might in the past have been considered noise around some theoretical ideal. Not surprisingly, this has resulted in fervent interest in such “messy factors” as the movements of materials and organisms. Some of the best empirical examples come from past and recent riverine investigations of land-water linkages (e.g. leaf and wood inputs, hyporheic exchange, reciprocal fluxes of invertebrates) and the importance of consumer movement (e.g. fish migrations) among aquatic habitats. I review how such movement links what have been considered discrete, local communities into a broader spatial fabric, now being termed a “metacommunity” set in the context of a “riverscape.” Yet, the temporal complexity in both community membership and food web interactions that are created by movement has not been fully addressed. Moreover, new concepts should not simply point out complexity, but offer new general predictions. From examples including stream fishes, I describe a simple, “community-as-kaleidoscope” analogy that may mesh with the spatial, metacommunity and riverscape concepts to provide the basis for a set of theoretical generalizations.

S2-22

Migratory fishes as key subsidies in stream ecosystems

Alexander Flecker[1] (presenting), Peter McIntyre[2], Jonathan Moore[3]. [1]Cornell University, Ithaca, NY, United States, [2]University of Michigan, Ann Arbor, MI, United States, [3]University of California, Santa Cruz, Santa Cruz, CA, United States

Migratory fishes are common components of stream ecosystems throughout the world and are often the mainstay of large riverine fisheries. Here we review the evidence that migratory fishes provide key subsidies in stream ecosystems from two perspectives. Most commonly, the importance of migratory species as subsidies has been considered within the context of material inputs of energy and nutrients drawn from outside the recipient ecosystem. Material subsidies by stream fishes should be most significant in oligotrophic ecosystems with large numbers and biomass of migratory species. In addition, the liberation of imported energy and nutrients requires a mechanism such as predation, senescence, or excretion. As a complement to this view of migratory species as "mobile bags of nutrients", migratory species can be important ecosystem drivers by directly modulating biogeochemical processes within the recipient ecosystem. For example, some migratory species strongly influence rates of nutrient cycling, productivity, and other ecosystem processes. Migratory fishes should be particularly vital as ecosystem drivers when they play functionally unique roles in streams. The strong material and functional roles of migratory fishes have important implications for conservation and management, as these fish species can be critical for maintaining the ecological integrity of river systems.

S2-23

Ecological stoichiometry as a synthetic framework in stream fish ecology

Peter McIntyre[1] (presenting), Alex Flecker[2]. [1]University of Michigan, Ann Arbor, MI, United States, [2]Cornell University, Ithaca, NY, United States

Ecological stoichiometry refers to the use of ratios of elements to evaluate their relative availability to the biota. Such ratios have long been analyzed in primary producers, but their application to animals is more recent. Here we summarize the ecological stoichiometry framework and highlight three key contexts in stream fish ecology: dietary stoichiometry, body stoichiometry, and roles in ecosystem nutrient cycling. Due to the variety of food types used by stream fishes, the stoichiometry of their diets varies widely. Consuming foods with high carbon:nutrient can produce nutrient-limited growth, in contrast to generalizations about energy limitation in fishes. Elemental demands for growth are strongly influenced by the stoichiometry of carbon and nutrients in body tissues. Body stoichiometry has been measured in dozens of stream fish species, and exhibits phylogenetic and size-based patterns. Ingested nutrients that are not incorporated into body tissues must be defecated or excreted. These waste products can be a critical component of ecosystem nutrient cycles. We argue that ecological stoichiometry provides a valuable theoretical framework for merging perspectives across individual, population, community, and ecosystem levels. Broader application of this approach to stream fishes will offer particular insight into consumer-resource interactions and ecosystem functioning.

S2-24

Disturbance mediated effects of stream fishes on ecosystem processes

Keith Gido[1] (presenting), Katie Bertrand[2], Justin Murdock[1], Walter Dodds[1], Matt Whiles[3]. [1]Kansas State University, Manhattan, KS, United States, [2]South Dakota State University, Brookings, SD, United States, [3]Southern Illinois Universtiy, Carbondale, IL, United States

Stream fishes can exert strong top down and bottom up effects on ecosystem processes. The dynamic nature of streams, however, constrains our ability to generalize these effects, particularly in frequently-disturbed systems. We developed a conceptual framework that predicts the role of fishes in non-equilibrium systems over a variety of spatial and temporal scales by considering how species affect rates of ecosystem processes in the context of disturbance regimes. Specifically, recovery of stream function is predicted to vary with time since disturbance, magnitude of disturbance and the resilience of autotrophic and heterotrophic communities following disturbance. We surveyed field and mesocosm experiments that quantified fish species influences on primary production, nutrient dynamics and invertebrate communities to evaluate the importance of disturbance in mediating these interactions. We also evaluated how these interactions change as systems recover from disturbance events. Understanding the interactions between disturbance and species effects is necessary to predict how altered biodiversity will interact with predicted changes in disturbance regimes under future climate change scenarios.

S2-25

Direct and indirect effects of predation on stream fish communities

David Hoeinghaus[1] (presenting), Fernando Pelicice[2], Alexandre Garcia[3]. [1]Kansas State University, Manhattan, Kansas, United States, [2]Universidade Estadual de Maringá, Maringá, Paraná, Brazil, [3]Fundação Universidade Federal de Rio Grande, Rio Grande, Rio Grande do Sul, Brazil

Many studies have demonstrated top-down effects on community structure and function. Most examples are from relatively stable ecosystems, such as lakes, but communities or species in dynamic non-equilibrium ecosystems such as streams may also respond

strongly to predation pressure. We review studies of trophic interactions in lotic ecosystems, focusing on effects of predation on fish species composition, abundance, functional traits and habitat use. The patch-dynamics concept provides an appropriate landscape framework for our review, as the species and functional diversity and density of predators are not distributed evenly across the stream network, and because indirect effects of predation, such as shifts in habitat use by prey species, require a heterogeneous environment. Disturbance is a fundamental component of the patch-dynamics concept, and both natural and anthropogenic disturbances such as spates, droughts, and river impoundment strongly affect the relative influence of predator – prey interactions in structuring stream fish assemblages. Effects of predation vary temporally, and may be more pronounced during different times of the year for different stream ecosystem types. While dynamic abiotic conditions play a strong role in organizing stream communities, predation pressure interacts with environmental conditions and may have strong direct and indirect effects on fish assemblage structure and function.

S3. Human Disturbance to Aquatic Habitats in Midwest Glacial Lakes

S3-1

The Midwest Glacial Lakes Partnership: protecting and restoring aquatic habitats in glacial lakes in the Upper Midwest

Patrick Rivers[1] (presenting). [1]MN Dept. of Natural Resources, Brainerd, MN, United States

While some glacial lakes in the Upper Midwest remain largely undisturbed (such as the northern extremes of Minnesota, Wisconsin, and Michigan), much of the region is under increasing pressure from rapid population growth, development and agricultural land use practices. Development pressure is focused in lake-rich areas of the region, where typical consequences include the loss of functioning riparian areas, water quality degradation, invasive exotic species, and the direct removal of fish habitat, as well as the cumulative impacts of all of these challenges acting in concert with one another. Because agriculture is a major regional land use, increased emphasis on biofuels also poses additional potential threats for the region's lakes. While a number of conservation strategies are being successfully employed in this region, we believe a coordinated multi-state strategic approach is our best chance at implementing positive conservation change at a regional scale. The Midwest Glacial Lakes Partnership (MGLP) is a collaboration of entities (such as governmental, tribal, non-profit, conservation organizations and citizens) working toward the protection, restoration and enhancement of fish habitat in glacially formed lakes. MGLP is currently recognized as a Candidate Fish Habitat Partnership by the National Fish Habitat Board and is working under the direction and guidance of the National Fish Habitat Action Plan. This talk highlights the progress MGLP has made to date and discusses future directions for the partnership.

S3-2

Impacts of residential lakeshore development on habitat of Michigan lakes

Kevin Wehrly[1] (presenting), Lizhu Wang[1], James Breck[1]. [1]Institute for Fisheries Research, Michigan Department Natural Resources and University of Michigan, Ann Arbor, MI, United States

Human activities along lakeshores can impact lake ecosystems by altering physicochemical and biological conditions. Determining the relationships between human activity and habitat conditions is therefore critical for understanding ecological potential of lakes and for developing appropriate management policy and actions. We used the number of dwellings per kilometer of shoreline to evaluate the impacts of residential development on habitat conditions in 200 Michigan lakes. We evaluated the impact of dwelling density on shoreline complexity, the amount of large woody debris in the littoral zone, water clarity, extent of anoxia in the hypolimnion, and concentrations of nutrients and chlorophyll a. Dwelling density had a strong influence on physical structure of the shoreline and on quantity of large woody debris in the littoral zone; a moderate influence on water clarity, extent of hypolimnetic hypoxia, and chlorophyll a concentration; and no measurable influence on late summer nutrient concentrations. We developed a model to predict residential lakeshore development from readily available landscape data such as lake position, soil type, geology, topography, and landuse. This model coupled with our habitat-dwelling density relationships provides a means to assess the impacts of residential lakeshore development for the larger statewide population of lakes that have not been surveyed.

S3-3

Lake shoreline coarse wood and riparian forest research in central Ontario

William Cole[1] (presenting), Elaine Mallory[1], Karen Smokorowski[2]. [1]Ontario Ministry of Natural Resources, Sault Ste. Marie/ON, Canada, [2]Fisheries and Oceans Canada, Sault Ste. Marie, ON, Canada

Federal fisheries legislation in Canada regulates the impacts of aquatic habitat alterations on aquatic productivity from human activities such as shoreline development, road construction, and logging. Assessment of possible harmful alterations of aquatic habitat may require comparison to expected conditions, including amount, size and distribution of nearshore coarse wood. Forest harvesting in Ontario has been restricted or prohibited within at least 15 m of lake shorelines for the past several decades to try to minimize sedimentation and nutrient loading to adjacent aquatic systems, and to try to protect the aesthetic values of continuous forest cover near lakes. However, predicted wood fibre deficits in Ontario over the next 25-50 years have prompted discussions on possible new areas to harvest, including lake riparian zones. Increased logging in forest riparian zones may affect the species, size classes and recruitment rates of coarse wood into the nearshore zone, with mostly unknown impacts on the quantity and quality of fish habitat. A much better understanding of ecological patterns and processes relating to coarse wood in riparian and lake littoral zones is necessary to make informed decisions about allowable riparian harvest levels and their potential terrestrial and aquatic impacts. Working with fish habitat and aquatic population research partners, our research program has focused on two main riparian-littoral zone topics: 1) littoral zone coarse wood demographics (species, size, shoreline density, littoral zone residence times); and 2) riparian zone forest stand species composition and structure, tree mortality rates, and littoral zone wood input rates. Significant species differences in aquatic wood properties and behaviours have emerged from studies on several lakes, including maximum eastern white pine littoral zone residence times of nearly 700 years, and relationships between wood species and aquatic coarse wood distribution and orientation attributes. From an ongoing long-term tree mortality study on 7 lakes in the Boreal Shield ecozone, we observed annual tree mortality rates ranging from 0.3% for eastern white-cedar and white pine to 3.9% for balsam fir, with a mean of 1.3%. Of the trees rooted within our plots (< 10 m from the lake shoreline) that died or fell down, just over 11% contributed coarse wood to directly to the littoral zone. Patterns of tree mortality and breakup will be discussed.

S3-4

Experimental test of the importance of habitat on the productivity of inland lakes.

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The assumption underlying fish habitat protection policies throughout the world is that habitat availability and quality are directly related to fish production. We tested this assumption in small inland lakes in central Ontario by removing coarse woody habitat from experimental systems and referencing the changes to fish populations in unaltered control systems. We predicted that removal of habitat would change lake-wide biomass and productivity, shift the interspecies allocation of biomass and production, and alter the within-lake distribution of fishes. Our longer-term assessment (6 years post-habitat removal) of the aquatic community indicates that only some of the predicted changes have occurred. Structurally complex habitats contained the highest fish densities and biomass, and provided the greatest potential for production, but we could not detect a change in fish distribution due to the wood removal. Interspecies fish biomass allocation shifted, with an initial loss but subsequent recovery of more sensitive species and an increase in abundance and biomass of more tolerant species. While all lakes demonstrated inter-annual variability in total fish biomass and production, overall there was no significant effect detectable from the wood removal. These results demonstrate the importance of assessing impacts of habitat alteration over a longer time period prior to using the results as a basis for management decisions.

S3-5

Quantifying the spatial extent of dock structures in the littoral zones of central Minnesota Lakes

Lyn Bergquist[1] (presenting), Michael Duval[1], Paul Radomski[1], Andrew Williquett[1]. [1]Department of Natural Resources, St. Paul, MN, United States

Dock structures have been shown to negatively impact the aquatic habitats of lakes through shading and disruption of sediments, leading to reductions in plant biomass, abundance of juvenile fishes and habitat complexity. In order to understand the magnitude of these impacts in north-central Minnesota lakes, we quantified the spatial extent and overlap of dock structures with lake littoral zones and shorelines across a five-county study area. We digitized 9965 docks from a random sample of 175 lakes re(presenting) three DNR regulatory shoreland classifications. Using GIS, we summarized the littoral zone acreage (i.e. prime fish habitat) and shoreline covered by dock structures in the study lakes. The total number of dock structures and sum of dock acreage were highest on General Development (GD - least restricted) lakes. However, Recreational Development (RD - moderately restricted) lakes had greater relative dock coverage per lake acre. The ratio of dock acreage to littoral zone acreage (defined as <15 foot depth) was also highest for RD lakes, while the percentage of shoreline intersected by docks was highest for GD lakes. Natural Environment (NE - most restricted) lakes had very few dock structures but are a growing target for residential development. These results indicate that dock structures cover a sizeable area of the littoral and riparian zones of lakes in the study area. Combined with permitted plant removal and plans for full lakeshore development, the potential of cumulative impacts on littoral zones and shorelines can become significant. Fish habitat, shoreline stability and water quality may suffer under existing development rules. The results of this study will help to inform future processes that address dock development and regulation, with the objective of providing greater habitat protection for aquatic and riparian species.

S3-6

A 72-year analysis of Lake Koshkonong water levels and corresponding riparian wetland losses

Paul Cunningham[1] (presenting), Jeff Kraemer[2], Paul Rasmussen[1]. [1]Wisconsin Department of Natural Resources, Madison, WI, United States, [2]Natural Resources Consulting, Inc. Cottage Grove, WI, United States

Similar to nationwide trends, many glacial lakes face increased demands for recreational boating. Not only has boating activity increased, but increased size and horsepower of motor boats often bring interests in maintaining higher and stable water levels to accommodate this demand. Throughout the Midwest numerous shallow lakes are often raised by the placement of dams. Riparian wetlands are susceptible to management actions that favor these stable higher water levels. However, fluctuating water levels play a key role in the dynamic process of marsh rejuvenation, promoting and maintaining high levels of species richness and habitat diversity. A number of researchers have noted that prolonged stabilization of water levels has detrimental effects on shallow marshes. Dam operations often eliminate low water conditions which serve to consolidate sediments and stimulate expansion of both emergent and submergent macrophytes. Here we investigate a 72-year water-level record for Lake Koshkonong and concomitant changes in Lake Koshkonong's riparian wetlands. We reviewed aerial photographs for four of Lake Koshkonong's major wetland complexes from years 1937-2000. Historic aerial photographs were digitally geo-referenced utilizing geographic information system technology to evaluate emergent wetland vegetation loss and shoreline recession. Within the four wetland complexes that we evaluated there have been a total of 520-acres of open water development within emergent and forested wetlands over the last 50-60 years including shoreline recession. For Lake Koshkonong, the primary causes of riparian wetland loss are increased summer water levels through the years (1.5 feet increase from 1932-2003) and the elimination of natural water level fluctuations that occur during drought conditions.

S3-7
Framework for classification of Michigan lakes
James Breck[1] (presenting), Lizhu Wang[1], Kevin Wehrly[1]. [1]Institute for Fisheries Research, Ann Arbor, MI, United States

The statewide management of inland lakes is a daunting but necessary task. For example, Michigan has over 11,000 inland lakes greater than 5 acres, and information about all of these lakes is needed to develop statewide wildlife action plans, assist with forest certification, design lake sampling programs, manage fish populations, and prioritize the protection, restoration and enhancement of fish habitat. We developed a framework for classifying inland lakes that allows us to characterize all inland lakes using information from several spatial scales, ranging from local to landscape. Our database of lake attributes includes information describing the lake (including in-lake data), the direct catchment, the catchment of tributaries, and lake position in the surface-water network. For both direct and tributary catchments, which have been delineated for all inland lakes in the state, we have summarized information on climate, geology, land use and soil type. We have compiled information on lake area, shape, fetch, latitude/longitude, elevation, depth, chemistry, and fish. For certain important variables, such as depth and water chemistry, we are developing models to estimate values for lakes without measured values. We will show how this framework allows multiple lake classifications to be developed depending on the specific problems being addressed.

S3-8
Water quality and fisheries in Iowa - development of the State Lakes Classification Project
Joe Larscheid[1] (presenting). [1]Iowa DNR, Spirit Lake, IA, United States

Many of the traditional approaches to fisheries management in Iowa are largely species-specific and on a very small, local scale. These approaches can be very successful, but they also tend to be short-lived solutions and do not address the larger problems impairing fisheries in Iowa (e.g. poor water quality). Recently we began a very aggressive program attacking water quality issues statewide. The hope is that by improving water quality in our lakes will translate to healthy, self-sustaining aquatic ecosystems. Detailed data were collected and compiled from 132 of Iowa's principle lakes and impoundments. Very comprehensive water quality data were collected three times each year for five continuous years. Zooplankton, phytoplankton, and fisheries biota were also assessed during this period. Watersheds were delineated for each lake. Land-use patterns and other watershed characteristics were included for each watershed. Lake contour maps were scanned and many lakes were remapped. Previous studies (e.g. management and research projects) were scanned and included into this project. All of these data were included into a comprehensive database that is available to any interested stakeholders via the World Wide Web (http://limnology.eeob.iastate.edu/lakereport/). This system is very useful for developing lake classifications, describing historical trends, providing very detailed information on individual lakes, and comparing our lakes across the state. We are still mining and adding to this phenomenal database. We have already used this data to help garner money to fund our restoration activities. We do have lots of challenges in Iowa. But, properly managed we can be the breadbasket of the world, and still have excellent water quality and recreational opportunities.

S3-9
Landscape based identification of human disturbance gradients and reference condition for inland lakes in Michigan
Lizhu Wang[1] (presenting), James Breck[1], Kevin Wehrly[1]. I[1]nstitute For Fisheries Research, Ann Arbor, United States

Anthropogenic disturbances are a major threat to the health of inland lakes in the U.S. Traditionally, lake condition is assessed using physicochemical and biological indicators measured within a lake. Because of the natural variation in these indicators among lakes, it is difficult to ascertain whether poor lake condition is natural or a result of human disturbance. We describe a process for identifying natural condition and assessing disturbance gradients in inland lakes using readily available, geo-referenced databases.

We demonstrate the utility of this process by applying it to all 11,000 inland lakes that are equal or greater than 5 acres in Michigan, and use it to identify which human disturbance factors have the greatest impact on each lake. Our process for assessing lake health represents a significant advantage over other routinely used methods. It uses both local lake catchment and river network catchment, permits the evaluation of lake health statewide, yields an overall disturbance index that is a weighted sum of multiple disturbance factors, and identifies key disturbance factors for individual lake so that management efforts can be prioritized. Our approach is less robust for identifying lakes that are influenced by local-scale human disturbances that are not captured by landscape data.

S3-10

Application in benefit-cost analysis: improving water quality in Iowa's Lakes

Kevin J. Egan[1] (presenting), Catherine Kling[1], Joseph Herriges[1], John Downing[1]. [1]University of Toledo, Toledo, OH, United States, [2]Iowa State University, Ames, IA, United States, [3]Iowa State University, Ames, IA, United States, [4]Iowa State University, Ames, IA, United States

According to the U.S. Environmental Protection Agency the most recent (2000) national water quality inventory shows that 45% of assessed lake acres in the U.S. are impaired. In states like Iowa, agriculture is a primary source of nutrients, though urban runoff also contributes. Iowa's impaired waters list reports nutrients and suspended solids as practically the sole source of the impairment (EPA Water Quality Inventory for the State of Iowa, 2003). This focus on physical measures of water quality for the listing of impaired waters raises the question of whether physical water measures collected by ecologists are important determinants of water quality as perceived by recreationists. An important empirical question is if, or to what degree, visitors consider the physical water quality of an aquatic resource when making recreation choices. This paper presents results from a uniquely comprehensive data set to address this question. The data is unique in terms of the large number of observations collected on a very large set of choices by recreationists and the detailed physical water quality data collected (14 water quality measures from each of 129 lakes). A random population survey was sent to 8,000 Iowans to collect information on their recreation behavior to all of the 129 lakes. This paper illustrates that visitor's trip behavior is significantly responsive to physical water quality measures. Benefit estimates are calculated from two different scenarios. The first scenario improves the water quality of nine lakes evenly placed throughout the state to the level of the cleanest lake in the state. The second scenario considers improving the 61 impaired lakes as listed by the EPA to a high enough quality level to remove them from the list. These scenarios show that Iowans highly value their lakes, but would benefit the most from a few more lakes with superior water quality rather than all recreational lakes being brought to an adequate water quality level. Lastly, cost estimates for the water quality improvements are considered, leading to recommendations for which lakes to improve and to what level, based on benefit-cost analysis.

S3-12

Paleolimnological diatom communities and their use in establishing reference conditions for lake assessments

Paul Garrison[1] (presenting). [1]Wisconsin Dept of Natural Resources, Madison, WI, United States

Diatoms, which are algae that have siliceous cell walls, are often fossilized in lake sediments. Diatoms are especially useful as they are ecologically diverse and their ecological optima and tolerances can be quantified. Certain taxa are found under nutrient poor conditions while others are more common under elevated nutrient levels. Diatom communities from over 120 glacial lakes in Wisconsin and Michigan have been used to estimate historical phosphorus and water clarity levels. Lakes were divided into six classes based upon their hydology, maximum depth, and size of their watersheds. Reference conditions for phosphorus in seepage lakes was similar whether they were deep or shallow. The mean reference concentration was 11 µg L-1. For drainage lakes, the size of the watershed was not as important as water depth. The reference phosphorus concentrations for shallow drainage lakes was 16-19 µg L-1 while it was lower at 14 µg L-1 for deep drainage lakes. Most of the lakes that have undergone significant anthropogenic disturbance in their watersheds have more macrophytes now than historically. Exceptions to this are lakes that have experienced large increases in phosphorus.

S3-13

The role of land trusts in lake conservation and protection: The Nature Conservancy in the Upper Midwest

Kristen Blann[1] (presenting), Meredith Cornett[1], Matt Dallman[2], Patrick Doran[3]. [1]The Nature Conservancy, Minnesota, United States, [2]The Nature Conservancy, Wisconsin, United States, [3]The Nature Conservancy, Michigan, United States

The Nature Conservancy has adopted freshwater systems as a major focus of conservation planning towards meeting its 2015 biodiversity goals. In the Upper Midwest, glacial lakes are in great demand for seasonal cabins, year-round residences, water supply, and recreational activities, and face significant development, recreational use, and water quality pressures. In Minnesota, the Conservancy recently completed a statewide, ecologically-based lake classification and portfolio to set priorities for lake conservation in the "Land of 10,000 lakes". Many existing preserves and easements already adjoin or contain significant riparian areas and natural lakes, providing protection for riverine and major source waters. In the Brainerd Lakes Conservation Area (BLCA) of the Upper Mississippi River Basin, the Conservancy recently completed its first conservation action plan in Minnesota developed primarily for aquatic systems targets. Efforts are underway to develop innovative partnerships that move beyond traditional land acquisition and easements, and to develop science-based strategies for prioritizing critical in-lake aquatic habitats. Throughout Northern Wisconsin the Conservancy has protected more than 90,000 acres of land in 3 major watersheds within the Lake Superior Basin and one major watershed of Lake Michigan. The entire shoreline or major stretches of shoreline on more than 50 inland lakes and 70 miles of river were protected with these transactions. In Michigan, the Conservancy has focused primarily on a working forest easement strategy in combination with traditional acquisition and management of key natural areas (e.g. Two-hearted River Watershed). For example, over the past several years, the Northern Great Lakes Forest Project has protected more than 300 natural lakes, more than 500 miles of river and trout streams, more than 50,000 acres of wetlands, and tens of thousands of acres of buffer adjacent to existing national forest, state park, and national lakeshore protected areas.

S3-14

Lake Sensitivity using the MINLEAP Model, Itasca County, Minnesota

Rian Reed[1] (presenting), Noel Griese[1], Paul Radomski[1], William W. Walker[1]. [1]Minnesota Department of Natural Resources, Grand Rapids, MN, United States, [2]Itasca County Soil and Water Conservation District, Grand Rapids, MN, United States, [3]Minnesota Department of Natural Resources, Brainerd, MN, United States

Itasca County and the MNDNR have used the Minnesota Lake Eutrophication Analysis Procedure (MINLEAP, Wilson & Walker, 1989) to predict lake eutrophication potential from shoreline development. MINLEAP uses information that is readily available for most lakes (watershed area, lake area, mean depth, and ecoregion). The original model was calibrated using data from minimally impacted lakes in each of four ecoregions in Minnesota. It provided a simple screening tool for predicting a baseline water quality condition that is consistent with other regional lakes and adjusted for lake-specific features (e.g. watershed size, morphometry). The first phase of the project was to calibrate the MINLEAP model to any new lake water quality data that had been taken since 1989. Walker (2005) calibrated and tested the MINLEAP model equations against data from 163 lakes in the Northern Lakes & Forests ecoregion, most of which were in Itasca County. In addition, algorithms where added for evaluating lake sensitivity to shoreline/riparian development, expressed in terms of predicted change in lake phosphorus levels resulting from full development of shoreline relative to baseline, undeveloped conditions. First tier riparian lot phosphorus loading was estimated based upon existing lot dimensions and loading factors for runoff and septic tank effluents assuming full build out of private upland riparian property. Second tier and remaining watershed areas were given export coefficients consistent with natural forested phosphorus yields. Lakes above the 75th percentile were selected as Phosphorus Sensitive Lakes, as they have the greatest potential for experiencing undesirable shifts in transparency and algal blooms caused by shoreline development. More protective zoning was established for these lakes to maintain water quality conditions.

S3-15

Minnesota's Sensitive Shoreland Designation Project

Paul Radomski[1] (presenting), Donna Perleberg[1], Pam Perry[1], Kristin Thompson[1], Kevin Woizeschke[1]. [1]Minnesota Department of Natural Resources, Brainerd, United States

One of the key tools for regulating human disturbance within shorelands is the implementation of land use zoning districts. In Minnesota, local units of government may implement ordinances to increase the protection of ecologically sensitive shoreland areas; parcels that are identified as sensitive can be put into a more protective zoning category. Lakes that would benefit most from the application of this innovative tool are Minnesota's most valuable lakes—moderate to large-sized lakes, some with significant undeveloped shorelands. The Minnesota DNR and Cass County have initiated a multi-year project to provide greater protection to sensitive shorelands. We established objective, science-based criteria to identify sensitive lakeshores, and assembled the protocol in a manual that describes the criteria and methodology. Cass County identified high priority lakes for assessment. To date, we have completed sensitive lakeshore area assessments on numerous lakes, and Cass County has developed ordinance provisions for sensitive lakeshore areas. This presentation will summarize these efforts to identify sensitive areas and to incorporate identified sensitive areas into local zoning.

S3-16

The Indiana Lake and River Enhancement Program

James Ray[1], Angela Sturdevant[1], Gwen White[1] (presenting). [1]Indiana Dept Natural Resources, Indianapolis, IN, United States

The Indiana Lake and River Enhancement (LARE) Program has been working to improve publicly accessible lakes and rivers throughout the state since 1987 through state funding assessed with annual watercraft registration. The program offers financial and technical assistance to address sediment, nutrients, and water quality impairment. Grants are awarded to lake associations, municipalities, park boards, and other entities for diagnostic studies, engineering feasibility and design, construction of remedial measures, watershed management plans, and innovative projects. LARE partners with county soil and water conservation districts on multi-year "watershed land treatment" directed primarily at agricultural conservation on private lands. About $600,000 is awarded each year as cost-share funds for 25 to 30 active watershed projects around the state. Legislation in 2003 increased the program scope to include sediment removal, control of exotic or invasive plants or animals, and IDNR marine law enforcement in lakes. In 2006, more than $1.25 million was awarded for sediment removal and aquatic plant control projects in 52 lakes across 18 counties. Funding is awarded annually on a competitive basis. The presentation will provide an overview of the program, a summary of recently completed projects, and an update on recent grant awards and innovative projects.

S3-17

Measuring the value of wildlife habitat restoration on northern Wisconsin lakes - the Wisconsin Lakeshore Restoration Project

Michael Meyer[1] (presenting), Dan Haskell[2]. [1]Wisconsin Department of Natural Resources, Rhinelander, WI, United States, [2]Michigan Technical University, Houghton, MI, United States

Recent studies conducted by Wisconsin Department of Natural Resources Science Services and University of Wisconsin Trout Lake Research Station have documented dramatic alteration of riparian habitat (terrestrial and littoral zone) on many lakes in northern Wisconsin. The alteration is primarily due to riparian housing development and has resulted in negative changes in native plant communities, simplification of habitat structure, and changes in fish, amphibian, and bird populations. In this experiment, riparian habitat restoration projects are underway on a sample of lakes in northcentral Wisconsin with the goal of quantifying the ecological benefits of the restoration via biotic surveys. The project focuses restoration efforts on a sample of 6 lakes where habitat impacts are significant and private landowners on a significant portion of the shoreline agree to participate. Incentives are offered to recruit participants. The study also includes a control; shoreline on the same lakes, also with significant habitat alteration, that do not receive restoration efforts. Site-specific restoration plans are developed for 12-15 property owners within the treatment shoreline on each lake. Restoration activities include conservation (no-cut, no disturbance) and restoration of native vegetation (terrestrial buffer zone and near-shore littoral zone), removal of exotic and invasive species, placement of physical structures and coarse woody debris to reduce erosion and run-off, and other proven management techniques designed to enhance wildlife diversity and abundance. Finally, each developed lake is paired with an undeveloped (reference) lake with similar lake and upland characteristics. Pre-restoration (baseline) and post-restoration quadrat and transect measures are made at paired reference (undeveloped), control (developed, no restoration), and impact (developed, with restoration) shorelines using the Before-After-Control-Impact-Paired (BACIP) design. Surveys quantify relative abundance and diversity of native vegetation, herptiles, breeding birds, small mammals, and furbearers, and will recur periodically for a minimum of 10 years. Results are designed to assist development of best management practices for riparian habitat mitigation efforts throughout Wisconsin.

S3-18

Minimizing human development impacts to aquatic habitat: lessons learned in running the Shoreland Habitat Grant Program

John Hiebert[1] (presenting). [1]Minnesota Department of Natural Resources, St Paul MN, United States

Minnesota has experienced a significant rise in lakeshore development. Northern Minnesota alone has experienced a greater than 600% increase in seasonal housing density since 1980. In many cases, this increase has been in larger year-round homes, which have a significantly larger footprint on the land. These highly developed sites also contain significantly less native trees, shrubs and aquatic vegetation than lightly developed and undeveloped sites. Shoreline vegetation is critical to many species of fish and wildlife and to protecting a lake's water quality. The Minnesota Department of Natural Resources, Division of Fisheries and Wildlife, created the Shoreline Habitat Program in 1998, to help address these concerns. The program was created to distribute grants to counties, cities, watershed districts, and other local units of government, conservation groups and lake associations to restore native vegetation along shorelines. This talk will discuss the changes that have occurred in this program, from one that focused on getting the word out about natural shorelines and completed demonstration sites of appropriate shoreline management on highly visible sites, to a more integrated approach in relation to shoreland management. It will discuss the lessons that were learned in creating and managing a program that distributes over $400,000 annually in grants to improve aquatic habitats. It will also review the latest research completed by the program reviewing the success of shoreland and aquatic vegetation restorations. An overview of future research topics will also be highlighted, including projects relating the value of shoreland restorations to fish and wildlife communities and a human dimensions study that will attempt to determine the barriers that prevent shoreline owners from restoring disturbed shorelines and protecting natural ones, and developing and implementing strategies based on these findings to help reverse this trend.

<u>S4. Sensitivity of Fish and Fisheries to Climate Change: Response and Adaptation</u>

S4-2

Potential effects of climate change on stream flows and water levels in Mississippi Valley Watershed

Sobhalatha Kunjikutty[1] (presenting), Paul Lehman[1], Bahram Gharabaghi[2]. [1]Mississippi Valley Conservation Authority, Lanark, Ontario, Canada, [2]University of Guelph, Guelph, Ontraio, Canada

Fish, fisheries, and water resources in the Great Lakes Basin are changing with global climate change. Water and aquatic resources require attention and research as they will experience additional stress with shift in surface water temperature and runoff patterns from historic norms with increased global warming, forcing aquatic ecosystems and resource users to adapt to changing conditions. Stakeholders within Ontario's Mississippi River watershed recently completed a water management plan to balance competing interests for water resources by integrating environmental and socio-economic values in stream flows management along the river system. The water management plan provides a policy basis on which to manage risk and promote adaptation associated with projected changes in watershed hydrology and aquatic ecosystems. With funding support from Natural Resources Canada, Climate Change Impacts and Adaptation Program, a project has been undertaken to quantify the potential effects of climate change on water resources in the watershed and examine the opportunities and capacity of the river system and resource users for adaptation. The project consists of four integrated subprojects including Fish and fisheries: Adapting to a changing climate, Stakeholder outreach and science transfer workshops, Economics and consequences of climate change on fisheries resource use, and Water management response to climate change. The subproject on water management was to evaluate the capacity of the existing management plan and water control infrastructure to address future climate change impacts. Climate change projections for 2010-2099 from Canadian Global Climate Model [CGCM-II] were downscaled to the watershed and CLIMGEN, a weather data generating model used to generate future climate data. Future climate data used to estimate changes in evapo-transpiration, runoff and stream flow conditions in the watershed for 2010-2099 periods. In this Phase-I study, stream flows were subsequently routed through reservoirs to assess the potential impact on existing water management objectives and fish habitat and the opportunities for successful adaptation. The results showed significant increase in winter flows and early occurrence of spring freshet due to warmer temperature; however summer flows doesn't changed much, though the frequency of peak flows observed to be higher than normal.

S4-3

Intra-specific differences in preferred temperatures shape regional differences in sensitivity of lake trout to climate change

Brian Shuter[1] (presenting), Ken Minns[2]. [1]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada, [2]University of Toronto, Toronto, Ontario, Canada

Common garden experiments on young-of-year lake trout suggest that population-specific thermal preference values can vary by as much as 3C. Intra-specific diversity in thermal preference parameters can complicate species-specific assessment of climate change impacts. These complications are illustrated using a newly-developed national lakes impact assessment model for Canada. The national lakes assessment model uses spatially explicit data on the distribution of lakes of different size and shape to evaluate how the thermal habitat for a particular species will change on a regional basis, given the thermal preferences for the species and a specific climate change scenario. This model is used to evaluate the potential impact of climate change on lake trout for different regions of Ontario. Separate assessments are carried out and compared assuming: (i) all lake trout have a common set of thermal performance parameters; (ii) thermal performance parameters can vary among populations by as much as 3C.

S4-5

The response of shallow lake fish to climate change: the case of the three-spined stickleback

Rebecca Moran[1] (presenting), Ian Harvey[1], Heidrun Feuchtmayr[1], Brian Moss[1], Keith Hatton[1], Tom Heyes[1], David Atkinson[1]. [1]University of Liverpool, Liverpool, United Kingdom

Climate change will be extremely important in freshwater ecosystems due to the temperature sensitive nature of its ectothermic inhabitants. Presented here are the results from part of a large European shallow lakes climate change experiment. The response of three-spined stickleback populations in 24 experimental outdoor shallow freshwater ecosystems to combinations of temperature (ambient and ambient + 4°C) and three nutrient treatments were monitored over a 16 month period. The final harvest of fish populations showed that heating significantly reduced the stickleback populations as did nutrient addition. A combination of nutrients and heating resulted in the total loss of the stickleback populations. These results were mainly attributed to the increased likelihood of hypoxia in heated and nutrient addition tanks preventing the fish from breeding, killing their food source and ultimately killing the fish. The discussion will centre on the implications for temperate fish species under current climate change predictions.

S4-6

Sensitivity of fish and fisheries to a changing climate: response and adaptation

John Casselman[1] (presenting). [1] Queen's University, Kingston, ON, Canada

Changing climate is affecting aquatic environments, fish, and fisheries in the Great Lakes Basin. Long-term data from Lake Ontario and Ontario's Mississippi River watershed document changing conditions and fish responses. Over the past 7 decades, Lake Ontario inshore waters have warmed and ice cover decreased, most significantly since the thermal regime shift of the late 1970s. Long-term sampling in Lake Ontario provided predictive relations and documented that, with increasing midsummer temperatures, recruitment has increased in warm-water fish (e.g. centrarchids, +1oC=+2.2x to +3oC=+10.6x) and decreased in cool-water fish. Recruitment of fall-spawning cold-water fish was negatively affected by temperature at spawning (e.g. lake trout, +1oC=-1.5x to +3oC=-20.1x) and throughout fall and winter, confirmed by increasing December temperatures. Recruitment of lake trout in a set of Ontario and Quebec lakes documents declines, negatively correlated with midsummer temperature. Over the past 3 decades in the Mississippi watershed, recruitment of warm-water species has increased (+59%) and cold-water species decreased (-58%). Expansion and invasion of warm-water centrarchids in Ontario has accelerated. With increasing temperature, linear body growth, determined from calcified structure analysis, has increased in warm- and cool-water species and decreased in cold-water species (+1oC=±9% to +3oC=±28%). Esocid spawning behaviour is affected by decreasing spring water levels, resulting in some adaptation and hybridization. The challenge of managing fish resources and fisheries in a changing climate necessitates monitoring more intensively and adapting management to more liberally use increasingly abundant warm-water fish while protecting decreasing native cold-water species. We should respond and adapt by making local fish and fisheries an increasingly important part of the 100-mile diet.

S4-7

The effects of climate change and invasion of centrarchids on northern fish communities

Sapna Sharma[1] (presenting), Donald Jackson[1]. [1]University of Toronto, Toronto, Ontario, Canada

Increases in temperature due to climate change will have large implications for aquatic ecosystems. Warmwater fish species, such as smallmouth bass, *Micropterus dolomieu*, may have access to additional favourable thermal habitat under increased surface-water temperatures, thereby shifting the northern limit of the distribution of the species further north in Canada and potentially negatively impacting native fish communities, particularly lake trout. A database comprised of over 50,000 lakes was assembled consisting of data on geography, lake morphology, water chemistry, climate, and fish community composition. Water temperatures were predicted to increase by as much as 18°C by 2100, with the greatest increase in water temperature in northern Canada. By 2100, smallmouth bass thermal habitat is predicted to shift to the north with the majority of Canadian lakes expected to contain suitable thermal habitat. Examination of the pelagic and littoral forage fish communities identified nearly 9,700 lake trout populations threatened by 2100AD under climate-change scenarios, due to the potential invasion of smallmouth bass. The current range expansion of smallmouth bass has been facilitated by natural and human-mediated dispersal, stressing the importance of intensifying public education and regulation to limit the potential dispersal of invasive species.

S4-8

Partitioning the influence of climate variation from the effects of other concurrent stressors on the habitat and recruitment success of lake trout in Lake Simcoe

David Evans[1] (presenting), Audie Skinner[1], Jennifer Winter[2], Jake La Rose[3]. [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada, [2]Ontario Ministry of Environment, Toronto, ON, Canada, [3]Ontario Ministry of Natural Resources, Sutton West, ON, Canada

Lake trout distribution and habitat are defined by the species cold stenothermal requirements. Consequently, climate change has major implications for the ecology of this species. In Lake Simcoe, lake trout are subject to multiple stressors including eutrophication, invading zebra mussels and altered food web interactions each of which can influence water clarity, depth of light penetration, heating and mixing of the water column, and dissolved oxygen (DO) conditions, thereby potentially confounding the effects of climate change. Our objective was to separate the influence of these concurrent stressors before and after invasion of zebra mussels. We used a 30-yr record of monthly temperature profiles to characterize seasonal and annual variation in thermal structure and have evaluated trends in air temperature, phosphorus loading, algal density, water clarity, and hypolimnetic DO. Changes in thermal structure and heat content revealed a strong climate signal. As expected water clarity increased after the arrival of zebra mussels, but mixing depth did not change. The duration of the ice-free season has increased, thermal stratification has been extended by 3-4 weeks, hypolimnetic DO has improved significantly and lake trout recruitment has been observed after an absence of two decades. Our observations suggest a significant climate effect on habitat and the probable concurrent influences of phosphorus mitigation on phytoplankton production and decomposition, and clearance of the water column by zebra mussels driving a near-shore phosphorus shunt.

S4-9

North Atlantic Oscillation variability influences latitudinal trends in marine fish species richness

Jonathan Fisher[1] (presenting), Kenneth Frank[2], William Leggett[1], Nancy Shackell[2], Brian Petrie[2]. [1]Queen's University, Kingston, ON, Canada, [2]Bedford Institute of Oceanography, Dartmouth, NS, Canada

Poleward declines in species richness (latitudinal diversity gradients (LDGs)) remain among the oldest and most widespread of biogeographic patterns. However, their temporal dynamics remain largely unexplored, though climate change may modify LDGs if species richness varies in response to local climate conditions. Here we examine the causes and consequences of recent temporal variation within a marine fish LDG using 31 years of annual fisheries-independent trawl survey data from the northwest Atlantic continental shelf. The 27224 samples spanned 35N to 55N and the slopes of all 31 significant annual LDGs were examined in the context of the wintertime North Atlantic Oscillation (NAO), a dominant climate signal that varies inter-annually and alters the latitudinal gradient of northwest Atlantic continental shelf bottom water temperatures. Positive (negative) NAO anomalies across the surveyed latitudes are associated with cooler (warmer) than normal temperatures in the north and warmer (cooler) than normal temperatures in the south. The slopes of the annual LDGs were negatively related to both the sign and strength of the NAO. Steep latitudinal gradients in species richness during positive NAO anomalies were consistent with maximal dissimilarities between northern and southern bottom water temperatures and were influenced by changes in species richness at both low and high latitudes. These results demonstrate that this gradient in species richness is temporally dynamic and responds rapidly and reversibly to changing climate. Both species richness and temperature are positively correlated with the resilience of temperate marine fish assemblages to fishing pressure. Therefore, given that models predict that the NAO will trend positive and strengthen with increasing atmospheric carbon dioxide, this marine fish LDG could steepen in the future, with potential implications for the resilience of fished assemblages in the northwest Atlantic.

S4-10

Atlantic salmon at the southern limit of their range are faced with high temperatures during spawning: can they adapt?

Edward Beall[1] (presenting), David Grimardias[1], Michel Parade[1]. [1]INRA, St-Pée sur Nivelle, France

The impact of climate change should be more strongly felt at the southern limit of a species distribution, in particular during the critical period of reproduction for cold water fish such as salmon. Preliminary observations made on the Nivelle River, a coastal stream emptying in the Bay of Biscay (43°N, SW France), had suggested that spawning activity was inhibited above 12°C. We tested, on a large data set of spawning acts, observed in an artificial channel, paired with the temperatures at which they occurred, distributed in three categories (low, median and high temperatures), the hypothesis that females preferred cooler temperatures in each category. We found that they avoided the lower part of the range in the low temperature category (6-9.6°C), whereas spawning acts were evenly distributed in the high category (11-13°C). Further, we conducted experiments in a flume where we could control temperature variations, to determine exactly when spawning activity would be inhibited. Reproduction occurred at temperatures as high as 14.7°C. However, video recordings showed that the frequencies and intensity of typical spawning behaviors (digging, probing, leaving the nest, male courting) were altered at those high values, when compared to behavioural sequences at normal, constant temperatures (9°C). Time between spawning acts increased strongly, but there was no incidence on egg retention. We conclude that salmon from this southern population may be already adapted to reproduce in relatively extreme temperature conditions, and may be able to bear moderate climate change. However, altered behaviors due to high temperatures may have some other unforeseen consequences, for instance on sexual selection and mate choice, resulting in changes in the structure of populations.

S4-11

From local to global climate change effects on southern European Alantic salmon

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Although large-scale climate indices generally predict ecological processes better than local weather, both local and global changes can have strong effects on populations at the edge of the species distribution because of their increased sensitivity to climatic effects compared to those inhabiting the central portion of the species distribution. Southern European Atlantic salmon, which feed in West Greenland, are expected to be particularly affected by global warming. In northern Spanish rivers, the first salmon caught each year is called “campanu” and is highly prized in a public auction. Here we demonstrate that salmon run timing has changed over the last 50 years, as inferred from delays in the date of capture of the campanu, correlated with both local and global temperature indices. We also demonstrate that weight decreases are associated with an increase in global temperatures, and with changes in abundance of squid, an important marine prey. Decreased energetic reserves, as a consequence of reduced prey abundance and increasing temperatures, may lead to observed delays in return timing. Rapid changes in migration times for salmon in only four decades are likely a reflection of whole ecosystem-level effects, and will have important consequences for the species that interact with Atlantic salmon.

S4-12

Unconfounding the effects of climate and density dependence on spiny dogfish using 60 years of demographic data

Ian Taylor[1] (presenting), Vincent Gallucci[1]. [1]University of Washington, Seattle, WA, United States

The confounded effects of climate and changes in abundance on demography are particularly hard to separate for long-lived species because their demographic traits are the aggregated result of conditions faced over decades. Demographic parameters were compared for spiny dogfish (*Squalus acanthias*), the longest lived and latest maturing of all sharks, using samples from the 1940s and 2000s. During this 60 year period ocean temperatures have warmed significantly and landings of dogfish have fluctuated considerably. The age at 50% maturity for dogfish in the inside waters of Puget Sound was found to have declined between sampling periods from 45 years to 34 years, while the estimated average number of embryos per litter for a 100 cm dogfish was estimated to have increased from 5.9 to 6.7 over the same period. Growth parameters were also found to have changed significantly, with faster growth observed for the 2000s samples. Comparison with published demographic parameters from the 1970s and 1980s were made in an effort to estimate the timing of the changes and thus unconfound the potential causes. Implications for future management of spiny dogfish in the presence of global climate change are discussed.

S4-13

Climate warming implications for fisheries and fish communities of the African Great Lakes

Robert Hecky[1] (presenting), Piet Verburg[2]. [1]University of Minnesota-Duluth, Duluth, MN, United States, [2]University of Georgia, Athens, GA, United States

The African Great Lakes have the two most productive lake fisheries in the world and a disproportionate amount of global freshwater ichthyodiversity. They have also warmed over the last century, and at an increasing rate over the last several decades. The consequences of this warming to the fisheries and fauna are uncertain but critical to the riparian people. In deep meromictic, Lake Tanganyika, warming has increased water column stability and decreased vertical mixing thereby reducing nutrient loading to the upper mixed layer. Observations since 1974 and even earlier document decreases in phytoplankton abundance and increase in dissolved Si, both indicative of declining primary productivity with negative implications for the pelagic fishery which accounts for >90% of all landings. However, fishing effort continues to rise and technologies have improved so that landings have increased during the warming period making it difficult to decipher any impact on fish productivity in response to warming. On shallow Lake Victoria, climate warming has been implicated in the eutrophication of the world's largest lake fishery, but increased phosphorus external loading is the direct cause with climate playing a minor role by increasing stability of seasonal stratification and accelerating onset of hypolimnetic deoxygenation.

S4-14

Long-term climatic forcing of North Pacific salmon populations: Understanding future fisheries production in context of natural variability

Daniel Selbie[1] (presenting), Bruce Finney[2], Peter Leavitt[3], Daniel Schindler[4], John Smol[5], Irene Gregory-Eaves[1].
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Climate change is predicted to have marked impacts on the productivity and geographical distribution of salmon (*Oncorhynchus* spp.) in the North Pacific, with implications for socioeconomic and ecological systems. Accurate characterization of future trends and the ability to manage for them, however, are inherently dependent upon understanding the range of natural production variability as well as responsible forcing mechanisms. Salmon production has been correlated with high-frequency (annual to inter-decadal) modes of atmospheric and oceanographic variability in the North Pacific over the monitoring record, suggesting a potential underlying climatic driver. Paleoenvironmental evidence from Alaska spanning the past ~2,200 yr has revealed previously-undetected modes of variability in inferred sockeye salmon (*O. nerka*) population dynamics. Variation in these records, in relation to those of other fish species (e.g. sardines, anchovies), suggest that climatically-forced oceanographic change have influenced salmon over much longer time scales than that recorded over even the longest fisheries records (since the late- 1800s). We present multiple time series of inferred salmon production from nursery lakes around the northeast Pacific over the past six millennia. Inter-regional stock production exhibits distinct commonality and cyclicity, however, finer-scale variation is evident, revealing spatially-transgressive stock responses to coupled ocean-atmospheric forcing. In some systems abrupt (e.g. decadal time scales), non-linear state shifts in inferred salmon production have occurred. Novel links to Pacific basin-wide climatic phenomena and celestial forcing not evident in the monitoring record are discussed. The most substantial negative departures in production of northern stocks were observed across all systems during a period of past warmth analogous to conditions predicted over the next century. The long-term perspective afforded by these paleoenvironmental records suggests that adaptation to future warming-influenced Pacific salmon production variation will most likely necessitate substantial social, economic and ecological change in the North Pacific.

S4-15

Are recent historic high catches of pink and chum salmon an indication of a climate related change in the capacity of the subarctic Pacific to produce Pacific salmon?

Dick Beamish[1] (presenting). [1]Fisheries and Oceans Canada, Nanaimo, BC, Canada

The catches of pink and chum salmon by all countries around the rim of the North Pacific Ocean are at historic high levels. In 2007, for example, Russia had the highest catch of pink salmon in recorded history. Surveys have recently shown that substantial abundances of juvenile pink and chum salmon occur north of the Arctic Circle. Pink and chum salmon production in British

Columbia is also at high levels. The recent increasing trends may be related to earlier plankton production that matches more closely the timing of ocean entry by fry. However, the production of fry from hatcheries is over 6 billion and increasing. Thus it may be artificial enhancement that is the new match / mismatch mechanism linking a warming climate to Pacific salmon production.

S4-16

Management implications of climate change impacts on life history events of salmonids in British Columbia's southern interior

Kim Hyatt[1] (presenting), Margot Stockwell[1], Clint Alexander[2]. [2]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, B. C. Canada[1],ESSA Technologies Ltd. Vancouver, B. C. Canada

The Intergovernmental Panel on Climate Change (IPCC) has made a compelling case that atmospheric warming is well underway and virtually certain to affect all regions of the globe within less than a single human generation. Warming is expected to be especially pronounced in the north-temperate zone in which the Okanagan basin is situated. Global Climate Models (GCM's) are commonly used in association with regional data sets to provide plausible projections of future conditions with respect to annual or seasonal temperature and precipitation in a given location. GCM projections of future conditions have been used in recent studies to explore the impacts of climate change on agricultural production and water consumption in the Okanagan. We are currently using projections from the same suite of GCM's (HadCM3-A22, CGCM2-A21 and CSIRO MK2 A21) centred on the year 2050 to assess potential, climate change impacts on key life history stages of important coldwater fishes (sockeye and kokanee salmon) resident in river and lake habitats of the Okanagan valley. Climate change impacts have been assessed by comparing observations of the frequency of occurrence, timing or magnitude of a given life history event during a base period (1961-1990) versus projected outcomes for the same events during the future 2050's period (i.e. 2035-2065). Results from our analysis are highly consistent across all GCM projections and suggest: (a) adult migration delays for Okanagan sockeye salmon will increase from an average of 40 days (base-case) to an average of between 71-81 days (2050 case). (b) 2050 spawn timing will occur 2-3 weeks later relative to current timing. (c) 2050 egg hatch will occur 1-2 weeks later. (d) 2050 fry emergence will occur 1-2 weeks earlier. (e) The frequency and severity of climate induced losses of seasonal rearing habitat for juvenile sockeye in Osoyoos L. will increase greatly. We conclude that interactions among climate change and life history events identified here will exert a profound influence on future production trends, manageability and the probability of long-term persistence of sockeye salmon and perhaps the entire complex of coldwater fishes in British Columbia's southern interior.

S4-17

Impacts, adaptive capacity, and socioeconomic consequences of climate change on fish resource use and management in Ontario--a survey of resource users, businesses, and professionals

Lucian A. Marcogliese[1] (presenting), John M. Casselman[2]. [1]Research Biologist, Ameliasburgh, Ontario, Canada, [2]Queen's University, Kingston, Ontario, Canada

The survey dealt with fish resource issues in the context of climate change, observed changes in the environment and fish community, and impacts, adaptations, and economic consequences. In January 2008, approximately 800 surveys were distributed targeting anglers, fish resource businesses, and professionals in Ontario, of which 210 were returned. Analysis indicated that >70% of respondents have observed environmental changes they attribute to climate change, but most changes are not perceived as significantly affecting fish resource use except for unsafe winter ice conditions. Conversely, >65% have observed fish community changes that include invasive species, and changes in fish abundance and size, but < 50% attributed any of these changes to climate, nor do they know of the affects climate can have on fish resources. Fish community changes are perceived to be caused by over-fishing, enforcement issues, and shoreline development (loss of habitat). Angling has become a very social and recreational activity as only 52% indicated they fished for food, and it was not considered a high priority as to why they fished. Some warm-water fish are obviously responding to increasing climate conditions; fishers seem more reluctant to change and adapt. There may be a slight redistribution of use and fishing related revenues from fishers who would relocate to continue fishing preferred species, but respondents indicated a general tendency not to change; 95% of fishers would not change locations or were only willing to travel locally (1 hr, 100 km) to fish their preferred species. Respondents from all groups supported management actions (78%) and the development of science-based fish policies that incorporate climate change (85%), which should include participation from all levels of government, science, academia, non-government organizations, and knowledgeable local stakeholders.

S4-18

What has the IPCC said about fish and fisheries?

John J. Magnuson[1] (presenting). [1]Center for Limnology, University of Wisconsin-Madison, Madison, Wisconsin, United States

The Intergovernmental Panel on Climate Change (IPCC) was set up by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. The IPCC has prepared four assessments at approximately 5-year intervals (1990, 1995, 2001, and 2007). Working Group II reports considered impacts of and adaptations to a changing climate. The IPCC was recognized with a Noble Peace Prize following the 2007 assessment that was shared with former U.S. Vice President Al Gore who popularized the climate change issue. Fish and fisheries were considered in some depth in the 1995 Assessment (Working Group II) in Chapters 10 (Hydrology and Freshwater Ecology) and 16 (Fisheries). Fish and fisheries received less attention in 2001 Assessment (Working Group II) in Chapter 5 (Ecosystems and their Goods and Services) and in regional chapters such as Chapters 10 (Africa) and 13 (Europe). Fish and fisheries received even less attention in the 2007 Assessment (Working Group II) and are largely contained in the regional chapters. Useful information for freshwater fish and fisheries also are to be found in chapters relating to hydrology and water resources and marine fisheries in chapters on the coastal zone in all assessments. I review the main impacts identified in the four assessments on fish and fisheries and the possible adaptations mentioned. I consider challenges for the future IPCC assessments in respect to fish and fisheries.

S4-P-1

Air temperature, groundwater discharge and climate change influences on the thermal diversity of stream fishes in southern Ontario

Cindy Chu[1] (presenting), Nicholas Jones[2], Nicholas Mandrak[3], Andrew Piggott[4], Ken Minns[3]. [1]Trent University, Peterborough, ON, Canada, [2]Ministry of Natural Resources, Peterborough, ON, Canada, [3]Fisheries and Oceans, Burlington, ON, Canada, [4]Environment Canada, Burlington, ON, Canada

The availability of suitable thermal habitat for fishes in streams is influenced by several factors including flow, channel morphology, riparian vegetation and land use. This study examined the influence of air temperature and groundwater discharge, predictors of stream temperature, on the thermal diversity (coldwater, coolwater and warmwater preferences) of stream fish communities in southern Ontario watersheds. Site-level fish sampling data were used to assess the thermal diversity of 43 quaternary watersheds using three metrics, the proportion of sites within a watershed having 1) coldwater, 2) coolwater and 3) warmwater fishes. Our results indicated that 54% of the variances in coldwater and 54% of the variances in warmwater fish distributions within the watersheds can be attributed to groundwater discharge and air temperature variables. Climate change scenarios suggested that watersheds with high groundwater discharge and the associated thermal diversity of fishes within those watersheds are less sensitive to climate change than watersheds with low groundwater discharge. Conservation of groundwater resources will be required to lessen climate change impacts on the thermal habitat and thermal diversity of stream fishes in southern Ontario watersheds.

<u>S5. Effects of Climate-Related Drying and Surface Water Loss on Aquatic Ecosystems in Extreme Environments</u>

S5-1

Heterogeneity in climate warming effects on aquatic habitats

Jennifer Roach[1] (presenting), Brad Griffith[1]. [1]USGS, Alaska Cooperative Fish & Wildlife Research Unit, Fairbanks, Alaska, United States

Globally, the climate has warmed approximately 0.4oC since the late 19th century and the rate of temperature increase in the most recent 50 years has been dramatic. However, there has been, and continues to be, substantial temporal and spatial heterogeneity in warming both within and among continents. In addition, the annual variation about long term warming trends is substantial, especially in the Arctic where average warming is pronounced. As a result, it is ill-advised to assume uniform effects of warming on aquatic systems. In this presentation we summarize studies of the effects of warming on aquatic systems, emphasizing the Arctic and sub-Arctic, then conclude with preliminary results of our analyses of the differential characteristics of drying and non-drying closed-basin lakes in interior Alaska. There have been increases in water deficit (precipitation minus potential evapotranspiration) concurrent with warming during the past 50 years. As the Arctic has warmed, some lakes have thawed earlier which has increased the length of the ice free season, increased summer water temperatures and increased zooplankton densities. The nature of ice out on some rivers has changed from dynamic breakup and flooding that typically resulted in recharge of perched lakes adjacent to rivers to slower melting that does not provide dramatic flooding and recharge . Productivity of non-recharged lakes has declined. Drying of closed basin lakes in the discontinuous permafrost regions of Alaska and Russia has resulted in reductions in lake area of 4-35%, but similar drying has not been evident in areas of continuous permafrost. Even within areas of most dramatic lake drying, a substantial portion of lakes have remained stable or increased in area. We compared the physical characteristics of 24 pairs of drying and non-drying lakes in the discontinuous permafrost region of Alaska and found that drying lakes had a higher surface to volume ratio and a more extensive floating vegetation mat than non-drying lakes. These observations suggest that both vegetation encroachment form shorelines and water deficit may have contributed to the net reduction in water area of these closed-basin lakes during the past 50 years.

S5-2

Effects of water loss on fish communities in the Arctic – landscape perspectives and future research directions

Amanda Rosenberger[1] (presenting), Stan Triebenbach[1], Anupma Prakash[1], Terry Chapin[1], Joseph Margraf[2].

[1]University of Alaska Fairbanks, Fairbanks, Alaska, United States, [2]USGS Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, Alaska, United States

Evidence of rapid global climate change in arctic and subarctic ecosystems continues to accumulate, and conservation efforts and environmental planning for aquatic environments in Alaska that assume a static environment are unlikely to succeed. To strategically and proactively manage fishery resources, an understanding of ecological processes that are important for fish population persistence in a changing physical environment is required. Arctic and subarctic environments in Alaska have potential to experience some of the strongest effects of climate change. These environments offer an opportunity to understand mechanisms for fish resilience in systems that do not suffer from other major anthropogenic influences or a complement of invasive fish species. Further, close connections exist between the indigenous human cultures and the ecology of Alaska systems. These connections offer an opportunity to explore how changes in ecosystem services can be managed to enhance both the adaptive capacity and resilience of socio-economic institutions while maintaining the resilience of those resources on which they depend. The Yukon Flats region, which has over 40,000 lakes in the National Wildlife Refuge alone, is experiencing landscape-level changes in surface waters, particularly peripheral lakes, due to altered river flow regimes and extensive melting and loss of permafrost. Widespread changes may be leading to fragmentation of aquatic habitats, changes in water chemistry and nutrient fluxes, and alteration of ice-cover patterns. In addition, increased frequency and intensity of wildfire has potential to exacerbate or accelerate physical changes to aquatic environments. This work presents the risks to fishery resources in the basin under climate change scenarios by investigating ecological, life-life history, and physical mechanisms that contribute to fish population resilience and persistence. It also identifies the role of remote sensing and Geographic Information Systems (GIS) technologies to map past and current state of ecosystem, and predict changes in ecosystem services that could affect human access to subsistence resources in the basin.

S5-3

The role of seasonal drying in structuring Australian floodplain fish assemblages

Dale McNeil[1] (presenting). [1]South Australian Research and Development Institute, South Australia, Australia

Little is understood about how climatic variables impact the fish community of Australia's inland waterways. This is a particular concern given the recent predictions of hotter and dryer climate for the area into the future. This paper outlines a research project conducted on the Ovens river floodplain in South Eastern Australia that investigated the role of seasonal drought in structuring floodplain fish communities. A set of 50 individual billabongs (floodplain waterholes) was surveyed before and after summer drying to quantify the physical and chemical changes associated with seasonal habitat desiccation between periods of inundation. Whilst most fish species were generally distributed across most floodplain habitats following the cessation of floodwaters, distinct fish assemblages developed by the end of the dry season. These assemblages were associated with a range of physicochemical variables related to harsh climatic impacts including pool size, minimum oxygen levels, pool morphology and permanence, as was species diversity and patterns of species abundance. The study provided insight into the role that harsh summer conditions play in structuring billabong fish communities and highlights some of possible impacts and changes that might occur under a regime of increasingly harsh periods of seasonal drying.

S5-4

Are fish assemblages ultimately maintained by booms or busts in an Australian arid-zone river?

Stephen Balcombe[1] (presenting), Angela Arthington[1], Stuart Bunn[1]. [1]Australian Rivers Institute, Griffith University, Queensland, Australia

Fish in dryland rivers must cope with the vagaries of living in an unpredictable environment. The hydrological conditions vary between extreme dry (bust) and large floods that inundate floodplains (boom). Floodplain booms lead to massive increases in fish abundance and species richness. These numbers, however, quickly diminish through competitive interactions and resource depletions. These rapid changes in fish distributions and abundances open up the possibility, that the ability for dryland fish to persist through dry periods plays a much greater role in their long-term persistence than the short-term benefits gained from irregular flooding. This presentation will discuss how the fish assemblages in dryland river waterholes are sustained across a range of hydrological conditions from boom to bust.

S5-5

Climate change implications for drought, refugia, and population and community persistence in streams

Nick Bond[1] (presenting), Paul Reich[1], Sam Lake[1]. [1]Monash University, Melbourne, Australia

There is now general acceptance of climate change and its potential to impact on both terrestrial and aquatic ecosystems. In southern Australia, as in many other parts of the world, climate change is forecast to cause an overall decrease in rainfall, shift rainfall timing and increase the frequency and severity of drought. As evidenced by the impacts of the current and prolonged drought affecting southern Australia, this will impact greatly on aquatic ecosystems, depleting natural refugia and causing local extinctions of biota. Here we combine forecasts of hydrologic change and existing stream-flow models for northern Victoria in southeastern Australia with empirical data on the local dynamics of refuge habitats to predict long-term changes in fish populations. Despite considerable uncertainty in climate change forecasts, these results forecast the loss of populations at the landscape, if not regional scales. While the realisation of climate change may be some time away, attempts to restore aquatic ecosystems - involving long time frames - should begin now to consider climate change when setting restoration goals and targets.

S5-6

Effects of stream drying on fish refuge use and species persistence: forecasting effects of global climate change

Dan Magoulick[2] (presenting), Gary Huxel[1], Matt Dekar[1], Shawn Hodges[1], Chris Bare[1]. [1]University of Arkansas, Fayetteville, Arkansas, United States, [2]USGS, Arkansas, Coop Fish and Wildlife Research Unit, Fayetteville, Arkansas, United States

Drought and summer drying can be important disturbance events in many small streams and these disturbances are expected to increase in intensity and frequency in some regions given global climate change scenarios. We used empirical studies to examine the influence of stream drying on fish refuge use and species persistence at multiple spatial and temporal scales. This information was then used to parameterize models predicting effects of potential climate change scenarios on fish refuge use and species persistence. Empirical studies showed fish moved at large spatial and temporal scales to use intermittent streams, especially for spawning and rearing, and fish densities were high in intermittent streams, especially for small species-size classes. Fish moved at smaller spatial and temporal scales to avoid drying habitats. Riffles were more likely than pools to dewater during drying events and refugia were species- and size-class dependent. There appears to be a trade-off between selecting more permanent pool habitats with increased biotic interactions versus less permanent riffle habitats with increased risk of isolation and complete drying. Model results showed extinction probability was positively correlated to drought frequency and intensity, and species persistence was related to life history type.

S5-7

Forecasting the combined effects of urbanization and climate change on stream ecosystems: from impacts to management options

K C Nelson[1], M A Palmer[1], J E Pizzuto[2], G E Moglen[1], P L Angermeier[3] (presenting), R H Hilderbrand[4], M Dettinger[5], K Hayhoe[6]. [1]University of Maryland, College Park, MD, United States, [2]University of Delaware, Newark, DE, United States, [3]U.S. Geological Survey, Blacksburg, VA, United States, [4]University of Maryland, Frostburg, MD, United States,[5] U.S. Geological Survey, La Jolla, CA, United States, [6]Texas Tech University, Lubbock, TX, United States

Streams collect runoff, heat, and sediment from their watersheds, making them vulnerable to urbanization and climate change. Process-based models of these disturbances can help managers understand the likely impacts. We integrated a biotic model with four physical models (climate projection, stream hydrology, geomorphology, and water temperature) to predict responses of stream fish growth and reproduction to climatic and urban stressors. The biotic sub-model links information on habitat and temperature preferences and feeding and spawning habits of a fish assemblage with daily variation in stream conditions. We applied the model to headwater streams in Maryland by postulating nine scenarios: Baseline (low urbanization, no construction, present-day climate); four Climate Change scenarios (Hadley and PCM models under medium-high and medium-low emissions); and the same four Climate Change scenarios plus Urbanization (more impervious surface, less forest, significant construction). Urbanization alone stressed 8 of 39 fish species, while climate change alone stressed 22-29 species. Most recreationally important species and six of the ten most common species were predicted to be significantly stressed by one or both stressors. Thus, the model predicts considerable change in fish assemblage composition. Urbanization adds to the loss of ecosystem structure and services attributable to climate change alone. Local stakeholders cannot control global climate but they can mitigate land use impacts. Therefore, we recommend proactive measures to minimize impacts on fish assemblages, including restoring riparian vegetation, improving storm-water management, controlling erosion, and preserving land. Delaying these measures will exacerbate the impacts of climate change and urbanization on headwater ecosystems.

S5-P-1

Dynamics of peripheral aquatic habitats in the Yukon River Drainage.

Stan Triebenbach[1] (presenting), Amanda Rosenberger[1]. [1]University of Alaska Fairbanks, Fairbanks, AK, United States

Freshwater ecosystems in the arctic, particularly lake and slough habitats peripheral to large rivers, have shown evidence of widespread drying and loss of connectivity in the past 50 years, which may pose a serious challenge to the ability of fish to inhabit these areas. This study used remote sensing imagery to identify features that may be associated with potential fish habitat and monitor how those features change seasonally and annually. Aerial photographs from the 1950's and 1970's, contemporary Landsat and synthetic aperture radar (SAR) images, and aerial thermal imagery were used to extract habitat variables important for fish, such as water surface area, partial or total winter freezing, the presence of springs, and variability in surface water temperature. Preliminary analyses of aerial imagery from 1978 and Landsat 7 images from 2001 indicate that the Yukon River Basin is a highly

dynamic area, with intra- and inter-annual variability in water levels and connectivity between aquatic habitats, which may have strong fisheries implications. Further analyses will incorporate current fish habitat usage in geographic information systems to predict how changes in climate will affect these habitats and the fish therein.

S6. Atlantic Salmon Restoration in Changing Environments

S6-2

Atlantic salmon restoration solutions in Nova Scotia

Bob Rutherford[1] (presenting). [1]Nova Scotia Adopt-a-Stream Program, Barss Corner, NS, Canada

Atlantic Salmon habitat in Nova Scotia faces many challenges. Acid rain has lowered the pH and increased metal levels in most of the rivers. Changing rainfall patterns have resulted in the 1:5 year, and in some areas the 1:10 year, storms of twenty years ago becoming the 1:2 year storm today with resultant impacts on river widths, and pool riffle formation. Summer droughts, the worst on record in eight of the past twelve years, have taken their toll. These broad impacts combined with poor land use and river use practices from past and current activities in and around a wide range of habitat types present restoration challenges. This means that restoration efforts need new comprehensive approaches and careful planning to be successful. Restoration projects need the adjacent landowners to invest in proper and innovative protection practices, and the regulatory agencies co-operation to allow approaches to watershed development and habitat restoration that address the health and needs of the aquatic habitat. Our planning approach is based on thinking like a fish. What habitats do they need for migration, spawning, juvenile rearing, pre smolt and smolt run? A limiting factor in any of these habitats can prevent the success of restoration. This presentation outlines the planning process and some of the successes we have had in watersheds with all major land use patterns.

S6-3

Eleven years of salmonid habitat restoration and monitoring in Brierly Brook, Nova Scotia. A success story

Charles MacInnis[1] (presenting). [1]Fisheries and Oceans Canada, Antigonish, NS, Canada

In 1992, a sub-watershed restoration project was initiated in Brierly Brook, a tributary to the West River at the town of Antigonish, Nova Scotia.. The brook once had a good population of Atlantic salmon and sea run Brook trout.Declines, in living memory, appeared to be coincident with a series of instream modifications (e.g. channelization, diversions), increasing ice jamming and flooding problems, urban development (e.g. subdivisions with little silt control, storm sewers, water pipelines, road crossings, drains, and a flood control dam) and livestock farming, most of the direct impacts took place during the 1960s and 1970s, but there is continuing pressures on the habitat. Despite better protection of the habitat the fish populations continued to decline.The watershed area is 33.2 sq. km and the brook flows from the forested hills west of the town, through an area of mixed farming, then through growing subdivisions and finally through the center of town. This gave us a mix of all common land uses in the Maritimes in one small area. Rainfall patterns have shown a tendency toward longer dry periods in the summer and short higher intensity rainfall in storms. The study period has been characterized by extremes in weather ranging from the longest cold spell recorded in the winter of 1992/93 to the lowest rainfall on record over the summer in a series of record breaking droughts in eight of the past 10 years. The objective was to improve the productive capacity of the fish habitat for Atlantic salmon and Brook trout. The focus was on increasing juvenile habitat by providing low water refuges, and lower silt loads. In achieving this we found that many other problems such as ice jamming, ice scour of banks, poor over-winter survival of parr, poor escapement into the upper reaches and low wildlife populations were also mitigated. There were many lessons learned from eleven years of restoration work and fish population monitoring.

S6-4

Large woody debris structures and their influence on Atlantic salmon spawning in a stream in Nova Scotia, Canada

Trevor Floyd[1] (presenting). [1]Fisheries and Oceans, Dartmouth, NS, Canada

Large woody debris from streamside vegetation has profound influences on channel morphology and habitat for salmonid fishes, but has often been depleted by channelization or deforestation of the riparian zone. We installed artificial structures mimicking naturally fallen trees in a third order stream in northern Nova Scotia from 1992 to 2004 to determine if the structures enhanced spawning success of Atlantic salmon *Salmo salar*. A total of 250 digger logs (which mimic 31 fallen tree trunks and stimulate formation of pools) and bank deflectors (which encourage meandering) were constructed in degraded reaches of Briefly Brook, beginning at the downstream end. We monitored spawning each year by counting redds during the fall spawning season. Spawning rates (redd counts) in the whole brook increased exponentially for the first four years after restoration work began, from 43 in 1992 to 592 in 1996. By 1996, the entire length of Brierly Brook contained redds, and Atlantic salmon were using gravel that accumulated behind digger logs to build redds. Thereafter, redd counts remained high (502-605) but no longer increased, suggesting that restoration near the mouth of the brook removed an impediment to upstream migration. In 2004, reaches with artificial structures had significantly more redds (336) than reaches without them (280). In reaches with artificial structures, 48% of the redds were associated with gravel pool-tails or the heads of riffles, 44% were near artificial structures, and 7% were near natural large woody debris. In reaches without artificial structures, almost 89% of the redds were associated with pool tails, and the remainder with natural large woody debris. It appears that large woody debris, whethernatural or artificial, is an important source of spawning habitat for Atlantic salmon. Artificial structures mimicking naturally fallen wood are effective in the restoration of spawning habitat.

S6-5

The West River Sheet Harbour Acid Rain Mitigation Project: an NGO Initiative

George Ferguson[1] (presenting), Lewis Hinks[2]. [1]Nova Scotia Salmon Association, Chester, NS, Canada, [2]Atlantic Salmon Federation, Chester, NS, Canada

Nova Scotia has lost the greatest percentage of fish habitat of any region of North America due to the effects of acid rain. Acid rain has negatively impacted the salmon populations in at least 50 of the65 salmon rivers draining the coastal plain that extends the full length of the Atlantic coast of mainland Nova Scotia, the Southern Upland. The combined effectsof acid rain and low marine survival are hastening the destruction of all but a small number of the Southern Upland salmon populations. The recovery of Nova Scotia's rivers affected by acid rain is a long-term commitment, possibly in the order of 50-100 years. The NOVA SCOTIA SALMON ASSOCIATION (NSSA) has initiated an ambitious project to restore one of the rivers damaged by acid rain. The West River was selected as the site for the demonstration project through an extensive review exercise carried out by the NSSA's Acid Rain Mitigation Committee (ARMC), comprised of representatives from various government and NGO organizations. The ARMC's review was guided by a report that detailed plans for liming four of the Southern Upland rivers. The report was contracted by the NSSA and prepared by Dr. Atle Hindar, a leading Norwegian researcher on liming strategies to combat acid rain effects. In Norway, liming programs have proven very successful and salmon populations have improved dramatically. The focus of the project is the mainstem of the West River system. The liming is being conducted using a single doser, operated year-around. The project will mitigate the high acidity effects on about 25% of the West River system's habitat that was once utilized by salmon. The treated habitat offers the potential to produce about 10,000 wild smolts and is sufficiently large to provide a natural refuge for a wild salmon population. Brook trout production is also expected to besignificantly enhanced. The dosing apparatus utilized is the Norwegian manufactured Kemira Kemwater lime system. This system is widely utilized in Norway. The Project will have a minimum life span of 10 years (i.e. twosalmon life cycles). The doser went into operation September 21, 2005 and we have seen an increase in pH values the river system. Six months after the lime doser began operation, pH downstream had risen to 5.6, a level within the acceptable range of Atlantic salmon. Monitoring of the West River is ongoing.

S6-6

Sonic tracking of Atlantic salmon smolts: opening the ocean black box

Fred Whoriskey[1] (presenting). [1]Atlantic Salmon Federation, St. Andrews, NB, Canada

Multiple years of sonic telemetry have been conducted to document Atlantic salmon smolt migration patterns and survival from fresh water river release sites to: 1) the head of tide, 2) through the estuary, and 3) across the Gulf of St. Lawrence to the Strait of Belle Isle. The rivers studied (Miramichi, Restigouche, Cascapedia and St. Jean (North Shore) Rivers) fell on an approximately 600 km south-to-north gradient. Survival patterns of smolts were generally similar among years for a given river. Consistent year-on-year differences in survival to the head of tide and across the estuary were also evident among rivers; however, these differences did not clearly correlate with latitude. Heavy losses occurred in most river estuaries. Twenty to 30% of the smolts that survived to exit the estuaries of the Miramichi, Restigouche and Cascapedia Rivers passed through the Strait of Belle Isle en route to ocean feeding grounds off Greenland. Travel rates in the Gulf were estimated as 17- 25 km/d, and survivals and travel speeds were not correlated with fish body lengths. Intrusions of potentially lethally cold (< -1 C) water were detected in the Strait of Belle Isle at the time smolts were passing through the area. This could result in elevated mortalities of the smolts if thermal refuges are not available.

S6-7

Genetic affinities of Lake Ontario Atlantic salmon assessed with ancient DNA

Oliver Haddrath[1] (presenting), Jerry Smitka[2], Jack Imhof[2], Allan Baker[1]. [1]Department of Natural History, Royal Ontario Museum, Toronto, ON, Canada, [2]Trout Unlimited, Guelph, ON, Canada

Lake Ontario once contained a population of Atlantic salmon in such great abundance that they were an important resource for Native Americans and European settlers. Agricultural and industrial development throughout the Lake Ontario watershed during the 19th century led to the decline and ultimate extinction of the salmon by 1900, due to habitat degradation and the proliferation of dams on the rivers and streams where the salmon bred. Questions remain on how distinctive this population was, and if so, what affinities they had with other extant salmon populations. Various hypotheses about possible relict populations that might serve as sources for population restoration can only be tested by genetic characterization of historical specimens. Here we report recovery of ancient DNA from six Lake Ontario salmon museum mounts as well as from bones from 13th and 14th century Native American middens, probably re(presenting) 13 individuals. To assess genetic affinities we compared allele frequencies at 18 microsatellite loci in historical specimens with 120 individuals sampled from 10 extant populations in North America and South America. We show that populations introduced to Argentina from North America in 1900 are genetically differentiated from the historical population, and that populations in the St. Lawrence River and its tributaries are genetically closer to Lake Ontario Salmon.

S6-8

Quantifying the fluvial habitat needed for the re-introduction of Atlantic salmon in Lake Ontario

Robert Randall[1] (presenting). [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada

Atlantic salmon (*Salmo salar*) inhabited Lake Ontario historically (before 1900) but are now extirpated. Habitat needs to support the re-introduction of this species were calculated using conservation targets (2.4 eggs/m2), fecundity, and size at maturity data from eastern Canada. To illustrate the method, and assuming a target population size of 10,000 salmon, the amount of fluvial habitat needed for juvenile rearing was estimated at about 500 ha. The conservation targets for the Credit River, the largest tributary on the Canadian side of Lake Ontario, were tentatively estimated to be 8.6 X 106 eggs and 3,600 female salmon. For tributaries targeted for restoration, accessible rearing habitat would be essential for re-introduction because allowable harm assessment indicated that population viability was sensitive to juvenile mortality. Based on known reproducing populations of other Salmoninae in Lake Ontario (*Salvelinus fontinalis*, *Salmo trutta* and Oncorhynchus spp.), suitable fluvial habitat for Atlantic salmon is available, and the re-introduction of this extirpated species is ecologically feasible. A restoration program for Atlantic salmon in Lake Ontario is ongoing.

S6-9

Survival, growth and emigration of stocked atlantic salmon in Lake Ontario streams

Russell Bobrowski[1] (presenting), Marc Desjardins[2], Chris Wilson[2], Nicholas Jones[2]. [1]Trent University, Peterborough, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

Atlantic salmon (*Salmo salar*) were once abundant in Lake Ontario, but died out in the late 19th century. A collaborative partnership between universities, government agencies, and NGO's has been established to attempt to restore self-sustaining populations of Atlantic salmon in Lake Ontario within the next ten to fifteen years. Key information needs for restoration include determining stocking and recruitment success of different stocked life stages, and assessing life-stage specific survival contributing to adult returns. To address these, we are assessing the relative survival and growth of different life stages (fry, fingerlings, and yearlings) stocked in tributaries, as well as their timing of emigration to Lake Ontario with respect to environmental cues. Results from the first field season indicate substantial differences in survival and timing of out-migration among stocked life stages. Abundance and distribution of stocked fish in lotic habitats were assessed by backpack electrofishing; emigrating smolts were captured using a stationary fyke net in the lower reaches of Cobourg Brook. Numbers of emigrants were estimated using injected tags and stratified mark-recapture techniques; identification of life stages relied on fin clips, scale pattern analysis, and size distribution. Outmigrating smolts from Cobourg Brook (n=7748) showed bimodal emigration intervals: one strong pulse coincided with increased stream discharge and warming temperatures, and a second, more diffused, emigration peak continued until mid-summer. These data will inform future stocking strategies for life stage and stocking density, and will provide baseline data for estimating percent returns of adult fish in future years.

S6-10

The impacts of Atlantic salmon stocking on rainbow trout in Barnum House Creek, Lake Ontario

Jason Dietrich[1] (presenting), Jim Bowlby[2], Bruce Morrison[3], Nicholas Jones[4]. [1]AMEC Earth & Environmental, Cambridge, ON, Canada, [2]Lake Ontario Management Unit, Ontario Ministry of Natural Resources, Picton, ON, Canada,[3]Fisheries Section, Ontario Ministry of Natural Resources, Peterborough, ON, Canada, [4]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, Peterborough, ON, Canada

We compared the impacts of stocking age-0 Atlantic salmon (*Salmo salar*) at high andlow densities, and no stocking on abundance and growth of age-0 rainbow trout (*Oncorhyncus mykiss*) in Barnum House Creek, Ontario during 1993 to 2005. A similar stream, Shelter Valley Creek, was chosen as an appropriate reference stream where age-0Atlantic salmon were not stocked. The catches of age-0 rainbow trout in Barnum House and the reference stream were highly correlated ($r = 0.96$) during years when no stocking occurred; however, this relationship did not persist in years when Atlantic salmon were stocked. The catch of age-0 rainbow trout in Barnum House Creek was significantly lower under both high ($P = 0.00026$) and low ($P = 0.011$) density Atlantic salmon stocking treatments compared with the no stocking treatment. The catches of age-0 rainbow trout and age-0 Atlantic salmon were negatively correlated in Barnum House Creek ($r = -0.63$). The length of age-0 rainbow trout in Barnum House Creek was depressed significantly ($P = 0.004$), under the high intensity Atlantic salmon stocking treatment, but not under the low intensity treatment ($P = 0.20$). In contrast, the length of age-0 rainbow trout in Shelter Valley Creek was unchanged over the same period. Restoration stocking of Atlantic salmon in Lake Ontario tributaries may impact rainbow trout abundance and growth.

S6-11

Techniques used to maximize smolt production of landlocked Atlantic salmon for the Lake Champlain fishing restoration program

Kevin Kelsey[1] (presenting). [1]Vermont Fish and Wildlife Department, Grand Isle, VT, United States

The stocking of landlocked Atlantic salmon smolts to enhance sports fishing restorations efforts in inland waters is well documented. Many if not most tributaries of inland water bodies that are inhabited by landlocked salmon have dams that have limited or marginal passage and often times are impassable. This requires stockings to be direct lake entry and/or below the first dam impassable to fish. Fish stocked in this manner should exhibit out migration behavior and pelagic disposition (true smolts) to ensure performance for program objectives. Maximizing first year smolts from any given year class requires culture techniques (feeding, grading, lighting, flow rates) that promote increased smolt recruitment. The techniques employed at the Ed Weed Fish Culture Station in Grand Isle Vermont on Lake Champlain are outlined in this presentation.

S6-12

A century of challenges and successes for landlocked Atlantic salmon in the company of hydropower on the Clyde River, a tributary to Lake Memphremagog on the Vermont / Quebec border

Leonard Gerardi[1] (presenting). [1]Vermont Fish and Wildlife Department, St. Johnsbury, VT, United States

For over a century landlocked Atlantic salmon have been a prominent feature of Lake Memphremagog, a 9532 ha lake in the St. Francis River basin on the Vermont / Quebec border. Although the origins of Memphremagog's salmon are arguable, the population that flourished during the 1920s and 1930s declined coincident with the expansion of hydroelectric operations on the lower Clyde River, the lake's principal salmon spawning and nursery tributary. Federal re-licensing of the hydroelectric system several years ago requires mitigation measures that set the stage for restoration of a viable self-sustaining salmon population, while the failure of an involved dam during the re-licensing process and the subsequent federal order for its complete removal put the Clyde River and its salmon in the national spotlight. At present, the Vermont Fish and Wildlife Department is involved in an aggressive fry and smolt stocking program. The hydroelectric system's new owner has instituted an operation regime with salmon-friendly flows. Its recently constructed upstream and downstream fish passage facilities went into service in 2007. This paper will review the history of the rise and fall of Memphremagog's salmon, the current status of restoration efforts on the Clyde River, and the outlook for the future.

S6-13

Connecticut River Atlantic Salmon restoration science and sociology

Caleb Slater[1] (presenting). [1]Massachusetts Division of Fisheries and Wildlife, Westborough, MA, United States

Atlantic salmon were extirpated from the Connecticut River around 1800. An early attempt at restoration was thwarted in the 1860s by poor fish passage and overfishing. The current restoration of Atlantic salmon to the Connecticut River basin began in 1967. It is a major cooperative effort between the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. Forest Service, the North Atlantic Salmon Conservation Organization, State fish and wildlife departments in the watershed, private organizations, and industry. The Connecticut River Atlantic Salmon Commission was established by Congress in 1983 to provide guidance to these many entities and to ensure cooperation. Management practices include raising salmon in hatcheries, capturing and spawning sea-run Atlantic salmon, stocking juveniles in tributaries, and providing access to habitat by building fish passage facilities. These cooperative management efforts have resulted in the successful reintroduction of Atlantic salmon to the Connecticut River watershed. Issues to be discussed include the programmatic shift from a smolt-dominated to a fry-dominated stocking program, broodstock management, fry growth and survival, ocean survival, and managing expectations.

S6-14

Community-based efforts for Atlantic salmon recovery in the Maritimes

Todd Dupuis[1] (presenting). [1]Atlantic Salmon Federation, St. Andrews, NB, Canada

The Atlantic salmon (*Salmo salar*) has long been part of the culture and economic heritage of the Maritime Provinces. Originally a food source for First Nations people, it became an important factor in both the domestic and commercial life of the developing colonies where it provided a recreational outlet for anglers and a target of commercial fisheries. The history of the Atlantic salmon is fraught with instances of overexploitation, destruction of habitat and ineffective conservation measures. An estimated 1.5 million salmon swam in the Atlantic Ocean in the early 1970's. Today that number is approximately 500,000. However, public interest in restoring Atlantic salmon stocks is high and a number of projects are underway to rehabilitate depressed or extirpated stocks. Those range from backyard stream restoration to major fish passage projects around hydroelectric dams. Success ofrecovery efforts vary and are difficult to measure as ocean survival rates decline. Better landuse planning along with coordinated restoration and research

efforts are necessary to reverse the decline of Atlantic salmon stocks.

S6-15

55 years of community-based conservation on the Miramichi: experiences of the Miramichi Salmon Association

Mark Hambrook[1] (presenting). [1]Miramichi Salmon Association, South Esk, NB, Canada

The Miramichi Salmon Association has been a voice for salmon conservation on the Miramichi since 1953 and has watched over the Miramichi as a champion of conservation on behalf of anglers, outfitters, guides and all others with economic, environmental and recreational interests in the river. The organization is managed by directors from Canada and the United States and thanks in part to MSA efforts, the result is a well managed river system that has more miles of salmon angling water and holds larger and healthier populations of Atlantic salmon than any other river in North America. The organization has evolved from being an education and advocacy group to an active participant in salmon research, stock assessments, stock restoration, angling regulations and education. The organization employs two full time biologists and a field staff dubbed the "Miramichi Conservation Corps" with an aim to employ as many aboriginals as possible in conservation work. The organization continues to grow and raises over $500,000 each year.

S6-16

Restoring Atlantic Salmon stocks through Community Stewardship: Experiences in Newfoundland.

T. Rex Porter[1] (presenting). [1]Department of Fisheries and Oceans, St. John's, NL, Canada

Atlantic Salmon populations in Newfoundland and Labrador seriously declined in the late 1980's due to a decrease in survival rates at sea, similar to most salmon populations in the Northwest Atlantic. Commercial fisheries were closed and additional restrictions were placed on the recreational fisheries in 1992. Commensurate with these harvest restrictions the escapement of salmon into rivers and spawning stocks increased, even though the overall sizes of the populations remained low. However, in some rivers the populations continued to decline to alarmingly low levels, with spawning stocks below 50% of their conservation requirements. In 2001, the Department of Fisheries and Oceans embarked on a trial strategy to engage stakeholders in the development of Atlantic salmon stock restoration and conservation plans for two rivers. This trail strategy was highly successful in increasing the number of salmon entering the two rivers, increasing the size of the spawning stocks, developed a sense of resource stewardship in the communities. The process for engaging the communities are discussed as well as the benefits, short-comings and lessons learned in restoring salmon stocks through community stewardship.

S6-17

Lake Ontario Atlantic salmon restoration program and partnership

Marion Daniels[1] (presenting). [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

Atlantic salmon were extirpated from Lake Ontario by the late 1800s, primarily as a result of the loss of spawning and nursery habitat in the streams. They were a valued resource for First Nations communities and early European settlers. As a top predator, they played a key ecological role in the offshore fish community. As such, Atlantic salmon are recognized as an important part Ontario's natural and cultural heritage. This species is also a good indicator of environmental health and is sought by anglers the world over. The Lake Ontario ecosystem has continued to experience significant change over the past century. However, two decades of stream research and substantial improvements in the health of the watersheds have laid the foundation for moving forward with a plan to restore self-sustaining populations of Atlantic salmon to Lake Ontario. An exciting partnership to bring back Atlantic salmon was launched in 2006. Among the more than 30 partners and sponsors working together to restore this native species are conservation agencies and organizations, corporations, industry, community groups, landowners, educators and all levels of government. The restoration program has four essential components: habitat enhancement, fish production and stocking, research and assessment and outreach and education. Restoration planning and implementation is guided by a multi-organization steering committee and recovery team. Benchmarks have been set to help measure progress. Efforts to identify and address potential challenges to restoration will continue. An adaptive management approach has been adopted, with a focus on sound, scientific studies, a restoration plan that is dynamic and responsive to new findings, strong partnerships and community involvement.

S6-18

Rags to riches of Northwest River Atlantic salmon: a tale from Sherwood Forest...

David Cote[1] (presenting). [1]Parks Canada, Terra Nova National Park, Newfoundland, Canada

Northwest River is a rugged river in eastern Newfoundland, flowing through open barren country and over cascading falls on its way to the Atlantic Ocean. For generations, local community residents have enjoyed angling for salmon on the Northwest but by the mid-1990s, both that tradition and the salmon stock were at risk. Declining numbers of salmon returning to Newfoundland's rivers forced the closing of the commercial salmon fishery, but stock levels in the Northwest failed to substantially improve. To protect the remaining salmon, Parks Canada and DFO closed the Northwest to recreational fishing in 1996. Despite the cessation of recreational fishing, the number of returning salmon continued to decline. Traditional solutions clearly weren't working, so local residents joined forces with government agencies (Parks Canada and DFO) to form the Northwest River Atlantic Salmon Conservation Working Group. Led by two local citizens, this advisory group created a population recovery and conservation plan. The plan centered around an incentive-based fishery that would ensure conservation and sustainability of the stock while providing realistic and tangible benefits if the stock was looked after. The approach relied on in-season run projections to reopen the recreational fishery. Each salmon caught illegally diminished the likelihood of the river opening that season. This incentive-based approach was augmented with efforts to involve and educate local people and anglers about the cultural and natural heritage of the river. The salmon stock went from being at risk of extirpation to three consecutive record-breaking runs in less than four years. Community interest has gone from apathy to strong public involvement and mutual understanding and respect now typify working relations with government.

S6-19

Partnerships in headwaters restoration for Atlantic salmon: Credit River, Ontario, Canada

Mark Heaton[1] (presenting). [1]Ontario Ministry of Natural Resources, Aurora, Ontario, Canada

Atlantic salmon are an important component of the natural and cultural heritage of the Lake Ontario basin, and historically the Credit River was considered “the queen of all Ontario salmon streams”. However, European settlement and agricultural cultivation of Upper Canada lead to the eventual extirpation of this species from Lake Ontario by 1896. In 1988, the Ontario Ministry of Natural Resources (OMNR) began experimental research to determine the feasibility of reintroducing Atlantic salmon. The research program concluded that restoration of the species was possible in select rivers with optimal characteristics. In 2005, the Ontario Federation of Anglers and Hunters, Trout Unlimited Canada, corporate sponsors, and local watershed stakeholders partnered with OMNR to implement a large-scale, multi-year restoration program for the salmon. The program is based on four components including habitat rehabilitation, stocking, education and research. One of the key best-bet tributaries for restoration is the Credit River, and ongoing partnerships there have delivered monitoring projects for assessing temperature regimes and Atlantic salmon productivity. Flexible partnerships have also emerged to initiate an Atlantic Salmon Habitat Rehabilitation Plan, initially focusing on Rogers Creek, a Credit River headwater tributary. Through 2006 and 2007, five partnership projects on Rogers Creek were completed to restore salmon nursery habitat.

S6-20

Classrooms, graduate students, government, conservation agencies and Atlantic salmon: a winning combination in re-introduction initiatives

Michael Rennie[1], Shidan Murphy[1] (presenting), Mark Heaton[2], Chris Robinson[3]. [1]University of Toronto at Mississauga, Mississauga, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Aurora, Ontario, Canada, [3]Ontario Federation of Anglers & Hunters, Peterborough, Ontario, Canada

Atlantic salmon, extirpated from Lake Ontario in the late 1800’s, have recently become the focus of re-introduction efforts in Ontario, Canada. A major component of this effort is to inform the public living around Lake Ontario of the program through outreach. Here we describe a unique public outreach program that has developed into a multi-agency partnership and has rapidly facilitated the development and expansion of a classroom-based Atlantic Salmon Hatchery Program in Ontario. In 2005, the Let’s Talk Science (LTS) Partnership Program at the University of Toronto at Mississauga (part of a national science outreach organization administered and delivered by graduate students) partnered with the Belfountain Community Fish Hatchery (BCFH) and the Ontario Ministry of Natural Resources (OMNR) to expand an existing classroom hatchery program into the Greater Toronto Area. Based on the “Fish Friends” model developed by the Atlantic Salmon Federation, classrooms were provided with a hatchery and Atlantic Salmon eggs. Classrooms cared for the fish as they developed into fry and near the end of the academic term released them into a stream site targeted by the OMNR for restoration. Graduate student volunteers, provided by the LTS Partnership Program, helped setup and provided advice on hatchery maintenance, developed and delivered hands-on activities related to Atlantic salmon biology and coordinated release events. Classrooms received all materials and graduate student expertise free of charge. In 2005, funding for the hatcheries was provided by Fishing Forever and the LTS Partnership Program. Eggs and technical support were provided by the BCFH, and the OMNR provided direction for salmon release. This program grew significantly in 2006 when the Bring the Salmon Back Partnership provided additional funding for hatcheries, educational materials and volunteers for classrooms, and again in 2007/08 when the program further expanded to neighbouring cities. This mix of stakeholders will ensure continued program expansion as Atlantic salmon restoration efforts continue on Lake Ontario tributaries.

S6-21

What do children have to do with fish restoration?

Pamela Gibson[1] (presenting). [1]Peel District School Board, Mississauga, ON, Canada

Children naturally gravitate toward water and fish. They are very open to acquiring an understanding of how fish function in their natural environments. As part of an integrated, environmentally-driven program like the Lake Ontario Atlantic Salmon Restoration Program, young students very quickly absorb concepts such as appropriate stewardship of local streams and conservation of the fish that inhabit them. Come and learn how students can play a significant role in fisheries management activities such as fish stocking, fish monitoring surveys, fish data syntheses and native species restoration initiatives. As students assist in improving the health of local streams their umbrella understanding of how healthy watersheds work increases. Most importantly, their passion for the life these rivers support blossoms. This is good news for fish! Children formulate action plans and carry them out with dedication and vision for the future. And...more good news...these same children grow up to be aware, knowledgeable stewards of our streams and rivers wherever they go; volunteers that contribute to local conservation initiatives. Already, I can see the future looking a little brighter for our fish!

S6-22

Corporate conservation ─ the Banrock Station Experience.

Tony Sharley (presenting). Banrock Station, Australia

Banrock Station wines are grown in South Australia and sold in more than 40 countries including Canada. As a global wine brand, Banrock Station takes its environmental role seriously. In 1993, Banrock Station commenced a 1000 hectare wetland restoration program around its vineyards that led it to make a donation per bottle sold to wetland conservation projects in its major markets. Since 1993, almost 100 conservation projects have been funded in the 13 countries and in 2000 the Banrock Station Wetland Foundation Canada was established and now supports projects in four Canadian provinces. The most significant project outside Banrock's own Ramsar listed wetland in Australia is *Bring Back the Salmon* ─ which aims to recover Atlantic Salmon populations in Lake Ontario in partnership with the Liquor Control Board of Ontario, Ontario Federation of Anglers and Hunters, Ontario Ministry for Natural Resources and Churchill Wines. This project has just achieved its one millionth fish released in the 3rd year of a five year sponsorship. This presentation will outline the lessons learned from a decade of corporate conservation and the importance of achieving real conservation outcomes.

S7. Sustainable Sturgeon: Conservation of Sturgeon Populations in the Face of Increasing Resource Demands and Climatic Change

S7-1

Genetic assessment of population fragmentation of lake sturgeon (*acipenser fulvescens*) in the Ottawa River

Kristyne Wozney[3] (presenting), Chris Wilson[1], Tim Haxton[1], Shawna Kjartanson[2]. [1]Ministry of Natural Resources, Peterborough, Ontario, Canada, [2]University Of Toronto, Toronto, Ontario, Canada, [3]Trent University, Peterborough, Ontario, Canada

Lake sturgeon (*Acipenser fulvescens*) are of conservation concern throughout their range. Lake sturgeon are a fluvial dependant species, which have been increasingly impacted and fragmented by human development. Although lake sturgeon were historically abundant in the Ottawa River and its tributaries, commercial harvest caused severe decline in lake sturgeon populations. Other anthropogenic factors such as logging, agriculture, and water quality decline have continued to suppress lake sturgeon numbers. In addition, river fragmentation by hydroelectric and water control dams may be increasing isolation among habitat patches and local rates of decline, raising concerns for persistence of local populations. We used fourteen microsatellite DNA markers to assess population structure and diversity of lake sturgeon in the Ottawa River, and analyzed samples from 10 sites that cumulatively represent more than 500 kilometers of riverine habitat. To test for evidence of anthropogenic fragmentation, patterns of genetic diversity and connectivity (dispersal and gene flow) within and among river segments we tested for concordance with geographic location (upper vs. lower reaches), separation by distance and obstacles to migration, considering both natural and unnatural barriers as well as barrier (dam) age. The results of this study will have implications as to the proper conservation and management of this species throughout this river system.

S7-2

Genetic evaluation of lake sturgeon (*Acipenser fulvescens*) designatable units in Canada

Shawna Kjartanson[1] (presenting), Chris Wilson[2], Nathan Lovejoy[1]. [1]University of Toronto, Scarborough, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

Canada's largest landlocked fish, the lake sturgeon (*Acipenser fulvescens*), is a heritage species with considerable social and economic value. Unfortunately, over-exploitation and habitat alteration has led to the collapse of lake sturgeon fisheries across North America. In light of the assessment of lake sturgeon by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), there will be a demand for tailored management strategies for this threatened species. As COSEWIC recommends species status changes, it recognizes designatable units (DUs) if necessary. These are defined as irreplaceable units based on significant ecologic, geographic, or genetic differences. The hierarchical system of differentiation, in order of priority, includes 1) taxonomic distinctiveness, 2) genetic evidence, 3) range disjunction, and 4) biogeographic distinction. Based on the available (yet scarce) information, COSEWIC identified eight DUs in its most recent lake sturgeon status report. Lake sturgeon populations are initially divided into four units, largely re(presenting) the "National Freshwater Ecozones" (Western Hudson Bay, Saskatchewan-Nelson Rivers, Southern Hudson Bay and the Great Lakes-St.Lawrence). Only the Saskatchewan-Nelson ecozone can be divided further into five, based on unpublished data from three microsatellite loci. Without sufficient evidence for further sub-structuring, the remaining ecozones are left intact as distinct DUs. In this study, eleven microsatellite loci are used to characterize 50 populations across the range of lake sturgeon in Canada. The robustness of the current designations are tested and discussed.

S7-3

Hydropower facilities & sustainable sturgeon: a conservation genetic approach

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Hydropower facilities have been a barrier to lake sturgeon recovery in the Great Lakes. Dams have prevented lake sturgeon from reaching their historic spawning grounds. The water being released from the dams has affected spawning success and larval and juvenile survival. On the Kaministiquia River in Lake Superior, a remnant lake sturgeon population may be impeded or restricted from accessing their historical spawning site due to dewatering from upstream dam operations. The operation of this dam provides flows for power production and scenic flows for Kakabeka Falls Provincial Park. Water flows on the river are dependent on the operation of several dams throughout the watershed. Lake sturgeon continue to spawn on the Kaministiquia River but uncertainty remains about the number of individuals that successfully reproduce. Genetic data can provide information on the number of full-sibling families represented in a cohort and on the number of adults breeding during that spawning season. During two spawning seasons (2005 and 2006), lake sturgeon adults moving up the river to spawn were captured and genetic samples were taken. Following the spawning events, larval samples were collected. All samples were analyzed at 14 microsatellite loci. Using genetic data from the captured adults, full-sibling families were simulated. Relatedness values were calculated for the simulated data set and the actual data set. A UPGMA tree was constructed and the simulated data were used to determine the threshold for full-sibling family determination. Genetic samples from known full- and half-sib families were also analyzed to verify the analytical methods used. Results indicate that not all of the potential parents were sampled. Additionally, not all of the adults that were sampled successfully reproduced. The information on the number of families will have important implications on the operation of the hydropower facilities. With a low number of families, flows being released from the dam may need to be adjusted in order to maintain a sustainable lake sturgeon population on the Kaministiquia River.

S7-4

Identifying the fundamental unit of management in U.S. Atlantic coast sturgeons: A genetic-based approach

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Sturgeons are remnants of the once flourishing chondrosteans, dominant fishes of the Permian period. The continued existence of these "fossil" fishes is in jeopardy throughout North America, Europe, and Asia and they require conservation efforts to identify and sustain ecological processes and evolutionary lineages. However, sturgeons present significant challenges for investigating the evolutionary processes shaping the nuclear genomes of extant species due to the presence of autopolyploidy ranging in a series from 4N-8N-12N-16N times the haploid number. Microsatellite DNA markers have become the tool of choice for investigating genetic variation and determining the fundamental unit of management in species of conservation concern. We will present the results of range-wide surveys of microsatellite DNA variation for two at-risk species exhibiting different ploidy levels: Atlantic sturgeon (Acipenser oxyrinchus; 4N) and shortnose sturgeon (*Acipenser brevirostrum*; 12N-16N). In addition to the delineation of population structure throughout the range of *A. oxyrinchus*, microsatellite variation at 12 loci allowed the confirmation of the presence of a reproducing population within the Chesapeake Bay (James River). Polysomic microsatellite markers (N=11) have allowed delineation of population structure and a re-defining of the number of distinct population segments among A. brevirostrum collections. Comparisons will be made with patterns observed by other researchers using mitochondrial DNA sequence variation.

S7-5

Drift dynamics and abundance of larval lake sturgeon in the Peshtigo River, Wisconsin, USA

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Drift-net catches of larval lake sturgeon *Acipenser fulvescens* have been used to determine spawning success, drift duration, and relative year-class strength. However, little or incomplete information is available regarding absolute abundance and vertical distribution of drifting larvae. This lack of information and past assumptions of benthic or uniform drift confound estimates of spawning success, year-class strength, and abundance. The objective of this research was to estimate abundance and determine the

vertical distribution of drifting larval lake sturgeon in the Peshtigo River, Wisconsin. Catches from four D-frame drift nets, equally spaced across the channel and 100 m below lake sturgeon spawning habitat, were used to determine abundance during 2006 and 2007. Two sets of stacked, rectangular-frame drift nets were used in 2007 to assess the vertical distribution of larvae. An estimated 3,260 (95% CI: 829 – 6,776) larvae were produced from the 2006 year class. While lake sturgeon larvae were captured drifting in all parts of the water column in 2007, their distribution was not equal: 36% were captured near the surface, 77% drifted in the upper half of the water column, and only 5% were captured in the 0.2 m section adjacent to the bottom. If the 2006 abundance estimate were modified to incorporate this unequal drift, it would increase to 6,208 (95% CI: 2,357 – 13,037) larvae. In 2007, after correcting for the unequal distribution, abundance was estimated to be 13,207 (95% CI: 628 – 32,474) larvae. These results suggest that the vertical distribution of larvae is neither benthic nor uniform and confirm the necessity of assessing the vertical distribution of drifting lake sturgeon larvae before estimating abundance.

S7-6

Tracking temporal trends in female effective population size for white sturgeon in the lower Columbia River

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Anthropogenic pressures such as habitat destruction have disturbed recruitment in many white sturgeon populations, although a direct relationship between spawner abundance and habitat disturbance has not yet been quantified. In highly fecund species such as white sturgeon, the number of female spawners surviving to contribute offspring each year can be used as an indicator of population viability. We examined trends in white sturgeon female effective population size and genetic diversity in samples collected pre- and post-impoundment of the Lower Columbia River system. We genotyped white sturgeon spawned in 1937-1941 (directly after impoundment), 1982-1987, and 2001-2005 at fifteen microsatellite loci and calculated pairwise relatedness values to determine kinship between white sturgeon juveniles from each time period. Archived data from known full-sibling white sturgeon families were used to determine a relatedness threshold value distinguishing between full-sibling and unrelated juveniles. This threshold relatedness value was applied to estimate the minimum number of female spawners contributing to the Lower Columbia River white sturgeon collection by identifying the number of full-sibling and unrelated groups in each time period. Recognition of declines in genetic diversity and/or reductions in the minimum number of female spawners since impoundment would provide evidence that this particular habitat modification may be contributing to recruitment declines in this white sturgeon population.

S7-7

Effect of rearing temperature on the onset and duration of dispersal of early life stages of shortnose sturgeon

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Shortnose sturgeon undergo a downstream dispersal during the larval life stage. The objective of this study was to determine the effect of three temperature regimes on the timing and pattern of downstream dispersal of Connecticut River (MA, USA) shortnose sturgeon larvae. Tests were conducted in artificial stream tanks with three replicates at each of three temperatures, 10°, 15°, and 20°C. Fish were introduced to experimental tanks immediately upon hatching, and their movements were monitored day and night with video cameras. Rearing fish at 10°C caused development to slow and delayed the onset of dispersal. Fish in the 10°C group had a single peak of dispersal lasting 8 days. Increasing the temperature (15 and 20°C) caused fish to begin dispersing at a younger age (in days after hatch), but also produced a dispersal with multiple peaks. Fish were all at or close to the beginning of the larval life stage (i.e. beginning exogenous feeding) and were all morphologically similar when they began dispersing, regardless of temperature. Fish in the 15 and 20°C treatments required a similar number of degree-days to become larvae, but fish in the 15°C group took more degree-days to begin dispersal than fish in the 20°C group. Fish in the 10°C group took many more degree-days both to become larvae and to initiate dispersal than fish in the other two groups. These results show development and dispersal of shortnose sturgeon early life stages can be influenced by river temperature, and anthropogenic impacts that alter river temperature regimes have the potential to affect sturgeon dispersal patterns.

S7-8

Dispersal and behaviour of early life stages of Kootenai white sturgeon: a laboratory study

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For 3 years, we used artificial stream tanks to observe the dispersal and behavior of free embryos and larvae produced by different Kootenai white sturgeon *Acipenser transmontanus* parents. Most photonegative free embryos remained hidden in cover, but some left and moved weakly downstream, a move that would not likely carry them a far distance. However, when free embryos developed into feeding larvae, all initiated a strong day and night dispersal that lasted for many days. This dispersal is greatly affected by velocity, with larvae in artificial streams with fast velocity (mean, 23.4 cm/s) initiating dispersal earlier, with greater intensity, and moving more days (14 d) than larvae in slower velocities. Substrate size may also affect dispersal with more downstream movement of larvae in tanks with gravel compared to fish in tanks with cobble. During dispersal, larvae mainly used channel flow, and those entering the low velocity in a side eddy, quickly left, suggesting wild larvae do not use side eddies, but instead have a strong preference for fast velocity in order to remain in the main flow and move a far distance. The strong long dispersal style of larvae is likely an adaptation to move fish a far distance from the egg deposition reach to the rearing reach for larvae and early juveniles.

S7-9

Spatial distribution and movement of juvenile lake sturgeon in an impounded reach of the Winnipeg River

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Many studies have focused on relatively large juvenile lake sturgeon (i.e. > 500 mm fork length) in small rivers and tributaries of the Great Lakes, but little is known regarding juvenile habitat utilization in large, northern rivers. To address this lack of information, we tagged 64 juvenile lake sturgeon (16 > 500 mm and 48 < 500 mm) with acoustic transmitters in a 35 km long impounded reach of the Winnipeg River, Manitoba. During the open water season of 2007, fish implanted with acoustic transmitters were monitored using: a) a VRAP telemetry system (VEMCO, Halifax, NS Canada) to monitor fine scale movements and micro-habitat preferences; and b) an array of 74 VR2 receivers (VEMCO) to monitor coarse scale, long distance movements. In addition, recapture information from over 300 juvenile lake sturgeon marked with Floy-tags during 2006 and 2007 have been collected. Information from the Floy-tag recaptures, indicates that lake sturgeon exhibit high site fidelity and suggests that juvenile lake sturgeon may avoid moving either upstream or downstream through areas of high water velocity. Data from the VRAP system indicates that juvenile lake sturgeon prefer deep water areas with sand or sand/gravel substrates, and may move for extended periods of time (i.e. weeks) in relatively narrow areas of the river in a pattern parallel to water flow. Results from the VR2 receiver array, including movements of 6 larger juveniles, and 13 smaller juveniles that were relocated, will also be presented.

S7-10

Juvenile Gulf sturgeon winter habitat use patterns in the Suwannee River estuary and in Apalachicola Bay as defined by automated acoustic listening post telemetry

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Pilot telemetry studies were conducted in winter 2005-06 in the Suwannee River estuary and nearhore Gulf of Mexico, and in winter 2006-07 in estuarine Apalachicola Bay. Studies were undertaken using a set of 14 automated acoustic listening posts and acoustically-tagged Gulf sturgeon to document patterns of movement and trophic habitat use by juvenile and adult sturgeons on the winter feeding grounds in estuarine waters. In the Suwannee estuary, individual juveniles displayed a characteristic pattern of frequent and substantial movement, with extensive forays out of a core river-mouth feeding area into the open Gulf of Mexico. In Apalachicola Bay, both juveniles and adults remained within a very restricted area of the river-mouth throughout the winter, with limited movements close to shore in shallow water, and with little evidence of offshore forays (except for the largest adults). It is hypothesized that anthropomorphic food sources (seafood processing facilities discharging wastes into the Apalachicola river-mouth) may influence the winter habitat use pattern of sturgeons in the Apalachicola population, keeping the population concentrated within a limited activity area. In contrast, the Suwannee population, with food resources uninfluenced by human activities, depends upon naturally-occurring benthic prey species with patchy distributions. Individual movement patterns displayed in Suwannee Gulf sturgeon juveniles are interpreted as evidencing searching/foraging behavior. A much more robust (52 acoustic listening posts deployed in a systematic grid pattern)0 follow-up study was conducted for the Suwannee population in winter 2007-08, with data to be downloaded in May and reported at this symposium, as well.

S7-11

Habitat selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone

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Habitat selection of early juvenile Atlantic sturgeon *Acipenser oxyrinchus* have been little studied and remain largely unknown throughout the species' range. A recent multidisciplinary project on the ecological impacts of dredged sediment disposal operations in the St. Lawrence estuary presented us with an opportunity to examine some aspects of Atlantic sturgeon ecology. In 2000–2002, survey trawling, ultrasonic telemetry, benthos sampling, and hydrodynamic modeling were used to determine habitat use and selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone. Fish were located mostly in freshwater

relatively close to the salt wedge boundary and far from the shore, intertidal zones, and islands. They mostly used the 6–10 m depth range relatively close to a channel, in areas with low bottom current velocities, and over silt–clay substrates. Salinity and distance from the salt wedge were the two most important variables explaining their habitat selection. Young-of-the-year Atlantic sturgeon used similar depth ranges, bottom salinities, and current velocities, but occupied mainly sandy substrate. Management implications of these results are discussed in relation to the impact of dredging and sediment disposal operations in the St. Lawrence estuary.

S7-12

Evidence of behavioural habitat selection in juvenile Atlantic and shortnose sturgeons

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Laboratory-derived bioenergetics models have been used to predict habitat suitability for endangered and depleted species such as Atlantic and shortnose sturgeons. Implicit in the application of these models is the assumption that the distribution of sturgeons is determined through the behavioural selection of suitable habitats. In a series of laboratory choice experiments, we evaluated behavioural responses of 57 juvenile Atlantic and 49 juvenile shortnose sturgeons (individual mass ~ 25 g), divided and acclimated into three temperature, two oxygen saturation and three salinity levels. Behaviour experiments were conducted using a binomial choice chamber composed of two converging raceways supplied with a constant water flow where temperature, dissolved oxygen saturation (DO) and salinity were controlled to meet experiment specifications. Nine binary combinations of salinity, temperature and DO (choices) were randomly allocated to each chamber arm and tested on each fish, following a random sequence of treatments. We observed that both species were similarly capable to discriminate of selecting the highest offered DO-level (incidence=65% ± 7.0 (SE)), with stronger selection when the lowest prescribed DO saturation (40%) was applied. Behavioural responses to temperature were significantly different between species. Juvenile Atlantic sturgeon chose the lowest provided temperature option at 76% ± 5.7 (SE) incidence, regardless of treatment and acclimation temperature. Juvenile shortnose sturgeon, on the other hand did not show a significant preference among any of the offered temperature choices. No significant preferences were observed among salinity choices involving 1, 8 and 15, with the exception of juvenile Atlantic sturgeon acclimated to 15, which showed selection for this salinity over any of the other choices in 75% ± 8.9 (SE) of the trials. Behavioural responses to dissolved oxygen were the strongest and matched expectations from bioenergetics and survival models. Habitat choice for temperature and salinity did not match model predictions as consistently.

S7-14

Circadian or diel depth changes in shortnose (*Acipenser brevirostrum*) and Atlantic sturgeon (*A. oxyrinchus*) in Connecticut waters

Tom Savoy[1] (presenting), Jacqueline Benway[1], Kevin Friedland[1]. [1]CT Dep. Environmenatl Protection, Old Lyme, CT, United States

Circadian rhythms are apparent in all phyla, yet little understood in fish. We present evidence of apparent diel patterns in movement of two species of sturgeon in Connecticut waters from acoustic telemetry. Depth-sensing ultrasonic transmitters were implanted into shortnose sturgeon (20 in 2002, 19 in 2003) and Atlantic sturgeon (18 in 2006, 22 in 2007). Over 1.4 million observations of shortnose sturgeon and over 200,000 observations of Atlantic sturgeon were recorded from acoustic receivers deployed throughout Connecticut waters. Numbers of observations per individual ranged from 853 to 120,896. Shortnose and Atlantic sturgeon utilized deeper water during daylight hours. Shortnose sturgeon were active throughout all months of the year with similar movement patterns. Atlantic sturgeon are not present in Connecticut during the winter and thus receivers were only deployed seasonally and information available from May thru November. Individuals of both species move to greater depths during daylight hours. and continued this behavior even when moving into deep water (>15.0 m for shortnose, and >30.0m for Atlantics), despite the likelihood of few visual cues from light attenuation in turbid waters. All sturgeon with ultrasonic transmitters did not display precise diel patterns, some fish display unique movement patterns to confound analyses.

S7-15

Growth variation among juvenile lake sturgeon: a consequence of competitive interactions or an adaptive strategy?

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Size variability within cohorts, generated by inter-individual differences in growth rates, has been observed across plant and animal populations. It is particularly interesting that these deviations can emerge within cohorts reared together with adequate resources under controlled conditions. Social interactions (e.g. dominance hierarchies) are most often attributed to growth variations; however, trade-offs between increased growth and mortality for some species (e.g. reduced antipredatory responses, immune function and resistance to physiological stressors) suggest an adaptive quality to slow growth rates and an explanation for its persistence in some populations. Growth variability within lake sturgeon (*Acipenser fulvescens*) cohorts has been observed under culture conditions but the processes involved that influence this phenomenon have received limited exploration. Progeny from wild lake sturgeon collected in the spring of 2008 will be reared under two treatments (isolation and groups) in an attempt to determine whether growth rate is an inherent trait or the product of competitive asymmetries. Experiments will be conducted on offspring produced from a single cross (i.e. one male and female) to control for genetic differences. If variable growth rates are due to inherent differences, we would expect variance among growth rates to be similar between treatments. Conversely, if variable growth rates are due to competitive interactions, the growth rates of fish reared in groups should be more variable than those individuals reared in isolation. Results may suggest that the lake sturgeon's life-history strategy is to produce phenotypically diverse offspring to maximize fitness (i.e. form of bet hedging). Alternatively, results may suggest that lake sturgeon populations consist of competitively dominant and inferior individuals. Both outcomes present interesting insights into the potential structure of lake sturgeon populations.

S7-16

A GIS-based niche model for mapping and monitoring white sturgeon habitat in the lower Columbia River, USA

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We developed a GIS-based niche model that characterizes in a spatially explicit manner white sturgeon *Acipenser transmontanus* habitat in the lower Columbia River, USA. The niche model was developed using riverbed slope and roughness, water depth, fish positions collected in 2002, and Mahalanobis distances (D2). In the model development stage, we compared a full-rank model based upon dissimilarity to an optimum configuration to two reduced-rank models that focused upon a minimum set of basic habitat requirements. We calibrated the models by identifying a D2 threshold under which 70% of white sturgeon relocations occurred in 2002. Our project goal was the identification of the most appropriate model for characterizing sturgeon habitat and assessing changes in potential habitat within the project area. Model selection involved comparing the accuracy and specificity of each model to an independent dataset that was collected in 2003. We selected the full-rank model to meet our project goal because it had higher accuracy and specificity than the reduced-rank models. Our analysis revealed that white sturgeon prefer moderate to high water depths and riverbed slopes, and moderate riverbed roughness. Using these criteria, as represented by a D2 threshold ≤ 3.19 (i.e. high-potential habitat), the model was 81.2% accurate in 2003. The eigenvectors indicated that riverbed slope and roughness were more important than water depth, but all 3 variables were important. We assessed the sensitivity of the full-rank model to channel modifications by synthetically filling a deep-water pool to different depths and calculating the change in D2. Synthetic pool-filling revealed that high-potential habitat declined ≤ 2.1% when up to ~9 m of fill was added, declined 15.1% when ~12 m was added, and declined 42.7% when the pool was completely filled (~15 m of fill added). Future research should consider water velocity as a variable as well as model applicability to other areas in the Columbia River.

S7-17

Evidence of fall spawning in Gulf of Mexico sturgeon, *Acipenser oxyrinchus* desotoi, in the Suwannee River, FL

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Gulf of Mexico sturgeon, *Acipenser oxyrinchus* desotoi, spawn in March and April following immigration into rivers. However, probable fall spawning has been indicated in the Suwannee River, FL, from captures of sturgeon that were ripe or exhibited just-spawned characteristics in the fall. The capture of a 93 mm TL young-of-the-year Gulf sturgeon on 29 November, 2000, which would have been spawned in late September, 2000, is conclusive evidence that fall spawning occurs in the Suwannee River. Analysis of age-at-length data indicates that approximately 20% of the Suwannee River Gulf sturgeon population may be attributable to fall spawning. The option to spawn in either spring or fall may represent an elegant solution to the hazards of climatic change, in that Gulf sturgeon have spawning alternatives to counter environmental variables such as drought.

S7-18

Use of pop-up satellite archival tags and GIS to estimate movements, habitat use, and threats for adult Atlantic sturgeon in the ocean

Daniel Erickson[1] (presenting), Andy Kahnle[2], Michael Millard[3], Gosia Bryja[4], Amanda Higgs[2], Jerre Mohler[3], John Sweka[3], Gregg Kenney[2], Mark Dufour[2], Ellen Pikitch[1]. [1]University of Miami, Pew Institute for Ocean Science, New York, New York, United States, [2]New York State Department of Environmental Conservation, New Paltz, New York, United States, [3] U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, Pennsylvania, [4]United States Wildlife Conservation Society, Bronx, New York, United States

Oceanic migratory patterns and habitat use by Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) are largely unknown. Although mark-recapture studies have been conducted to describe these patterns for juvenile Atlantic sturgeon, results are incomplete because sample sizes are small (i.e. rare recapture events) and data are biased since they are fishery-dependent. Virtually nothing is known about oceanic-migratory patterns for adult Atlantic sturgeon. We used pop-up satellite archival tags (PSATs) to describe movements, habitat use, and concentration sites for adult Atlantic sturgeon while in the open ocean. These tags record date, time, light, depth, and water temperature while attached to fish. At a programmed date, the tags release, float to the surface, and transmit summarized data to satellites. Twenty three adult Atlantic sturgeon were tagged with PSATs in the Hudson River during June and July of 2006 and 2007. These fish entered the river to spawn, and returned to the ocean between July and October of the tagging season. Although we encountered some problems (e.g. a number of tags were lost before the programmed pop-up date), we found that these tags produced numerous position estimates using light levels (day length and time at mid-day or mid-night). The precision of these light-based position estimates was improved using depth and temperature information. Our PSAT data have produced hundreds of reliable position estimates as well as preferred depths and water temperatures for adult Atlantic sturgeon in the ocean - independent of fishing operations. Using these data, we describe the migratory corridors and concentration sites for adult Atlantic sturgeon from the Hudson River while in the ocean. Potential threats to this stock of Atlantic sturgeon are described by combining these results with other data sources (e.g. fishing).

S7-19

Movement patterns and habitat use of adult lake sturgeon in an impounded river system

Holly Labadie[1] (presenting), Steve Peake[1]. [1]University of New Brunswick, Fredericton, NB, Canada

Lake sturgeon are endemic to the large lakes and rivers of the Hudson Bay, Great Lakes and Mississippi drainages. These fish are endangered or threatened throughout most of their natural range because of habitat destruction and over fishing. The purpose of this study was to determine seasonal adult lake sturgeon movement patterns and habitat use in the Winnipeg River, Manitoba, Canada. Adult lake sturgeon were caught using large mesh gill nets in the Winnipeg River between two generating stations in the spring and fall of 2007. Twenty eight fish were tagged with acoustic transmitters and released, and 74 Vemco VR2 hydrophone dataloggers were deployed such that the entire stretch of river (approximately 34 km) was covered. Substrate samples were also taken, and water quality parameters were measured along several transects passing through various sections of the river (i.e.: rapids, narrow areas and lakes). Movement data as recorded from the VR2 array (collected in 2008) will be presented in context with measured habitat variables.

S7-20

Using telemetry to evaluate modification in the spatial distribution of the Eastmain River lake sturgeon (*Acipenser fulvescens*) after dam construction and reservoir impoundment in James Bay territory (Québec)

Frederic Burton[1] (presenting), Marc Gendron[1], Michel Simoneau[1], Jean-Jacques Fournier[2]. [1]Environnement Illimite inc, Montreal (Quebec), Canada, [2]Hydro-Quebec, Montreal (Quebec), Canada

After impoundment of the Eastmain 1 reservoir, during winter 2005-2006, 76 adults lake sturgeon were marked with internal or external radio transmitters and tracked down below the dam and the power plant. Tracking was conducted four months/year, from May to July to identify the modification in the spawning and feeding habitat, and in February to locate the wintering habitats. Those localizations are compared with pre-construction localizations. We find out a significant difference in habitat utilization after reservoir impoundment as re-localization of spawning and wintering habitats. In the reservoir Eastmain 1, a program of lake sturgeon implantation is going on since 2005 where the objective is to introduce 30 lake sturgeons per year until 2014. At the present time, 80 of those planted sturgeons have been marked with radio transmitter. We wanted to see how lake sturgeon will colonize a newly impounded reservoir. Since the beginning of the introduction program, we observe that lake sturgeon mainly stay in lotic environment in the upper part of the reservoir.

S7-21

Fine-scale movement patterns of adult lake sturgeon during spawning

Stephan Peake[1] (presenting). [1]University of New Brunswick, Fredericton, NB, Canada

Lake sturgeon are spring spawners, and may undertake extensive migrations to reach the spawning grounds, which are often located downstream of migratory barriers such as rapids or hydroelectric installations. However, detailed information on behaviour and micro-habitat use, relative to available habitat and hydropower operations, is scarce because it is difficult to track spawning fish into turbulent and acoustically noisy environments. We used various methods (netting, telemetry, egg traps, etc.) in an attempt to provide this information for a population inhabiting the Winnipeg River, Manitoba, Canada. Data in 2007 suggested that adults spawned near the tailrace of a large hydro dam, where water flows were highest (water levels in spring were low and spillways were not in operation). Substrate in the area was relatively poor in quality (primarily bedrock). High flows are expected in 2008 and, based on 2007 results which suggest fish select habitat based primarily on hydraulic variables, we expect behaviour and habitat use during a high water season to be markedly different.

S7-22

Balancing mineral resource extraction and protection of a lake sturgeon population in a northern Ontario River

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The extraction of mineral resources can, if not well planned, significantly impact the surrounding natural environment where that activity is occurring. The operation of a nickel/cooper mine associated with a known lake sturgeon spawning area within the Upper Groundhog River, part of the James Bay watershed, represents an example of how a balanced approach can be taken to managing mineral extraction while at the same time providing for the protection of an important species of concern. This paper will review the development of a monitoring program and comment on the challenges and benefits derived from an adaptive management approach. Treated mine water effluent from the Montcalm Mine, located near Timmins, Ontario, is discharged to the Upper Groundhog River via a buried pipeline and in-river diffuser system. As a result of permitting requirements stipulated by the province of Ontario, the mine has undertaken an annual monitoring program since 2004 to evaluate the potential impacts of mine water effluent on the spawning population within the area known as Six Mile Rapids. The monitoring program focuses on the lake sturgeon spawning period to determine if the release of treated mine water effluent is impacting the spawning population. Initially the challenge was designing a program that included measurable monitoring end points to determine if impacts were occurring in the context of a long lived species with a protracted life history. The result was the design of a program which was divided into a series of study components with the overall objective of assessing the potential pathways, or linkages, between the discharge of treated mine effluent and lake sturgeon in the Groundhog River. Study elements include monitoring spawning habitat utilization, evaluating egg/larval survival and development; and collecting population characteristic (i.e. length, weight, age, tag returns, genetic structure) data. Results from the annual monitoring programs have been used by both the mine operator and regulator as an adaptive management tool and have resolved some of the operational concerns originally associated with the mine. Lessons learned from this program may prove helpful to other industries and regulators faced with the challenge of managing development in the presence of lake sturgeon.

S7-23

Understanding lake sturgeon spawning demographics in a northern Ontario river

Chris Pullen[1] (presenting), Robert Mellow[1], John Seyler[1], Dana Shmidt[1]. [1]Golder Associates, Ottawa, Ontario, Canada

Lake sturgeon spawning activity has been monitored since 2003 within the James Bay watershed at two locations on the Groundhog River. Population data has been collected as part of a monitoring program that has specific objectives that must be met on an annual basis as specified in mine authorizations from the provincial government. While the monitoring program is not designed to test a hypothesis in the traditional sense, the data collected on lake sturgeon is valuable in understanding lake sturgeon population structure and dynamics from a population that has not been subject to intensive study. This paper summarizes the data that has been collected to date and compares and contrasts it with data from other spawning populations in North America. The population characteristics data set collected spans the period from 2003 to 2007. Data collected include length, weight, age, sex, tag returns and spawning habitat characteristics. An analysis of the data indicates that the Groundhog River's annual spawning cohorts display demographic structure, meristic characteristics and age ranges similar to other populations monitored in more southern locations.

S7-25

Indirect measures of reproductive state in lake sturgeon

Peter Allen[1] (presenting), W. Gary Anderson[1], Stephan Peake[2]. [1]University of Manitoba / Canadian Rivers Institute, Winnipeg, Manitoba, Canada, [2]University of New Brunswick, Fredericton / Canadian Rivers Institute, Fredericton, New Brunswick, Canada

Techniques that indirectly measure reproductive developmental state and minimally impact sampled animals are important for management purposes, and particularly for the conservation of rare species. The lake sturgeon, *Acipenser fulvescens*, is a declining or endangered species in many Canadian ecosystems. Low abundance, late reproductive maturity, slow egg development, long reproductive intervals, and a lack of external sex characteristics pose challenges for population assessment of this species. Population management and size estimates can be greatly improved with additional information on reproductive maturity. Understanding the annual size of the spawning population can benefit population status assessments and long-term population modeling for estimates of reproductive output. We sampled wild adult lake sturgeon from the Winnipeg River, Manitoba in order to determine indicators of reproductive development for use in population assessments. Adult lake sturgeon were sampled for blood indicators of sex and stage of maturity, and gonadal biopsies were collected for histological verification. Fish from both sexes and all reproductive stages were used to determine the best indicators of sex and reproductive development stage. Results will be discussed in the context of management and conservation of this species. Research supported by Manitoba Hydro and NSERC (CRDPJ 321520-05).

S7-26

Shortnose sturgeon in the Ogeechee River, Georgia

Daniel Farrae[1] (presenting), Douglas Peterson[1]. [1]University of Georgia, Athens, GA, United States

The Ogeechee River, Georgia is thought to contain one of the smallest populations of the endangered shortnose sturgeon (*Acipenser brevirostrum*). Despite more than four decades of federal protection, recent studies suggest that the population has not recovered. The objectives of this study were to: 1) estimate current abundance, and 2) evaluate the population age structure as an indication of potential population bottlenecks that may be limiting recovery. From June–August 2007, we used bottom-set entanglement gear to sample the population and to conduct a mark-recapture estimate of abundance. Over the 3-month sampling period, we captured 111 shortnose sturgeon, including 15 recaptures, yielding a Schnabel estimate of 368 (95% CL; 223–657) individuals. Age determinations from pectoral fin spines revealed that <2% of the fish captured were juveniles. Similar studies of shortnose sturgeon in the Altamaha river showed that juveniles comprise >50% of that population. These findings suggest that while the Ogeechee River population may have increased slightly in recent years, it remains limited by persistent recruitment failure.

S7-27

Use of fishery independent surveys to determine abundance, habitat, distribution and age class structure of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) within the Atlantic Ocean

Keith Dunton[1] (presenting), Adrian Jordaan[1], Michael Frisk[1], David Conover[1]. [1]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, United States

In 1998, a 40 year moratorium was enacted to prevent the harvest of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*. Currently there are concerns that Atlantic sturgeon recovery is being hindered by by-catch in the near-shore oceanic fishery. While little information exists on the oceanic habitats of Atlantic sturgeon, commercial fishers have frequently reported large by-catch of this species within the near-shore environment. We used the results from NJDEP, NYSBU, and NMFS fishery independent surveys to identify the relative abundance, distribution, age-class structure and habitat preferences of Atlantic sturgeon within the Northeast Atlantic Ocean. Long term data trends from NJDEP survey suggest that juvenile recruitment to the marine fishery has improved over the last four years. Observations suggests sturgeon have a strong depth preference of 10-15 m with no sturgeon captured in water deeper than 30 m. CPUE and distribution varied with each season with the highest catches occurring in NY and NJ. Results show that 42% of all sturgeon captures occurred within a small area near the mouth of the Hudson River. Limited tag recaptures suggests that the population within this area is may be quite large and warrants further protection as essential fish habitat. Sturgeon sizes within this area ranged from 66-248 cm TL with peak size distribution ranging from 90-110 cm TL. Preliminary analysis suggests that 81% of the sturgeon encountered within this area were juveniles between 5-11 years old. A total of 11% represent fish that are potentially mature adults.

S7-28

Predicting local extinction of pallid sturgeon in the Mississippi River

James Garvey[1] (presenting), Steven Bartell[2], Thomas Keevin[3]. [1]Southern Illinois University, Carbondale, IL, United States, [2]E2 Consulting Engineers, Inc. Maryville, TN, United States, [3]US Army Corps of Engineers, St. Louis, MO, United States

The pallid sturgeon *Scaphirhynchus albus* is an US federally endangered species that resides in the drainages of the Mississippi and Missouri Rivers. Natural reproduction only occurs in a portion of its range, including the 200-km reach of the Mississippi River where harvest of its congener, the shovelnose sturgeon *S. platorynchus*, is still permitted. Incidental harvest of the pallid sturgeon occurs, even given the best efforts of the conservation enforcement community; we explored the potential impact of harvest at varying rates on population dynamics of this endangered species using empirical data plus population viability modelling. We quantified mortality, sex-specific maturation schedules, and reproduction through standardized sampling (gill nets plus trawling) across multiple years. An age-structured demographics model was constructed to assess how population density changes as a function of differing scenarios of fishing mortality. Annual mortality rate of the pallid sturgeon was similar to that of the sympatric shovelnose sturgeon. Current rates of purported fishing mortality led to extinction of the local population of pallid sturgeon in the demographics model within 15-20 years, given no other stochastic events that affect reproductive success. However, in the absence of any fishing mortality in the model, the population grew unchecked. Therefore, we need to improve our understanding of mechanisms regulating population growth in this river reach (e.g. density dependence, habitat, etc.). Given the likely vulnerability of the pallid sturgeon to incidental harvest and the difficulty in enforcing the prevention of intentional or accidental take, we recommend that regulatory agencies consider curbing harvest of the shovelnose sturgeon to allow the congener to recover.

S7-29

Validation of true age of lake sturgeon and implications for population and harvest management

Ronald Bruch[1] (presenting), Shannon Davis-Foust[1], Michael Hansen[2], Steven Campana[3]. [1]WI Dept. of Natural Resources, Oshkosh, WI, United States, [2]University Of Wisconsin-Stevens Point, Stevens Point, WI, United States, [3]Bedford Oceanographic Institute, Dartmouth, Nova Scotia, Canada

Age data are likely the most important data collected on managed fish populations. Ages of sturgeon have been estimated by counting growth marks on a variety of bony structures but the structure of choice for the last 100 years, pectoral fin rays, have never been fully validated to verify the ages estimated from them are the true age of the fish sampled. The validity of ages estimated from growth marks on pectoral fin ray sections of lake sturgeon from the Winnebago System in east central Wisconsin was examined through mark and recapture of known age fish, and by comparing bomb radiocarbon levels in otolith cores to a reference time series of bomb radiocarbon developed for Lake Winnebago. Ages estimated from pectoral fin ray sections were found to be relatively accurate for fish up to 13-15 years of age (98-103 cm, 39-41 in), but generally underestimates of true age for fish older than 15 years of age. The power function True Age = 1.35703*(Est Age^0.9606) was used in an age error key to correct >14,000 age estimates collected during winter spearing harvests from 1954-2007. Corrected catch-age data were used in a Statistical Catch at Age model to estimate annual recruitment, instantaneous fishing mortality and abundance. The harvest predicted by the SCAA model correlated 94.9% with actual harvest. For the period 1954-2007, SCAA estimated average F at 0.0369 (S.E. 0.0044), and A at 0.0965 (S.E. 0.0038). A sensitivity analysis estimated M to be 0.065. The validation of true age of lake sturgeon shows the species grows slower and matures later than reported earlier for the Winnebago System, and verifies that maintaining annual exploitation rates below 5% will allow a lake sturgeon stock to grow at an intrinsic rate of population increase (r) of 0.0585. Lake sturgeon life history parameters used in management decision making need to be based on accurate age estimation data to prevent overharvest of this k-selected species.

S7-30

Evaluation of recovery goals for endangeredwhite sturgeon in the Kootenai River, Idaho USA

Vaughn Paragamian[1] (presenting), Michael Hansen[2]. [1]Idaho Department of Fish and Game, Coeur d Alene, Idaho, United States, [2]University of Wisconsin Stevens Point, Stevens Point, Wisconsin, United States

Our objective was to evaluate recovery goals for endangered white sturgeon *Acipenser transmontanus* in the Kootenai River, Idaho. We used demographic statistics for white sturgeon in the Kootenai River in a stochastic density-dependent population model to estimate recruitment rates needed for population recovery. We simulated future abundance of white sturgeon in the Kootenai River over a 25-year period and a range of hypothetical recruitment rates to estimate the level of recruitment that would lead to population recovery (7,000 fish, the number that were present before the population suffered recruitment failure). We compared simulations of future abundance at enhanced levels of recruitment to those based on the present status of the population and to the recruitment criterion in the Kootenai River White Sturgeon Recovery Plan. We found that the population would decline to only 57 individuals after 25 years and 6 individuals after 50 years if recruitment failure continued. The population reached the target carrying capacity of 7,000 individuals within 25 years only when each adult produced 0.4 age-1 recruits, a recruitment rate equivalent to reaching the target level of recruitment in the recovery plan every year. In contrast, the population grew to only 1,200 individuals if the target level of recruitment in the recovery plan was produced in only three of every ten years, as specified in the recovery plan. We recommend that recovery goals for white sturgeon in the Kootenai River be modified as follows:[1] a population goal of 7,000 sub-adults and adults;[2] population recovery within 25 years; and[3] a minimum recruitment rate of at least 20 age-1 juveniles detected from each year class in each of 10 years using a standardized monitoring protocol.

S7-31

Stock-recruit dynamics of Atlantic sturgeon in the Altamaha River, Georgia: a baseline for evaluating species recovery

Paul Schueller[1] (presenting), Douglas Peterson[1]. [1]University of Georgia, Athens, GA, United States

Recent studies of Atlantic sturgeon spawning runs in the Altamaha River, Georgia, have documented annual run sizes of approximately 190-390 adults, however evaluating population recovery is difficult without historical (pre-exploitation) abundance data. To help assess recovery of the population, the objective of this study was to quantify recruitment of age-1 juveniles in relation to annual adult run size to better understand stock-recruit dynamics of the population. From 2004-2007, we used entanglement gear to collect adults and juveniles in the tidally influenced portion of the Altamaha River. We used Multi-strata, Robust design models to estimate demographic parameters, including juvenile and adult abundance, annual survival, and recruitment. Over the 4 years of the study we captured 370 adults, and 1127 juveniles. Annual run sizes of 324, 386, and 211, produced age-1 cohorts of 1417, 326, and 1323. Peak outmigration occurred at age-2 or 3, depending on abundance of younger cohorts. Our data suggest that small variations in annual run size (<50%) may result in large variations (up to 400%) in corresponding cohort abundance. These findings should provide a baseline for monitoring population recovery in other southern rivers; however, further studies are needed to better understand how environmental variations affect stock-recruit dynamics.

S7-32

Lake sturgeon (*Acipenser fulvescens*) artificial fertilisation, rearing and propagation at the Eastmain-1 hydroelectric

development (Québec): a conservation program in collaboration with the Cree.
Jerome Gingras[1] (presenting), Frederic Burton[1], Marc Gendron[1]. [1]Environnement Illimite inc, Montreal Quebec, Canada

The construction of the Eastmain-1 powerhouse began in 2002, impoundment of the reservoir was completed in June 2006 and the powerhouse commissioning was staggered between August and December 2006. One of this project's mitigation measures is the production and release of lake sturgeon in the Eastmain River just downstream of the dam and in the Eastmain 1 reservoir. The stocking program began 2004 and will end in 2014. Lake sturgeon larvae and YOY are produced in a field hatchery close by the river. At every step of the protocol, there is a collaboration with members of the Cree nation with the aim of technological transfert. Since 2004, a total of 89 000 larvae (2 cm), 24 747 larvae (3 to 4 cm) and 21 920 YOY (6 to 10 cm) where introduced in the Eastmain River just downstream of the dam. In the Eastmain 1 reservoir, a total of 29 000 larvae (2 cm), 21 866 YOY (6 to 10 cm) and 88 adults where introduced in the new reservoir with the objective of starting a new population.

S7-33
Status of Stocked Lake Sturgeon in Targeted Restoration Waters of New York
Dawn Dittman[1] (presenting). [1]USGS Tunison Laboratory of Aquatic Science, Cortland NY, United States

In response to the imperiled status of the key native species, lake sturgeon (*Acipenser fulvescens*), the NYSDEC is following a recovery plan to maintain or reestablish lake sturgeon populations in at least eight separate locations. The Genesee River received 1,900 fingerlings in 2003-2004. As of October of 2007, 677 individuals have been recaptured and floy tagged. Catch rates in 07 were 20 to 35 sturgeon per night. The estimate of the number juvenile sturgeon still using the river is 900 to 1,200. The average size of 4 year old fish was 603mm & 918g. The 3 year old fish averaged 505mm and 571g. In Cayuga Lake system 3,772 fall fingerlings of 4 year classes (95, 98, 00, 04) were stocked. In 2005, 16 sturgeon were caught in the Cayuga outlet, the average length was 1.13m. In May 06, 2 sturgeon were caught. One was a ripe male, 9.29 kg and 1.21m. At 11 years old he was in the lower range of age for the start of sexual maturity in sturgeon. Netting in August resulted in 29 sturgeon, average size 1.1m and 8.1kg. In addition, to these detailed evaluations, I will discuss the status and observed habitat use of stocked sturgeon in other target restoration rivers, including the St. Regis (received 5,000 fingerlings 98-04) and the Raquette, received 800 fingerlings in 2004. Understanding the life history details and success of stocked sturgeon in the available habitat is a vital input into sturgeon management progress in New York and across the Great Lakes Region.

S7-34
Lake sturgeon reintroduction in the Coosa River System, Georgia, United States
Justin Bezold[1] (presenting), Douglas Peterson[1]. [1]University of Georgia, Athens, Georgia, United States

Lake sturgeon *Acipenser fulvescens* were once abundant in the Coosa River of northwestern Georgia; however, habitat degradation and over-exploitation during the 1900s contributed to their extirpation. In fall 2001, the Georgia DNR initiated a new reintroduction program to restore the population. Our objectives were to evaluate the success of this reintroduction program. From fall 2004-2007, we captured juvenile lake sturgeon using bottom set entanglement gear to evaluate post-stocking growth and survival. We also used radio-telemetry to monitor seasonal movements and habitat use of age-1+ juveniles. Over 3 years of sampling, we captured 682 lake sturgeon measuring 270 – 790 mm TL, with annual cohort survival rates varying from 1 – 14%. Length at age analysis showed that although growth was slightly slower than expected, relative conditions were comparable to those reported for northern populations. Radio-telemetry data showed that lake sturgeon were most active in spring and fall and that reservoir habitats were preferred in all seasons except during late summer when dissolved oxygen declined to <3.0 mg/L. While our findings show that a juvenile lake sturgeon population has been re-established in the Coosa River System, reservoir hypoxia during the summer months may limit the ultimate success of the restoration program.

S7-P-1
Lake sturgeon spawning habitat enhancement through flow manipulation
Mike Friday[1] (presenting). [1] Lakehead University, Thunder bay, Canada

The base of Kakabeka Falls on the Kaministiquia River ON is an historical spawning site for adult lake sturgeon. This site however, is often dewatered during the period of spawning for power production and scenic flows for Kakabeka Falls Provincial Park. Controlled flow conditions over the falls were provided by Ontario Power Generation to determine flows necessary for adult sturgeon to access this site and facilitate successful spawning, hatch and larval drift. We examined flows of 23 m3/sec (2004 and 2005), 17 m3/sec (2006) and "scenic flows" in 2007. Scenic flows fluctuate between 0.34 m3/sec (at night), 4.25 m3/sec (weekdays) and 8.5 m3/sec (weekends). To monitor sturgeon movements into the spawning area radio telemetry was utilized. Adult sturgeon were tagged in the lower river (with external radio transmitters) when they were known to be migrating upstream to spawn. Their movement into the spawning area and migration back downstream was monitored using an ATS data logger. Larval drift netting was carried out to document spawning success under these flow regimes. During flows of 23 m3/sec and 17 m3/sec access and successful spawning occurred. Scenic flow conditions resulted in limited access and reduced spawning success.

S7-SP-1

Results of a formal review of recruitment failure hypotheses for white sturgeon (*Acipenser transmontanus*) from the upper Columbia River

Gary Birch[1] (presenting), Paul Higgins[1], Robin Gregory[2], Graham Long[3]. [1]BC Hydro, Burnaby, B.C. Canada, [2]Decision Research, Galiano Island, B.C. Canada, [3]Compass Resource Management Ltd. Vancouver, B.C. Canada

The Upper Columbia River White Sturgeon Recovery Initiative was formed in 2001 and brings together over 25 U.S. and Canadian government, industrial, First Nations and public stakeholders dedicated to the recovery of the white sturgeon in the upper Columbia River basin upstream of the Grand Coulee Dam. The initiative published a recovery plan in 2002 which has since directed the efforts of the program in several areas including conservation culture, population monitoring, recovery research and public outreach. In 2006, the government of Canada listed the white sturgeon in the upper Columbia as endangered under the Species at Risk Act, which formalized the initiatives efforts under a national recovery plan umbrella. Stakeholders and governments have provided variable degrees and time periods of support, driven by different goals and objectives. This has led to effects on program direction, focus and efficiencies in delivery. During 2007-08, the program recovery group re-examined the original recovery plan as well as subsequently developed hypotheses that were being used to explain recruitment failure and develop mitigative responses. The process involved multi-stakeholder decision making which utilizes the weighted judgement of a combination of program experts and external non-aligned experts within a decision framework model. The process was designed to reach consensus among participants on priority hypotheses to be tested and future program direction. This presentation summarizes the results of the review, and demonstrates the importance of using a decision framework to refocus variable opinions within a recovery team scenario.

S7-SP-2

Long-term field evaluation of external and internal telemetry-tagged shortnose sturgeon

Micah Kieffer[1] (presenting), Boyd Kynard[2]. [1]USGS Conte AFRC, Turners Falls, MA, United States, [2]BK-Riverfish, Amherst, MA, United States

We monitored the affects of several tagging procedures on adult shortnose sturgeon *Acipenser brevirostrum* in the Connecticut and Merrimack rivers. Tags mounted externally on dorsal scutes detached after a mean of 95.9 d. Tags mounted through the dorsal fin base were retained a mean of 262.2 d, significantly longer than scute-mounted tags. Loss of external tags resulted from either tissue erosion or tag mount failure. Scute or dorsal fin erosion caused by external tagging healed and had no long-term effects. Tags surgically implanted into the body cavity were usually retained for the tag's operational life, and in most cases, for much longer (mean, 1,370.7 d). Poor healing of incisions was rare. Some internal-antenna (IA) tags were ejected by an unreported method: the tag moved to the posterior end of the body cavity and is forced against the thin body wall adjacent to the anal opening. This tissue ruptures, allowing the tag to exit the body cavity through the rupture in the body wall just to one side of the anal opening. Tag ejection was reduced by coating tags with an inert elastomer. Internal-antenna tags had no deleterious affects on fish and were well-suited for long-term studies. Fish carried IE tags (internal transmitter and external antenna) a mean of 1,532.3 d. The best antenna exit site was at the edge of or through a ventral scute. For IE tags, antenna chafing and tag encapsulation were minimal, and all physical damage healed causing no lasting effects. Neither spawning success of 13 wild females in an artificial spawning stream nor sperm release of 12 wild IA-tagged males observed in the field was affected by internal tagging procedures. There was no effect of tagging on growth as growth of IA and non-tagged males was similar.

S7-SP-3

Determining the timing of seawater migration in juvenile green sturgeon through LA-ICP-MS of pectoral fin rays

Peter Allen[1] (presenting), James Hobbs[2], Joseph Cech[3], Joel Van Eenennaam[3], Serge Doroshov[3]. [1]University of Manitoba, Canadian Rivers Institute, Winnipeg, Manitoba, Canada, [2]Bodega Marine Laboratory, Bodega Bay, California, United States, [3]University of California, Davis, Davis, California, United States

We investigated the use of laser ablation-inductively coupled plasma-mass spectrometry on green sturgeon (Acipenser medirostris) pectoral fin rays, for the examination of initial seawater entry. In control, hatchery fish (n=6), reared 1-2 years in fresh water and 1-3 years in seawater, we found a significant increase in strontium (Sr)/calcium (Ca), decrease in barium (Ba)/Ca, and increase in Sr/Ba (16.5-fold) in fresh water versus seawater calcified growth zones. In wild adults captured in the Klamath River (n=10), the combined evaluation of Sr/Ca and Ba/Ca concentrations proved to be more valuable than Sr/Ba concentrations, likely due to a more complex life history. Ba/Ca concentrations dropped significantly between growth zones 1 and 2 (0.5-1.5 years) indicating a transition into saline waters, such as the estuary. Sr/Ca concentrations increased slightly in the same location, but increased to concentrations found in control fish held in seawater between growth zones 3-4 (2.5-3.5 years). Sr/Ca, Ba/Ca, and Sr/Ba concentrations in growth zones 4-6 (4.5-6.5 years) of wild fish were similar to those found in control fish held in seawater, and corroborated with previous physiological studies and limited field data. These results demonstrate the usefulness of trace element analyses of green sturgeon pectoral fin rays, and an early age of entry into seawater.

S8. Tagging and Its Use in Stock Assessment

S8-1

Using tagging data to inform stock assessments

Paul Conn[1] (presenting), Doug Vaughan[1], John Hoenig[2]. [1]National Marine Fisheries Service, NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, NC, United States, [2]Virhinia Institute of Marine Science, College of William and Mary, Gloucester Point, VA, United States

Stock assessment models often require that scientists make a variety of assumptions about movement, selectivity, mortality, and catchability. If designed and implemented properly, tagging studies provide information about one or more of these parameters, and thus may be ideal complements to traditional assessment approaches. In this talk, we provide a short review of available methods for analyzing tagging data, together with key assumptions that are most likely to be violated in studies of fish populations. We also discuss how such studies can be integrated with age-based methods, focusing on improving the defensibility of stock assessments.

S8-2

Use of natural tags in capture-recapture models: modeling misidentification.

Ken Pollock[1] (presenting), Jun Yoshizaki[1]. [1]North Carolina State University, Raleigh NC, United States

Misidentification of animals is potentially important when naturally existing features, (natural tags) such as DNA fingerprints (genetic tags) are used to identify individual animals. For example, when misidentification leads to multiple identities being assigned to an animal, traditional estimators tend to overestimate population size. Accounting for misidentification in capture-recapture models requires detailed understanding of the mechanism. We outline a framework for modeling the effect of misidentification in closed population studies when individual identification is based on natural tags that are consistent over time (non-evolving natural tags), and introduce methods for estimating population size. We show that conventional estimators can seriously overestimate population size when errors due to misidentification are ignored, and that our new estimators perform better for the cases with moderately high capture probabilities or high misidentification rates.

S8-4

A method for estimating tag induced mortality and initial tag shedding rate of southern rock lobsters (*Jasus edwardsii*)

Matthew Smith[1] (presenting). [1]Virginia Institute of Marine Science, Gloucester Point, Virginia, United States

In tagging studies, initial tag shedding rate and tag induced mortality is often assumed to have a value of 0, which implies that of newly tagged animals, 100 % survive the tagging and 100% of the tags are retained. This assumption is usually justified by cage studies but may be false under natural conditions. Using data obtained from the repeated recapture of southern rock lobster, we develop a method for estimating the joint probability ϕ of surviving the tagging process and retaining the tag. The method requires an initial cohort of lobsters to be tagged, released, and allowed to experience mortality for a period of time at least long enough for any initial tag shedding and tag induced mortality to occur. Subsequent tagging events will recover some previously tagged animals and some untagged animals. The previously tagged animals are recorded and quickly returned to the water and from this point forward are assumed to have a ϕ of 1. Untagged animals are tagged and returned to the water as a second cohort which will experience tag induced mortality and initial tag shedding. If we assume fishing and natural mortality affect the two cohorts equally, the difference in the ratio of tag returns will estimate ϕ. We use moment and maximum likelihood estimators to estimate ϕ for the southern rock lobster. Application of this method is limited by the large number of animals that must be recaptured, but the method may have application for other sessile species and species that congregate in a predictable and recurring manner.

S8-5

A tagging model for estimating survival rates when tag fouling affects detectability: application to queen conch stock assessment

Lynn Waterhouse[1] (presenting), Matthew Smith[1], Steven Newman[2], Kristene Parsons[2], Kathy Lockhart[3], John Hoenig[1]. [1]Virginia Institute of Marine Science, Gloucester Point, Virginia, United States, [2]Center for Marine Resource Studies, School for Field Studies, Turks and Caicos Islands, Turks and Caicos Islands,[3]Department of Environment and Coastal Resources, Turks and Caicos Islands, Turks and Caicos Islands

The “Brownie” tagging models are commonly used for estimating survival rates from multiyear tagging studies. The basic model, Model 1, assumes that all tags have the same tag reporting rate. An alternative, Model 0, allows for newly tagged animals to have a different tag reporting rate than previously tagged animals. It does so through the use of an additional parameter which leads to less precision than Model 1. Model 0’, a brand new model, also allows for newly tagged animals to have a different tag reporting rate than previously tagged ones. It makes use of a known fouling time, the time it takes for newly tagged animals to have the same

visibility as previously tagged animals, to divide the year into two parts. During the first part of the year, newly tagged animals are more visible than previously tagged ones while in the second part all tagged animals have the same visibility. Dividing the year into parts avoids the failure of assumption that all tags have the same reporting rate, makes more use of the data, and provides estimates of the survival rate at the end of the 2nd year instead of after the 3rd year (as in Model 0). Queen conch, strombus gigas, is a commercially and socially valuable mollusc throughout the Caribbean. In many places conch has been overfished and is now protected by the Convention on International Trade in Endangered Species. The Turks and Caicos Islands has a sustainable fishery and is an ideal place to study population dynamics of conch. Model 0' will be used in a tagging study of queen conch in the Turks and Caicos Islands because tags become fouled rapidly there.

S8-6

Estimating rates of mortality and movement using single tag-recovery data unbiased by tag non-reporting and short-term tag losses

Richard McGarvey[1] (presenting), Janet Matthews[1]. [1]SARDI (South Australian Research & Development Institute), Henley Beach, Adelaide, South Australia, Australia

Single tag-recovery data are widely available for stocks of exploited fish and invertebrates. However, incomplete reporting, and short-term tag shedding and tag-induced mortality induce bias using standard estimation models of exploitation rate (Petersen) and movement (Hilborn). Currently under-utilised classes of estimators of mortality and movement are reviewed that are unbiased by these common tag-recovery experimental effects, denoted 'recapture-conditioned' estimators. Using the times-at-large from recaptures, the maximum likelihood estimate of instantaneous total mortality rate is simply one over the mean time at large. Because the mean time-at-large is not biased if some recaptures are omitted from the set of reported recaptures, non-reporting does not bias time-at-large mortality estimates. Chapman derived a finite-sample correction to the maximum likelihood estimate, providing an exact estimate of total mortality rate using conventional single tag-recovery data. Based on a complete sufficient statistic, Chapman's time-at-large estimator for total mortality rate also achieves minimum variance, the highest precision that the data will allow. For estimating movement rates, a constant rate of non-reporting appears top and bottom in a 'recapture-conditioned' model. Thus, the reporting rate cancels from this movement estimation likelihood. Short-term (type 1) tag-induced mortality and tag shedding rates also cancel. By not using the number of animals tagged and released, while using any representative sub-sample of recaptures, these recapture-conditioned mortality and movement estimators obviate type 1 biases, thereby overcoming principal obstacles to wider use of single tag recoveries in fishery stock assessment. The estimates of total mortality rate using the sum of recapture times-at-large from conventional single tag recovery data are straightforward to calculate in a spreadsheet. Data simulation tests of time-at-large mortality estimates under a range of scenarios are presented confirming freedom from biases due to non-reporting and short-term tag losses. For the movement (but not mortality) estimators reviewed, on-going (type 2) losses due to tag shedding and tag-induced mortality also cancel to a good approximation. However, the movement estimates cannot claim minimum variance, not being functions of a complete sufficient statistic. These unbiased mortality and movement rate estimation methods are applicable to historical tag-recovery data sets. Estimated mortality or movement rates can directly inform management decision-making, or be integrated into overarching stock assessment likelihood models. A method of integrating time-at-large data into a stock assessment likelihood is presented. A principal drawback of time-at-large mortality estimation is the relatively long experimental time frame.

S8-7

Sensitivity of tag-recovery mortality estimates to tag shedding, handling mortality, and reporting rate inaccuracies

Travis Brenden[1] (presenting), Michael Jones[1], Mark Ebener[2]. [1]Michigan State University, East Lansing, MI, United States, [2]Chippewa Ottawa Resource Authority, Sault Ste. Marie, MI, United States

We used Monte Carlo simulations to evaluate the sensitivity of tag-recovery mortality estimates to inaccuracies in tag shedding, handling mortality, and tag reporting. The data-generating model used in the simulations assumed that tagging was conducted every year for four years with tag recoveries occurring over a four year period, and that instantaneous fishing (F) and natural (M) mortality were constant at 0.15 and 0.40, respectively. The data-generating model additionally assumed that short-term tag shedding and handling mortality equaled 10%, long-term tag shedding was a sigmoidal function of time since tagging, and tag reporting rates declined exponentially with distance from the tagging site. Estimates of F and M based on the numbers of recovered tags from the data generating model were obtained by assuming different rates and functions for tag shedding, handling mortality, and tag reporting. Tag reporting inaccuracies strongly affected estimates of both F and M. Estimates of M were also strongly affected by inaccuracies associated with long-term tag shedding and by level of tagging effort. When conducting a tagging study, care should be taken to ensure that long-term tag loss and tag reporting have been accurately measured, as inaccuracies in these rates may impart significant biases on mortality estimates.

S8-8

Survival of yellowtail flounder (*limanda ferruginea*) in the northwest atlantic derived from tag-recapture data

Anthony Wood[1] (presenting), Steven Cadrin[1]. [1]NRC/SMAST, New Bedford, MA, United States

Survival of yellowtail flounder off the Northeast coast of the U.S was estimated from analysis of mark-recapture data. Traditional Brownie recovery models were fit to yellowtail tag-recapture data from a recent yellowtail flounder tagging study. Program MARK was used to examine models with time-variant and invariant parameters over different temporal scales (annual, seasonal, and monthly). The models with a monthly time step for both survival (S) and recovery rate (f) had the best overall fit and returned reasonable parameter estimates. Preliminary simulation work to test the goodness of fit of the general model (fully parameterized based on time step) suggest an acceptable model fit. Residual patterns were also explored and no obvious trends were observed. It is likely that non-mixing is taking place for newly released individuals which could be affecting the model fit and resulting parameter estimates. The next step in this study will be to reconfigure data summaries and model structure to better define parameter estimates. Once the models and the data are refined, the overall fit and the resulting parameter estimates should be greatly improved. Estimates of survival from mark-recapture analysis will be considered in 2008 stock assessments of yellowtail flounder.

S8-9

Estimates of fishing and natural mortality of black sea bass in the Mid-Atlantic based on a release-recapture experiment

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Black sea bass between Massachusetts and Cape Hatteras, NC, are exploited by both recreational and commercial fisheries. Fisheries independent survey data for adult fish are highly variable which limits the information necessary for age-based catch at age models. An alternative approach using release-recapture methods was applied to this stock based on three years of tag releases and subsequent recaptures. A seasonal instantaneous rates model was used to estimate fishing and natural mortality. Fishing mortality estimates were between 0.3 and 0.4 whereas natural mortality was greater than 0.2 calculated from maximum age. Higher rates of natural mortality may be a function of different mortality rates among sexual stages of this hermaphroditic species.

S8-10

Estimates of abundance from mark-recapture analysis of v-notched American lobster

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In 1996, an oil spill off the Rhode Island coast killed an estimated nine[9] million lobsters. Protection of female lobsters through the application of a V-notch was selected as a restoration tool, aimed at increasing local recruitment. V-notching, however, does not provide a discrete mark, which means the V-notch data are unsuitable for many conventional tagging models. Mark recapture models were used to evaluate changes in population abundance during the restoration period. Three batch-tagging models (Schnabel; Schumacher and Eschmeyer; and Overton) were modified to account for mortality and mark-loss, thereby relaxing conventional model assumptions. Ancillary analysis of a smaller sample of banded lobsters using the Jolly Seber model helped with model structure, estimation, and interpretation. The resulting estimates indicate that lobster abundance increased in the recovery area during the restoration program.

S8-11

Estimation of yellowtail flounder abundance using a Petersen mark-recapture experiment

Jessica Melgey[1] (presenting), Steven X. Cadrin[1], Kevin Stokesbury[1], Christopher Legault[2]. [1]University of Massachusetts, Dartmouth, School for Marine Science and Technology, Fairhaven, MA, United States, [2]National Marine Fisheries Service, Northeast Fishery Science Center, Woods Hole, MA, United States

Yellowtail flounder on Georges Bank are currently considered overfished. Management of the stock is based on quotas, and where the stock overlaps with other commercially-important stocks – for example, scallops – an economic loss may occur when the total allowable catch (TAC) quota is reached via bycatch of the species and the fishery is shut down. Currently, uncertainty exists in the Georges Bank yellowtail stock assessment. A Petersen mark-recapture experiment is being used to provide an estimate of yellowtail flounder abundance and spatial distribution in 'Closed Area II' on Georges Bank which will supplement the conventional stock assessment. The Petersen method is a single recapture event model in which the following assumptions are made: the population is closed, samples are random, marked animals are representative of the population, marks are not lost between capture and recapture events, and all recaptures are reported. Model estimates of abundance and variance as well as adherence to assumptions will be evaluated from the data, along with spatial analysis and investigation into length, age, and maturity structure of the population. Few Petersen studies have been conducted in the open ocean environment, so testing the closure assumption will be very important in order to determine the validity of the model on this spatial and temporal scale. The tagging experiment is planned to be conducted over approximately 10 days, on four vessels, with a total of 100,000 tags applied at random sample stations in the study area. Random tows to sample the population for the proportion tagged will be made in the final three days of the study. The estimate of abundance will be completed shortly thereafter, with analysis of assumptions and spatial distribution occurring in the fall.

S8-12

Fishery management and tag-return estimates of fishing mortality:an example in the NC southern flounder fishery

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Tag-return programs can generate direct estimates of fishing mortality to compliment traditional indirect approaches that use landings data. Tag-return estimates are relatively unbiased and precise, and with adequate study design, they allow immediate, fine-scale estimates of the temporal and spatial distributions of fishing mortality. A large southern flounder (Paralichthys lethostigma) tag-return study was initiated in the New and Neuse Rivers, North Carolina, in order to assess the effects of management changes which were recently enacted to reduce harvest mortality in the fishery. Monthly instantaneous rates of fishing mortality were estimated in each river, after accounting for tag return rate, tag loss, and tagging-induced mortality, parameters to which the tagging model showed sensitivity. Estimates of annual fishing mortality suggested that the targeted fishing mortality was not likely to have been met in all estuaries in years 2005 or 2006. Interannual and interestuary variability in fishing mortality characterized these estimates. The temporal and spatial distributions of fishing mortality illustrate that time and area closures may be an effective tool for reducing statewide fishing mortality. Future NC southern flounder stock assessments can identify the most efficient times and areas for closures by including tag-return estimates of fishing mortality from several estuaries that contribute significant portions of the total annual landings.

S8-13

Hierarchical Bayesian approach to age-structured tagging models

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The Brownie models have long been used to estimate mortality and tag recovery rates from multiyear and age structured tag-return data. Recent formulations by Jiang et al (2007) have modeled the impact of a disease outbreak on Chesapeake Bay striped bass on natural mortality rates. Hierarchical Bayesian (HB) methods allow easy implementation of change point models that incorporate the uncertainty of the timing of the outbreak within the variance structure, reducing the bias in error estimates. In addition, HB inference may increase flexibility of selectivity and mortality estimators within the Brownie framework. Finally, discussion will center on augmenting the model through auxiliary data sources incorporating to improve estimates of aging error, tag reporting rates and mortality.

S8-14

Tag-recapture data and spawning stock survey data indicate potential for a recreational fishery for mature male striped bass in the Delaware River and Bay

Desmond Kahn[1] (presenting). [1]Delaware Division of Fish and Wildlife, Little Creek, Delaware, United States

The Delaware River spawning stock of striped bass is one of the three major stocks producing the Atlantic coastal migratory mixed-stock complex. This stock was reduced to a very low level of abundance during the twentieth century primarily due to water pollution. Secondary sewage treatment upgrades were completed by the late 1980s, allowing increased larval survival and production of young-of-year striped bass. The age structure of mature females on the spawning grounds has steadily expanded, indicating that survival of immature and adult striped bass has been relatively high. Current regulations under Amendment 6 of the Striped Bass Management Plan require recreational fisheries outside of the Chesapeake Bay, Albemarle Sound and the Hudson River to have a 28" minimum size. Length frequency data of mature males on the Delaware River spawning grounds shows that less than 5% of mature males are 28 inches or greater in total length. In contrast, 95% of mature females captured on the spawning grounds are larger than 28" total length. The male component of this stock is largely not exploitable under these regulations. Tag recovery data shows that males infrequently undertake coastal migrations to New England, unlike mature females. Instead, males are more likely to remain in the estuary or move to nearby coastal regions. This sexual differentiation is consistent with current theory on the evolution of anadromy. Mature males in the Delaware River stock are currently subject to only a very restricted quota-regulated commercial fishery, and tag-recovery data indicates that fishing mortality is quite low. There is a good potential for a sustainable recreational fishery targeting these mature males in the estuary, as exists in other producer areas on the Atlantic coast. One approach would be to have a slot limit with limited harvest of fish from 18" to 24" in the estuary. One issue is a need to avoid targeting immature females, which may move onto the continental shelf in warmer weather.

S8-16

An integrated model using catch, catch-per-unit-effort, and tagging data to estimate mortality and abundance for the Aleutian Islands golden king crab (*Lithodes aequispinus*) stock

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The Aleutian Islands golden king crab (*Lithodes aequispinus*) stock contributes to a commercially important male-only fishery. Despite its economic importance, the stock has not been surveyed annually, biological data are limited, and assessment models are lacking. An integrated analysis method is developed which combines commercial catch, triennial pot survey catch-per-unit-effort (CPUE), observer CPUE, and tagging data. The data series ranges from 1983 to 2007 for catch, 1992 to 2007 for observer sampling, and 1997-2006 for triennial pot surveys and tagging experiments. The data are separated into East 174W and West 174W regions because of different fishing period and magnitude of harvest. A Maximum likelihood method is used to estimate time series of fishing mortality, harvest rate, legal male (≥136 mm carapace length, CL) abundance, male recruit (≥101 mm CL) abundance, selectivity, and pot gear catchability. The trends in male recruits, legal male abundance, fishing mortality, and harvest rate are discussed. The recruit and legal male abundances appear not declined in recent years under constant total allowable catch policy.

S8-17

Using a combined telemetry-tag return method to aid the assessment of red drum in North Carolina

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Traditional stock assessment approaches for red drum *Sciaenops ocellatus* are complicated by slot limit harvest regulations and the unique biology of red drum in North Carolina. Subadult red drum *Sciaenops ocellatus* (ages 1-3) are harvested within a slot limit in North Carolina, and the long-lived adults are protected. We used 24 years of tag-recovery data and 3 years of telemetry data to address several limitations of previous red drum stock assessments. Our novel combined tagging-telemetry model estimated the annual natural mortality rate of subadult red drum, which was lower than the rate included in previous assessments using a life history approach. We also estimated an annual fishing mortality rate for 24 years, and a monthly fishing mortality rate in 2005 – 2007; these estimates corresponded well with recent stock assessment results. The tag return model also estimated age-dependent selectivity patterns required by the stock assessment. In addition, the length distribution of caught-and-released fish was estimated using a generalized linear model based on tags recovered within three months of release. Tagging and telemetry approaches can be a viable way to address a variety of shortcomings of traditional stock assessment approaches, as long as several key model assumptions are met.

S8-18

Mark-recapture abundance estimates for 4 species of Pacific Salmon returning to upper Cook Inlet, Alaska using passive integrated transponder tags and radio telemetry

Mark Willette[1] (presenting), Robert DeCino[1], Timothy McKinley[1], Scott Raborn[1]. [1]Alaska Dept of Fish and Game, Soldotna, Alaska, United States, [2]LGL Alaska Research Associates, Inc. Pineville, Louisiana, United States

We estimated the total abundance and harvest rates of coho, pink, and chum salmon returning to Upper Cook Inlet (UCI), Alaska in 2002. Passive integrated transponder (PIT) tags were applied to each salmon species in lower Cook Inlet during July and early August, and tag recoveries in commercial fishery harvests were used to estimate abundance. Radio telemetry tags were also applied to coho salmon to estimate spawner distribution and total escapement into all UCI streams. Coho salmon abundance was estimated at 2.5 million (95% CI: 2.2-2.9 million) giving a commercial harvest rate of 10%. Pink salmon abundance was estimated at 21.3 million (95% CI: 1.6-41.0 million) giving a commercial harvest rate of 12%. Chum salmon abundance was estimated at 3.6 million (95% CI: 3.1-4.2 million) giving a commercial harvest rate of 6%. The total escapement of coho salmon into all UCI streams was estimated at 1.36 million (95% CI: 1.0-1.9 million) with 49% of radio-tagged coho salmon found in the Susitna River watershed. In 2006, we used the same technologies to estimate sockeye salmon abundance in the Kenai River, Alaska. PIT tags were applied to sockeye salmon in the lower river and all salmon swimming through 2 weirs were scanned for tags. Radio telemetry tags were also applied to sockeye salmon to estimate spawner distribution in the watershed. Sockeye salmon abundance was estimated at 3.1 million (95% CI: 2.5-3.8 million). The final destinations of 52% of radio tagged sockeye salmon were between Kenai and Skilak lakes, with only 27% found in the Skilak Lake outlet, an area previously thought to support more spawners. In sockeye salmon, estimated PIT tag retention was 98-100%, and tagging-induced mortality was 7%. Use of two PIT tag antennas to scan for tags at each site allowed for estimation of tag detection rates. Population estimates were adjusted for these sources of error; however,

behavioral effects of tagging may still have biased our abundance estimates.

S8-19

Contributions of radio tagging to the assessment of Susitna River sockeye salmon productivity

Richard Yanusz[1], Mark Willette[1] (presenting), Ted Spencer[1]. [1]Alaska Dept. Fish and Game, Palmer, AK, United States

A basic portion of stock assessment in anadromous salmon management is the escapement, or number of spawning salmon, each year. The escapement of sockeye salmon *Oncorhynchus nerka* returning to the Susitna River in Alaska was estimated using capture-recapture techniques. Both radio tags and passive integrated transponder tags were used to generate escapement estimates and assess model conditions. Radio telemetry yielded additional information on the stock, such as the comprehensive identification of spawning areas, the relative distribution of fish, and the habitat type. This information was used to guide sampling for a genetic baseline and, when combined with ongoing limnological and juvenile salmon sampling, will be used to describe spatial productivity patterns in the Susitna River drainage and improve management.

S8-20

The use of radio-telemetry and coded-wire tags in estimating stock parameters of wild coho and Chinook salmon populations on the Kenai Peninsula, Alaska.

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Multiple tagging technologies were employed to conduct mark-recapture studies of coho and Chinook salmon on the Kenai Peninsula, Alaska. Using coded-wire tags and an across years mark-recapture approach we estimated the drainage-wide (5,206 km2) abundance of Kenai River coho salmon smolt (hundreds of thousands) annually for 16 years. Kenai River coho salmon adult abundance (tens of thousands) was estimated annually for 6 of these years using external spaghetti tags supplemented with backpack radio-tags to estimate the number of effective marks in the population. Spawning escapement and annual marine survival estimates were also derived. Abundance of adult Chinook salmon in the Kasilof River (thousands) was estimated annually for 3 years using external spaghetti tags; a subset of marked fish were tagged with esophageal radio-tags, which yielded important information about the behavior of tagged fish. The study design presented unique challenges: it was necessary to tag fish in the intertidal area where drop-out rates are typically high due to handling and osmo-regulatory stress; and, the condensed study area (river is only 29 km long) precluded using geographic criteria to classify drop-outs. Instead we combined migration data obtained from radio telemetry with time- and area-specific maturity data obtained from the recaptured population to estimate the probability of spawning success for each radio tagged fish. The mean probability of spawning success was used to reduce estimates of M for mark-recapture calculations.

S8-21

Use of a collaborative, integrated acoustic telemetry network to monitor marine and anadromous fishes in the Puget Sound

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Acoustic telemetry is being used at various scales throughout the world to monitor migrations of marine mammals and fishes. Most applications are conducted by individual investigators at small scales or by single large organizations at greater scales. In the Puget Sound, a collaborative and integrated telemetry network has been developing that allows monitoring at multiple scales from individual streams, Puget Sound-wide (2500 miles of shoreline), and along the North American coast-line. The collaboration includes a wide variety of organizations (25 total) and more than 40 investigators or collaborating staff. These groups and researchers have formed an informal consortium that plans, communicates, and implements telemetry research in all geographic areas (freshwater, estuary, marine) of the Puget Sound. The Puget Sound work is integrated with the Pacific Ocean Shelf Tracking (POST) project, an international monitoring network along the west coast that allows tracking of fish as far as Alaska. To date, over 19 species of fish, including freshwater, anadromous and marine, have been studied. The partnership allows development of optimized study designs integrating tagging and receiver deployments for multi-species and multi-objective investigations that could not be realized by individual researchers or organizations.

S8-22

Conflicting results from a large multi-stratum PIT tag study and the Pacific Halibut stock assessment.

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In 2003 and 2004, the International Pacific Halibut Commission (IPHC) released around 67000 electronically tagged Pacific halibut coastwide in the Pacific Northwest, British Columbia and Alaska.   Tag-recovery data to date have been analyzed using multi-stratum tag-recovery models in order to estimate rates of commercial fishing mortality, and rates of migration among IPHC regulatory areas. Recovery rates of tagged fish were unexpectedly low in most areas, leading to much lower estimates of commercial fishing mortality than those obtained by the IPHC stock assessment models. There was significant migration among some regulatory areas, particularly from the western Gulf of Alaska to eastern areas. This finding has overturned the previous assumption of negligible migration of adult fish along the coast, and has led to a change in the IPHC stock assessment from modeling by regulatory area to a single coastwide model. However, the implausible estimates of commercial fishing mortality from the tag-recovery study mean that explicitly integrating the tag-recovery data into the stock assessment modeling would not be desirable.

S8-23

A finite-state continuous-time approach to estimating abundance and instantaneous migration and mortality rates for mixing stocks from tagging and catch data

Tim Miller[1] (presenting). [1]NMFS, Northeast Fisheries Science Center, Woods Hole, MA, United States

Spatially-structured population dynamics models are important tools for assessing harvested fish species that move between stock regions. Many models have been developed to estimate mortality rates and movement rates between regions from tagging experiments. The stochastic process underlying these tag models is also a natural framework for untagged animals that are captured in either commercial fisheries or independent surveys where the cohort identity and region of capture is known. Here I present probability models that derive from treating the regional location and fate of individuals as a stochastic finite-state continuous-time process. The probability models use both recoveries from tagging experiments and raw age measurements from surveys and landings to estimate[1] numbers of individuals recruiting by cohort and stock area and[2] instantaneous migration, fishing and natural mortality rates. I also demonstrate the potential utility of the approach with an example application to a commercially valuable multi-stock species.

S8-24

Consideration of spatial patterns in modeling and managing spawning groups of cod

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Typically, stock assessments assume that fish populations are distributed temporally and spatially as a homogeneous, dynamic pool. Recent tagging investigations of spawning aggregations of Atlantic cod (*Gadus morhua*) off the coast of New England provide high-resolution, individual-based data, which reveal complex patterns of movement and productivity among spawning groups. Evaluation of movement information requires large tagging sample sizes and equally distributed releases to accurately represent stock structure and movements at large geographic and time scales. The mismatch between the individual-based observations from tagging and the dynamic pool assumption of most assessment models makes integrating tagging data into stock assessment models extremely difficult, especially when the level of complexity of movement patterns differs with scale. Movement information, however, can often be of great use in considering or reevaluating stock boundaries, and in harmonizing assessment results affected by differential movement rates and productivity patterns across stock units.

S8-25

Improvement of a spatial age-structured model with mark-recapture data

Terrance Quinn[1] (presenting), Sara Miller[1], Peter-John Hulson[1]. [1]University of Alaska Fairbanks, Juneau, Alaska, United States

A key component in the move towards ecosystem-based fisheries management is resolution of population dynamics at finer spatial and temporal scales. Most current stock assessment models lack a spatial dimension, owing to lack of data about movement. Fish movements can be quite extensive, particularly for marine populations, such as eastern Bering Sea walleye pollock. The main direction of movement for pollock is between the northwest (NW) and southeast (SE) Bering Sea. A prototype two-area, two-season, age-structured stock assessment model previously developed (Miller et al. in press) was used to determine parameter estimability under two scenarios. In the first scenario, fishery and survey data were disaggregated by season and area, but no other data sources were used. In the second scenario, a mark-recapture study was assumed to have occurred during a multi-year period, with recaptures coming from the fishery. Simulated mark-recapture "data" were then generated under various movement scenarios. Other available datasets included fishery and survey catch and age-structure. Surprisingly, many population parameters could be estimated in the first scenario, even when mark-recapture data were not available. Not surprisingly, estimation performance, especially for movement parameters, improved in the second scenario when mark-recapture data were available. We envision that spatial age-structured models for stock assessment will be more widely used in the future, especially if auxiliary information about movement from mark-recapture or other methods can be collected.

S8-26

A Spatially Explicit Model of Yellowtail Flounder

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Accurately modeling yellowtail flounder, *Limanda ferruginea*, is vital because all three U.S. stocks are rebuilding from an overfished condition, and large discrepancies have occurred between model predictions and subsequent stock assessments. Recent tagging data demonstrate movements of yellowtail between stock areas, and this may be affecting the model results as negligible immigration and emigration is assumed in all three assessments. The purpose of this study is to evaluate the sensitivity of stock assessment results to movements of fish between populations. To do this, a spatially explicit forward projection stock assessment model is being developed that includes a mark-recapture component (based on yellowtail tagging data) to the objective function to estimate movement. Future work will also include development of an external large-scale circulation model to assess the effects of egg and larval drift, both within and among stock areas, on recruitment. A simulation study will be performed on the integrated model to assess model performance, and to evaluate the types and amounts of movement which most affect the population dynamics of yellowtail flounder.

S8-27

A simulation-based approach for assessing the performance of a yellowtail flounder (*Limanda ferruginea*) movement-mortality model

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A movement-mortality model was developed in association with a tagging study for yellowtail flounder to evaluate the spatial dynamics of the three yellowtail stocks in the New England region. As the impact of stock mixing on population dynamics parameters is unknown, a simulation approach was used to gauge the effects of measurement and process errors on datasets with similar characteristics as the tagged yellowtail flounder population. Stochastic simulations were developed in which tagged "virtual" fish were released and subsequently recaptured in the model. A reference population was simulated for which "true" parameter values are known, and used to generate release and recapture data as model inputs. Estimates from the statistical model were then compared to the "true" reference values to assess bias and precision. Results from the simulations of moderate movement rates (10-25% per year) and moderate precision of input data (10% to 25% CV) show that fishing mortality and movement were well estimated (<10% bias). Conversely, for scenarios that simulate no movement, low movement (5%) or high movement (45%), model estimates tend to be confounded, indicating that movement rates and fishing mortality could not be effectively differentiated in the model. The implication these results indicate that there is a substantial penalty for imprecise input data, and parameter correlation may be a problem for some applications.

S9. Modeling and Model Selection in Fisheries Science

S9-1

Model based inferences in the aquatic sciences: the concepts of information and evidence

David Anderson[1] (presenting). [1]Department of Fish, Wildlife, and Conservation Biology, Fort Collins, CO, United States

A substantial paradigm shift is occurring in aquatic ecology and resource management. The past century relied on null hypothesis testing, asymptotic distributions of the test statistic, P-values and an arbitrary ruling concerning "significant" or "not significant." These traditional methods are being replaced by "information-theoretic" methods (and to a lesser extent, at least at this time, by a variety of Bayesian methods). These approaches focus on an a priori set of plausible science hypotheses,

$$H1, H2, \ldots, HR .$$

Evidence for or against members of this set of "multiple working hypotheses" consist of a set of probabilities and (relative) likelihoods. Specifically, Prob{H1, H2, …, HR , given the data} and L(H1, H2, …, HR , given the data). These probabilities and likelihood values are direct evidence, where evidence = information = -entropy. Simple evidence ratios allow a measure of the formal strength of evidence for any two science hypotheses. Statistical inference should be about models and parameters, conditional on the data. The new methods have been extended to allow formal inference to be based on all the models in an a priori set (multimodel inference). These methods are relatively simple to compute and understand.

S9-2

Evaluating the use of Akaike's Information Criterion (AIC) in American Fisheries Society publications

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Akaike's Information Criterion (AIC) is increasingly used as a data analysis tool in American Fisheries Society publications. Although AIC represents a valuable approach to examine complex relationships in biological systems, we frequently find studies that do not follow guidelines for the evaluation and interpretation of AIC models. To evaluate how AIC methods are being applied and reported, we reviewed papers published in American Fisheries Society publications from 2002 – 2007. We quantified the number of papers utilizing AIC (N = 95), and evaluated each papers use of this method based on published guidelines. Forty-three percent of authors chose to integrate other statistical paradigms (e.g. testing the significance of parameters and/or whole models) with AIC which represents a serious infraction of the model selection paradigm. The most common infraction we encountered was that 73% of authors failed to include a table of pertinent AIC parameters. Akaike's Information Criteria is a powerful tool that allows for multimodel inference from several models, and we encourage the use of information criteria methods for analysis of fisheries data. However, we recommend that authors follow developed guidelines for the use and interpretation of AIC, and if they decide to deviate from published guidelines they should justify their methods. The continued use of AIC and other model selection techniques in AFS publications could lead to a better understanding of ecological relationships in natural systems, and we hope our findings will generate discussion regarding how AIC results should be used and reported in fisheries literature.

S9-3

Model selection uncertainty with measurement error models: a simulation study

Yan Jiao[1] (presenting). [1]Virginia Tech University, Blacksburg, VA, United States

Measurement error is observed in many variables in fisheries assessment, such as spawning stock size, individual growth information, or population abundance estimated from a survey or from a model. Measurement error models have been used in Stock Recruitment (SR) modelling, in catchability modelling and in many other natural resources models. In this study, we analyzed the SR relationships of Lake Erie walleye and Atlantic cod fisheries using measurement error models. We also analyzed the relationship between commercial catch per unit effort (CPUE) and estimated population biomass from the walleye fishery using a measurement error model. A Bayesian approach was used to estimate the parameters, which were then used in a simulation study to investigate the uncertainty of model selection based on measurement error models. For the simulation study we generated data with measurement error of the spawning stock size, and then used both measurement error and non-measurement error models to fit the simulated data. We estimated the relative estimation error of the parameters and the Deviance Information Criterion (DIC). We found that although the measurement error model was the "true" model, the chances of finding the true model were always low using model selection criterion. We suggest that measurement error models be applied if simulation studies and practical experience suggest that they will be superior to non-measurement error models.

S9-4

Model selection and estimate precision for length-selective field samples: a shark simulation study

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Length-composition field samples are commonly used to estimate age-at-length parameters. However, estimates may be biased due to the length-selective sampling gear. Few studies have assessed the magnitude of error introduced by sample size or gear selectivity. We simulated field samples of variable sample sizes and length-selectivity, drawn from eight simulated populations of Dusky and Sharpnose sharks in stable age-distribution. We used published mortality parameters and fitted raw field data fitted by the von Bertalanffy, Schnute, Gompertz, and Logistic models. We fitted simulated samples with these same growth models and implemented Akaike Information Criterion (AIC) multi-model estimation. We used AIC to evaluate model fit and measured estimate precision by calculating average percent error (APE) in four parameters: growth rates at birth and maturity, length at birth, and asymptotic maximum length, L_∞. Model selection results based upon AIC often conflicted with model selection minimizing APE. However, AIC-based multi-model estimation generally minimized APE at sample sizes of above 200, while single-model methods yielded more precise growth and length estimates at smaller sample sizes. These results suggest the use of AIC multi-model estimation for larger samples, and other models for smaller samples.

S9-5

Evaluation of alternative model structures for Bayesian mark-recapture models

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Bayesian model evaluation criteria were applied to assess the utility of fishing effort as a covariate for the probability of recapture in mark-recapture models for tagging data collected in a recreational catch-and-release fishery. Inclusion of effort data may be useful to reduce the number of estimated parameters in mark-recapture models and account for seasonal and spatial variation in fishing effort in predicting the number of recaptures in different seasons and areas. Models that included effort as a covariate had higher posterior probabilities than those that did not include a covariate for the recapture probability. Comparisons of parameter estimates from models that included or omitted fishing effort data showed significant differences in posterior capture probabilities (models that did not include effort data) relative to estimated posterior harvest rates for models that included effort data; these were associated with significant differences in estimated posterior movement coefficients.

S9-6
Information-theoretic modeling of capture-recapture data to assess population dynamics and status of two endangered sucker populations in the Upper Klamath Basin, Oregon

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We used fourteen years (1995 – 2008) of capture-mark-recapture data to assess population dynamics of endangered Lost River suckers and shortnose suckers in Upper Klamath Lake, Oregon. Temporal symmetry models were used to estimate annual survival and recruitment and information-theoretic model selection was used to assess variation in these parameters due to time, gender, species, and spawning sub-populations. Model rankings based on Akaike's information criteria indicated gender and year effects on survival for both species. Survival was generally lower for shortnose suckers than Lost River suckers. Shortnose sucker survival was poor in years that experienced a summer fish kill (1995 - 1997) and was also low in several years without an observed fish kill (2002, 2004), suggesting high mortality can occur but not be noticed in the form of a fish kill. We found survival was not only different between the two sucker species, but was also substantially different between two different spawning sub-populations of Lost River suckers. Models indicated consistently low recruitment into adult spawning populations for both species over the past five years. Future survival and recruitment analyses should focus on the role that algal blooms, water quality, disease, and water management play on sucker population dynamics in Upper Klamath Lake.

S9-7
An information-theoretic assessment of juvenile salmonid passage and survival at McNary Dam on the lower Columbia River

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Under current operations for lower Columbia River dams, Washington, the spillway is one of the preferred passage routes, generally resulting in fewer fish passing through the turbines and higher survival through the dam. However, passing fish through conventional spill bays requires large volumes of water. In light of increasing population growth and decreasing water availability in the western United States, efforts are underway to find ways to pass fish with less water while improving fish survival. At McNary Dam during 2007, we assessed the efficacy of using two prototype surface-oriented fish passage structures (temporary spillway weirs; TSWs) to improve fish passage and survival. We released 1,771 acoustic-tagged subyearling Chinook salmon 10 km upstream of the dam, and 1,182 fish just below the dam (0.75 km) to evaluate survival at the dam. For analysis, we used a route-specific survival model, which uses a branching process to estimate conditional passage probabilities and partition survival and detection probabilities among reservoir and route-specific components. We used an additional branching process that enabled the route-specific survival model to be further partitioned among treatments (40% vs. 60% of total discharge spilled) and diel periods (day vs. night). Over a series of candidate models, we used Akaike's Information Criterion in conjunction with likelihood ratio tests to: 1) assess assumptions associated with using fish releases below the dam as a control, and 2) test for differences in fish passage and survival among reservoir reaches, passage routes, treatments, and diel periods. This analytical approach was unique because, to our knowledge, this is the first time that operational treatments and diel periods have been directly incorporated into a model of fish passage and survival at a hydroelectric dam. Results indicated that the higher spill treatment (60% of total discharge) resulted in higher fish passage probabilities through conventional spill bays and the TSWs, which in turn, increased fish survival through the dam.

S9-8
Disentangling patterns of trout survival and movement before and after logging using model based inferences

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In both the private and public agriculture sectors of North America's Pacific Northwest Region, clearcut timber harvesting continues to be a common logging practice that frequently results in a patchwork of disturbance across the landscape. Though

harvest techniques have greatly improved over the past half-century (e.g. riparian buffer strips, cable yarding, and reductions in the areal size of individual timber management units), the impact(s) that current harvest methods have on adjacent (point) as well as downstream (cumulative) segments of the aquatic network is not well understood. Therefore, we sought to quantify spatial and temporal patterns of coastal cutthroat trout (Oncorhyncus clarkii clarkii) survival and movement before and recently after systematic [clearcut] logging treatments in two, experimentally paired watersheds in the Cascade Range Mountains of Oregon, USA. A total of 4,406 trout (>100 mm FL) were implanted with half-duplex passive integrated transponder (PIT) tags and individually monitored seasonally over a 5-year period (3 years pre- and 2 years post-harvest) using three types of PIT-tag data: handheld scanner, mobile tracking antenna units, and stationary gate antenna arrays. These technologies allowed for individual fish identification, passive multi-year repeated sampling of individuals, continuous directional movements at stationary gate arrays, and when combined, higher recapture rates. Several probabilistic models were developed to compare different hypothesis about survival rates, transitions (i.e. movement), and recapture rates in these watersheds and were evaluated using mark-recapture data. The best models were selected (according to AICc) and incorporated jointly (weighted average) to make multi-model inferences. By incorporating a range of spatial and temporal scales into our models, we were able to investigate how scale-dependent environmental factors influence trout survival and movement, and how synergism between them may help to evaluate current timber management policies.

S9-9

A retrospective evaluation of sockeye salmon management adjustment models for the Fraser River, British Columbia

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Fisheries management entails a trade-off between harvest and conservation goals. A major factor that negatively impacts both Fraser river sockeye salmon conservation (i.e. spawning escapement) and harvest is large in-river losses of fish (estimates have exceeded half million fish in 8 of past 16 years), commonly associated with extreme migration conditions. Underestimates of the loss can lead to conservation concerns, while overestimates can result in foregone catch. Therefore, efficient management of the Fraser River sockeye fishery depends, in part, on the prediction of precise and unbiased estimates of river loss. Biologists currently use ecosystem-based models (Management Adjustment (MA) models) to predict discrepancies between lower river and spawning ground escapement estimates from forecasts of river environmental conditions. Predictions of river loss are then used to provide management advice on appropriate harvest adjustments to increase the probability of achieving spawning escapement targets. A number of MA models have been proposed and historically applied; however there has been no formal assessment of past model performance. A retrospective analysis was conducted to rank a suite of potential MA model structures and predictor variables (e.g. Fraser River temperature and flow conditions, river entrance date, historical discrepancies, and abundance) using a variety of different performance measures (e.g. mean absolute error, root mean square error, mean raw error, AIC, R2). A sensitivity analysis was performed to determine the robustness of the rank order of model selection to uncertainties in input predictor variables, and to the relative weight placed on achieving the conservation versus harvest objectives. Ranks order of model selection was dependent upon the performance measures chosen and the relative weight placed on specific management objectives (e.g. weight of harvest versus conservation goals, and weight of achieving fisheries objectives on an annual versus a multi-year time scale). In conjunction with clearly specified management objectives, the results of this study will help provide a standardised process for selection of MA models which will increase the probability of achieving spawning escapement targets while balancing the trade-offs between conservation and harvest goals.

S9-10

Evaluating mercury dynamics and methylmercury accumulation in aquatic systems: a multi-model approach.

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Mercury contamination of aquatic systems has received much recent attention because of potential health concerns for wildlife and humans. Although numerous factors affecting mercury deposition, conversion to biologically-active methylmercury (MeHg), and bioaccumulation in aquatic systems have been identified, equivocal results specific to particular species or systems have hampered policy making. Our study addresses this problem through a comprehensive, statewide synthesis of current data on mercury contamination and the environmental factors associated with MeHg formation and transport through aquatic food webs. Using data collected by the North Carolina Department of Environment and Natural Resources, the Environmental Protection Agency and others, we examined the relationships between these factors and the highly variable fish-tissue mercury concentrations found in North Carolina. Multivariate tests were conducted to create predictive statistical models of mercury in fish, and Akaike's Information Criterion (AIC) was used to examine the relative strength of candidate models. Analyses thus far indicate that trophic status of fish, ecoregion within the state, pH, and nutrient load are important predictors of mercury in fish tissue. Continued analyses will provide policy-makers the predictive relationships needed for managing fishery resources and addressing human health concerns.

S9-11

Modeling the feeding ecology of Atlantic menhaden to address water quality concerns in Chesapeake Bay

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As filter-feeding planktivores, Atlantic menhaden (*Brevoortia tyrannus*) have the potential to positively impact water quality through the filtration and ingestion of phytoplankton and the assimilation of nutrients. To evaluate the impact of young-of-the-year (YOY) and age-1+ menhaden in Chesapeake Bay, a eutrophic estuary, age-specific rates of ingestion of phytoplankton (chlorophyll a) and relative excretion of total dissolved nitrogen (TDN) were measured and modeled in response to phytoplankton concentration. Ingestion rates of YOY menhaden increased in response to increasing phytoplankton concentration, while age-1+ menhaden exhibited virtually no ingestion of the phytoplankton offered. The YOY ingestion rates were modeled in the traditional functional response context, and corrected Akaike Information Criterion (AICc) suggested that the sigmoid-shaped type-III functional response model best described the response. Relative excretion rates of TDN were essentially constant across phytoplankton concentrations for YOY and age-1+ menhaden, indicating a constant excretion rate irrespective of feeding intensity. A model was developed for predicting the potential impact of YOY menhaden on Chesapeake Bay nitrogen concentrations by combining the YOY ingestion model with the mean TDN excretion rate, thus producing rates of net removal of nitrogen as a function of phytoplankton concentration.

S9-12

Population dynamics of juvenile American shad and bluebackherring in lower Chesapeake Bay nurseries

Troy Tuckey[1] (presenting). [1]VIMS, Gloucester Pt. VA, United States

American shad and blueback herring populations in Virginia remain at low levels of abundance compared with historic records. Improvements in water quality, elimination of dams and/or the creation of bypass structures, along with reductions in fishing mortality and stock enhancement through hatchery operations (for American shad) have been implemented to rebuild stocks. Despite these efforts, anticipated increases in stocks have not been observed. Cohort-specific estimates of growth and mortality from species with overlapping spawning and juvenile nursery habitats from neighboring rivers were examined to investigate spatial and temporal variability in year-class production. Historic collections of juvenile American shad and blueback herring from two York River tributaries have consistently shown greater production of juveniles in one of the tributaries relative to the other through processes that are not clearly understood. By examining factors that have been shown to effect growth and mortality (water temperature, water flow and relative abundance) in an Information-Theoretic context, a greater understanding of variation from within and between populations may provide insight into factors shaping year-class strength. This information can be used to model population dynamics by providing vital rates and associated variances for discreet stocks, as each is considered a separate management unit.

S9-13

The role of spatial dynamics in the stability, resilience, and productivity of fish populations: An evaluation based on white perch in the Chesapeake Bay

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Identification of factors important to long-term persistence and productivity of populations is critical for effective fisheries management, particularly as populations respond to harvesting and climate change. The goals of this research were to incorporate complex spatial dynamics into local population models, and to examine the consequences of spatial structuring on the stability (variance in spawning stock biomass), resilience (time to rebound from disturbance), and productivity (long-term average spawning stock biomass) of populations. We evaluated the role that contingents (portions of a population with divergent habitat use) play in mitigating population-level responses to unfavorable environmental conditions, using white perch (*Morone americana*)—a species that exhibits retentive and dispersive contingents—as an example. Age-structured modeling results revealed that population responses were sensitive to the proportion of individuals within each contingent and the degree of independence in the response of contingents to environmental stochasticity. Increased levels of population dispersal resulted in increased productivity and resilience, but decreased stability. Negative correlation in the response of contingents to the environment resulted in increased stability and productivity, with little affect on resilience. Our results support the conclusion that resource management should strive to conserve spatial structuring to promote the long-term productivity and persistence of populations.

S9-15

A simple binomial likelihood model to estimate the probability of habitat use: a case study of lotic fishes from the Apalachicola River, Florida USA

Oliver Burgess[1] (presenting), Aaron Bunch[1], Dan Gwinn[1], William Pine[1], Michael Allen[1]. [1]University of Florida, Gainesville, FL, United States

Riverine water allocation issues are rapidly becoming a topic of major importance to fisheries managers across North America, even in areas such as the eastern United States where water has historically been abundant. Changes in water use practices may alter the flow regime in these systems, possibly leading to negative ecological consequences such as changes to nutrient inputs and access to historic spawning and rearing habitats. We used telemetry data and a simple binomial likelihood model to estimate the probability of several fish species using mainstem and/or tributary floodplain habitats. We then used model results to examine the relationship between habitat use and biotic and abiotic factors (e.g. species, sex, release location, aspects of the flow regime). Preliminary analysis suggests a relationship exists between flow regime and the probability of a fish using a given habitat. Managers may use this approach to make informed decisions regarding timing and quantity of flow as it pertains to habitat availability.

S9-16

Application of occupancy models to compare summer habitat use of age-0 and age-1 endangered Lost River and shortnose suckers in Upper Klamath Lake, Oregon

Summer Burdick[1] (presenting), Scott VanderKooi[1]. [1]U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls, Oregon, United States

A rarity of endangered age 1 and older sub-adult Lost River *Deltistes luxatus* and shortnose *Chasmistes brevirostris* suckers throughout Upper Klamath Lake and a lack of substantial recruitment into adult populations in recent years suggest high juvenile mortality. Poor apparent juvenile sucker survival may be exacerbated by an underlying lack of suitable in-lake rearing habitat. However, little is known about sub-adult sucker habitat use. To estimate summer time habitat use, we used Royle and Nichols occupancy models, which accounted for variation in localized abundance and imperfect detection. Age 0 suckers are habitat generalists with some tendency toward the use of shallow, vegetated, near-shore habitats, with small to mid-sized substrates. The best predictor of age 0 sucker summer habitat use may be species richness calculated for all juvenile fishes. However, our preliminary results indicate age 1 suckers have a strong tendency toward the use of small substrates (fines, clay, and sand), but do not select habitats by presence of vegetation, distance from shore, depth, cover, species richness, temperature, dissolved oxygen concentrations, pH, or distance to novel water sources such as springs or tributaries. Given that fines are the dominant substrate type in Upper Klamath Lake, it is unlikely summer habitat availability is limiting age 1 and older sub-adult sucker survival.

S9-17

Habitat selection by juvenile striped bass in lower Chesapeake Bay tributaries: inferences from occupancy models

David Hewitt[1] (presenting), Mary Fabrizio[1], Amanda Hewitt[1], Julia Ellis[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

In studies of habitat quality, such as those that seek to define essential fish habitat or juvenile nursery areas, habitat quality is often inferred by comparing the occurrence or abundance of animals among available habitats. Catch data from fisheries surveys generally provide weak inferences about habitat quality because they do not account for detectability, or the probability that an animal was present but not captured. We evaluated habitat selection by juvenile striped bass in lower Chesapeake Bay using 18 years of data from the long-term VIMS seine survey. We used multi-state occupancy models to incorporate information from the relative abundance (catch) data and to estimate and account for species-level detection probability. We estimated the effects of both water quality variables and physical habitat characteristics on site occupancy and detectability by including covariates in models, and inferences were based on model selection using AIC. Detectability of juvenile striped bass was much less than 1.0 and changed over the sampling period, reinforcing the need to account for detectability in estimating occupancy. Occupancy was generally high, and we were able to assess the relative importance of various habitat characteristics to site occupancy by juvenile striped bass.

S9-18

An evaluation of the influence of streamflows and species traits on meta-demographic parameters of stream-dwelling fishes

James Peterson[1] (presenting), Colin Shea[2]. [1]USGS, GA Coop Fish & Wildlife Reserach Unit, Athens GA, United States, [2]Warnell School of Forestry and Natural Resources, Athens GA, United States

Fishery biologists are increasingly recognizing the importance of considering the dynamic nature of streams when developing streamflow policies. Such approaches require information on how flow regimes influence species-specific demographic rates, which can be cost-prohibitive to collect. A more cost effective alternative could be the use of species traits to predict how species are likely to respond to changes in flow. To appraise the efficacy of this approach, we used an information theoretic approach to evaluate the relative support for hypothesized relationships between species traits and the persistence, colonization, and recruitment of stream fishes in relation to seasonal stream flow conditions. We used 4 years of seasonal fish collection data from 23 streams in the lower Flint River Basin, Georgia. Using multi-state, multi-season occupancy models we modeled the meta-demographic rates of

42 species in relation to flow conditions and as a function of a several species-specific traits, including morphological, reproductive, and life-history characteristics. Modeling indicated that meta-demographic rates were influenced by streamflows, particularly during short-term periods. The results also suggested that small-bodied species with generalized life-history and reproductive characteristics were more resilient to flow variability than were large-bodied species with specialized reproductive and life-history characteristics. The plausible models will be applied to a regional study investigating how stream-dwelling fishes are likely to respond to changes in the flow regime.

S10. Hydropower Development and Sustainable Fisheries: What Have We Learned

S10-1

Community responses to flow regime: empirical tests, generality and predictability

Nicolas Lamouroux[1] (presenting). [1]Cemagref, Lyon, France

Despite evidence of the relationship between several aspects of flow regime and aquatic communities, it is still difficult to identify general, repeatable rules linking aquatic communities to their physical habitat. As in other fields of ecology, we are not good at predicting changes, and this is largely due to the complexity of aquatic systems and their simultaneous responses to mixed pressures. I will select a number of empirical studies testing the predictability of the effects of flow regime change on fish populations, fish communities and macroinvertebrate communities. These examples suggest that communities may respond to some aspects of flow regime such as low flows in a predictable way, and that community dynamics and in particular recruitment are generally affected by seasonal flow patterns. A special focus will be made on flow rehabilitation experiments in the large Rhone river in France. Predictive tests of the effects of flow regime changes are difficult because they require anticipation for describing initial states and a sustained monitoring effort. Recent developments of simplified habitat models may facilitate such tests and provide decision support for the management of stream reaches and whole catchments.

S10-2

Effectiveness of instream flow mitigation: a review of biological monitoring to assess flow alteration

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Instream flow requirements (e.g. minimum flow requirements, change in operations from peaking to run-of-river, and ramping rate restrictions) have been instituted and subsequently modified at many hydropower dams to mitigate the impacts of altered flow regimes. We searched peer-reviewed and grey literature for monitoring studies designed to evaluate the effectiveness of flow mitigation. In particular we were interested in finding evidence of improved aquatic communities after flow modification. Our review identified 25 studies at projects with sufficient post-enhancement data and data for comparison (either pre-enhancement or reference data) to evaluate a biological response. Of those, 15 had enough data to subjectively conclude that a positive biological response to flow enhancement had occurred. Positive biological responses included increased numbers of fish, greater biodiversity in the fish community, more returning spawners, and an improved macroinvertebrate community. A biological response was not found for the remaining 10 projects either because there were no consistent trends, the data were inadequate, or other factors made it difficult to relate changes to flow enhancement. Data insufficiencies and confounding factors included: lack of sufficient number of years of sampling (either pre or post); concurrent mitigation that could affect monitored populations; significant differences in background conditions among years (e.g. meteorology, flow, predator dynamics); and an inability to differentiate mitigation-related change from natural variation. For future monitoring programs, better study design would help ensure that the results obtained can be applied in a defensible way to evaluate mitigation effectiveness.

S10-3

Variation in large-bodied fish community structure and abundance in relation to water management regime in a large regulated river

Tim Haxton[1] (presenting), Scott Findlay[2]. [1]Ontario Ministry of Natural Resources, Peterborough, Canada, [2]University of Ottawa, Ottawa, Canada

We investigate variation in life history traits (growth, condition, mortality and recruitment) and relative abundance of 11 large-bodied fish species among three water management regimes (unimpounded, run of the river and winter reservoirs) in a large regulated river (Ottawa River, Canada). If waterpower management has an effect on fish, then i) we would expect to detect community structuring among water management regimes; and ii) species with similar life history traits should be affected in a similar manner. Large-bodied fish communities were assessed using two different standard index netting techniques, one using trapnets and the other gillnets. Community structure could be discriminated based on species caught in nets using Discriminant Function Analysis (74% Jackknifed classification rates using trapnets and 76% using gillnets) and neural networks (78.8% correct overall classification rate using trapnets and 76.0% using gillnets) therefore water management regimes affect community structure in the Ottawa River. Littoral zone benthivores were significantly lower in abundance ($P<0.001$) or absent in winter reservoirs whereas the abundance of planktivores or species that were planktivorous at young ages were significantly greater than unimpounded river reaches. Growth, condition and mortality of did not vary among reach types except smallmouth bass were in better condition in winter reservoirs than unimpounded reaches. Lake sturgeon recruitment was impaired in run-of-the-river reaches whereas recruitment for other species that spawn in fast water were not affected.

S10-4
Spatial patterns of benthos in relation to natural and regulated flow regimes
Nicholas Jones[1] (presenting). [1]OMNR-Trent Univeristy, River and Stream Ecology Lab, Peterborough, Ontario, Canada

The ecological integrity of flowing waters depends on their natural flow regime. Deviations from a natural flow regime may result in new constraints on community structure of river-dwelling fishes and invertebrates and loss of productive fish habitat. In this study benthic invertebrate communities are compared from the Magpie River to 15 natural reference rivers. The Magpie River has a water power facility with a ramping constraint of 1 m3·s-1 with a minimum flow of 7.5 and a maximum flow of 45 m3·s-1. This flow regime results in a variable wetted perimeter with a frequency and duration wetting set by market energy prices and energy demands. Benthic samples were collected in mid-July 2004-2007 using a Surber sampler fitted with a 500 µm mesh net. Samples were collected along transects on each river leading from the shore to mid-channel. Differences were evident in the distribution and abundance of invertebrates in relation to the distance from the dam and shore. Transects close to the dam (<8 km) had much higher densities of lotic and lentic derived invertebrates, whereas areas close to shore in the Magpie contained invertebrates (e.g. oligochaetes, flatworms, gastropods) capable of withstanding harsh environmental conditions. More environmentally sensitive invertebrates belonging to the groups Trichoptera, Diptera, Ephemeroptera, and Coleoptera were scarce in nearshore areas but common in deeper offshore samples of the Magpie. Similar trends in invertebrate abundance and composition could not be found in the reference river. The implications for benthic fish production are discussed.

S10-5
Historic and current monitoring trends of resident sport-fish in the Columbia River and their relationship to flow regulation and other environmental factors
Dana Schmidt[1] (presenting), Dustin Ford[1], Robyn Irvine[1], Joseph Thorley[2], David DeRosa[3], Brent Mossop[4]. [1]Golder Associates Ltd. Castlegar, BC, Canada, [2]Poisson Consulting Ltd, Nelson, BC, Canada, [3]BC Hydro, Castlegar, BC, Canada, [4]BC Hydro, Burnaby,BC, Canada ,

In Canada, flow regulation of the lower Columbia River became a reality in the late 1960s, with the development of multiple hydroelectric dams and storage reservoirs constructed as part of the Columbia River Treaty. The Columbia River Treaty is an international agreement between the US and Canada detailing water rights and benefits to each country of several large water storage projects in Canada and the US. Most changes in flow variation occurred during the establishment of flow regulations in the late 1970s and the 1980s, with further changes in flow regulation occurring during the early 1990s. From 2001 to 2007, intensive monitoring allowed the detailed evaluation of temporal trends in recruitment and survival of sport-fish populations. In addition, reduction in effluent from a pulp mill and a zinc and lead smelter, increased abundance of introduced species, and climate change may correlate with changes in fish population parameters. The application of Age-Structured Mark-Recapture (ASMR) analysis may allow the extension of available fisheries time-series data to assess population parameters during periods when environmental changes were most apparent (i.e. prior to 2001). Backcasting recruitment trends is possible with ASMR by use of the age structure from more recent samples of the population. By assembling long-term indices of abundance of important species, inferences may be made as to what factors are most likely to contribute to the observed trends. This study illustrates the utility of a long-term time-series of fish population data in understanding changes in fish populations, but also illustrates the difficulties of assessing the causes of change because of the multitude of important environmental factors that may contribute to the observed changes.

S10-6
Habitat and hydrodynamic assessment relating to flow releases below EB Campbell Hydroelectric Station on the Saskatchewan River
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The need to explore alterations to flow management for the benefit of fish and fish habitat below E.B. Campbell hydropower station in the Saskatchewan River, led to a cooperative research effort by the Saskatchewan Power Corporation and Fisheries and Oceans. Efforts to achieve this objective included the revision of the two-dimensional finite element model “River2D” (www.river2d.ca) to simulate hydrodynamics, and estimate weighted usable areas for several species at three study sites within approximately 40 km of river downstream of the facility. The study models the changes in habitat resulting from minimum daily flows between 50 and 150 m3/s, and compares them to a “natural” flow regime as received by Saskatchewan from Alberta.

S10-7

Effects of hourly variation in flow and density on spawning, incubation mortality, habitat use and survival of age-0 rainbow trout in the Colorado River below Glen Canyon Dam

Josh Korman[1] (presenting). [1]University of British Columbia, Department of Zoology, Vancouver, BC, Canada

Limiting the extent of hydropeaking and other unnatural components of the hydrograph in regulated rivers is a common element of restoration efforts, however empirical support for such recommendations is limited. In this study, we evaluate the effects of spawner and age-0 density and unnatural aspects of the hydrograph from Glen Canyon Dam on the early life history stages of a rainbow trout population in the Lee's Ferry reach of the Colorado River. Four years of data on spawn-magnitude, -timing, and -elevation, in conjunction with measurements of intergravel temperatures, were integrated in a model to predict seasonal trends in incubation mortality resulting from flow fluctuations. Predicted hatch date distributions were compared to backcalculated distributions from extensive sampling of the age-0 population and precise length-at-age relationships. In spite of flow-driven incubation mortality rates of 20-50% during years with high fluctuations, there was little evidence of any effect in observed hatch date distributions. The age-0 population size was relatively insensitive to the number of viable redds, with the majority of compensation occurring between emergence and first capture at approximately 30 mm. There was limited use of low-angle cobble bars by age-0 fish, and strong evidence of an ontogenetic habitat shift to steeper talus shorelines habitats that depended on both density and flow. Catch rates of age-0 trout in nearshore areas were 2- to 4-fold higher at the daily minimum flow compared to the daily maximum, indicating that most age-0 trout do not maintain their position within immediate shoreline areas during the day when flows are high. A striping pattern, identified by the presence of atypical daily increments formed every 7 days, was evident in over 50% of 259 otoliths examined in 2003, but in only 6% of 334 examined in 2004. The weekly pattern was caused by a reduction in the extent of hourly flow fluctuations on Sundays during the growing season, which occurred in 2003, but not in 2004. Atypical increments were 25% wider than adjacent increments and were indicative of significant short-term increases in otolith growth under low and steady flow. Describing impacts of hydropower operations on fish populations must be done in the context of biological dynamics that govern recruitment success, such as the timing and strength of density-dependence and critical ontogenetic habitat shifts.

S10-8

Suitability of flow regimes in sustaining unionids and fishes in North America

Marguerite Xenopoulos[1] (presenting), Daniel Spooner[1], Daelyn Woolnough[1]. [1]Trent University, Peterborough, ON, Canada

We tested for the relationship between various environmental flow indicators (e.g. maximum flow, minimum flow, mean discharge, number of days ephemeral streams are dry) and mussels and fish. We used modelled WaterGAP hydrological data and species-discharge curves to evaluate how changes in stream flow affect freshwater fish and mussels communities. We show that discharge is a strong predictor of both fish and mussel biodiversity. Using species-discharge relationships we show that mussels are more sensitive to reductions in flows than fish by a factor of two. Realizing that mussels use an array of fish hosts for their complex life-history, we modelled fish/mussel relationships concluding that the potential decline of mussels with reductions in flows is associated with mussel traits and not just confounding fish-host biogeography. Since mussels are relatively sessile, they lack the ability to seek refuge in the event of droughts.

S10-10

Walleye recruitment in the Peace-Athabasca Delta: can we use environmental correlates to assess instream flow needs?

Andrew Paul[1] (presenting). [1]Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta, Canada

A proportional catch-at-age model was developed using commercial fishery data to test the hypothesis that walleye recruitment in the Peace-Athabasca Delta showed inter-annual variability. The variable recruitment model was strongly supported by data when compared to a constant recruitment model. Given inter-annual variability, recruitment strength was assumed established in the first year of life and a priori hypotheses were tested for correlative relations between: a) flow patterns in the Athabasca or Peace rivers; and, b) Lake Athabasca water levels. The data best supported a model positively relating walleye recruitment to water levels in Lake Athabasca; however, a second model positively relating recruitment to mean winter discharge from the Athabasca River could not be dismissed given the data. Both models performed significantly better than a null model and were robust to ageing error (assessed through Monte Carlo simulations using observed ageing errors). The walleye recruitment versus winter discharge model was then used to assess effect of upstream water withdrawals given reference points for: a) percent reduction in recruitment; and, b) recruitment failure. Coupling the model with reference points provided a tool to assess value-based impacts on the walleye population. Confidence for a predicted impact was measured as the likelihood of exceeding a reference point given uncertainty in the underlying model.

S10-11

Monitoring salmon smolt outmigation to evaluate the response of fish populations to flow manipulations

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The response of fish populations to alternative flow regimes in regulated rivers is highly uncertain, and monitoring is commonly used to evaluate this response. Monitoring the outmigration of salmon smolts is well suited to such evaluations as it provides a measure of fish production at the end of freshwater residence that integrates biological effects over many lifestages. We estimated outmigration from mainstem and side channel habitats in regulated rivers in coastal British Columbia, Canada, under different flow regimes. Reliable outmigration estimates were consistently generated for target species in side channels and most mainstem habitats. However, precise estimates could not consistently be estimated for coho and steelhead smolts in larger mainstem habitats of some rivers due to protracted migration timings, periodically low and flow-dependent catchability, and analytical challenges resulting from sparse data. To increase the accuracy and precision of mainstem estimates for these species, we are implementing field and analytical techniques that are more robust to these conditions. Outmigration estimates in conjunction with associated physical and biological monitoring data are an effective approach to evaluate the effects of alternative flow regimes on juvenile salmon in these rivers.

S10-12
Understanding the natural flow regime, a key component in instream flow studies
Daniel Caissie[1] (presenting). [1]Fisheries and Oceans, Moncton, NB, Canada

The fundamental understanding of the natural flow regime of rivers is becoming increasingly important when conducting instream flow assessments of hydro development projects. This phenomenon has been described in the literature as the Natural Flow Paradigm (NFP) concept wherein the natural flow regime is recognized as being a key ecological component of river ecosystems. As such, the natural flow regime can be used as the bench mark against which managers evaluate acceptable level of changes when conducting instream flow studies. This study will focus on describing the natural flow regime of rivers in relation to instream flow requirements. Important hydrologic characteristics that best describe the flow regime within the NFP concept were studied on 72 hydrometric stations across the Maritime Provinces. Analyzed flow characteristics included the mean annual flow, high and low flow events and frequencies, as well as flow duration. The timing of flow events will also be described as it plays an important role in defining habitat suitability requirements. Regional flow equations will be presented and comparisons among provinces and hydrological areas will be illustrated.

S10-13
Year 12 of an adaptive management experiment for instream flows in the Bridge River, British Columbia
Mike Bradford[1] (presenting), Paul Higgins[2], Josh Korman[3], Chris Perrin[4]. [1]Fisheries and Oceans Canada, Burnaby, BC, Canada, [2]BC Hydro, Burnaby, BC, Canada, [3]Ecometric Inc. Vancouver, BC, Canada, [4]Limnotek, Vancouver, BC, Canada

There remain relatively few cases where instream flow methodologies have been evaluated for their efficacy. Consequently adaptive experimental management has been promoted as a means to empirically test the relationship between alternative flow regimes and valued ecosystem components such as fish abundance. In 1996 a long-term flow experiment was started to evaluate at least three different flow regimes in the Bridge River, a regulated tributary of the Fraser River, BC. An extensive monitoring program was initiated, primarily focused on juvenile salmon biomass, along with the secondary indicators of water quality, and primary and secondary productivity. We have currently completed the monitoring of two flow regimes and are considering options for the third. The experimental flow consisted of a hypolimnetic release from the dam using a refitted flow control structure. This flow rewetted 4 km of channel that was previously dry; the new reach was rapidly colonized by spawning salmonids and it continues to be productive. The impacts of the augmented flow on previously flowing downstream reaches are less clear. The dam releases have altered the thermal regime in the river and this has changed in life history of Chinook salmon, and may be reducing their abundance. Our other indicators may be relatively insensitive to the flow regime. Perhaps more importantly, there have been significant changes in the stakeholder composition and their values during the 12 years since the inception of the experiment, and a much broader suite of indicators than just juvenile salmon biomass will enter in the final decision about flow. The length of the experiment, the investment in time and resources required, and a changing social environment are all significant challenges to using adaptive management to resolve instream flow issues.

S10-14
Examination of the efficacy of controlled flows from a reservoir for the purpose of moderating migration temperatures for Pacific salmon: a case study in the Nechako Watershed.
Steve Macdonald[1] (presenting), John Morrison[1], David Patterson[1]. [1]Fisheries and Oceans Canada, West Vancouver, Canada

Since the early eighties a water temperature management program has been in existence on the Nechako River system in central British Columbia, Canada. The program attempts to use water releases to meet a summer temperature target downstream to benefit

spawning migrations of sockeye salmon in the Nechako River. This study whose purpose is to: a) assess the success of the water management scheme in terms of moderating high summer water temperatures in the Nechako at the target location upstream of the Stuart confluence, b) consider the effects of the management scheme on temperatures in the Nechako downstream of the Stuart confluence and, c) assess the overall effect on sockeye salmon that migrate through the Nechako upstream and downstream of the Stuart confluence to spawn, has found that the temperature management program has been successful at moderating summer temperatures and thus has improved migration conditions and has likely had a positive influence on spawning success rate of sockeye that migrate through the system. Our principal component analysis of the factors contributing to target temperature show that the controlled cooling flow releases accounted for 24% of the temperature variability and that they were successful in keeping the river below the program's target temperature. We were also able to show that during most summers, the Nechako was cooler than the Stuart River, providing a cooling influence in the reach used by the majority of migrating sockeye salmon. Nechako water temperature is related to pre-spawning mortality (12% of variability) suggesting that attempts to moderate summer water temperatures through releases in the upper Nechako watershed can enhance the spawning success of sockeye populations migrating through the lower reaches of the system. The future for our research is a modeling process used to assess a possible change in the temperature and flow management mechanisms in the Nechako River system with the construction of a coldwater release facility at Kenney Dam. Possibly, current summer temperature targets can be achieved with smaller amounts of cooler water. We report on possible management options but caution watershed planners and managers to consider a broad range of environmental and operational factors.

S10-15

The effect of ramping rates and other environmental parameters on the stranding rates of fish below hydro-electric dams in British Columbia, Canada.

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Juvenile fish can strand in pools or in interstitial spaces when the water elevation drops in regulated rivers due to flow reductions. Three years of summer and winter experiments on the Columbia and Kootenay rivers (Canada) and four years of fall experiments on the Duncan River (Canada) have assessed the effect of the rate of change in water level (ramping rate) on the probability of pool and interstitial stranding for juvenile (<100 mm) fish. The factors of wetted history of the site, time of day, natural fish density and the occurrence of a conditioning reduction prior to the operational reduction were also examined for their effect on stranding. Experimental net pens were constructed to test these factors in situ in the varial zones of the rivers. Linear mixed effects models with combinations of the potential explanatory factors and a null model were fitted to the logistically transformed data and ranked using the second-order Akaike Information Criterion (AICc). The null model was the top ranked model for the interstitial stranding analyses for the Columbia and Kootenay rivers and was the top model for the pool stranding on the Duncan River, highlighting that none of the variables tested had a strong enough relationship with the dependent response of the probability of stranding. However, models within 2 AICc values of the top model are considered equally valid and these models included such variables as time of day, natural fish density, wetted history of the site, ramping rate and the presence of a conditioning reduction. Implications of the studies and future direction for the experimental programs will be discussed.

S10-16

Fish and invertebrate response to 3 years of experimental unlimited ramping rates on a river regulated by a peaking hydroelectric generating facility

Karen Smokorowski[1] (presenting). [1]Fisheries and Oceans Canada, Sault Ste. Marie, Ontario, Canada

Fisheries and Oceans Canada, Ontario Ministry of Natural Resources, and Brookfield Power Corporation are collaborating on a long-term, adaptive management experiment to test whether regulating the rate of change of water flow (ramping rates) through hydroelectric facilities can provide a more favourable environment for fish, while optimizing energy production. A suite of physical and biological measures were taken from an experimental regulated river and an unregulated reference river to quantify conditions under highly restricted ramping rates (baseline phase 2002-2004) and under unlimited ramping rates (experimental phase 2005-2007) under a Before-After-Control-Impact (BACI) design. The response of the fish and invertebrate communities to the change in ramping rate will be presented. Annual changes in invertebrate abundance were similar on both rivers and we could detect no impact from the shift to unlimited ramping on the experimental river. Invertebrate richness also was not impacted by the unlimited ramping regime; however, we did detect a significant negative effect on invertebrate diversity. Electrofishing fish biomass varied by river, habitat type, and valley segment, but was unaffected by the change to unlimited ramping. Fish diversity also did not change significantly as a result of the unlimited ramping rate discharge regime. Results will be examined in conjunction with hydrological, habitat and other biological impacts (e.g. see Marty et al. this conference) and will be incorporated into provincial and federal waterpower guidelines and policy.

S10-17

The responses of the food-web to hydropeaking: an experimental approach based on stable isotopes.

Jerome Marty[1] (presenting), Michael Power[1], Karen Smokorowski[2]. [1]University of Waterloo, Waterloo, Ontario, Canada, [2]Department of Fisheries and Oceans Canada, Sault Ste Marie, Ontario, Canada

Effects of flow alteration on the aquatic biota have predominantly been reported in relation to diversity, and few studies have focused on its effect on food webs. In this study, we applied a Before After Control Impact experimental design (BACI) to determine the response of the food web to fluctuating ramping rates using stable isotopes. Carbon (δ13C) and nitrogen (δ15N) stable isotope values of invertebrates and fish were compared under restricted (2003/2004) and unrestricted (2005/2006) ramping rate flow regimes. Study control sites consisted of 3 sites on the unregulated Batchawana River and one upstream site on the Magpie River. Two sites situated below the Steephill dam on the Magpie River were considered as impacted sites, subject to ramping rate variations. The unrestricted ramping rate flow regime had little impact on the transfer of carbon through the food web as no significant differences in δ13C values were found when applying BACI analysis to each trophic level of the food web. However, macroinvertebrate and fisḥδ15N values were significantly higher in the impacted sites compared to the control sites, with the trend toward differences being greatest under unrestricted ramping rate for macroinvertebrates. The changes may result from the physiological response of organisms to water temperature changes. Food web length, calculated based on the difference between macroinvertebrate and fish δ15N values, was also affected by the flow regime and was significantly shorter under the unrestricted ramping flow regime, implying a shift in the diet of fish toward lower trophic level invertebrates. Results from this study highlight the influence of ramping rates on the functioning of the lotic food web, suggesting the need for information on flow alterations to be considered in river management decisions.

S10-18

Influence of hydropeaking on sediment suspension

Colin Rennie[1] (presenting), Robert Metcalfe[2]. [1]University of Ottawa, Ottawa, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

Regulated rivers have altered magnitude, duration, frequency, timing, and rate of change of discharge (ramping, m3s-1hr-1). The response of fluvial ecosystems to the alteration of flow regimes is an increasing field of study. The purpose of the present research is to assess the consequences of short-term fluctuations in discharge. Dam managers often employ hydropeaking to optimize hydroelectric power production to meet user demand, with consequent rapid fluctuations in tailwater discharge and water levels. The rapid fluctuations can influence fluvial morphology and associated habitat by altering patterns of sediment erosion, transport, and deposition. The present study measures the influence of hydropeaking on suspended sediment concentration downstream of the Steephill Falls waterpower facility on the Magpie River, Ontario. Suspended sediment was measured by direct sampling and with a turbidity meter during individual hydropeaking events in 2006 and 2007. An acoustic doppler current profiler (aDcp) was used to measure discharge and velocity, shear stress, and suspended sediment sectional distributions during four of these events. Hydropeaking was observed to cause sediment suspension, with a good correlation between peaking events and suspended sediment concentration sediment. The ultimate goal of the present research is to understand how hydropeaking and the subsequent potential to move finer material more frequently alters sediment transport mechanics and thereby affects fluvial habitat.

S10-19

Improving downstream passage of juvenile salmonids in the Federal Columbia River Power System – what has worked at dams and what has not over the last 14 years.

John Beeman[1] (presenting), Noah Adams[1]. [1]U.S. Geological Survey, Cook, Washington, United States

Dam passage of juvenile salmonids in the Federal Columbia River Power System has been studied for decades in an effort to increase their survival. Changes in structures and operation of the system have resulted in improvements in survival to what some believe are near pre-dam levels, yet the search for improvements continues as mandated by the U. S. Endangered Species Act. A variety of actions have been implemented, with the most recent being passing fish through shallow-spill devices, as these pass many fish and result in high survival. Dam-passage survival is near 1.0 at many hydropower sites in this system, leaving losses in the reservoirs, estuary and ocean as the logical places for further study. For example, at Lower Granite Dam on the Snake River in 2006, the dam passage survival probability of radio-tagged stream-type Chinook salmon (*Oncorhynchus tshawytscha*) was 0.98 (SE 0.008), juvenile steelhead (O. mykiss) was 0.98 (SE 0.007), and ocean-type Chinook salmon was 0.91 (SE 0.014). Further on-site changes may improve survival of ocean-type Chinook salmon at this and other sites, but increasing survivals of the other groups is unlikely, given their current values. These high survivals are a result of changes in operations and structures over many years, and similar changes have occurred at other projects within the hydropower system. Changes at Lower Granite Dam over the last 14 years will be used as a case study of structures and operations that have been tested to improve survival of downstream migrants in the Federal Columbia River Power System.

S10-20

An overview of studies to test the efficiency of a retrofitted bypass system for downstream migrating Atlantic salmon at Bishop's Falls, Exploit's River, Newfoundland Canada.

Keith Clarke[1] (presenting), David Scruton[2], Curtis Pennell[1], Chuck Bourgeois[1], Rick Goosney[1], Wilmore Eddy[3].
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The hydroelectric facility at Bishop's Falls on the Exploit's River underwent an extensive refurbishing in 2002/03 which included a new retrofitted surface spill fish bypass system for downstream migrating Atlantic salmon. An intensive evaluation of the efficiency of this new bypass system was conducted from 2003-2005 and revealed an average fish guidance efficiency for radio tagged smolt of 63%, 71.7%, and 61.7% in 2003, 2004 and 2005, respectively. Average guidance efficiency was much higher for kelt at 92.3% in 2004 and 95% in 2005. Route specific passage was evaluated for 64 radio tagged smolt and 24 kelt in 2005. Of these fish, 75% of both the smolt and kelt entered the forebay of the hydroelectric facility and once in the forebay had the same guidance efficiency of those in the directed trials. Additionally a limited number of trials were conducted in 2007 to test the system in an 'open' configuration where fish were not handled at the bypass. Under 'open' conditions the guidance efficiency for smolt averaged 69.2%, with smolt passing through the system in a very short timeframe.

S10-21

Effects of trashrack geometry on flow patterns and hydraulic head loss in an attempt to reduce hydro turbine mortality for fish

Chris Katopodis[1] (presenting), J. M. Tsikata[2], M. F. Tachie[2], D. Lemke[3], H. Ghamry[1]. [1]Freshwater Institute, Central and Arctic Region, Fisheries and Oceans Canada, Winnipeg, MB, Canada,[2]Department of Mechanical & Manufacturing Engineering, University of Manitoba, Winnipeg, MB, Canada,[3]Manitoba Hydro, Winnipeg, MB, Canada

Extensive experiments were conducted to study the effects of bar inclination, bar depth, bar spacing and bar shape on flow pattern and head losses in an effort to reduce fish mortality by excluding larger fish from hydro turbines. In these experiments, a variety of approach flow velocities (Ue = 0.26 m/s, 0.52 m/s and 0.76 m/s), bar inclinations (δ = 0o, 6o, 9o and 12o), bar thicknesses (s = 6mm, 9 mm and 12 mm), bar depths (L = 50, 76 mm and 110 mm), bar spacing (ba = 40 mm, 50 mm, 63 mm and 70 mm) and bar shapes (rectangular and streamlined cross-sections) were investigated. A high resolution particle image velocimetry technique was used to obtain flow pattern around the trashracks. The water elevations upstream and downstream of the trashracks were measured to evaluate hydraulic head losses. Velocity fields and head losses are important both from fish behaviour and power efficiency perspectives.

S10-22

Survival capacity of spring-summer chinook salmon in the Federal Columbia River Power System

Jennifer L. Tran[1] (presenting), James J. Anderson[1]. [1]University of Washington, Seattle, WA, United States

To mitigate the effects of the Federal Columbia River Power System hydropower system on the migration of juvenile spring-summer chinook salmon (*Oncorhynchus tshawytscha*), the U.S. Army Corps of Engineers barges fish past the dams. While survival of barged fish through the hydrosystem is nearly 100% fish compared to the 30% to 50% rate of in-river migrants, the ocean survival of barged fish is generally lower than the ocean survival of the in-river migrants. I hypothesize that the additional ocean mortality or "latent mortality" of barged fish results from their reduced survival capacity or "vitality" compared to the in-river migrants. The hypothesis will be tested comparing the survival profiles of barged and in-river migrants collected at the Juvenile Fish Monitoring Facility at Bonneville dam (the lowest dam on the river). Throughout the 2008 smolt migration season, groups of fish will be collected weekly and starved under increased temperature to attain survival curves. The relative differences in survival among barged and in-river migrants will help characterize whether latent mortality can be attributed to changes in the vitality of fish through the two passage routes.

S10-23

Expanding the 'toolbox' for measuring the impacts of hydropower on fish and fish habitat using individual-based techniques: a case study from the Puntledge River, British Columbia

Caleb Hasler[1] (presenting), Rana Sunder[1], Michael Donaldson[1], Ester Guidmond[5], David Patterson[4], Brent Mossop[2], Scott Hinch[3], Steven Cooke[1]. [1]Carleton University, Ottawa, ON, Canada, [2]BC Hydro, Vancouver, BC, Canada, [3]University of British Columbia, Vancouver, BC, Canada, [4]Fisheries and Oceans Canada, Burnaby, BC, Canada, [5]Consultant, Courtenay, BC, Canada

Global energy needs have resulted in an increase in hydropower developments around the globe. The infrastructure (i.e. dams, fishways) and operations (i.e. variable flows) associated with hydropower development impact fish and fish habitat in a variety of ways. Previous research has focused on evaluating impacts on fish populations and aquatic communities, with few efforts to assess

hydropower impacts on the behaviour, physiology and condition of individual fish. We argue that there are a multitude of tools available for use by scientists and managers to evaluate the of effects hydropower on fish and fish habitat, including gene arrays, physiological telemetry, biochemical and nutritional assays, and condition-based indices. By combining all, or some of these tools, we submit that we will be in a better position to understand the suite of hydropower impacts on fish and fish habitat and to enhance predictive models and enact more informative policy. To highlight the use of these individual-based tools, we present a case study from the Puntledge River, British Columbia. We evaluated individual variation in the migratory behaviour, physiology, and fate for an imperilled stock of Chinook salmon in a regulated river system characterized by multiple barriers (both natural and artificial). Using non-lethal field biopsies and EMG telemetry, we were able to evaluate how the initial condition of fish at time of river entry affected their subsequent behaviour in relation to river barriers. Collectively, this work provides theoretical and empirical evidence that individual-based techniques are an effective means for studying fish responses to hydropower infrastructure and operations.

S10-24

Biological knowledge, engineering expertise, and money: the key ingredients for effective fish passage facilities at hydropower dams

John Williams[1] (presenting). [1]Northwest Fisheries Science Center, Seattle, WA, United States

Efforts over the past 50+ years to develop effective fish passage facilities at dams in the Columbia River basin have provided valuable insight into what leads to success. It requires, in sum: biological knowledge of fish behavior associated with flows at individual dams and particularly at proposed fishway locations; engineering expertise to predict/model flows and develop facilities that provide flow conditions that fish seek or do not reject; and money…often substantial amounts for biological testing, engineering design, and post-construction evaluation, particularly where specific knowledge of fish behavior does not exist. Further, development of successful passage facilities requires biologists and engineers working together. Where the biological or engineering components (or both) are missing, development of effective passage facilities often takes on a trial and error approach that may require years (to decades) in order to attain success…even where money, time, and will exist. Evaluations of installed juvenile and adult fish passage facilities (whether prototype or permanent and whether fish successfully used them or not) suggest that migrant fish have evolved to primarily use cues from changes in water velocity to determine their migration routes to the ocean or on return to spawning grounds. Knowing fish responses to these cues provides the basis for developing engineering solutions that fish will use. Because upstream migrating fish swim into the flow, developing passage solutions for them presents a slightly less difficult task, as fish potentially have considerable time to seek flow conditions that they prefer. Yet, fish ladders or bypass channels, even with good attraction flows, will fail if incorrectly sited. On the other hand, developing successful installations for downstream migrants has proven much more difficult. Downstream fish tend to go with the flow and will spend little time at entrances to bypasses. If they encounter flow conditions at a bypass entrance where water velocity decreases or increases at rates outside of ranges they prefer, they will likely move to another area and miss the bypass, in many cases leading to passage through turbines. Lessons from the Columbia River and examples from around the world will illustrate these principles.

S10-25

Species-specific attraction efficiency and passage efficiency of fish passage structures and instream barriers to fish migration

Christopher Bunt[1] (presenting). [1]Biotactic Fish & Wildlife Research Inc. Kitchener, Ontario, Canada

Attraction efficiency and passage efficiency data were reviewed and compared from 30 monitoring studies at Denil fishways, Alaska steeppass fishways, vertical slot fishways, pool and weir fish ladders, Ice-Harbor fishways, fish locks, fish bypass channels, velocity chutes, siphon tubes and open dams for 23 species of anadromous and potamodromous fishes in 14 countries. Mean attraction efficiency of technical engineered fish passage structures (excluding eel ladders and fish bypass channels) ranged between 47% and 88% and mean passage efficiency was consistent at approximately 31%. Fish bypass channels were the most effective engineered passage option and attracted 39% of upstream migrating fish while passing 50%. Optimum fish passage occurred at dams with open gates, where attraction was 90% and passage was 95%. This evaluation of overall patterns of fish passage effectiveness can be used to help restore river connectivity by providing guidance to ensure, when possible, the most appropriate structures are used to maximize upstream passage of target species.

S10-26

Fishway passage, water diversion and warming temperatures: Factors limiting successful spawning migration of Seton-Anderson watershed salmon

David Roscoe[1] (presenting), Scott Hinch[1], Steven Cooke[2], Lucas Pon[1], David Patterson[3], Andrew Lotto[1].
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Dams and other hydropower infrastructure can slow or prevent the upstream spawning migrations of anadromous fishes. For adult sockeye salmon returning to spawning grounds in the Seton-Anderson watershed in British Columbia, Canada, two areas affected by hydroelectric facilities are thought to present a challenge to migration. Sockeye must first pass a powerhouse outflow and then pass a dam and fishway further upstream. At both these locations a portion of the population is unable to pass but it is unclear why some fish are successful and others are not. We used physiological biopsy coupled with positional telemetry to evaluate the role of physiology and energetic status on the ability of sockeye to pass through two challenging reaches. Sockeye were captured in the Seton dam fishway, biopsied, fitted with a telemetry transmitter and released either upstream of the dam or downstream of hydroelectric facilities. Of the 30 sockeye released upstream of the dam, 93% reached spawning grounds. In contrast, only 49% of the 55 fish caught in the fishway and released downstream of hydroelectric facilities reached spawning grounds. Failed migrants had significantly higher plasma lactate and lower plasma sodium concentrations, suggesting that they were initially more physiologically stressed than successful migrants.

S10-27

The influence of acclimation pressure and exposure pressure on barotrauma driven mortal injury to juvenile salmonids exposed to rapid decompression during hydroturbine passage

Richard Brown[1] (presenting), Thomas Carlson[1], John Stephenson[1], Abby Welch[1], Craig McKinstry[1], Mike Langeslay[2], Martin Ahmann[3], Marvin Shutters[3]. [1]Pacific Northwest National Laboratory, Richland, Wa, United States, [2]US Army Corps of Engineers, Portland, OR, United States, [3]US Army Corps of Engineers, Walla Walla, WA, United States

Passage through hydropower dams may expose fish to rapid decompression and the risk of barotrauma. As fish pass through hydroturbines they are exposed to rapid decompression with nadirs which may range from near vapor pressure to several atmospheres. Mortality and injury to fish appears to depend upon the differential between the absolute pressure (depth) to which fish are acclimated prior to hydroturbine passage and the nadir pressure experienced during passage. Both spring and fall Chinook salmon were acclimated to neutral buoyancy at absolute pressure equivalents of 5, 15 or 25 ft of water depth. Following acclimation, juvenile Chinook salmon were exposed to simulated turbine passage pressure time histories with nadir pressures between 1 and 15 PSI absolute using computer controlled hyperbaric chambers. Rates of mortal injury for test fish were a function of the magnitude of ratio between acclimation and nadir pressures. The relationships between barotrauma and pressure exposure can be used to guide turbine operations and turbine design.

<u>S11. Harvest Control Rules: Experiences in Modeling and Application</u>

S11-1

HCR's - is backwards the best way forwards? - South African experiences

Doug Butterworth[1] (presenting). [1]University of Cape Town, Cape Town, Western Cape, South Africa

The role of HCR's in the formulation of management procedures (MP's) is illustrated through reference to the three major South African fisheries (for sardine and anchovy, hake and rock lobster), which have been managed on this basis for the past decade or longer. Practical experience has illustrated the importance of rule outputs being continuous functions of their inputs, and of including limits to the extent by which TACs may change from year to year to enhance industrial stability. MP's should also include metarules which override basic HCR's if unanticipated circumstances arise, such as the resource moving outside the range of circumstances for which the MP was simulation tested. The ideal would appear to be to apply HCR's to the output from an assessment model component of the MP, so that over time MP outputs take account of improved estimates of resource productivity. However, experience suggests preference for a return to a simpler empirical approach where the TAC is adjusted on the basis of trends in abundance indices. Here the "learning" aspect that an assessment-based approach provides is covered by instead updating the values of the parameters of the empirical relationship between TAC changes and abundance trends at each of a series of regular MP reviews. These are held at intervals of typically five-years, with the intent to possibly modify MPs so as to take account of recent advances in scientific understanding of resource dynamics. The important advantage that this provides is ready understanding by stakeholders (such as industry and managers) of the basis upon which TAC adjustments are recommended each year, which facilitates stakeholder buy-in to the process as a whole.

S11-2

The Evolution of HCRs in Europe

Laurence Kell[1] (presenting), Martin Pastoors[1], Beatriz Roel[1]. [1]Cefas, Suffolk, United Kingdom

In this paper we review the changing policy objectives of fisheries management in the European Union, from the introduction of the precautionary approach through commitments under international agreements, such as the WSSD to rebuild fish populations to levels at which MSY can be taken and subsequent commitments to the progressive implementation of an ecosystem based approach to fisheries management. As part of this process there has been a move away from ad-hoc management to the development of Harvest Control Rules (HCRs) under which both long-term goals and ways to reach them are pre-defined. We illustrate the required changes in governance by tracing the evolution of HCRs for fisheries managed in European Community waters under the Common

Fisheries Policy (CFP) from a single species to ecosystem based control rules and discuss the demands for scientific knowledge, tools and social processes.

S11-3

Precautionary Harvest Policies and the Uncertainty Paradox

Steve Cadrin[1] (presenting), Martin Pastoors[2]. [1]NOAA/UMass CMER Program, Fairhaven, MA, United States, [2]Wageningen-IMARES, Ijmuiden, Netherlands

In the last decade, many fishery management organizations implemented elements of the precautionary approach in the form of harvest control rules, with limit, threshold and target reference points for stock size and fishing mortality. However, a review of two large advisory and management systems indicates that many stock assessments are not sufficiently informative to support such control rules. After a nearly a decade of applying such control rules, a large portion of management units in the International Council for the Exploration of the Sea (ICES) convention and marine fisheries under United States jurisdiction still have uncertain status (i.e. lacking a complete suite of fishing mortality and biomass estimates and reference points). For those fishery resources with analytical stock assessments and associated reference points, fishing mortality has generally been reduced to within prescribed limits. The number of ICES stocks with excessive fishing mortality (i.e. greater than the limit reference point) decreased since 1997, but the number of stocks in need of rebuilding increased as a result of excessive fishing or revised reference points. The number of U.S. stocks with excessive fishing decreased and the number of stocks needing rebuilding decreased as a result of stock recovery, revised reference points or redefined management units. However, the number of U.S. stocks with uncertain or undefined status substantially decreased. The large portion of stocks with uncertain status in both systems illustrates that such precautionary control rules are applied only to data-rich stock assessments, and are not being applied to management of fishery resources with the most uncertain stock assessments.

S11-4

General properties of harvest rules: the theoretical approach

Dorothy Jane Dankel[1] (presenting). [1]Institute of Marine Research, Bergen, Norway, [2]University of Bergen, Bergen, Norway

Harvest control rules (HCRs) represent a new trend in fisheries management as a scientifically-tested and stakeholder-agreed method of deciding exploitation rates. Fisheries scientists routinely design candidate HCRs, based on management objectives, and subsequently test for a variety of performance measures including risk to the stock, catch stability and robustness of the rule under uncertainty. However, in this approach, we choose to turn the process inside-out by assessing how the relationships between performance measures depend on HCR parameters (such as fishing mortality and biomass limit reference points) as a basis to the design of a candidate HCR. To achieve this, we use a generic population model to find how performance criteria (precautionary approach, risk to population collapse) relate to different management objectives (e.g. stabile catch, stabile fishing mortality, low inter-annual variation in catch). By analyzing the trade-offs and relationships of different performance measures to each other, we aim to make general conclusions as to which HCR design is most appropriate. We deepen the discussion by including different life-histories with short-, medium- and long-lived prototype species. Based on these theoretical considerations, can we say something on what sort of management regime one should think of for a certain kind of stock and certain management preferences?

S11-5

Evaluating harvest control rules when life history varies: the case of lake whitefish in the Great Lakes

Jonathan Deroba[1] (presenting), James Bence[1]. [1]Michigan State University, EastLansing, MI, United States

Lake whitefish support a commercial fishery in the Great Lakes and experience spatial and temporal variation in life history traits, such as size and maturity-at-age. Currently, the fishery is managed by attempting to maintain a constant mortality rate. We used an age-structured simulation model that incorporates stochasticity in life history traits and multiple sources of uncertainty to compare the current strategy with a range of alternative control rules, including conditional constant catch (CCC), constant fishing rate (CF), and biomass-based (BB), where fishing mortality was reduced at low stock sizes. We found that with appropriate selection of policy parameters the CF and BB rules can attain higher average yield than the CCC rule or the current constant mortality rate strategy. The CCC rule had the lowest yearly variability in yield. For control rules using policy parameters that produce the same yield, biomass more often reached low values for the CCC, and least often for the BB rule. We explored the tradeoffs among performance statistics such as average yield, average biomass, and variation in yield, and also how life history variability affected absolute and relative performance of the control rules.

S11-6

Are threshold harvesting strategies evolutionarily sustainable?

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Humans strongly affect the demography of harvested populations. These demographic effects include decreased overall population abundance and truncated age- and size-structure. On top of these, increased mortality might also cause changes in life-history traits, thus further affecting the genetic and phenotypic structure of exploited stocks. Such evolutionary changes have been suggested to contribute to widespread trends towards fish maturing at earlier ages and smaller sizes. Threshold harvesting strategies have been suggested as a method for sustainably managing fluctuating resources. The benefit comes through protecting part of the population from fishing, thus ensuring that some population renewal will always take place. However, the effectiveness of threshold strategies in protecting the fish stocks from fisheries-induced life-history changes remains to be investigated. In this study we examine the possible benefits form threshold harvesting strategies in managing evolving resources. We use an individual-based evolutionary model that includes multiple evolving life-history traits covering growth, the maturation process, and reproductive investment. In addition, this eco-genetic model has density-dependent feedback on growth and reproduction. These results will help in the evaluation of threshold harvesting strategies as tools for evolutionarily enlightened management.

S11-7

Development, evaluation and implementation of harvest control rules for Northeast Arctic cod, haddock and saithe

Bjarte Bogstad[1] (presenting), Harald Gjøsæter[1], Asgeir Aglen[1], Sigbjørn Mehl[1]. [1]Institute of Marine Research, Bergen, Norway

Since 2000, harvest control rules (HCRs) have been developed and implemented for Northeast Arctic cod, haddock and saithe. Cod and haddock are managed jointly by Norway and Russia, while saithe is managed by Norway alone. The harvest control rules have been developed in cooperation between scientists and managers. For each stock, population models have been developed for use in the evaluation. These models include, in addition to stock-recruitment relationships, processes like predation and density-dependent growth and maturation. The harvest control rules are based on regulating the fishing mortality (F), with F being reduced at low stock sizes. In addition there are constraints on annual variation of the total allowable catch (TAC). The main emphasis in the evaluation has been put on ensuring that the harvest control rules are in accordance with the precautionary principle. The experiences with implementing the rules are described. For cod and haddock, problems with unreported catches as well as with getting the assessment accepted by ICES have caused problems with the implementation of the rules.

S11-8

Integrating stakeholder perspectives with management objectives: a modeling approach for recreational fisheries

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Fisheries resources provide a diversity of ecosystem services to different stakeholders. However, stakeholders differ in their valuation of resource attributes, and fisheries managers must thus find ways of assessing and reconciling these distinct preferences when determining the impacts of management measures on stakeholder utility. Focusing on the management of recreational fishing we use choice theory to describe how fishing utility for different stakeholders (i.e. angler types) varies with the perceived fishing experience, where utility depends on attributes such as harvest regulations, angler congestion and the state of the fishery resource. We then integrate the resultant behaviour of specific angler-types with fish population dynamics in a common modeling framework to determine how management regulations change stakeholder utility, and how these changes in utility in turn affect stakeholder behaviour. We find that accounting for heterogeneity in angler types and their preferences changes predictions about angling pressure, fishing mortality and optimal harvest regulations. The general method introduced in this study integrates descriptions of stakeholder utility and resource dynamics into a comprehensive quantitative framework for evaluating the tradeoffs associated with management measures and for understanding their implications for the sustainable management of recreational fisheries.

S11-9

Harvest control rules and user-group agendas: making the two compatible

Joseph Powers[2] (presenting), Elizabeth Brooks[1]. [1]Northeast Fisheries Science Center, Woods Hole, MA, United States, [2]Louisiana State University, Baton Rouge, LA, United States

The basis of fisheries management is to control the mortality on fish stocks such that the stocks and fisheries can be sustainable. Currently, harvest control rules are often examined by management strategy evaluations (MSEs) in which the interaction of data collection, assessment, management advice and implementation are tested to formulate robust strategies. However, users of the fishery resource often respond differently to a harvest rule depending upon their goals and agendas in the management process. Additionally, harvest control rules may have very different management constraints for different user-groups. Thus, conflicts (games) are created in which the actions of user-groups may lead to unsustainable behavior. Conflicts between users occur in many fisheries at various organizational levels: recreational versus commercial, trawl versus handline, nation versus nation. Simple MSEs of a simulated population coupled with game-theory were used to evaluate these conflicts for a recovering fish stock when proportional allocations between user-groups were fixed. Implementation of control rules depended upon the precision of monitoring and bias in reporting. Therefore, a user-group's realized yield could differ from either their allocation or their reported catch. Results indicate that user-group strategies in response to the control rule can lead to harvests in excess of management benchmarks, demonstrating the importance of monitoring and enforcement. Additionally, user-group incentives and strategies should be investigated further.

S11-10

Influence of sources of variation on the performance of a harvest control rule

James Bence[1] (presenting), Jonathan Deroba[1], Weihai Liu[1]. [1]Michigan State Univ. East Lansing, Michigan, United States

We conducted simulations to evaluate the performance of a harvest control rule that sets target fishing mortality (F) to zero below a lower threshold estimated biomass, to a constant above an upper threshold estimated biomass, and increases F linearly with estimated biomass between the thresholds. We assumed Beverton-Holt recruitment and age-structured dynamics that could be captured in a delay-difference framework. We explored the range of plausible policy parameters for different magnitudes of variation and autocorrelation in assessment and recruitment process errors. Our study reproduces previous work, which has shown that with uncorrelated recruitment errors and no assessment errors, control rule parameters that most closely approximate constant escapement are best for both maximizing average harvest and maintaining higher levels of stock biomass. Likewise our evaluation overlaps with previous studies, which have shown little influence of uncorrelated process variation in recruitment, and a tendency for increases in assessment error variance to favor control rules that are closer to constant F than constant escapement. The presence of autocorrelation and details on how it is incorporated have important influences on optimal control rule parameters and the relative performance of special cases such as constant F or constant escapement.

S11-11

Long term agreed management plan for western horse mackerel; "If history repeats itself, and the unexpected always happens, how incapable must Man be of learning from experience."

Ciaran Kelly[1] (presenting). [1]Marine Institute, Rinnville, Galway, Ireland

Western horse mackerel is a widely distributed pelagic stock in the north east Atlantic. Like many horse mackerel stocks worldwide it has exhibited spasmodic pulse recruitment. However this phenomenon, whilst it may support temporary Olympic fisheries, presents challenges to fisheries scientists in assessing the stock. In the case of the northeast Atlantic western horse mackerel stock, further challenges are presented by poor fishery independent data. For years ICES scientists struggled with these features and weak assessments led to weak advice. In 2006 a stakeholder led initiative set about developing a long term management plan. This development took almost 1 year and involved numerous explorations of issues from both a fish stock and fishers point of view. The final product was a plan which was tailored to the poor information base on the stock, yet which met the objectives of stakeholders in terms of fishery viability. This paper describes the challenges in formulating an HCR strategy for a spasmodic recruiter, and matching the expectation of fishers to the reality of our ability (or rather lack of) to predict the future. The details of the HCR simulations are presented and the methodology of the simulation frameworks described. The process of the development of the management plan is then outlined. The lessons learned form this process are then generalized, and some conclusions drawn. The fishing opportunity for this stock in 2008 was based on the HCR used in the plan, however not all fisheries are covered by the TAC, but that's another story…

S12. Sustainable Fisheries for Highly-Migratory Large Pelagics

S12-1

Oceanography and reproductive strategies of tunas and mackerels

Churchill Grimes[1] (presenting), Edward Houde[1], Dan Margulies[1]. [1]DOC/NOAA/NMFS/SWFSC/FED, Santa Cruz, CA, United States, [2]University of Maryland, Solomons, MD, United States, [3]Scripps Institution of Oceanography, La Jolla, CA, United States

We review and evaluate knowledge of distribution, abundance, trophic ecology and growth of early-life stages of several scombrid species, i.e. yellowfin and blackfin tuna, little tunny and king and Spanish mackerel from the U.S. south Atlantic and Gulf of Mexico and yellowfin tuna and Spanish mackerel from the Gulf of Panama in the Pacific Ocean. We propose that serially-spawning scombrid fishes have evolved to utilize oceanographic features at different spatial scales to assure reproductive success. Although adults of most species reside in relatively oligotrophic oceanic and coastal-shelf pelagic environments, they spawn in oceanographic features such as upwellings, estuarine plumes and frontal features where both physical and biological processes concentrate prey resources and may confer a trophic advantage that supports feeding, fast growth, and survival of larvae. However, oceanographic features also concentrate predators. To be successful enhanced foraging opportunities and faster growth in the features must outweigh elevated predation risk.

S12-2

Spatial perspectives of bycatch in fisheries targeting large pelagics: mapping the bycatch seascape

Larry Crowder[1] (presenting), Rebecca Lewison[2], Michelle Sims[1], Candan Soykan[2], Janet Franklin[2], Ramunas Zydelis[1]. [1]Duke University Center for Marine Conservation, Beaufort, NC, United States, [2]San Diego State University, San Diego, CA, United States

From a fisheries perspective, the central questions about non-target catch, and in particular bycatch of species of conservation concern, are spatial in nature: where do bycatch events occur and how are they distributed in space? Are there persistent areas of high bycatch? What are the habitat features of bycatch locations and how are they correlated to fisheries independent habitat characterizations? Here we present recent and ongoing analyses by Project GloBAL (http://bycatch.env.duke.edu/) that address these questions. Our research explores the challenges with mapping bycatch data; identifies bycatch 'hotspots' from a single species, multi-species, and fisheries perspectives; and incorporates animal distribution data into our bycatch assessments. This project highlights the importance of innovative approaches to improving our understanding and characterization of bycatch seascapes.

S12-3

Recent trends in the bluefin tuna (*Thunnus thynnus*) rod and reel fishery in the Northeast United States.

Ronald Salz[1] (presenting), John Foster[1]. [1]NOAA Fisheries, Silver Spring, MD, United States

Bluefin tuna (*Thunnus thynnus*) is the most targeted and valuable highly migratory species (HMS) in the Northeast U.S. Over 20,000 vessels are currently permitted to fish for bluefin tuna in one of three rod and reel categories: Angling, Charter/headboat, and General. Both the Charter/headboat and General categories allow captains to sell commercial sized bluefin, whereas the Angling category is strictly recreational. The potential cumulative impact of this rod and reel fishery on bluefin tuna stocks can be quite large. NOAA Fisheries closely monitors and regulates this fishery to adhere to internationally mandated quotas and domestic sector and area sub-quotas in an effort to achieve long-term sustainability of this valuable resource. The Large Pelagics Survey (LPS) is the primary data source used to monitor the bluefin tuna rod and reel fishery. The LPS consists of both dockside interviews with captains returning from fishing trips targeting large pelagic species, and telephone interviews with randomly selected HMS permit holders. This study focuses on recent trends in the bluefin tuna rod and reel fishery based on data collected from the LPS. Data analyses include the following variables of interest: estimated landings and releases, catch rates, directed effort, length frequencies, and fishing locations. Trends in bluefin tuna permit sales for the three rod and reel permit categories are also explored. Anglers' fishing behaviours (e.g. avidity, target species, locations fished) are often influenced by external factors including fish availability, regulations, substitute species, fuel prices, and weather. This is particularly true for off-shore highly migratory fisheries where large investments of time and money are often needed to pursue big game fish. The potential impact of external factors on the bluefin tuna fishery is discussed in light of trends and patterns suggested by the data analyses conducted.

S12-4

Resolving population boundaries in a mixed stock with Exon-Primed Intron-Crossing nuclear genetic markers (EPICs) using High-Resolution Melting Analysis (HRMA)

Brad Smith[1] (presenting), Jaime Alvarado-Bremer[1]. [1]Texas A&M University, College Station, TX, United States

Swordfish (*Xiphias gladius*) are epipelagic, scromboid fish that are found in all oceans. Highly migratory by nature, swordfish represent a mixed stock in the Atlantic Ocean whose boundaries remain largely unresolved. Previous studies using mitochondrial DNA to resolve stock boundaries have been limited by the maternal inheritance of such markers. The use of exon-primed intron crossing nuclear markers (EPICs) allows the variability inherited by both parents in the introns of nuclear genes to be utilized for resolving these stock boundaries. The inclusion of multiple EPICs (e.g. LDH, Aldolase, Mlc2, and CAM) further increases the statistical power that is needed for mixed stock boundary assessments. High-resolution melting analysis (HRMA) is a homogeneous, closed-tube method of genotyping that does not require the use of real-time PCR or probes. Single nucleotide polymorphism (SNPs) found in the variable introns of these nuclear genes can be genotyped using HRMA. When coupled with rapid-cycle PCR and a DNA dye like LCGreen I, HRMA has the potential to genotype SNPs for a fraction of the cost and effort of other methods like sequencing or labelled probes. The resulting allelic and genotypic frequencies obtained from multiple EPICs using HRMA have the potential to resolve the mixed stock boundaries of the swordfish in the Atlantic Ocean.

S12-5

Bycatch and incidental catches of sharks in the Hawaii-based pelagic longline fishery for swordfish, *Xiphias gladius*, in 2004–2006

William Walsh[1] (presenting). [1]University of Hawaii, Honolulu, HI, United States

A “shallow-set” pelagic longline fishery for swordfish, *Xiphias gladius*, has operated from Hawaii since 2004, subject to operational requirements intended to minimize interactions with and adverse effects upon sea turtles. As such, the fishery has changed relative to the Hawaii-based fishery in the preceding decade, which was less stringently regulated. This presentation summarizes recent trends in the catches of sharks in this fishery. The magnitude, species composition, survival on longline gear, and disposition (i.e. release or retention for consumption or sale) of the sharks catch will be described. Graphical output from preliminary analyses of the catch rates of the most common species (e.g. blue shark, Prionace glauca; shortfin mako, Isurus oxyrinchus), based upon the use of generalized additive models, will depict the “shapes” of the effects of extrinsic factors (e.g. sea surface temperature, latitude and longitude). These latter results will serve as the basis for the development of generalized linear models that will permit computation of the removals of sharks by this fishery with appropriate confidence intervals. Finally, shark bycatch will be discussed in the context of maintaining the sustainability of this fishery.

S12-6

Application of a Bayesian hierarchal meta-analysis in the assessment of pelagic sharks: a case study using the night shark, *Carcharhinus signatus*

John Carlson[1] (presenting), Kate Siegfried[1], Enric Cortés[1], Aaron MacNeil[1]. [1]NOAA Fisheries Service, Panama City, FL, United States

Night sharks, *Carcharhinus signatus*, are an oceanic species generally occurring in outer continental shelf waters in the western North Atlantic Ocean including the Caribbean Sea and Gulf of Mexico. Although information from some fisheries has shown a decline in catches of night sharks, it is unclear whether this decline is due to changes in fishing tactics, market conditions, or species identification. Despite the uncertainty in the decline, the night shark is currently listed as a species of concern due to alleged declines in abundance resulting from fishing effort, i.e. overutilization. A previous study concluded that the night shark did not qualify as a species of concern but the uncertainty in the trends in relative abundance precluded any determination of changes in stock status. Further, the “data-poor” situation precluded the application any typical stock assessment models. While some modeling-based frameworks (e.g. catch-free model) for estimating stock status in situations where catch data are poor have been utilized, the highly uncertain nature of the data for night shark also prevented application of these models. Previous standardized catch rates using a two-part generalized linear model gave conflicting results, with one series showing a decline, two series showing an increase and one series showing constant abundance. To address this uncertainty, we used a hierarchical meta-analysis in a Bayesian framework to estimate changes in relative abundance from fishery dependent and independent catch rate series. Prior probability distributions of the estimated parameters were developed using knowledge of data source and collection method. In general, priors were non-informative uniform distributions. The final model was fit using WinBUGS and estimates of trends were based on Markov chain Monte Carlo posteriors. The meta-analytic estimate indicated little decline overall suggesting night sharks have not suffered significant declines in abundance.

S12-7

Using historical data to estimate movement and fishing mortality rates of the blue shark (Prionace glauca) in the North Atlantic Ocean

Alexandre Silva[1] (presenting), Mark Maunder[2], Vincent Gallucci[1], Nancy Kohler[3], John Hoey[3]. [1]University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA, United States, [2]Inter-American Tropical Tuna Commission, La Jolla, CA, United States, [3]Northeast Fisheries Science Center, National Marine Fisheries Service, NOAA, Narragansett, RI, United States

Large numbers of blue sharks are caught as bycatch, and have even become the target species in pelagic longline fisheries in the North Atlantic Ocean. The status of the stock is ambiguous due to the limitations of the available fishery-dependent data. Paradoxically, the North Atlantic blue shark is data-rich compared to most of other pelagic shark species worldwide in terms of availability of tagging data. This study presents a spatially-explicit tagging model to estimate blue shark movement and fishing mortality rates in the North Atlantic. The model uses the blue shark tag-recovery data of the U.S.-N.M.F.S. Cooperative Shark Tagging Program (1965-2004). Four major geographical regions (two on each side of the ocean) are assumed and rates of annual mixing among regions are estimated. The blue shark fishing mortality rates (F) were found to be heterogeneous across the four regions. While the estimates of F obtained for the western North Atlantic were historically lower than 0.1 yr-1, the F estimates over the most recent decade (1990s) in the eastern side of the ocean are rapidly approaching an estimated reference point for conservation (Fmax=0.2 yr-1). Because of the particular life-history of the blue shark, these results suggest careful monitoring of the exploitation since the juvenile and pregnant female segments of the stock are highly vulnerable to exploitation in the eastern North Atlantic.

S12-8

Tales of the demise of large pelagic fishes: where's the truth?

Pierre Kleiber[1] (presenting). [1]NOAA Fisheries, Honolulu, Hawaii, United States

In recent years we have seen the publication of many articles decrying the parlous state of fisheries and making claims of doom for fisheries and fish populations. Some of these publications have been featured in high impact scientific journals such as Nature and Science. In an article claiming decimation of large pelagic fish populations, myself and other tuna scientists recognized exaggerations, misstatements, and faulty analysis that in some cases could lead to ill-advised management decisions. Our experience in attempting to rectify the public record by publishing in the same journals revealed an evident editorial bias favoring ecological disaster stories. That bias may reflect the growth of the environmental movement in society and a resulting ecological political correctness, or it may simply reflect journalistic partiality for the greater impact of astounding claims as opposed to sober reality. Fortunately some environmental advocates are beginning to recognize that advocacy science can easily stray from the path of objective science and that false or overblown claims can tarnish their credibility and ultimately be counter-productive. On the other hand, spinning of science for political ends is widespread in more fields than fisheries and is promulgated in more ways than publications in a few prestige journals. The abuse, misuse, and disregard of science is reflective of social and political currents in our society that are beyond what a small group of fishery scientists can deal with. But given that management policies in fishery management agencies are affected by the popular public record, it seems incumbent on us to do what we can to keep that record straight.

S12-9

Population structure, spawning fidelity and contributions of western and eastern origin populations to North American fisheries for bluefin tuna (*Thunnus thynnus*): evidence from otolith stable isotope analysis

David Secor[1] (presenting), Jay Rooker[2], Ryan Schloesser[2], John Neilson[3]. [1]Chesapeake Biological Laboratory, Solomons, MD, United States, [2]Texas A&M Galveston, Galveston, TX, United States, [3]Fisheries and Oceans Canada, St. Andrews, NB, Canada

It is generally accepted that there are two discrete populations of Atlantic bluefin tuna originating from the Gulf of Mexico or Mediterranean. We provide further evidence for these two populations, which differentially contribute to North American fisheries. Stable oxygen isotopes in otoliths of yearling bluefin tuna from six year classes (1999-2004) were significantly different between collections made in either the eastern (Mediterranean Sea/eastern Atlantic Ocean) and western (Gulf of Mexico/western Atlantic Ocean) nurseries. Milled otolith cores were used to classify adolescent and adult samples to nursery of origin. Cross-validated classification rate of known-origin juveniles to the two nurseries was 88%. Spawners in the Mediterranean and Gulf of Mexico were estimated to originate in eastern and western nurseries, respectively at >90% rates. All giant bluefin tuna sampled from Gulf of St. Lawrence fishery (n~200) were estimated to belong to the Gulf of Mexico population. In contrast, US fisheries (n~200) of mixed size classes showed strong contributions by the Mediterranean population at rates >50%. These results confirm spawning fidelity by two principal populations but also highlight the strong role the Mediterranean population has in supporting U.S. fisheries and the Gulf of Mexico population has in supporting the Gulf of St. Lawrence fishery.

S12-10

Age & growth and other life history aspects of swordfish in the central Pacific

Robert L. Humphreys, Jr.[1] (presenting), Edward E. DeMartini[1]. [1]NOAA, NMFS, Pacific Islands Fisheries Science Center, Aiea, Hawaii, United States

Sex-specific length-at-age growth curves were developed for central north Pacific swordfish based on a combination of daily growth increments on larvae and juveniles, annulus counts on anal spine sections of larger fish, and observed growth obtained from 3 tag-recaptures. A standard von Bertanlaffy growth model was fit to the data; females exceeded males in growth beginning at about age 3. Growth rates of swordfish in the central North Pacific (both sexes) were found to be greater than reported for the western Pacific (Taiwan). Daylight surface tows conducted off the Kona coast of the Island of Hawaii were successful in the collection of larval stages of swordfish. With the development and application of a shipboard PCR identification technique, swordfish eggs were also detected from plankton catches and found to have a similar distribution (within 1-25 nm off the coastline) as the larval stage. The occurrence of swordfish eggs predominated over istiophorid species; swordfish eggs were collected almost exclusively from tows when sea surface salinity was low.

S12-11

Efficient single-tube characterization of genetic polymorphisms in fishes: the use of high-resolution-melting analysis as a breakthrough to study the genetic population structure of the swordfish (*Xiphias gladius*)

Jaime Alvarado Bremer[1] (presenting), Mike Hinton[2]. [1]Texas A&M University at Galveston, Galveston, Texas, United States, [2]Inter-American Tropical Tuna Commission, La Jolla, California, United States

Substantial levels of geographic partitioning among swordfish populations has been described using mtDNA data, with a similar signal of differentiation using nuclear DNA (nDNA) obtained from exon-primed-intron-crossing (EPIC) loci but not from microsatellites. The reasons why microsatellites fail to provide a similar level of geographic partitioning in swordfish falls outside the scope of this presentation, but similar patterns exist in other highly migratory fishes. Additional nuclear markers in the form of EPICs are highly desirable to examine the levels of genetic differentiation of swordfish within ocean basins and to identify

boundaries between genetically distinct populations. A major challenge to genotype EPICs stems from the wide variety of laboratory techniques needed to identify informative polymorphic sites. Typically genotyping involves gel electrophoresis in combination with other techniques such as PCR-RFLPs, intron-length variation, direct sequencing, SSCP, and others. To complicate matters genotyping certain loci involves the use of more than one technique in order to identify all the alleles present. High resolution melting analysis (HRMA) is a rapid (2 min) closed-tube post-PCR genotyping alternative method that does not require probes or a real-time PCR instruments. Reagent costs for genotyping by amplicon melting are low because only PCR primers and the generic dye LCGreen Plus are needed. This system is capable of genotyping single-nucleotide polymorphisms (SNPs) after rapid-cycle PCR (12-20 min) when performed in a capillary instrument. Using HRMA we efficiently and unambiguously genotyped several EPICs including ldhA, aldolase, calmodulin, creatine kinase, among others, that are informative of the population structure of swordfish, but that are often difficult, time-consuming and\or expensive to genotype using conventional approaches. HRMA can be used in any study requiring fast-highly sensitive genotyping.

S12-12

Sustainability of the Hawaii-based pelagic longline fishery for swordfish: a case study of successful collaboration among fishery stakeholders

Russell Ito[1] (presenting). [1]NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, Hawaii, United States

Longline fishing for swordfish, *Xiphias gladius*, began in Hawaii in 1988, grew rapidly, then dominated longline landings in Hawaii from 1990 through 2000. However, it soon became apparent that this type of longline fishing was associated with unacceptably high rates of interactions between endangered leatherback (Dermochelys coriacea) and threatened loggerhead (Caretta caretta) sea turtles and longline gear. A lengthy period (ca. 5 years) followed in which litigation and various management decisions changed the nature of this fishery. Various stakeholders worked collaboratively to reopen this sector of the fishery with the dual objectives of achieving optimum yield of swordfish harvest without jeopardizing the existence of sea turtles. The effectiveness of this collaboration during 2005–2007 is reflected by substantial annual reductions of sea turtle interactions (leatherback: -86%, loggerhead: -96%). In addition, the swordfish-directed CPUE (fish per 1000 hooks) in 2005–2007 exceeded the long-term average, the mean weight of swordfish was close to the pre-closure size, and swordfish landings were about 50% of those in 1994–2000. The results of the collaboration are a sustainable fishery, in conformity to U.S. environmental laws.

S12-13

Biological reference points and status of North Pacific striped marlin, *Tetrapturus audax*

Jon Brodziak[1] (presenting), Kevin Piner[2]. Pacific Islands Fisheries Science Center, Honolulu, HI, United States[1], Southwest Fisheries Science Center, La Jolla, CA, United States[2]

North Pacific striped marlin (*Tetrapturus audax*) are managed under the auspices of four regional fishery management organizations. These fast-swimming apex predators are a bycatch in longline fisheries targeting tunas. Striped marlin are also a highly-prized game fish off the coast of Mexico. The most recent stock assessment indicated that spawning biomass had declined to between 6% to 16% of its 1950s abundance in 2003 and that current fishing mortality was roughly 0.7 yr-1. To characterize the status of this stock, data from the most recent assessment were used to estimate MSY-based biological reference points using alternative age-structured production models for two stock assessment scenarios. These models represented alternative hypotheses about compensatory or overcompensatory recruitment dynamics and flat or dome-shaped fishery selectivity under each scenario. Alternative model likelihoods were fit using Bayesian methods. Competing models were judged using the Schwarz criterion to select the most probable model. Model averaging was applied to measure the importance of model selection uncertainty and sensitivity analyses to the assumed natural mortality rate were conducted. Results indicated that North Pacific striped marlin is likely overfished and experiencing overfishing. Reducing fishing mortality on this stock would help rebuild spawning potential and would likely enhance recreational fishing benefits.

S12-14

Reducing pelagic bycatch: an analysis of two approaches to capture swordfish in Canadian waters

Gretchen Fitzgerald[3], Susanna Fuller[1] (presenting), Jen Ford[2], Scott Wallace[4]. [1]Dalhousie University, Halifax, Nova Scotia, Canada, [2]Ecology Action Centre, Halifax, Nova Scotia, Canada, [3]Sierra Club of Canada, Halifax, Nova Scotia, Canada, [4]David Suzuki Foundation, Vancouver, British Columbia, Canada

Until the early 1960's, swordfish in Atlantic Canada were fished exclusively with harpoons. There was no by-catch of non-target species and very little landing of juveniles. Following the advent of pelagic longlining in Canadian waters and adjacent seas, north Atlantic swordfish were reduced to their lowest known levels, a decade later in 1974. Longlines catch sea turtles, sharks, juvenile target species including bluefin tunas and swordfish. In Canada, 90% of the quota is allocated to longline vessels, with 10% of swordfish quota to harpoons, despite the harpoon being the historically used fishing gear. The most recent data available, based on low lovels of observer coverage for the longline fishery indicates that > 50% of the total catch of all species is discarded. We propose a way forward for conservation of pelagic species in Canadian waters that will result in a significant decrease in longline bycatch while restoring low impact gears as primary fishing methods.

S12-15

Biomass-based reference points for north Pacific albacore, *Thunnus alalunga*

Ray Conser[1] (presenting), Yukio Takeuchi[2], Paul Crone[1], Koji Uosaki[2]. [1]NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, CA, United States, [2] National Research Institute of Far Seas Fisheries, Shimizu, Japan

North Pacific albacore (*Thunnus alalunga*) are managed internationally, but agreed biological reference points have yet to be established. Recognizing that consistently productive, multinational, large-scale albacore fisheries have been conducted in the North Pacific Ocean for more than 60 years, it would seem prudent to maintain the albacore spawning stock biomass (SSB) at levels that historically, have produced these catches. This paper introduces a straightforward, fishing mortality-based, reference point designed to ensure that SSB in future years remains within the range of the historically 'observed' SSB. Potential utilization of this new reference point (FSSB) for albacore requires full accounting for the uncertainty in the stock assessment results and the likely uncertainty regarding the future condition of the stock. Finally, the approach can be used by fishery managers to associate a probability of success with any selected FSSB level – allowing full use of the precautionary principle in the face of uncertainty. The FSSB approach is illustrated using the results of a recent stock assessment carried out by the ISC Albacore Working Group.

S12-16

Are there sustainable fisheries for ICCAT Species?

Gerald Scott[1] (presenting). [1]NMFS, SEFSC, Miami, FL, United States

ICCAT is responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. The organization was established in 1969 after the International Convention for the Conservation of Atlantic Tunas was ratified. Today, there are 47 Contracting and Cooperating Parties. About 30 teleost species are of direct concern to ICCAT; although those for which the most attention has been paid are: Atlantic bluefin, skipjack, yellowfin, albacore and bigeye tuna; swordfish; and billfishes such as white marlin, blue marlin, sailfish and spearfish. Recently, ICCAT has expanded its species portfolio to include pelagic sharks and bycatch species such as seabirds. The fisheries involved use a wide variety of gears, although the main fishing methods, in terms of production, remain purse seine, baitboat, and longline fishing; each with differential impacts on the species of concern. The objective of ICCAT is to manage the Atllantic tuna fisheries in a way to assure sufficient biomass levels to permit maximum sustainainable harvests across the species of concern. The current status of the 13 stocks for which ICCAT's Scientific Committee has been able to conduct stock assessments, is mixed. Five stocks have been diagnosed as both being overfished and undergoing overfishing, with the others ranging from overfished, but rebuilding, to neither overfished nor undergoing overfishing. Management actions taken by the Commission have been attributed with promoting rebuilding of some stocks and reductions in effort levels observed in recent years may lead to further improvements. Rebuilding plans agreed for other stocks, for which rebuilding plans have been agreed, are considered inadequate to achieve the Convention Objectives unless additional conservation actions are agreed and implemented by the CPPs. ICCAT's stock assessment Report Card will be correlated with recent agreements for stock conservation, to address the question posed: "Are there sustainable Fisheries for ICCAT Species?"

S13. Contributions of Genetic Principles and Technology to Sustainable Fisheries: Concepts, Challenges, and Case Studies

S13-1

Canada's wild Salmon policy: conservation planning for an uncertain future

Brian Riddell[1] (presenting), Blair Holtby[1]. [1]Fisheries and Oceans Canada, Nanaimo, B.C. Canada

The goal of Canada's Wild Salmon Policy is to restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of Canadians in perpetuity. The first of six implementation strategies involves the identification of Conservation Units (CUs), which are novel population units that conceptually fall between the ESU and the local spawning population. CUs are, essentially, a modern reworking of the Ricker's 'stock concept' but with greater emphasis on adaptability of salmon. To describe CUs for each of five species of anadromous Pacific salmon (Oncorhynchus spp) covered by the Policy in a vast and diverse geography with over 10,000 known spawning locations, we developed a multi-species, multi-attribute method derived from the three-axis approach of Waples et al. (2001). Our approach began by compartmentalizing the freshwater habitat of British Columbia into 32 ecotypic "freshwater adaptive zones" and 12 near-shore and estuarine "marine adaptive zones". The watersheds within each freshwater zone have a similar climate, drainage density, gradient, hydrology, and connectivity and share a common zoogeographic history. Each marine zone has similar bathymetry, currents, tides, and biotic communities. Taken together, the freshwater and marine adaptive zones form 38 "joint adaptive zones" or JAZ. Each species-JAZ pairing is considered an ecotypic CU and absent additional genetic, ecological and life-history information would be considered a Conservation Unit. For most of the ecotypic CUs additional information was available. Genotypic, phenotypic and fine-scale ecotypic characteristics of the salmon were then considered as the ecotypic CUs are variously split or merged to define Conservation Units that comprised genetically and ecologically exchangeable populations. We concluded that there were 407 CUs of Pacific salmon in British Columbia. We found a

high concordance between ecotypic and genetic characterizations of intraspecific diversity. Molecular genetics was essential in areas of high genetic diversity but once identified, ecotypology appeared capable of mapping the genetic diversity suggesting that we were mapping real and likely adaptive diversity. An ecotypic approach has benefits of characterizing habitat in its broadest sense, thereby supporting the intent of the WSP to use CUs for conservation of both extant diversity and evolutionary processes.

S13-2

Sexual selection and breeding programs: the importance of genetic quality

Bryan Neff[1] (presenting), Trevor Pitcher[2]. [1]University of Western Ontario, London, Ontario, Canada, [2]University of Windsor, Windsor, Ontario, Canada

Each year, millions of salmon and other fish are caught and stripped for artificial breeding purposes in an attempt to augment natural populations. However, such breeding programs often neglect the potential genetic benefits of sexual selection. Genetic benefits can be classified into "good genes" and "compatible genes." Good genes refer to additive genetic effects on fitness while compatible genes refer to non-additive genetic effects. Empirical research suggests that good gene effects can explain only a small percentage of the variation in fitness, but less is known about compatible gene effects. Here, we examine the potential genetic benefits from sexual selection in Chinook salmon (*Oncorhynchus tshawytscha*) using split in vitro fertilization techniques and semi-natural spawning. First, 11 females were crossed with 11 males in all pair-wise combinations and the 121 families were raised until the end of the endogenous feeding period. Variation in offspring survivorship was then partitioned to good gene, compatible gene and direct maternal effects. We found that parental genotypes at the major histocompatibility complex (MHC) contributed to the good gene and compatible gene effects. Spawning trials with a second population showed that females, but not males, exercised mate choice and selected mates that increased divergence at the MHC in their offspring. These results suggest that incorporating sexual selection into breeding programs can enhance their effectiveness.

S13-3

Not long ago, in a galaxy not so far away: marker wars and the on-going campaign for standardized and shared inter-laboratory genetic databases

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Interest continues to grow in inter-laboratory standardization of genetic data, as they become increasingly important for a wide array of fishery management and conservation applications. The ability of multiple collaborating laboratories to combine and analyze common data provides a strong motivation for common markers and common genotyping conventions. There is a long history in the Pacific Northwest of inter-laboratory cooperation for standardization of salmon genetic data, from allozymes, to microsatellites, to single nucleotide polymorphisms (SNPs). Nevertheless, the rapidity of technological advance, combined with significant new demands and expectations of genetic data, has created a significant challenge to the continued coordination of both database construction and analytic methods. Legitimate differences of opinion among informed researchers are superimposed on common misconception and misinformation. I provide here an overview of recent developments in standardizing genetic data for multiple Pacific salmon species. I also discuss opportunities and caveats for exploiting new marker classes, standardized databases, and new analytic methods in both traditional and novel applications to ecological genetics.

S13-4

Differentiating salmon populations at broad and fine geographic scales with microsatellites and SNPs

Shawn Narum[1] (presenting). [1]CRITFC, Hagerman, ID, United States

Single nucleotide polymorphisms (SNPs) are appealing genetic markers due to several beneficial attributes, but uncertainty remains about how many of these bi-allelic markers are necessary to have sufficient power to differentiate populations, a task now generally accomplished with highly polymorphic microsatellite markers. In this study, we tested the utility of 37 SNPs and 13 microsatellites for differentiating 29 broadly distributed populations of Chinook salmon (n = 2,783). Information content of all loci was determined by In and G'ST, and the top 12 markers ranked by In were microsatellites, but the six highest, and 7 of the top 10 G'ST ranked markers, were SNPs. Individual assignment test accuracy was higher for microsatellites (73.1%) than SNPs (66.6%), and pooling all 50 markers provided the highest accuracy (83.2%). When marker types were combined, as few as 15 of the top ranked loci by G'ST (8 SNPs plus 7 microsatellites) provided higher assignment accuracy (73.4%) than either microsatellites or SNPs alone. Neighbor-joining dendrograms revealed similar clustering patterns and pairwise tests of population differentiation had nearly identical results with each suite of markers. SNPs proved to be equally or more effective than microsatellites in determining structure of moderately to highly divergent populations, but statistical tests and simulations indicated that closely related populations were better differentiated by highly polymorphic microsatellites. Our results indicate that both types of markers are likely to be useful in population genetics studies and that, in some cases, a combination of SNPs and microsatellites may be the most effective suite of loci.

S13-5

Conservation genetics of brook trout (*Salvelinus fontinalis*): phylogeography, population structure, and assessing the adaptive significance of observed differentiation

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Heritable genetic information offers an objective means of providing an evolutionary framework from which to develop and evaluate conservation priorities. To address this research need, the U.S. Geological Survey and U.S. National Park Service have collaborated to develop a suite (N=13) of microsatellite DNA markers and to conduct an extensive survey of genetic variation in over 8,200 brook trout collected from the major drainages within five national parks and several other populations (120 collections) comprising the native range of the species in the eastern U.S. and Canada. This survey has shown a range of allelic diversity (including some of the lowest levels reported for vertebrate populations) and differentiation at all hierarchical levels studied (i.e. individual to watershed). In addition to identifying previously undetected evolutionary relationships among populations, this study has proven useful in identifying collections that have experienced small effective population sizes (e.g. bottlenecks) and has highlighted collections that have been impacted by supplemental or restorative stocking. These findings create somewhat of a management conundrum for resource managers - Does the genetic divergence observed among brook trout show adaptive significance or is this indicative of drift-induced differentiation? The independent evolution of adaptively divergent phenotypes among closely related lineages is most likely the consequence of natural selection. Because natural selection ultimately acts on the genetic variation underlying character variation, identifying the genes associated with parallel evolutionary changes among recently diverged lineages is essential to uncovering candidate genes implicated in adaptive phenotypic variance. Indirect evidence from a study underway suggests that some portion of the observed differentiation may, in fact, reflect localized adaptation.

S13-6

A transcriptomic view on whitefish population genetics

Arne Nolte[1] (presenting), Louis Bernatchez[1]. [1]Université Laval, Québec City, Québec, Canada

The assessment of genetic diversity and population structure is of fundamental interest to develop management strategies and basic research questions. While the need to acquire knowledge from the use of neutral markers is undeniable, there is a trend towards considering genes that cause adaptation in natural conditions. This talk illustrates how transcriptomic studies in an evolutionary ecology context represent a holistic approach towards the identification of adaptive genetic variation. Studies in whitefish (*Coregonus clupeaformis* complex) permit a reassessment of how evolutionary divergence in adaptive traits and neutral markers are related. Patterns of gene expression divergence among populations of whitefish evolve under positive selection. We detect little adaptive divergence in developing embryos but a large number of genes that diverge in a predictable fashion in adult fishes. Our analyses show that adaptive changes in the transcriptome have a broad genetic basis rather than being caused by single genes. Complex evolutionary divergence may be evident at the level of the transcriptome despite a virtual absence of neutral divergence. Thus, a too naïve interpretation of neutral divergence may be misleading.

S13-7

Identification of lake trout morphotypes in large, deep lakes: a comparison of unexploited and exploited communities

Mara Zimmerman[1] (presenting), Charles Krueger[2], Randy Eshenroder[2]. [1]Michigan State University, Lansing, MI, United States, [2]Great Lakes Fishery Commission, Ann Arbor, MI, United States

Lake trout morphology and lipid content are known to have a genetic component and are associated with the use of different habitats depths in large, deep lakes. Thus aspects of lake trout genetic diversity are expressed morphologically and contribute to ecological traits such as habitat selection and feeding strategy. This study examines the morphological consequences in lakes where one morphotype is over-exploited. We compare exploited populations from Lake Superior (Isle Royale, Big Reef) to relatively unexploited populations in Great Slave Lake, Northwest Territories and Lake Mistassini, Quebec. Great Slave Lake is geologically of comparable age to Lake Superior; however, Lake Mistassini is at least 3,000 years younger in its formation. Morphotypes from each lake were identified and compared using geometric morphometric tools combined with model-based cluster analyses. Greater differentiation among morphotypes occurred in Great Slave Lake and Lake Mistassini than found in Lake Superior. We suggest that this has resulted from a collapse of morphological distinctiveness among the Lake Superior forms caused by a breakdown of stock isolating mechanisms. A similar collapse of morphological diversity has been observed for deepwater coregonids in lakes Michigan and Huron.

S13-8

Major histocompatibility genes can define populations of multiple species of fish: African and Arctic experiences

Brian Dixon[1] (presenting). [1]Dept of Biology, Univ. of Waterloo, Waterloo, ON, Canada

Major histocompatibility (MH) receptors bind to peptide fragments of proteins derived from pathogens and initiate immune responses in all jawed vertebrates. As such they must have the ability to recognize millions of different peptides. This variety in binding capability is achieved though population-scale polymorphism in the MH genes, which are the most polymorphic known nuclear encoded genes. This polymorphism is thought to be generated by recombination, aided by selection for alleles that can combat local pathogens, and to be maintained by balancing selection. Since MH genes are inherited co-dominantly, isolated groups tend to develop unique allele frequencies and sometimes unique alleles in response to local pathogens. This fact can be exploited to assist in the determination of population structures of organisms that contain these genes. Given that these genes are selected, these changes can occur rapidly, making them really useful for recently diverged populations. My research has used these genes to study two groups of recently developed fish populations. The first are the barbel species flock of Lake Tana, Ethiopia and the second are Arctic char populations situated around the arctic circle. In both cases clear differentiation of all populations and morphotypes could be achieved using the most polymorphic MH gene, MH class II beta, while the other polymorphic MH genes gave mixed results. These results are not only useful for population dynamics, but point to an interesting difference between fish and mammals, where the MHC class I gene is the most rapidly evolving and thus most useful for population dynamics studies, while the MHC class II alleles are maintained over millions of years.

S13-9

Genomic analysis of morphological and physiological indices of alternative migratory and non-migratory life history strategies in *Oncorhynchus mykiss*

Krista Nichols[1] (presenting), John Colletti[1], Alicia Felip[2], Paul Wheeler[2], Gary Thorgaard[2]. [1]Purdue University, West Lafayette, IN, United States, [2]Washington State University, Pullman, WA, United States

To migrate or to stay is a pervasive theme in the evolution of divergent life history strategies in salmonid fishes. Across the salmonid phylogeny, variation exists in both the propensity and timing of migration both among and within species groups. The decision to migrate or maintain residency is a complex integration of biotic and abiotic environmental cues with endocrine, physiological, and energetic processes, but the genetic basis of migration/residency is poorly understood. We have begun to dissect the genetic architecture of migration-related physiology and morphology in freshwater resident rainbow trout and migratory steelhead trout (both *Oncorhynchus mykiss*) using quantitative trait loci (QTL) analysis. In doubled haploid progeny produced from a cross between resident and anadromous O. mykiss, we have found a single QTL associated with multiple traits during the usual parr-smolt transformation in juveniles, and in post-smolt subadults and mature adults. Several single trait QTL have been identified for juvenile body morphology, skin reflectance, growth rate, and body condition. One genome region on linkage group 20 is associated with multiple single traits; this QTL explains 11-28% of the phenotypic variation, depending on metric, and is the only QTL identified when all traits are used in a multiple trait QTL analysis in juveniles. In post-smolt subadults and mature adults, body morphology was significantly associated with the QTL identified for juvenile characters on linkage group 20. One additional QTL was identified for adult or sub-adult body morphology, and together, these adult morphology QTL explain 9-35% of the phenotypic variation. With these results, we continue to evaluate the genes and regulatory regions associated with identified QTL. Ultimately, this work will contribute to our understanding of the evolution of migration/residency and the continuum of migratory life history types in the salmonid fishes. Furthermore, an understanding of the genetic components underlying migratory vs. resident life history diversity will contribute to decisions for the units of conservation for salmonid populations.

S13-10

Is size-selective fishing responsible for the declining size of Yukon River Chinook salmon?

Jeffrey J. Hard[1] (presenting), Jeffrey F. Bromaghin[2], Ryan Nielson[3]. [1]National Marine Fisheries Service, Northwest Fisheries Science Center, Conservation Biology Division, Seattle, WA, United States, [2]U.S. Fish and Wildlife Service, Fisheries and Ecological Services, Anchorage, AK, United States,[3]Western EcoSystems Technology, Inc., Cheyenne, WY, United States

The Yukon River gillnet fishery may be the only major fishery in the world that targets Chinook salmon (*Oncorhynchus tshawytscha*) with large-mesh gear. Concern regarding potential consequences of the selective removal of large fish is being expressed with increasing frequency among fishery professionals and in public meetings. Published reports are increasingly attributing changes in fish population size and structure (i.e. the age, sex, and size composition) to selective fisheries. However, relatively few of these investigations concern salmon, and even fewer consider Alaskan Chinook salmon. Exploratory analyses of data collected during typical harvest sampling or stock assessment activities are limited by the short time series of available data, as well as high natural variation. In addition, if the decades-old Yukon River Chinook salmon fishery has the capability of modifying population structure, the effects may now be largely manifested and investigations founded on available data, collected only in recent years, may be uninformative. We are investigating the potential long-term effects of large-mesh gillnet fisheries on Yukon

River Chinook salmon by stochastic modeling of population dynamics and evolution. Of primary interest are potential changes to the productivity and age, sex, and size structure of the population caused by the selective removal of large fish over a long period of time. Because some results indicate that long-term effects are likely, we are also exploring the resiliency of the population to alternative harvest strategies.

S13-11

Why both within- and between-population diversity are essential to conserve fitness in the wild: a lesson from Alaskan steelhead

Frank Thrower[1] (presenting), Jeff Hard[2]. [1]NOAA, NMFS, Juneau, Alaska, United States, [2]NOAA, NMFS, Seattle, Washington, United States

For two populations of Alaskan steelhead (*Oncorhynchus mykiss*) of common ancestry we evaluated inbreeding and outbreeding depression in second-generation descendants of wild fish derived from the same wild anadromous Alaskan stock in the 1920s. We measured phenotypes for growth, smoltification, and maturation in over 6,500 age-2 fish in 75 purebred and crossbred families. Smolting and precocious male maturity were highly variable among families within each population and significantly different between the populations. Genetic divergence of the populations was modest at both neutral loci and quantitative traits and appears to reflect primarily additive genetic effects and interactions among alleles within loci. However, marine survival to adulthood of progeny of resident parents released to the ocean was significantly lower than that of progeny of anadromous parents. Evidently, even low levels of adaptive differentiation can yield detectable outbreeding depression for survival in the wild. Both populations also exhibited inbreeding depression after a single event of close inbreeding. We compared offspring of full siblings to those of randomly mated controls within each population to determine if inbreeding has significant effects on survival and growth in captivity or the wild. In captivity, survival and size were highly variable within and among five broods during protective freshwater culture with no evident trends. However, in the wild marine environment, although significant differences between inbred and control lines in size of returning adults, egg size, egg number and total egg mass after two or three years at liberty in the ocean were relatively rare, most pairwise comparisons were consistent with inbreeding depression. More importantly, survival of marked smolts to adulthood in the wild marine environment was consistently and significantly lower in both inbred lines. The results have at least two important implications. First, disruption of "modest" local adaptations can impart significant fitness consequences for wild fish that undertake marine migrations. Second, natural selection in the wild substantially increases the amount of inbreeding depression detected, and inbreeding effects on survival and growth in captivity can be poor indicators of survival and growth in the wild.

S13-12

Genetic assignment of lake sturgeon in Lakes Superior and Huron

Amy Welsh[1] (presenting), Henry Quinlan[2], Lloyd Mohr[3], Bernie May[4]. [1]State University of New York - Oswego, Oswego, NY, United States, [2]U.S. Fish and Wildlife Service, Ashland, WI, United States, [3]Ontario Ministry of Natural Resources, Owen Sound, ON, Canada, [4]University of California - Davis, Davis, CA, United States

Many lake sturgeon populations throughout the Great Lakes have experienced a substantial decline in population size. To ensure the long-term sustainability of sturgeon throughout the basin, stocking has been implemented and fisheries have been managed. Stocking of lake sturgeon in the St. Louis River of Lake Superior has occurred, using fish from the Lake Michigan basin (Wolf River/Lake Winnebago) and Lake Superior. Genetic data can provide information about the movement of these stocked fish throughout Lake Superior and about the movement patterns of wild sturgeon in the lake. In Lake Huron, a Canadian commercial fishery has been active in the southern part of the lake. It is unknown which spawning populations are being affected by this harvest. Spawning populations throughout the Great Lakes have been sampled and analyzed at 12 microsatellite loci. This baseline of spawning populations was then used to determine the origin of non-spawning fish caught in Lake Superior (n=91) and of lake sturgeon caught in the commercial harvest on Lake Huron (n=181). In the St. Louis River, stocked sturgeon originating from the Wolf River and the Sturgeon River in Lake Superior were identified. Individuals from the Bad/White Rivers and Goulais River in Lake Superior were also detected, indicating the possibility of natural recolonization of rivers where sturgeon have been extirpated. Wolf River sturgeon were also identified at Mawikwe Bay (Wisconsin) and Pigeon Bay (Minnesota/Ontario). Therefore, these stocked sturgeon are leaving their stocked location and could potentially spawn with native remnant populations. For the Lake Huron commercial fishery, 82% of the sturgeon were from the Detroit/St. Clair River system; 10% were from Georgian Bay, Lake Huron; 5% were from Lake Ontario/St. Lawrence River; 3% were from Green Bay, Lake Michigan; and 0% were from Lake Superior. These results provide information about the movement patterns of non-spawning lake sturgeon and have implications for sustainable management of lake sturgeon in the Great Lakes basin.

S13-13

Relative importance of environmental and ecological variables to the comparative genetic structure among Great Lakes forage species

Wendylee Stott[1] (presenting), Kim T. Scribner[2], Kristi Bennett[2], Owen Gorman[1], Scott Libants[2], Chuck Madenjian[1], Jeffery Schaeffer[1]. [1]Great Lakes Science Center-USGS, Ann Arbor MI, United States, [2]Michigan State University, East Lansing MI, United States

Habitat alteration, species introductions, and climate change all work at different scales. Genetic data, when collected and interpreted across species, can lead to greater understanding of processes underlying change. We looked for commonalities and differences in the how genetic diversity was partitioned across the landscape among three species (deepwater sculpin, slimy sculpin, and ninespine stickleback) from the upper Great Lakes using analyses of mitochondrial DNA sequence analysis and microsatellite loci. These species are a major component of the diet of lake trout (a top predator and commercially important species) and also play an important role in energy transfer. Variables associated with the physical environment including basin bathymetry, current patterns, community structure, and remotely sensed temperature and productivity data were used to interpret spatial genetics data. We used pre-defined sampling groups and individual based approaches to determine how genetic variation was partitioned across lakes Superior, Michigan, and Huron. Two to three phylogenetic lineages were identified in each species which is consistent with what has been observed in other aquatic organisms in the Great Lakes region. Spatial structuring was most pronounced in the slimy sculpin; major genetic clusters corresponded to Lake Michigan, the Canadian north shore of Lake Superior, and western Lake Superior. Historical events had the greatest influence on the genetic structuring at all geographic scales. The effects of hydrology, community, and depth preference are driven by the difference between Lake Superior and the other two lakes for all species. Other factors such as hydrology and number of species were important at a smaller scale in the species with the most structuring, the slimy sculpin. Species with a limited depth distribution were impacted by more factors than the more widely distributed deepwater sculpin.

S13-14

Review of the population connectivity of various invertebrate and vertebrate species of the St. Lawrence system and the Northwest Atlantic

Jean-Marie Sévigny[1] (presenting), André Talbot[1], Alexandra Valentin[1]. [1]Fisheries and Oceans Canada, Mont-Joli, Quebec, Canada

Connectivity is by definition the exchange of individuals among geographically separated populations. This exchange is strongly influenced by the life-cycle of the species and may take place at different spatial and temporal scales. For most invertebrate and fish species, larval dispersal is the main pathway for exchanging individuals, but migration of older developmental stages may also be significant. Understanding connectivity among marine populations is of fundamental importance for understanding evolutionary and ecological processes and for the development and implementation of management and conservation measures. It requires the resolution of the biological and physical processes involved in individual dispersal or migration. Direct measurement of individual movement is difficult to achieve for practical reasons. Therefore, most information about population connectivity is inferred from indirect methods describing the characteristics of the populations (e.g. genetics, otolith elemental fingerprint, parasite infestation, morphometry). These methods assume that the difference between populations increases with isolation although the reality might more complex. The St. Lawrence system (Estuary and Gulf) is a semi-enclosed sea characterized by complex circulation patterns and exchanging waters with the Northwest Atlantic. Another interesting feature of the St. Lawrence system is the presence of fjords. Understanding the amount of connectivity between the populations of the various invertebrate and vertebrate species inhabiting this wide geographic area is a challenging task. In this presentation, we will review the different studies that have dealt with the population genetic structure of vertebrate (i.e. fish, marine mammals) and invertebrate (i.e. crustacea, molluscs) species of the St. Lawrence system and the Northwest Atlantic. Studies based on other approaches and bringing complementary information to the genetic results will also be considered.

S13-15

Adaptive variation in larval lake sturgeon phenotypic traits to environmental conditions during spawning.

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We tested the hypothesis that variability in larval lake sturgeon phenotypic traits are heritable and covary as a function of environmental conditions at the time of reproduction. Different segments of the adult population in Black Lake, Michigan spawn at different times. If the timing of reproduction is heritable and gene flow between early and late breeding adults is minimal, then adaptations should evolve in offspring to environmental conditions characterizing different spawning periods. We examined variance and covariance in embryonic and larval phenotypic traits using paternal half-sib matings in a quantitative genetic design under controlled environmental conditions at a stream-side facility. Incubation time and larval phenotypic traits covaried as a function of stream temperature associated with early and late spawning periods. Incubation time for offspring from early-breeding adults was significantly longer and offspring were significantly larger and had larger endogenous yolk reserves than offspring from later breeding adults. Growth and yolk-sac utilization efficiency also varied significantly between larvae from early and late spawning adults. Environmental conditions that vary over space and time within a breeding season can affect important juvenile

life-history and phenotypic traits that affect survival. Management for this species of conservation concern should recognize and maintain variation in adaptive traits.

S13-16
Landscape genetics and hierarchical genetic structure in Atlantic salmon: the interaction of gene flow and local adaptation
Melanie Dionne[1] (presenting), François Caron[2], Julian Dodson[1], Louis Bernatchez[1]. [1]Laval University, Quebec, Canada, [2]Ministère des Ressources naturelles et de la Faune, Quebec, Canada

Disentangling evolutionary forces that may interact to determine the patterns of genetic differentiation within and among wild populations is a major challenge in evolutionary biology. The objective of this study was to assess the genetic structure and the potential influence of several ecological variables on the extent of genetic differentiation at multiple spatial scales in a widely distributed species, the Atlantic salmon, *Salmo salar*. A total of 2,775 anadromous fish were sampled from 51 rivers along the North American Atlantic coast and were genotyped using 13 microsatellites. A Bayesian analysis clustered these populations into seven genetically and geographically distinct groups, characterized by different environmental and ecological factors, mainly temperature. These groups were also characterized by different extent of genetic differentiation among populations. Dispersal was relatively high and of the same magnitude within compared to among regional groups, which contrasted with the maintenance of a regional genetic structure. However, genetic differentiation was lower among populations exchanging similar rates of local as opposed to inter-regional migrants, over the same geographical scale. This raised the hypothesis that gene flow could be constrained by local adaptation at the regional scale. Both coastal distance and temperature regime were found to influence the observed genetic structure according to landscape genetic analyses. The influence of other factors such as latitude, river length and altitude, migration tactic, and stocking was not significant at any spatial scale. Overall, these results suggested that the interaction between gene flow and thermal regime adaptation mainly explained the hierarchical genetic structure observed among Atlantic salmon populations.

S13-17
Analysis of sub-population origin and run timing of Atlantic salmon in mixed stock fishery of the lower main stem of a large subarctic river
Juha-Pekka Vähä[1] (presenting), Jaakko Erkinaro[2], Eero Niemelä[2], Sturla Brørs[3]. [1]University of Turku, Turku, Finland, [2]Finnish Game and Fisheries Institution, Oulu, Finland, [3]Directorate of Nature Management, Trondheim, Norway

The yearly number of Atlantic salmon (*Salmo salar*) harvested by various recreational and net fisheries in the River Teno varies between 15 000 and 60 000, comprising up to 50-60% of the total annual run of ascending salmon. Previously, temporal and spatial genetic structure of the Teno river salmon was profiled using 29 microsatellite markers. The Teno salmon stock complex was found to consist of several demographically independent and temporally stable populations. Generally, each main tributary fosters a genetically distinct population with a mean population pairwise Fst = 0.09 (range FST = 0.015 - 0.2). Using this population structure as a baseline, we performed a genetic stock identification analysis of ~1700 1SW salmon caught with gill nets and weirs in the lowermost 30 km of the river. In addition to being an area where fish originating from different sub-populations are still present, it is also an area of most intensive harvesting. We analyzed the composition of the salmon catch of this mixed stock fishery and assessed the temporal variation in run timing of salmon from different tributaries. By contrasting the results from several years we also studied whether environmental variables, e.g. water flow, affect the possible patterns of run timing. The results are discussed in the light of conservation and management of local populations.

S13-18
Fitness consequences to wild Atlantic salmon from interbreeding with escaped farmed salmon in the Northwest Atlantic
Dylan Fraser[1] (presenting), Jeffrey Hutchings[1]. [1]Dalhousie University, Halifax, Nova Scotia, Canada

Interbreeding between escaped farmed and wild fishes may affect the genetic integrity and viability of wild populations. Mitigating these effects would be facilitated if they could be predicted according to the degree of divergence between parental populations. Based on the known genetic/ecological divergence between populations from three different regional groups of Atlantic salmon (*Salmo salar*) in eastern Canada, including the source of salmon farming, we tested the hypothesis that a positive association existed between parental divergence and the degree of outbreeding depression. Depending on the farmed-wild hybrid (F1, F2 or backcross) and on the fitness trait being examined, inter-population crosses generated both hybrid vigor and outbreeding depression associated with co-adaptation. Importantly, however, farmed-wild hybrids generally experienced greater reductions in fitness as the divergence between farmed and wild parents increased. These results are relevant to risk assessment in two regards: (i) they demonstrate that farmed-wild hybrids can have reduced fitness relative to wild fish; (ii) they suggest that the varying effects of farmed-wild interbreeding on depleted wild populations can be forecasted to a certain degree.

S13-19

Temporal changes in Atlantic bluefin tuna (*Thunnus thynnus*) genetic variation

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Within the framework of the Italian research project TUNING dealing with the characterization of the spatial and temporal patterns of genetic variation in the Mediterranean tunas and coordinated by the University of Bologna, we tried to reconstruct the demographic history and short-term temporal changes of genetic diversity in the Atlantic bluefin tuna (*Thunnus thynnus*) of the Mediterranean Sea. Bluefin tuna is experiencing a period of strong overfishing reflected by the lowering of mean age and size of catches, and FAO and ICCAT are adopting measures to recover this species. The comparative study of genetic diversity and genetic differentiation in historical (1900-1930) and contemporary (1999-2007) samples of Atlantic bluefin tuna sampled in the last 100 years in the Western and Central Mediterranean offered the opportunity to assess the impact of industrial fishery on the genetic variation of the stock. Genetic composition of tuna samples at 9 microsatellite loci was dissected by using several programs (Microsatellite, GENETIX 4.05, Arlequin3.01, FSTAT 2.9.3, MNE2, tm3, M_P_VAL, Bottleneck) to detect spatial and temporal changes in the population genetic parameters (gene diversity, genetic differentiation among population samples, effective population size) and to estimate the role of environmental (natural and anthropogenic) factors affecting genetic variation. Significant, if limited spatial heterogeneity was detected across all modern samples (Fst= 0.03, P< 0,0001) as well as significant genetic differentiation between north and south Thyrrenian Sea, and between Adriatic and Thyrrenian Sea. No decrease of genetic variation was observed in modern samples with respect to the ancient one. Both temporal and onesample methods agree that the effective population size is low with respect to comparable Theleost species (Ne= 1000-2000). The two methods we used to detect a bottleneck event had discordant results, with only one (M_P_VAL) clearly detecting a bottleneck. Because only dramatic reductions of population size in a short period result in a detectable signal for the software of Cornuet et al. these results do not rule out the possibility of a demographic decline. Rather they show that, if there was a decline, it was not drastic enough to erase a substancial fraction of DNA diversity, which did not apparently change in the last century.

S13-20

Managing the gag (*Mycteroperca microlepis*) fishery in the southeastern United States: is there a genetic basis for the current separation between Gulf and Atlantic stocks?

Elizabeth Cushman[1] (presenting), Nate Jue[2], Allan Strand[1], Erik Sotka[1]. [1]College of Charleston Grice Marine Laboratory, Charleston, SC, United States, [2]Florida State University, Tallahassee, FL, United States

The gag (*Mycteroperca microlepis*) is a large protogynous grouper important to fisheries in the United States. The gag fishery is currently managed as two separate stocks: the Gulf of Mexico and the Atlantic. A previous study found significant spatial genetic structure between sites in the Atlantic and the Gulf, but questioned whether this structure was really due to spatial differences between sites or to temporal genetic differentiation between yearly cohorts. We sampled adult and juvenile gag from North Carolina, South Carolina and Florida, 2005 young-of-the-year juveniles from North Carolina estuaries, and 1985 postlarvae from South Carolina estuaries, and genotyped one mitochondrial locus and eleven nuclear microsatellite. There was no spatial genetic differentiation between sampling locations in the Atlantic or in the eastern Gulf of Mexico and very little evidence of temporal differentiation between cohorts of varying ages. These results suggest that gag represent a single genetically panmictic population from North Carolina to the Florida panhandle. However, genetic homogeneity is also consistent with extremely low migration across populations that have not reached equilibrium between gene flow and drift. Thus, our genetic data can neither support nor refute current management schemes that independently regulate gag in the Gulf and Atlantic. Based on our results and evidence from other studies, we will discuss whether gag truly comprise a single stock population and what it will mean for the future management of the gag fishery.

S13-21

Genetic stock identification determines inter-annual variation in stock composition for legal and sub-legal Chinook captured in the Washington Area – 2 non-treaty troll fishery

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Chinook salmon (*Oncorhynchus tshawytscha*) are an abundant component of the north Pacific ichthyofauna, exhibit the most diverse anadromous life history patterns of all the Pacific salmon, and are an economically important species. An essential component of managing the substantial commercial and sport fisheries is determining the impacts of harvest on individual populations or regional aggregates of populations. The traditional method of estimating exploitation of salmon stocks is a physical mark system, the coded wire tag. Yet, fundamental issues are challenging the utility of the CWT system for fishery management. We investigated using hyper-variable DNA genetic markers coupled with genetic mixed stock analysis as an alternative to or an enhancement of the current management design. We analyzed unknown mixed collections made from the 2003 – 2005 non-treaty

troll commercial Chinook fishery in Washington's Area – 2. Dockside collections were made at landing facilities, and legal- and sub-legal-sized Chinook were sampled onboard fishing vessels. Population composition for fishery strata tended to be similar, with a small number of regional aggregates of Chinook populations consistently present in the Area – 2 catch, but variation in the frequencies of those stocks was observed within and among seasons. Population composition was similar for fishery strata collections when time periods within a year were compared and composition was stable over time. We compared dockside and legal fishery strata within and across years, and report the catch composition estimated using collections made from landing facilities were similar to those made onboard fishing vessels, even though the collection sources were different. We compared collections of legal-sized and sub-legal-sized Chinook captured onboard fishing vessels to provide direct observations about which Chinook populations are potentially impacted by incidental mortality. The legal collections appear to be a reasonable proxy for sub-legal stock contributions, although subtle differences were observed. We also compared genetic estimates of composition with expectations from FRAM pre-season model forecasts, and showed the observed intra- and inter-annual variation directly observed from genetic data was not captured well by the fishery management model.

S14. Global Management of Squaloid Sharks: Protection and Enhancement of Regional Fisheries in Light of Global Conservation Initiatives

S14-2

Spatial analysis of North Carolina spiny dogfish (*Squalus acanthias*) population movements

Jennifer Cudney[1] (presenting), Roger Rulifson[1]. [1]East Carolina University, Greenville, NC, United States, East Carolina [2]University, Greenville, NC, United States

Large numbers of spiny dogfish (1 to 2 million or more) form aggregations in North Carolina waters, move both up and down the coastline, and laterally across the continental shelf. Key questions about the nature of these aggregations have yet to be answered; how these aggregations use coastal habitat in North Carolina, the exact timing of migration, the cohesion of groups through time, or what factors may drive changes in both aggregation composition and location. To answer these questions, East Carolina University researchers tagged over 35,000 dogfish from 1997 – 2007 with single barb dart tags. Tagging events usually occurred in January of each year. Spatial analysis of the dogfish recapture incidents was completed to identify[1] the spatial extent of recaptures,[2] areas with high incidence of recapture,[3] the timing of migration, and 4) whether spatial patterns in movement could be identified. Tagged spiny dogfish were recovered from North Carolina to Newfoundland. Days-at-large (DAL) ranged from 1 day to 3,617 days, however most were recaptured with 1 year of tagging. Cluster analysis indicated several hotspots of recapture incidents between North Carolina and Cape Cod (n = 7). A time series analysis indicated that most dogfish stayed in North Carolina waters until 60-75 DAL. Linear directional mean analysis of mark-recapture Euclidean paths was used as a preliminary indication of group cohesion through time. Comparatively high group cohesion was noted for the first 90 days of migration. However, this analysis represented very coarse resolution and demonstrated a clear need for higher resolution tagging data.

S14-3

Integrating microsatellites and pop-up satellite tags to study population structure of dogfish, *Squalus acanthias*, in the Western North Atlantic

Walter Bubley[1] (presenting), James Sulikowski[2], Paul Tsang[1]. [1]University of New Hampshire, Durham, NH, United States, [2]University of New England, Biddeford, ME, United States

In the year 2000, as a result of the declining spiny dogfish stock, the Atlantic States Marine Fisheries Commission implemented an Interstate Fisheries Management Plan for spiny dogfish that places an annual quota limit on US landings. Central to any successful fishery management plan is the availability of accurate, detailed and updated life history information on the species and identifying population structure is an important component. Due to the lack of current knowledge into the population structure of spiny dogfish in the Northwest Atlantic, two approaches, DNA molecular markers and pop-up satellite tag technology, were employed. To assess molecular markers, fin clips were taken from sharks in the Atlantic Ocean along the eastern coast of the United States and Canada; three locations were north and three were south of Cape Cod, MA. DNA was then extracted and four microsatellite regions were amplified using polymerase chain reaction with primer sets specifically developed for spiny dogfish. The products were genotyped and alleles for each locus were scored based on size to determine if there was any structure within dogfish in the Northwest Atlantic. These data were then incorporated with those from three individual sharks that had pop-up satellite tags implanted into the first dorsal fin during late October/early November of 2007 in the Gulf of Maine. These satellite tags offer a powerful means to obtain data on real time movement patterns, including temperature and depth preferences, with no need to recapture the animal. By combining these two approaches, it allows for improved accuracy and reliability of the underlying biological information for the population structure of spiny dogfish in the Atlantic waters off the coasts of Canada and the United States.

S14-4

Fishery closed areas for deepwater dogfishes off southern Australia - design, monitoring and evaluation.

Ross Daley[1] (presenting). [1]CSIRO Marine and Atmospheric Research, Hobart, Tasmania, Australia

Three species of gulper shark (Centrophorus spp, Squalidae) have been nominated for protection under Australia's Environment Protection and Biodiversity Act. These species were targeted for their liver oil on the upper continental slope (400 – 600 m) off southern Australia and overfished in the 1990s. The Australian Fisheries Management Authority implemented a number of measures to end overfishing, including closing three areas to all fishing methods in 2007. The aim of these closures is to protect remaining healthy populations and allow reduced populations to recover. However, the data on abundance and distribution used to design the location and size of these areas was limited. In addition the biology, movements and distribution of gulper sharks is poorly known. Monitoring and evaluation of the closed areas will inform possible refinement of the closed areas. Specialist monitoring tools have been developed for application in the deep rough bottom habitats that gulper sharks prefer. These tools include acoustic tagging and underwater listening stations to study movements and underwater cameras to measure abundance and survival rates after tagging. These instruments were recently trialled in the Great Australian Bight at depths of 300–600 m.

S14-5

Adult, juvenile and neonate habitat preferences of spiny dogfish, *Squalus acanthias*: Density, temperature and neonate range expansion in the western Atlantic

Michael Frisk[1], Thomas Miller[2], Kathy Sosebee[3] (presenting), Jack Musick[4]. [1]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, United States, [2]Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, United States, [3]Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA, United States, [4]Virginia Institute of Marine Science, Gloucester Point, Va, United States

We present analyses of the movement, distribution and habitat preference of spiny dogfish, *Squalus acanthias*, from Cape Hatteras to the Gulf of Maine based on data collected by the National Marine Fisheries Service during annual autumn and spring bottom trawl surveys (1963-2006). Cumulative distribution functions (CDF) were utilized to estimate temperature and depth preferences of spiny dogfish neonates, juveniles and mature females. Neonate, juvenile and adult spiny dogfish selected significantly narrower ranges of temperatures than available in the environment and significantly different from each other. Younger stages selected warmer waters than older stages during both the spring and fall (Spring: 50th percentile of neonate dogfish distribution was 10.3○C, 9.3 ○C for female juveniles and 8.0 ○C for adult females, Fall: 50th percentile of neonate dogfish was 12.4 ○C, 12.2 ○C for juveniles and 11 ○C for mature females. Further, neonate range appears to have expanded onto the eastern edge of Georges Bank and into the eastern portion of the Gulf of Maine during periods of high spiny dogfish abundance in the 1980's. However, in recent years spiny dogfish still occupy this expanded range even after the population has declined. We explore the potential of the interaction between population size and environmental changes influencing range expansion, contraction and overall distribution of spiny dogfish.

S14-6

Population structure of the spiny dogfish in Atlantic waters inferred from nuclear microsatellites

Ana Verissimo[1] (presenting), Jan McDowell[1], John Graves[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

The spiny dogfish *Squalus acanthias* is a small, coastal squaloid shark that occurs in temperate waters of the Atlantic and Pacific oceans. It is a heavily exploited resource on both sides of the North Atlantic, being declared as overfished on the western side in 1998 (ASMFC, 2002) and as depleted and in danger of collapse on the eastern side (ICES 2007). This species has not been reported in areas with water temperatures above ca. 18□C, suggesting potential geographical isolation of spiny dogfish between the northern and southern hemispheres. However, several independent tagging studies have shown a high level of connectivity between areas of continuous spiny dogfish distribution along the eastern and western North Atlantic and also along the eastern North Pacific. Cases of transoceanic migration have also been reported in the North Pacific. A recent study using nuclear microsatellites markers also did not detect any population differentiation in North Pacific samples collected from Alaska to California. These data suggest that spiny dogfish are capable of a high level of dispersal. Based on this information, present fisheries management plans consider one stock unit to exist on each side of the North Atlantic, with a possible third stock unit along the eastern North Pacific. To elucidate the worldwide genetic diversity and population structure of spiny dogfish, particularly in Atlantic waters, we use a suite of nuclear microsatellite markers on tissue collections obtained from several geographical locations throughout the species range.

S14-8

Cooperative Winter Tagging of Spiny Dogfish in North Carolina Waters: 10 years of data

Roger Rulifson[1] (presenting), Jennifer Cudney[1], Wilson Laney[1]. [1]East Carolina University, Greenville, NC, United States, [2]East Carolina University, Greenville, NC, United States, [3] U.S. Fish and Wildlife Service, Raleigh, NC, United States

The Cooperative Winter Tagging Cruise, which sampled state waters of North Carolina and Virginia, was originally initiated in 1988 to tag striped bass and other commercially valuable species. Spiny dogfish catch was consistently high through the cruise history, and tagging was started in 1996 for the species. Historical data (1997-2007) were compared to data collected on the 2008 cruise to identify long term trends in North Carolina and Virginia waters. In 2008 average total length of female dogfish was 817.1 ± 58.6 mm (n = 4,507 dogfish), while the total length of male dogfish was 748.8 ± 50.8 mm TL. The overall average sex ratio was

4:1 (F:M), but in regions were just males and females were caught the average sex ratio was 6.6:1 (F:M) and ranged from 0.2:1 to 28:1. The type of data collected in each cruise varied, and will be discussed. Some variability was noted among years in length and relative abundance across the study area. Sex ratios varied spatially and temporally.

S14-9

Management of spiny dogfish (*Squalus acanthias*) and a demographic risk analysis for the Gulf of Alaska

Cindy Tribuzio[1] (presenting). [1]University of Alaska Fairbanks, Juneau, AK, United States

In the Gulf of Alaska, shark species are not targeted, but can have high bycatch levels in certain fisheries or areas. In federal fisheries, spiny dogfish are allowed to be retained as up to 5% of the total catch and in state fisheries retention not allowed with a few exceptions where up to 100% of the catch may be retained as dogfish. Given the fishing conditions of these exceptions, bycatch in state fisheries is largely unquantified, and federal fisheries bycatch is quatified by the observer program. Spiny dogfish (and all sharks) are managed as a group under the Tier System of the North Pacific Fishery Management Council. As a Teir 6 species group, total allowable catches (TACs) are determined by the average or maximum catch from previous years. Spiny dogfish have historically been a low priority species for stock assessment, so data is limited. The objective of this study was to perform a demographic analysis on spiny dogfish which only requires life history parameters and to conduct a risk analysis to determine how the population may react to different fishing pressures or bycatch rates.

S14-10

The possible role of spiny dogfish in the Strait of Georgia ecosystem

Richard Beamish[1] (presenting), Ruston Sweeting[1], Chrys Neville[1]. [1]Fisheries and Oceans, Nanaimo, British Columbia, Canada

Spiny dogfish are a slow-growing species that can remain in the Strait of Georgia for periods that exceed the life span of most humans. Spiny dogfish have historically comprised a major commercial fishery (although current exploitation levels are low), and contribute significantly to the fish biomass within the Strait of Georgia ecosystem. As long-lived, year-round residents of the strait, trends in dogfish population structure could be altered as the physical and biological aspects of climate continue to change. Juveniles remain in the pelagic areas for approximately 15 years before migrating into the demersal areas. We propose that it is this pelagic period that determines the recruitment to the spawning population. We summarize 15 years of seasonal survey data throughout the pelagic areas and speculate on the role(s) of spiny dogfish as key species within the ecosystem.

S14-11

Phylogeography of two wide ranging, deep-sea squaliform sharks *Centroscymnus coelolepis* and *Centrophorus squamosus* – inferences from mitochondrial DNA control region

Ana Verissimo[1] (presenting), Jan McDowell[1], John Graves[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

Organisms occurring deep in the water column usually have wider geographic ranges than their shallow water counterparts, a feature some authors have suggested may be due to the almost "universally" homogenous habitat of the deep sea. However, little is known about the processes of dispersal from the ancestral centers of origin to their contemporary geographic distributions. This is true for deep-sea elasmobranchs in general and deep-sea sharks in particular. To address this issue, two medium-sized, wide ranging species of squaliform sharks, the Portuguese dogfish *Centroscymnus coelolepis* and the leafscale gulper shark *Centrophorus squamosus*, were chosen as case studies. These species were selected because they have been reported to occur in the Atlantic, Indian and western Pacific oceans, and are either targeted by fisheries or are taken as bycatch of other deepwater fisheries throughout their geographic ranges making sample collection tenable. In this study, 20 – 30 individuals of each species were taken from several geographic locations throughout their respective ranges and mitochondrial DNA (mtDNA) control region sequences were obtained from each individual. The geographic distribution of the different mtDNA haplotypes, i.e. maternal lineages, will be used to make inferences about the historical demography and phylogeography of these two squaliform shark species. The results will be used to surmise which biogeographic factors have been important in shaping the current distribution of these species considering each species life history strategy and bathymetric habitat – from middle bathyal to upper abyssal depths for C. coelolepis and from upper to middle bathyal depths for C. squamosus.

S14-12

Trophic structure of a nearshore marine fish assemblage off Assateague Island, MD

Ryan Woodland[1] (presenting), David Secor[1]. [1]University of Maryland, Chesapeake Biological Laboratory, Solomons, MD, United States

Recent evidence suggests many juvenile marine fish recruit to both estuarine and marine habitats; yet the bulk of historical research on the ecology of these early life stages has focused on estuaries. By evaluating the food web structure of the relatively understudied marine habitats we can begin to understand some of the consequences of juvenile habitat selection for species that simultaneously recruit to estuaries and neritic habitats. Here we analyze the ichthyofaunal food web from a low-relief, nearshore marine habitat dominated by unconsolidated sediments off the coast of MD, USA. Species were collected from sites within an 7 x 11 km grid (10-19 m depth) using a 30 m Yankee benthic trawl deployed along 1.85 km north-south transects during August 2007. Previous analysis indicates a large component of the late summer ichthyofaunal assemblage is composed of young-of-the-year marine and estuarine species (e.g. Cynoscion regalis, Leiostomus xanthurus, Mustelus canis). By using traditional gut content analysis and isotopic tissue signatures (□13C & □15N), we determined trophic relationships as well as basal carbon source for the nearshore assemblage. Our findings suggest that the nearshore marine environment provides a juvenile foraging arena that is functionally similar to putative estuarine nursery habitats.

S15. Viral Hemorrhagic Septicaemia (VHS) Virus in the Great Lakes: What Have We Learned?

S15-1

An introduction to the Viral hemorrhagic septicemia (VHS) virus in the Great Lakes Basin: what have we learned?

Elizabeth Wright[1] (presenting). [1]Ontario Ministry of Natural Resources, Fish Culture Section, Peterborough Ontario, Canada

This Symposium will focus on both the disease (VHS) and the virus (VHSV), including occurrence, monitoring, management, lessons learned and research needs in the Great Lakes Basin. Viral hemorrhagic septicemia is a fish disease that has been implicated in large scale die-offs world-wide. There are several strains of the VHS virus including the Great Lakes strain (Type IVb). First identified in 2005, the Great Lakes strain of VHSV is currently known to infect 25 species of freshwater fish. This fish virus attracted widespread attention when the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) issued a Federal Order in October 2006. This Federal Order was designed to prevent the spread of VHS into US aquaculture facilities. Since it was issued, many Great Lakes jurisdictions have initiated fish movement restrictions and surveillance activities. Research activities have addressed a variety of questions related to this newly identified strain of VHSV. Bringing together Canadian and US expertise in fish disease and fisheries management, will benefit symposium participants who will obtain a comprehensive update on the status of VHS and VHSV activities in the Great Lakes Basin. Presentations on pathways and spread, strain virulence, impacts on fish and fish populations, testing procedures, treatment and controls, modelling, management responses, regulatory approaches and research needs have been contributed.

S15-2

Emergence of Viral Hemorrhagic Septicemia Virus among populations ofwild fish in the Great Lakes Region of the United States and Canada

James Winton[1] (presenting). [1]Western Fisheries Research Center, Seattle, Washington, United States

Viral hemorrhagic septicemia virus (VHSV) is among the most important viral pathogens of finfish and is listed as reportable by many nations and international organizations. For several decades following its initial characterization, VHSV was thought to be limited to Europe where it was regarded as a freshwater pathogen affecting farmed rainbow trout. Subsequently, it was found that VHSV was endemic among marine and anadromous fish in both the Pacific and Atlantic Oceans where it can cause significant mortality among important populations of wild and cultured fishes. Beginning in 2005, reports from the Great Lakes region indicated that VHSV was present in wild fish that had experienced very large die-offs. As of early 2008, VHSV has been isolated from fish in Lake Michigan, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, the Saint Lawrence River as well as inland lakes in New York, Michigan and Wisconsin. The Great Lakes strain of VHSV has an exceptionally broad host range and has been isolated from over 25 species of finfish to date. Among these susceptible species, large mortalities have occurred in muskellunge, freshwater drum, yellow perch, round goby, emerald shiners and gizzard shad. While control of VHSV among wild populations presents a significant challenge, management agencies in the US and Canada have begun increased surveillance activities to further define the host and geographic range of VHSV in the Great Lakes region along with instituting movement restrictions and required fish health inspections to prevent the spread of the virus into new geographic areas or into hatcheries operated by natural resource agencies or by the private aquaculture industry. In addition, research on various control methods including: disinfection of eggs, treatment of hatchery water supplies, environmental modification, and vaccination is being conducted to prevent losses from VHS should the virus be introduced into fish culture facilities where such control methods can be used. This presentation will review the evolution of our understanding about VHSV and, using information from Europe, Asia and the west coast of North America, develop predictions about the virus in the Great Lakes and summarize future research needs.

S15-3

Viral Hemorrhagic Septicemia Virus (VHSV): Development of improved detection methodologies and viral stability at various environmental conditions.

Kyle Garver[1] (presenting), Laura Hawley[1], Sandra Edes[1]. [1]Fisheries and Oceans Canada, Nanaimo, BC, Canada

Historically, VHSV in North America has only been associated with marine fish populations. However, in the spring of 2005 the virus was isolated for the first time from a freshwater drum (*Aplodinotus grunniens*) in Lake Ontario. Since this first freshwater occurrence of VHSV in North America the virus has been detected in more than 25 species of fish in the Great Lakes regions of Canada and the US including Lake Michigan, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, Saint Lawrence River and from inland lakes in New York, Michigan and Wisconsin. Additionally, this Great Lakes strain of VHSV has been associated with significant mortality in muskellunge, freshwater drum, yellow perch, round goby, emerald shiners and gizzard shad. The devastating occurrence of this virus has prompted the need to gain a better understanding of VHSV and to establish proper isolation and identification methodologies. To this end, we've evaluated traditional cell culture techniques as well as developed a quantitative RT-PCR for universal VHSV detection. The qRT-PCR assay targets a conserved region of the nucleoprotein (N) gene of the virus and is highly specific and sensitive, detecting as little as 10 copies of VHSV RNA transcript per reaction. Moreover, viral stability studies have been conducted that compare the newly isolated Great Lakes VHSV to other North American strains at various environmental conditions. Viral stability was inversely correlated with temperature, such that stability was highest at the lowest temperatures, and all VHSV isolates tested were found to be more stable in freshwater rather than saltwater.

S15-4

Stability and abundance of VHSV in Great Lakes diagnostic submissions

Rodman Getchell[1] (presenting), Ashleigh Walker[1], Geoffrey Groocock[1], Rufina Casey[1], Stephen Frattini[1], Paul Bowser[1].
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Several groups of fish were collected and taken to the Aquatic Animal Health Program at Cornell University for the purpose of studying viral stability and abundance of viral hemorrhagic septicemia virus (VHSV). The sample groups included fifteen moribund, fresh dead (red gills), and decomposing (white gills) gizzard shad from Dunkirk Harbor on Lake Erie; six round gobies from Lake Ontario; one rock bass from Oneida Lake; and five round gobies from the St. Lawrence River. All of the fish came from separate mortality events in 2007, except for the final group of five round gobies, which was part of a surveillance collection of apparently health fish. Cell culture, RT-PCR, and quantitative RT-PCR (qRT-PCR) were used on pooled organ samples from the fifteen gizzard shad. The remaining groups of fish were tested using qRT-PCR and RT-PCR on spleen, kidney, heart, and liver to look at tissue tropism and freeze/thaw effects on VHSV. The three groups of five gizzard shad had low levels of VHSV as measured by qRT-PCR, but all were cell culture negative. There were no significant differences in tissue tropism and no effect of two freeze/thaw cycles with the round goby samples. Interestingly, even though all fish tested positive for VHSV with qRT-PCR, only samples with approximately 106 viral copy numbers tested positive with RT-PCR. This raises the issue of true detection of VHSV with the current OIE standard of cell culture and RT-PCR.

S15-5

Viral hemorrhagic septicemia virus IVb sensitivity to UVC and viability at 4C and -20C.

John S. Lumsden[1] (presenting), Paul Huber[1], Brian Petri[2]. [1]University of Guelph, Guelph, Canada, [2]Trojan Technologies, London, Canada

VHSV IVb is a now significant fish health issue in the Great lakes watershed. Since the virus is newly recognized and genotypically unique it presents an ongoing challenge since there is not yet sufficient knowledge as to its viability under a variety of circumstances. Therefore the viability of the virus to UVC and storage were examined. Treatment of incoming water with ultraviolet light (UVC) is one potential strategy to limit the likelihood of infection. Using a UVC collimated beam, it was revealed that VHSV IVb is very susceptible to irradiation at 254nm, with a reduction in titre of four logs using a dose of 2.5 mJ-cm-2. After a period of 10 days storage of a VHSV IVb infected trout kidney homogenate at 4 oC or -20oC, there was no significant decline in viral titres as determined by plaque assay.

S15-6

Emergence of Viral Hemorrhagic Septicemia in the Great Lakes basin: lessons learned and effectiveness of surveillance strategies

Mohamed Faisal[1] (presenting), Robert Kim[1]. [1]College of Veterinary Medicine, Michigan State University, East Lansing, MI, United States

The Viral Hemorrhagic Septicemia Virus (VHSV) emerged in the Great Lakes basin leaving behind a trail of fish kills, food web disturbances, and grave concerns about its future spread in North America. While scientists were able to identify the presence of VHSV in apparently healthy and diseases fish, determine its exact genotype, and fulfilling Koch's postulates, there are severe gaps of knowledge regarding the dynamics of VHSV transmission and the details of the host-virus intricacies. Field and laboratory investigation shed light on the potential threat VHSV may pose to the recruitment of VHSV-susceptible fish species, a matter that has been overlooked while developing the initial surveillance strategies. Great Lakes fish species differ in their susceptibility to VHSV IVb. Depending on the species, VHSV IVb-disease course can run a peracute (mortalities, no signs), acute, and chronic forms. Moreover, Determining VHSV carriers among surviving fish proved to be a daunting task that requires diagnostic assays of sensitivity and specificity that are higher than those routinely approved by regulatory agencies. Unlike with other VHSV strains, disease signs vary among fish species, a matter that adds to the complexity of disease identification. VHSV IVb seems to be spotty in its distribution within the Great Lakes and its spread seems to be relatively slow. Surveillance and monitoring strategies should consider a comprehensive, food-web approach to ensure its effectiveness.

S15-7

Response of freshwater drum to outbreak of Viral Hhemorrhagic Septicemia (VHS) in Lake Ontario

Gavin Christie[1] (presenting), Jim Hoyle[1], Jim Bowlby[1], Bruce Morrison[2], Beth Wright[2]. [1]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Glenora, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Fisheries Section, Peterborough, Ontario, Canada

Freshwater drum (*Aplodinotus grunniens*) is an abundant native species in the near shore waters of eastern Lake Ontario. The first reported occurrence of viral hemorrhagic septicemia (VHS) in freshwater in North America was observed during a die-off of freshwater drum in Lake Ontario. This new Great Lakes strain of VHS is known to affect a range of fish species in Great Lakes including valuable sport and commercial species and observations of dead fish have caused significant government and public concern. Significant numbers of freshwater drum (estimated 30,000) were observed dead in the Bay of Quinte and eastern Lake Ontario during spring 2005. The relative abundance of freshwater drum was assessed through gill net and trawling surveys designed to monitor the fish community and through incidental catch recorded in surveys of recreational fisheries. There was no significant decline in the abundance of age 1 and older drum after the die-off. Either the number of drum that died was insignificant relative to the total drum population or deaths caused by the disease replaced deaths that would have occurred due to other causes. Paradoxically, there was a significant increase in young-of-year drum abundance after the disease outbreak. We suggest that the rapid and visual accumulation of dead fish may have caused an initial over-estimation of the die-off's effect on the drum population.

S15-8

Effects of VHS on the muskellunge population in Lake St. Clair

Geoff Yunker[1] (presenting), Megan Belore[1], Mike Thomas[2], Mohamed Faisal[3]. [1]Ontario Ministry of Natural Resources, Wheatley, Ontario, Canada, [2]Michigan Department of Natural Resources, Harrison Township, Michigan, United States, [3]Michigan State University, East Lansing, Michigan, United States

Clair for more than 100 years. Ecological changes, fishing regulations, and angler behaviour all contributed to high muskellunge abundance in the 1990's. In 2002, muskellunge with external lesions were found to be infected with Piscirickettsia spp. an intracellular bacterium. Furthermore, Viral Hemorrhagic Septicemia (VHS) Virus genotype IV, sublineage b, was also isolated from muskellunge caught in survey trap nets from 2003 to 2006. Extraordinary muskellunge mortality events were evident on the lake and the Detroit River in the spring of 2003 and 2006. Only 1 fish was collected in a state fresh enough to permit laboratory testing. That sample tested positive for both VHS and Piscirickettsia infection, confounding their roles in the mortality events. Despite two muskellunge mortality events, assessment data suggested no major change in adult muskellunge abundance occurred from 2002 to 2007. Laboratory trials indicated age 0 muskellunge fingerlings experienced high mortality when injected with VHS virus. However, no age 0 muskellunge index survey data exist for Lake St. Clair, so VHS impacts on muskellunge recruitment remain uncertain. Interestingly, 34 muskellunge sampled during VHS surveillance efforts in spring 2007 tested negative for the VHS virus.

S15-9

Die-off of muskellunge (*Esox masquinongy*) in the Upper St. Lawrence River caused by Viral Haemorrhagic Septicaemia, 2005-2007: impacts and consequences

John Casselman[1] (presenting), Tom Lusk[2], John Farrell[3], Colin Lake[4]. [1]Queen's University, Kingston, ON, Canada, [2]Parks Canada, Mallorytown, ON, Canada, [3]State University of New York, Syracuse, NY, United States, [4]Ministry of Natural Resources, Picton, ON, Canada

A catastrophic die-off occurred in the prized muskellunge population of the Canadian and U.S. waters of the 1,000 Islands section of the upper St. Lawrence River. Fish collections and regular river travel, particularly in Canadian waters, provided 102 dead muskellunge, primarily mid-May to mid-June 2005 (75%), and a similar time in 2006 (15%) and 2007 (9%).. Some dying fish were observed, but most had died earlier, possibly late winter or early spring. Detailed necropsies of 63 Canadian samples indicated all were mature; most (90%) had not spawned. In 2005, rapidly rising temperature was the suspected primary cause. However, temperature changes that year were no more extreme than some in the past three decades; viral haemorrhagic septicaemia (VHS) was subsequently confirmed as the cause. Dead fish were large and old: 60% females and 40% males; TL 129 and 108 cm; WT 14.9 and 10.0 kg; age 14.7 and 16.1 years. Both sexes were older, slower growing, and smaller ultimate size than muskellunge angled before die-off. Ovaries of older fish were underdeveloped; fecundity peaked in the 12-18 age range. Individuals that died in 2006 and 2007 were faster growing in years just prior to the mortality than those that died in 2005; mortality was higher in slower-growing individuals, possibly influenced by maturity, spawning, and temperature. Anglers reported increased handling stress, and 2003-2007 creel logs confirmed a 49% decline in catches of larger mature individuals (October to December). VHS probably killed half the mature population; management actions are needed to restore this high-quality population and fishery.

S15-10

Round goby mediated viral distribution and impacts to smallmouth bass in the St Lawrence River.

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The invasive and highly abundant round goby (Apollonia melanostomus) and its role in mediating prevalence of the disease among smallmouth bass is a main theme of the research. Goby are now a primary prey of bass and many other piscivorus in the system and they are known to carry VHSV. We are interested in how this interaction will ultimately affect disease manifestation in the bass population and potential implications to other fish species in the system. Data on smallmouth gut contents, relative abundance of bass and goby, measures of fish condition, and assays to quantify viral presence and load are being collected. Seasonal variation of VHSV prevalence in bass and goby, as well as size and sex dependant variation among our smallmouth bass are current objectives. Investigating this disease in the context of ecological interaction will aid understanding of large-scale effects of epizootics in aquatic ecosystems. Currently, field sampling is underway (began May 2007, will be completed summer 2008) and a strong seasonal pattern of VHSV prevalence is emerging wherein there was high incidence of diseased smallmouth among our pre-spawn sample. This presentation will highlight analyses and findings to date.

S15-11

Fisheries management responses to the detection of VHS in Ontario

Brenda Koenig[1] (presenting), Steve Kerr[1], Chris Brousseau[1], Elizabeth Wright[2]. [1]Ontario Ministry of Natural Resources, Fisheries Section, Peterborough Ontario, Canada, [2]Ontario Ministry of Natural Resources, Fish Culture Section, Peterborough Ontario, Canada

Viral hemorrhagic septicemia (VHS) was first identified in Ontario during 2005 after a die-off of fish in the Bay of Quinte, Lake Ontario. The virus has now been found in more than 25 species of fish in the Great Lakes, including walleye, yellow perch, small-mouth and large-mouth bass, muskellunge and several species of baitfish. In January 2007, interim measures to control the harvest and transport of live baitfish were invoked. This involved the designation of management zones across the province; an infected zone, a buffer zone and a virus-free zone. Baitfish harvest from an area encompassing the lower Great Lakes was prohibited. These measures were designed to slow the spread of VHS from the Great Lakes to inland waters and had significant impacts on baitfish harvesters within the VHS infected and buffer zones. Following this, the Ontario Ministry of Natural Resources (OMNR) met with several stakeholders to share information and gather feedback on potential management approaches for the future. A revised one-year interim management strategy was announced in March 2007 and included a broader definition of virus-positive waters and a VHS Management Zone, The operation of fishways and existing manual transfers of fish over barriers did not change, however restrictions were placed on the use of fish, eggs and spawn collected from the VHS Management Zone. The new strategy allowed baitfish harvesters and dealers in the VHS Management Zone to resume limited operation but restricted movement of live baitfish out of the zone, helping to slow the spread of the virus. Challenges existed because other movements of fish such as anglers moving baitfish were not restricted. The OMNR initiated an education and awareness campaign to share information about the VHS virus and potential impacts on fish and preventative actions that the public and stakeholders could take to help slow the spread. This initiative included the development of factsheets, a website, and slide presentations. Another aspect of the management response included monitoring through the collection of fish for VHS testing in the spring and fall of 2007.

S15-12

So how do fisheries agencies respond when a new virulent pathogen such as VHSv shows up in their waters: A case study from the Great Lakes

Gary Whelan[1] (presenting). [1]Michigan Department of Natural Resources - Fisheries Division, Lansing, MI, United States

The Great Lakes region has been under siege from a range of new fish diseases with the latest being Viral Hemorrhagic Septicaemia virus (VHSv). VHSv emerged as an epizootic agent during 2005 to 2007 in selected areas in the Great Lakes region and has caused a number of fish kill events. This virus has infected 25 species in the region and is likely to continue to spread in the region without intervention by fisheries management agencies. The initial response came from international agreement (OIE) obligations from a U.S. federal agency (USDA-APHIS) in October 2006 who put in place interstate and international fish movement restrictions. These federal regulations have been modified several times. The next level of response to deal further with interstate and intrastate issues was from the state and provincial fisheries management agencies. The Great Lakes region is fortunate to have the Great Lakes Fishery Commission – Great Lakes Fish Health Committee (GLFHC) as a forum to develop pathogen control recommendations for Great Lakes fisheries agencies. In October 2006, the GLFHC developed 39 recommendations in 9 areas including: pathogen and disinfection testing; surveillance; fish culture; fish transfers; other management actions including angler and aquaculture regulations; commercial fishing; bait industry; public information; and other measures including ballast water regulation and research. These recommendations have prompted 6 of the 9 fisheries agencies to adopt regulations to engage the bait

industry and anglers as partners in pathogen control and all 9 agencies have adopted and implemented the recommendations as needed in each jurisdiction. As a result of the actions of GLFHC along with the federal actions have lead to a set of fish pathogen control actions which have the potential to slow the spread of this pathogen and are a model for how other emerging pathogens should be handled.

S15-13

Evolution of VHS regulations in the Great Lakes: the importance of harmonizing rules to effectively manage human and fish populations

Jill Finster[1] (presenting), John Dettmers[1], Roger Knight[2], Rob MacGregor[3]. [1]Great Lakes Fishery Commission, Ann Arbor, MI, United States, [2]Ohio Department of Natural Resources, Sandusky, OH, United States, [3]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

In response to the 2006 Federal Order on VHS, individual jurisdictions in the Great Lakes mobilized quickly to enact regulations to reduce the spread of VHS. With the implementation of these regulations, it is becoming apparent that improved consistency among jurisdictions would significantly increase their effectiveness and promote meaningful enforcement. VHS-susceptible species are moved throughout the basin for sale, by recreational and tournament anglers, and for research. Because human-mediated fish movement throughout the basin is extensive, managers seek regulations that share a common foundation. If regulations fail to effectively address joint fishery management and law enforcement objectives, in even a single jurisdiction, the entire Great Lakes basin may be adversely affected. We will report on a process to facilitate provincial, state and tribal action, through the Council of Lake Committees, that is being developed to address regulatory disparities that affect fish farmers, bait dealers, and anglers. This process will present a rapid response framework to identify common themes to be considered and addressed when jurisdictions draft positions/regulations. While uniformity of basin-wide regulations is unrealistic, the development of consistent regulations among Great Lakes jurisdictions is an achievable goal and a vital component of all efforts to reduce the spread of VHS.

S15-14

From risk assessment to disease control measures: VHSV case study.

Grace Karreman[1] (presenting), Kim Klotins[1], Brian Peart[1], Lori Gustafson[2], Rod Penney[1]. [1]Canadian Food Inspection Agency, Aquatic Animal Health Division, Ottawa, Ontario, Canada, [2]US Department of Agriculture, Fort Collins, Colorado, United States

The Canadian Food Inspection Agency (CFIA) has a mandate to make informed science-based decisions to manage aquatic animal health among other commodities and activities regulated by the Agency. In anticipation of proposed regulatory changes being approved for the National Aquatic Animal Health Program (NAAHP) in 2008-2009, CFIA is currently developing the framework for national disease control measures for aquatic animal diseases. Outbreaks of Viral Hemorrhagic Septicaemia virus (VHSV) in Great Lakes fish populations since 2005 were used as a case study to develop the initial framework. Four efforts were undertaken to address VHSV federally, including[1] bilateral surveillance with the US in the Great Lakes;[2] convening of an Expert Panel to determine risk factors mostly likely associated with the presence of VHSV in watersheds;[3] a multi-commodity Biosecurity workshop in May 2007 to outline existent and future biosecurity measures for diverse stakeholders affected by VHSV;[4] a structured Risk Assessment for introduction and spread of VHSV through live animals and uneviscerated product within Canada. Results of each of these four efforts have been used to outline disease control measures to prevent introduction and limit the spread of VHSV into and within Canada. Efforts underway include[1] the delineation of zone boundaries; and[2] determining putative health status of watersheds and zones based on data to date; and[3] a framework for movement controls using risk-based assessment of movements.

S15-15

The role of risk assessments in guiding management and response decisions: Viral Hemorrhagic Septicemia Virus case study.

Kim Klotins[1] (presenting), Carol Tinga[2], Pascale Nérette[1], Grace Karreman[1]. [1]Aquatic Animal Health Division, Canadian Food Inspection Agency, Ottawa, Ontario, Canada, [2]Epidemiological Consultant, Guelph, Ontario, Canada

The Canadian Food Inspection Agency (CFIA) conducts risk assessments to assist with its mandate to make informed science-based decisions to manage animal health, plant health, and other commodities and activities regulated by the Agency. CFIA's National Aquatic Animal Health Program (NAAHP) is currently under development in partnership with Fisheries and Oceans Canada. The NAAHP includes export, import, national disease control and contingency planning, surveillance and risk assessment components that are aimed to foster access to international markets for trade in aquatic animals and protect the health and welfare of Canada's wild and cultured aquatic animals. Regulatory amendments allowing more substantial implementation of the NAAHP are expected within the year. Since the first recognized fish mortality event associated with isolation of Viral Hemorrhagic Septicemia Virus (VHSV) in Lake Ontario in 2005, more outbreaks in a number of wild fish species have occurred in several watersheds of the Great Lakes Basin. In addition, the virus has also been isolated from a number of species not experiencing clinical signs of disease. Federal and State/Provincial authorities have, to a greater or lesser extent, introduced measures to control the spread of VHSV. In anticipation of implementation of the regulations, the Aquatic Animal Health Division is conducting 2 risk assessments specific to VHSV. One addresses the risks associated with importation into Canada of live fish, including gametes and embryos, uneviscerated product, and their associated transport waters. This risk assessment will be used to determine if importation should proceed and under what conditions. The other risk assessment addresses risks associated with live fish movements, uneviscerated fish product movements to processing plants and its use as bait or aquatic animal feed, human-induced movements of contaminated water and equipment, and vectors, such as birds, within Canada. This risk assessment will be used to outline VHSV positive, negative, surveillance and unknown zones, emergency response decisions, fish movement permitting conditions, and other disease control activities that will assist with the management of VHSV.

S15-16

Modeling expert opinion to guide VHS surveillance in the US and Canada

Lori Gustafson[1] (presenting), Sarah Tomlinson[1], Amber Barker[1], Kim Klotins[2], Grace Karreman[2].
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Surveillance is important not only for the detection of new disease, but also for the designation and management of disease-free regions or sectors within known-infected countries. Surveillance programs for emerging diseases of uncertain distribution, however, can be extremely costly. We developed a method to combine expert belief on viral hemorrhagic septicemia virus (VHSV) IVb risk with surveillance findings to jointly determine a region's disease status and to prioritize surveillance resources to regions with the greatest need. An international panel of 30 experts on VHSV and fish health was established. A group process technique was used to identify 9 risk factors associated with watershed context (e.g. the watershed's distance from known-affected regions, or its history of transfer of un-tested live bait from affected regions) and estimate likelihood ratios re(presenting) the magnitude of risk associated with each factor. The resulting expert data can be used to inform disease control efforts, to supplement surveillance findings in disease freedom investigations and also to estimate the time value of historical information. Panel results and example applications are provided and discussed.

S15-17

Fish health and ecosystem dysfunction in the Great Lakes

Stephen Riley[1] (presenting), Kelly Munkittrick[2], Allison Evans[4], Charles Krueger[3], John Dettmers[3]. [1]USGS Great Lakes Science Center, Ann Arbor, MI, United States, [2]University of New Brunswick, St. John, New Brunswick, Canada, [3]Great Lakes Fishery Commission, Ann Arbor, MI, United States, [4]Oregon State University, Corvallis, OR, United States

Disease may be an important variable affecting wild fish population dynamics in the Great Lakes; however, a lack of information on the ecology of fish disease currently precludes the prediction of risks to fish populations. We propose a conceptual framework for conducting ecologically-oriented fish health research that addresses the inter-relationships among fish health, fish populations, and ecosystem dysfunction in the Great Lakes. The conceptual framework describes potential ways in which disease processes may relate to ecosystem function, and suggests that functional ecosystems are more likely to be resilient with respect to disease events than dysfunctional ecosystems. We suggest that ecosystem- or population-level research on the ecology of fish disease is necessary to understand the relationships between ecosystem function and fish health, and to improve prediction of population-level effects of diseases on wild fish populations in the Great Lakes. These concepts are embodied in a research theme promoted within the Great Lakes Fishery Commission's research program, which is designed to encourage ecologically-oriented research on fish disease in the Great Lakes.

S15-18

Predicting and detecting VHS impacts on populations using modelling results: is VHS mortality separable from M?

Kevin A. Kayle[1] (presenting), M. Elizabeth Wright[2]. [1]Fairport Harbor Fisheries Research Unit, Ohio DNR Division of Wildlife, Fairport Harbor, OH, United States, [2]Fish Culture Section, Ontario Ministry of Natural Resources, Peterborough, ON, Canada

We discuss how fish mortality caused by the viral hemorrhagic septicemia (VHS) virus may function and be expressed at the population level. We examine where population-level effects due to changes in growth, mortality, production and recruitment could be detected and will present how these changes could affect population models. It is not as simple as a direct adjustment in the model to the natural mortality rate, M. We also discuss how these changes may be masked by compensatory and depensatory mechanisms in the responses of these rate functions to VHS virus associated infection and mortality. We review possible interactions between VHS virus related effects, density dependent effects, and other deterministic and random effects. We discuss mortality patterns, time horizons, cycles of infection and resistance, and how these characteristics would be borne out in populations, in our estimations of M, and expressed in our catch-age modelling. We present abundance, growth and rate function components, and residual patterns for a population of Lake Erie yellow perch that has been impacted by the VHS virus. This population is extensively monitored and modelled through a detailed interagency process. Using catch-age models as a diagnostic

tool during the time periods prior to, during, and after exposure to the virus, preliminary conclusions about fish mortality will be related directly and indirectly to VHS exposure and infection.

S16. Fisheries Governance: New Lenses for Sustainable Futures

S16-1

Are fisheries governable? A reality check

Ratana Chuenpagdee[1] (presenting), Svein Jentoft[2]. [1]Memorial University of Newfoundland, St. John's, NL, Canada, [2]University of Tromso, Tromso, Norway

Fundamentally, we all expect fisheries governance to deliver ideal outcomes such as achieving ecological, economic and social sustainability all at once. But is this a realistic expectation? Perhaps we are demanding too much or asking governance system to deliver too quickly. We may be expecting consensus when it is unthinkable that it will deliver outcomes that are acceptable by all. Before deciding on what governance systems should be established, we need to critically examine how governable these fisheries are, at least in the particular context. Following the interactive governance theory, this paper presents the governability assessment framework to evaluate what governance systems can do and should do in order to enhance their performance.

S16-2

Slippery as fish: theoretical perspectives on systems-to-be-governed

Maarten Bavinck[1] (presenting). [1]University of Amsterdam, Amsterdam, Netherlands

Interactive governance theory, which has emerged from the domains of public administration and sociology, distinguishes systems-to-be-governed from governing systems and argues that the former join together a natural and a social realm. As the nature of a system-to-be-governed co-determines its overall governability, its circumscription is of some importance. In the areas of capture fisheries and aquaculture, a system-to-be-governed can be studied as a ‘fish chain’ running across different scale levels, from ecosystem to the consumer’s plate. Fish chains are characterized by diversity, complexity and dynamics. This paper compares recent perspectives on systems-to-be-governed, paying special attention to issues of identity and boundaries. Turning to the social dimension, it explores the theoretical legacy of functionalism and its relevance to present-day debates on resilience and interactive governance. The paper argues that although social scientists largely – and for good reasons too - abandoned functionalist theory in the late 1960s, it may have a new contribution to make. The functionalist interpretation of the nature of social systems adds depth to and raises challenging questions for resilience and interactive governance theory alike.

S16-3

The inverted pyramid: an alternative image for the governance of fisheries and coastal systems

Svein Jentoft[1] (presenting), Ratana Chuenpagdee[2], Alida Bundy[3], Robin Mahon[4]. University of Tromsø, Tromsø, Norway[1], [2]Memorial University of Newfoundland, St. John's, Canada, [3]Bedford Unstitute of Oceanography, Halifax, Canada, [4]University of West Indies, Cave Hill, Barbados

Governance always rests on an idea of how the world works. Governors always have some image of what they are interfering with and of their own role in it. These images are often implicit; they are among the things which are taken for granted and therefore not much reflected on. Yet we know that our representations are not inevitable. They are natural but social and cultural. Our governing images could well be different from what they currently are. The issue is a serious one. Such images have real consequences because they are acted upon, sometimes with the effect of creating self-fulfilling prophesies. We create the world in our own image. Thus, governance theory (Kooiman 2003) argues that images are not external to the governance process but, deliberately or not, very much an integrated part. Governance is therefore also about image formation. It is where the governing process should start – and perhaps also end, as we should always try to learn from our actions. In this paper we contrast: the classical image ecosystem thinking that places humans at the top of the pyramid with an image that turns the pyramid on its head; “the inverted trophic pyramid” We argue that it is essential that governance of fisheries and coastal systems work from the idea that humans are fundamentally dependent of a healthy ecosystem, are vulnerable in the event of their demise, and at the same time pivotal to their health. For that, governance must commence from a different image than the classical one, that is from the inverted pyramid. If not, governance is bound to fail.

S16-4

Institutional adaptation as a governability problem in fisheries

Derek Johnson[1] (presenting), Jan Kooiman[1]. [1]University of Manitoba, Winnipeg, Canada, [2]Erasmus University, Rotterdam, Netherlands

In the context of the abundant writing on the institutional dimension of fisheries governance over the past 25 years, this paper analyzes the problem of institutional adaptation from the perspective of three current approaches to fisheries governance. Interactive governance theory is the reference point against which complex adaptive systems thinking and adaptive co-management are contrasted.

S16-5

Alleviating poverty in small-scale fisheries: the governance perspective

Paul Onyango[1] (presenting), Svein Jentoft[1]. [1]University of Tromsø, Tromsø, Norway

This paper will discuss challenges of poverty alleviation in small-scale fisheries. The paper will argue that governance is very crucial in alleviating poverty in small-scale fisheries, however when poverty strategies are designed and implementation through governance regime that do not conform to community values, poverty is aggravated other than alleviated. The basis of this argument is that most community values underpinning the way various actors define their tasks and roles are embedded in their societies. The same is however, not true for externally originated governance regime, tools and or systems. The paper discusses what happens if institutions of an externally originated governance regime are not sufficiently grounded in small-scale community fisheries socio-cultural environment can be unsustainable and ineffective. The unsustainability and ineffectiveness imply interference with local communities social and power structures thus eroding community abilities to control their livelihoods promote vulnerability and reduce abilities to access fish resources required for alleviating poverty. The paper will conclude that poverty alleviation within small-scale fisheries can be achieved through an interactive governance system.

S16-6

Discount factors as economic indicators of fisheries governance

Marcos Domínguez-Torreiro[1], Ussif Rashid Sumaila[2] (presenting). [1]Universidade de Vigo, Facultade de Ciencias Económicas e Empresaria, Vigo, Spain, [2]Fisheries Economics Research Unit, Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

We investigate the performance of different fisheries governance systems (command and control, self-governance and co-management) under two discounting scenarios: exogenous and endogenous discount factors. For exogenous discount factors, self-governance management regimes do better than command and control (in economic and ecological terms), if the fisher's discount factor is higher than that of the regulator, and vice versa if the discount factor of the regulator is higher. Under the assumption of endogenous discount factors, the decision whether to promote a command and control management system or a self-governance or co-management structure will depend on (i) the magnitude of the intertemporal preferences of both the fishers and the regulator, and (ii) the relative weight or political influence of the fishers on the regulator´s decision making process. These two conditions, intertemporal preferences and fisher-regulator influence, must be taken into account in the decision making process, such as when deciding what governance system to promote.

S16-7

Exploring social networks in marine resource governance: the case of the Grenadine Islands

Robin Mahon[1] (presenting), Patrick McConney[1], Katherine Blackman[1], Rhonda Lee[1]. [1]Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Cave Hill, Barbados

The Grenadines islands lie transboundary on the Grenada Bank in the southeastern Caribbean. There are nine inhabited islands extending over 60 km of bank with a population of about 18,000. The Grenadines comprise a tropical marine social ecological system (SES) with coral reefs, mangroves and seagrasses as prominent ecosystems. Livelihoods depend on marine resources. There is fishing for lobster, conch, coastal pelagics reef fishes and pelagics. Tourism is based on beach use, swimming, snorkelling and diving, day cruises and yachting. Most people and goods move by sea. Fisheries are overexploited and there is clear evidence of degradation of coastal and marine habitats. The Sustainable Grenadines Project addresses marine resource and biodiversity conservation. Intervention was based on the view that change towards equitable governance requires that civil society, government and the private sector all play their roles effectively. The civil society component of the SES comprised many small local NGOs of low capacity, so the project set out to strengthen its capacity to play its role in marine resource governance. Social network analysis [SNA] was used to initially explore and map relationships between stakeholder organisations. This was done with the aim of revealing the nature and distribution of linkages among organisations. The analysis revealed a low number of linkages relative to the possible number and that most were unidirectional. Several organisations were not linked to any others. Transboundary linkages were also weak. Low centrality suggests that few organisations play key roles that can either strengthen flows or control them depending on the nature of the linkages. The overall picture is one of a large number of small civil society entities that are largely disconnected, thereby posing challenges to governance.

S16-8

Governance potentials and limitations in inland fishery: a case of Lake Malawi

Andrew Song[1] (presenting), Ratana Chuenpagdee[1]. [1]International Coastal Network, Geography, Memorial University of Newfoundland, St. John's, Canada

This study gathers insight from a systematic assessment of governability, which intends to uncover the potentials and limitations of a system, guiding the fisheries and coastal governance into a realm of more realistic and 'good enough' outcomes. It also recognizes that governance performance should be viewed in light of diversity, complexity, dynamics and scale issues with which a system is inherently associated. In this study, these four key variables are examined in Kadango and Nkhata Bay, the two examples of a fishery system in Lake Malawi. For instance, low diversity is exhibited in the natural system of Lake Malawi vis-à-vis other tropical systems such as estuaries and coral reefs, while the socio-economic system shows high complexity due to the seasonality of fishing, geographical mobility of migrant fishermen, disparate gender roles and mix of ethnicity. The complexity and dynamics of the governing system is influenced by the recent institutional set up of Beach Village Committees as a vehicle for a decentralization process and the continued inclination towards developing deepwater offshore fishery. Analyzed in its totality, the discovered features reveal how governable the fisheries in Kadango and Nkhata Bay are. This paper summarizes the key findings of the assessment, highlighting the potentials and limitations that affect governance performance. Such understanding may contribute to improving the governance of Lake Malawi.

S16-9

Sustainability of salmon aquaculture: governance systems, regulatory approaches and implementation challenges

Yajie Liu[1] (presenting). [1]University of British Columbia, Vancouver, British Columbia, Canada

Salmon aquaculture has become the world's fastest growing food producing sector, and its production has increased at an exponential rate as a result of technological advances and the globalization of fish trade. However, the rapid expansion of salmon aquaculture has encountered a number of internal and external challenges, which may have limited its continued growth. A set of governance systems has been established in order to response to these challenges. Therefore, this paper first looks at the evolution of salmon aquaculture development and its associated problems and challenges. It also explores how governance systems have progressed at different levels and dimensions in order to meet different objectives. The research further examines the effectiveness of regulatory approaches and implementation challenges. Finally, some potential market-based measures and indicators are introduced to ensure that salmon aquaculture is environmentally benign.

S16-10

Future of small-scale fisheries: Thailand's on-going governance experiment

Kungwan Juntarashote[1] (presenting). [1]Coastal Development Centre, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand

The exploitation of coastal fisheries resources in Thailand, as in many countries in the region and elsewhere, has followed a pattern of development that involves changes in fishing technology and gears. Such changes have led to resource degradation and over-exploitation, as well as conflicts between small-scale and large-scale operators. These factors, together with the complex nature of the ecosystems, contribute to the difficulties in the governance of fisheries resources. An analysis of the development in fisheries and fisheries management in Thailand provides useful lessons for sustainability, particularly as Thailand plans to implement the FAO Code of Conduct for Responsible Fisheries. Also important is the government's interest in developing joint venture fisheries and distance water fleet. This paper addresses the impacts of such initiatives on small-scale fisheries and the livelihoods of coastal communities. It also analyzes the degree of correspondence between these fisheries policies and the current decentralization and institutional reform. Finally, we examine whether fisheries governance in Thailand can once again be referred to as an 'unplanned' experiment. Or the uncertainty in the management outcomes is actually what one could expect as part of the learning process in the governance of small-scale fisheries.

S16-11

How we fish matters: assessment and governance of ecosystem impacts of fishing in Canada

Susanna Fuller[1] (presenting), Ratana Chuenpagdee[2], Jennifer Ford[3], Candace Picco[4], Lance Morgan[5], Dorthea Hangaard[3], Fan Tsao[5]. [1]Dalhousie University, Halifax, Nova Scotia, Canada, [2]Memorial University, St. John's, Newfoundland, Canada, [3]Ecology Action Centre, Halifax, Nova Scotia, Canada, [4]Living Oceans Society, Vancouver, British Columbia, Canada, [5]Marine Conservation Biology Institute, Bellevue, Washington, United States

The impacts of fishing gears on marine ecosystems are receiving a growing amount of attention from scientists and policy makers. As the fragility of our ocean environments increases and attempts are made to implement an ecosystem approach to fisheries management, understanding how we fish matters. We conducted an assessment of the ecosystem impacts of fishing gears used in Canada, using available scientific information and consulting broadly with stakeholders. As fisheries governance operationalizes the precautionary approach, and begins to include risk averse management strategies, information on the severity of ecological impacts from fishing is imperative for responsible decision making processes. We present our assessment results within the framework of existing and proposed governance structures relating to Canadian fisheries management.

S17. Innovative Approaches to Bycatch Reduction

S17-1

Progress and effective strategies for reducing fisheries bycatch

Yonat Swimmer[1] (presenting). [1]NOAA Fisheries, Pacific Islands Fisheries Science Center, United States

The incidental capture of sea turtles, elasmobranchs, cetaceans, and seabirds in fisheries has been implicated in the rapid decline of several populations and is one of the most significant issues affecting fisheries management today. For the fishermen, bycatch can be a cause of inconvenience, loss of income due to time involved in handling non-target species, and can even pose potential danger. For the species involved, it can be the cause for serious population declines and eventual population extinctions. Fisheries bycatch is, by nature, a very complex biological, social, economic, and political issues, often times affecting an international scope. Due to these complexities, effective bycatch reduction strategies must also be comprehensive and integrative, often requiring creative collaborations. As a growing human population demands increased exploitation of marine resources, it is imperative to improve our understanding of the multiple dimensions to fisheries bycatch and to work collaboratively and effectively to improve the selectivity of fishing gear to avoid unwanted waste of precious marine resources.

S17-2

Use of electropositive metals to reduce shark feeding behavior

John Wang[1] (presenting), Lianne McNaughton[1], Yonat Swimmer[2]. [1]JIMAR, University of Hawaii, Honolulu, HI, United States, [2]PIFSC, NOAA Fisheries Service, Honolulu, HI, United States

Understanding the sensory and behavioral ecology of sharks are important components to developing strategies aimed at reducing shark incidental catch in fisheries. Elasmobranchs have an electroreceptive system (ampullae of Lorenzini) that is capable of detecting very small electric fields. This sensory modality allows them to detect prey in the absence of any other sensory stimuli. Very strong electric fields, however, have been shown to deter approaching sharks. Sharks are most likely perturbed by the large electric fields that may overload their electrosensory system. Unfortunately, the devices that generate large electric currents are not suitable for use in most fisheries due to their size and power requirements. A possible alternative to these electronic shark deterrent devices is to use highly electropositive metals (e.g. Lanthanide metals). Electropositive metals have a strong tendency to release electrons and generate large oxidation potentials when placed in seawater. It is thought that these metals perturb the electrosensory system in sharks causing the animals to exhibit aversive behaviours. We conducted experiments to test the ability of electropositive metals to deter sharks from feeding on baitfish. Utilizing a shark viewing cage, we are able to film and observe choice experiments with Galapagos (Carcharhinus galapagensis) and sandbar sharks (Carcharhinus plumbeus). Results indicate that bait associated with lead metal was eaten over bait associated with electropositive metal. In addition, sharks exhibited more aversion behaviours as they approached bait associated with the electropositive metal. These results suggest that electropositive metals do influence feeding behaviour in sharks and could be potentially used to reduce the incidental capture of sharks in longline fisheries.

S17-3

Sensory-based approaches to sea turtle bycatch reduction in longline fisheries

Amanda Southwood[1] (presenting), Kerstin Fritsches[2], Richard Brill[3], Yonat Swimmer[4]. [1]University of North Carolina Wilmington, Wilmington, NC, United States, [2]University of Queensland, Brisbane, QLD, Australia, [3]NOAA-NMFS Cooperative Marine Education and Research Program, Gloucester Point, VA, United States, [4]Pacific Islands Fisheries Science Center, Honolulu, HI, United States

Mortality due to capture in longline fisheries has been implicated as a significant factor contributing to population declines for several species of threatened or endangered sea turtles. Identification of methods to reduce or prevent sea turtle bycatch is a high priority for fisheries managers and a necessary component of conservation efforts. Consideration of sea turtle behavior and the nature of interactions between sea turtles and fishing gear may lead to innovative solutions to the bycatch problem. The factors that attract sea turtles and target fish species to longline gear and bait are not well understood, but multiple sensory cues are probably involved. Identification of differences in sensory capabilities of sea turtles and pelagic fishes, as well as potential sensory attractants or repellents for these animals, could guide efforts to refine fishing techniques to more specifically target desired species and reduce capture of sea turtles. This presentation will provide an overview of studies conducted to assess the auditory, chemosensory, and visual capabilities of sea turtles, as well as the large pelagic fishes that are targeted by longline fisheries. We discuss the potential for exploiting differences in the sensory biology of sea turtles and pelagic fishes to develop economically viable gear modifications to reduce sea turtle bycatch, and comment on the advantages and disadvantages of this approach. Based on the current evidence, differences in visual capabilities of sea turtles and pelagic fishes provide a promising avenue for development of a sensory-based deterrent.

S17-4

Using field trials to examine sea turtle and target species CPUE in the presence of visual deterrents

Cody Hooven[1] (presenting), Adrian Alvarez[1], Khanh Chi Dam[1], Shara Fisler[1], Yaffet Mehari[1], Marlem Rivera[1], Ahiram Rodriguez[1], Yonat Swimmer[2], Edgar Trujillo[1], John Wang[3]. [1]Aquatic Adventures, San Diego, CA, United States, [2]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, United States, [3]Joint Institute for Marine and Atmospheric Research, Honolulu, HI, United States

Finding solutions to reduce the incidental capture of sea turtles in both pelagic longline and gillnet fisheries is a priority for fisheries managers, the fishing industry, and the conservation community. While there is an urgent need to employ methods that will result in fewer sea turtle interactions with fishing gear, these methods must simultaneously result in acceptable capture rates (CPUE) and economic viability in order for them to be adopted by the industry. In response to this, we have conducted a series of experiments testing the effects of visual deterrents on CPUE of both sea turtles and target species in Baja California, Mexico. In 2006 through 2008 we examined the effect of visual deterrents on capture rates of Eastern Pacific green turtles (Chelonia mydas agassizii) in gillnet fishing gear. During the day, we compared gillnets with and without shark-shaped banners (that would serve similar to a scarecrow) to determine its potential effectiveness to reduce sea turtles from approaching and becoming entangled in the net. During the night, we compared CPUE in gillnets with and without illumination from light emitting diodes (LEDs). The experiment using shark-shaped banners found that use of the banners resulted in a 54% reduction in sea turtle CPUE, and the experiment using LEDs demonstrates a 31% reduction in sea turtle CPUE as compared to control nets with no modifications. In 2008 we tested the application of these gear modification techniques on incidental capture and target species CPUE and market value in an existing commercial gillnet fishery. These strategies to reduce sea turtle interactions may be directly applied to gillnet fisheries and may even be exported with modifications to longline fisheries as well.

S17-5

Integrating people into fisheries management plans to reduce bycatch

Martin Hall[1] (presenting). [1]Inter-American Tropical Tuna Commission, La Jolla, CA, United States

Fishers at sea are, in the vast majority of cases, “free” from laws and regulations which can’t be monitored or enforced. In order to achieve the goal of reducing bycatches in fisheries, we need the fishers to become part of the solution. We need their practical knowledge of the fishing operations to devise solutions that are feasible to implement, and that allow the continuation of a viable fishery. We need their help in putting together management measures that are sensible and affective. And more than anything, we need their will to take the extra step when they are out at sea without witnesses. To motivate fishers to change their behaviour is the central challenge of bycatch reduction. I will provide examples, where the development of constructive interactions between scientists, managers, fishers and conservation organizations resulted in successful outcomes, and discuss the incentives that operated in each case. Initially, most organizations and governments were ill-prepared to address the issues. In some cases they relied on top-down heavy-handed solutions to mandate changes that were difficult to monitor or enforce. Conservation organizations brought the issue to the public’s attention, but their ability to influence the many governments involved, and the various fisheries across the world was very limited. Industry organization opted for a denial strategy. Academic organizations and researchers in many cases spent significant resources in futile attempts to quantify the problem. For some, the only solution available was to shut down fisheries or close large areas of the ocean. The socio-economic conditions prevailing in the fishing communities of the developing world drastically limit the options available to solve the problem, and it became quickly apparent that those options proposed were not viable. The realistic solutions came from a handful of researchers, managers, industry and conservation leaders, working in different regions of the world, who realized that only a cooperative, and bottom-up approach could bring together all the components of a solution. In spite of the cultural and economic differences, successful formulas are remarkably similar in their context.

S17-6

Engaging community in developing strategies to reduce bycatch: a collaborative education and research effort

Shara Fisler[1] (presenting), Adrian Alvarez[1], Khanh Chi Dam[1], Cody Hooven[1], Yaffet Mehari[1], Marlem Rivera[1], Ahiram Rodriguez[1], Yonat Swimmer[2], Edgar Trujillo[1], John Wang[3]. [1]Aquatic Adventures, San Diego, CA, United States, [2]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, United States, [3]Joint Institute for Marine and Atmospheric Research, Honolulu, HI, United States

The human dimensions of the fisheries bycatch problem call for cross-sector solutions. Successful management strategies are reliant upon developing widespread understanding of the implications of incidental capture for ecosystem function, species populations, fishing industry and communities. In 2005, a collaboration between diverse stakeholders was developed to increase understanding of the bycatch issue and to develop approaches to reduce interactions of non-target species with fishing gear while optimizing the social and economic outcomes. Partners include: Aquatic Adventures Science Education Foundation, a non-profit marine science-focused education organization; government agencies including NOAA and the Comisión Nacional de Áreas Naturales Protegidas; University of Hawaii’s Joint Institute for Marine and Atmospheric Research; and a group of artisanal fishermen in Baja California, Mexico. Through this unique collaborative effort, we bring urban high school students from the U.S. to Mexico, where they conduct fisheries research in partnership with U.S. scientists and agencies, fishermen, and local resource managers. This talk will focus on education aspects of this work – both the education of young people and their development as future scientists, fisheries managers

and conservationists, and an educational exchange between scientists and fishermen as they work in collaboration to develop fishing techniques to reduce incidental capture.

S17-7
Better marketing, less bycatch?
Douglas Meyer[1] (presenting). [1]Bernuth & Williamson, Washington, DC, United States

Changes in laws, social norms, and individual behaviors can often be traced back to the work of social movements and advocacy organizations. What lessons might we learn from the successes and failures others have had on their issues, and how might we apply those lessons to our own efforts to reduce bycatch? Douglas Meyer, a marketing specialist and partner in the consulting firm, Bernuth & Williamson, will cover these questions in a presentation that touches on topics as diverse as the decline in tolerance for drunk driving to the increase in interest in sustainable seafood, and relates it all back to the matter of reducing bycatch.

S17-8
Supporting effective bycatch reduction efforts with your seafood choices
Jesse Marsh[1] (presenting). [1]Monterey Bay Aquarium, Monterey, CA, United States

Fisheries bycatch is a global issue, and one that can be addressed in part by innovative mitigation solutions—fishers play a key role in the development of these solutions. Consumers can support such mitigation efforts by purchasing seafood from these fisheries. Seafood pocket guides, such as those produced by the Monterey Bay Aquarium, allow consumers to identify more eco-friendly seafood in the marketplace. By purchasing seafood that is caught in more sustainable ways, consumers have the power to support healthy oceans and the fishers that are working to reduce bycatch.

S17-9
Case studies of bycatch reduction strategies by Hawaii longline vessel operators
Amy Gough[1] (presenting), Stewart Allen[1], Yonat Swimmer[1]. [1]NOAA Fisheries Service - PIFSC, Honolulu, HI, United States

NOAA Fisheries' management of bycatch in the Hawaii longline fleet has focused on regulations intended to reduce interactions between longline vessels and protected species—primarily sea turtles and sea birds. The purpose of this study is to further explore the human dimensions involved in successfully implementing effective bycatch reduction strategies among Hawaii longline vessels. This includes a) consideration of the issues leading to adoption of bycatch reduction strategies; b) exploration of the factors leading to perceived success of bycatch reduction strategies; and c) consideration of alternative bycatch reduction attempts desired by fishing vessel owners and operators. Our goal was not to attempt to document the full range of longline fishermen's attitudes, beliefs, values, and behaviors regarding bycatch reduction and its management. Instead, we wanted to develop a small set of in-depth case studies which would document success stories of existing or potential bycatch reduction strategies, from the fishermen's perspective. We set out to better understand these techniques from the fishermen's perspectives and explore reasons why they may or may not be adopted—but with an emphasis on the positive. Other fishermen and managers alike could learn from the successful experiences of fishermen who have worked through some of the challenges associated with these techniques or from ntrepreneurial fishermen whose new ideas and innovations could spur similar thinking among others. We also wanted to learn more about not just gear, but social mechanisms which play a role in the rate of adoption of bycatch reduction strategies.

<u>S18. Well-Managed Fisheries: Defining Best Practices in Fisheries Management</u>

S18-1
Well managed fisheries: what do we mean and what are some candidates?
Ray Hilborn[1] (presenting). [1]University of Washington, Seattle, WA, United States

The term "well managed" can mean something very different to various groups involved in fisheries. From a narrow biological perspective we generally consider the health of the stock in question, from a broader biological perspective the impacts of the fishery on the ecosystem, particularly non-target species. Economists generally look at the profitability in relation to the potential profits. Sociologists and anthropologists look at the communities. Managers look to levels of funding and the institutional structure. Fishermen look at the viability of their business. What is well managed to a fisherman may be poorly managed to a conservation NGO, and what is well managed to an economist may be a disaster to a sociologist. I explore a range of fisheries in these dimensions and look for examples that are well managed by many of the possible criteria.

S18-2
Best practices in fisheries management: a literature review
Howard Powles[1] (presenting). [1]Telfer School of Management, University of Ottawa, Ottawa, Ontario, Canada

Available literature and other information on best practices in fisheries management can be grouped into five categories: textbooks and manuals, compilations (symposia, workshops, volumes of collected papers), articles and reviews, case studies, and certification programs. There has been increasing interest in describing best practices in the past decade, and certification schemes are gaining importance as a tool in fisheries management, but the lack of case studies and of thematic papers distilling best practices from experience is somewhat surprising. Much literature on best practices reflects the disciplinary interests of the authors, with earlier publications giving more attention to biological aspects of management than to economic and social aspects, and increasing interest in the past decade in user rights, governance mechanisms, and a broader ecological approach to resource conservation and management. Good fisheries management requires addressing multiple issues, and a "sustainability" framework including ecological, economic, social, and institutional elements may be useful for judging success. Key elements of success in fisheries management include a formal conservation framework based on knowledge of biological (ecological) limits; a predictable user rights regime; clearly defined and agreed objectives; strong institutions and governance structures, with clearly defined roles and responsibilities and scope for full participation by users; and the ability to adapt to unforeseen challenges.

S18-3

85 years of Pacific halibut management – NOW we're talking sustainable!

Bruce Leaman[1] (presenting). [1]International Pacific Halibut Commission, Seattle, WA, United States

While many fisheries have a long history, few have a history of management like the Pacific halibut fishery. Pacific halibut management began with the establishment of the Canada-U.S. International Pacific Halibut Commission (IPHC) in 1923. Over its 85 year history, the IPHC has conducted the assessment and research upon which management has been based. Despite the long period of fishing, exploitable biomass is currently equal to B40, and current removals from the stock are over 30% above the long-term average. The elements of the successful halibut management are deceptively simple: high-quality science, comprehensive data collection on all removals, significant outreach and communication with harvesting sectors, conservative harvest policy, institutional and industry commitment to management, and a participatory and transparent management process. I outline the underlying processes that have led to this success, including the metrics of management performance. However, the Commission has also been challenged to evolve its research, management, and communication strategies in response to environmental changes, formalized allocation agreements among existing and new harvesting sectors, dedicated access privileges, and the demands of an ecosystem approach to fisheries management. Significant impediments to effective management have been the control of halibut bycatch in non-target fisheries, the impacts of biomass changes in co-occurring species, maintaining programs in the face of reduced funding, and uncontrolled harvest by sport fisheries in some areas. While yield from the halibut fishery has been sustained over the 85 year history of the Commission, sustainability needs to be evaluated over the longer time frames of both population processes and environmental dynamics. For species like Pacific halibut, these time frames should encompass several generation times and can be 50-75 years.

S18-4

Pacific herring stock assessment and management, a successful partnership

Jake Schweigert[1] (presenting), Dennis Chalmers[2], Lorena Hamer[3]. [1]Pacific Biological Station, Nanaimo, BC, Canada, [2]Ministry of Agriculture, Victoria, BC, Canada, [3]Fisheries Management, Nanaimo, BC, Canada

The Pacific herring fishery began in 1877 and has provided ongoing contributions to the British Columbia (BC) economy. In the early 1900s, scientists initiated the first scientific studies of Pacific herring in BC focussed on stock identification to understand the interrelationships and movement of fish spawning in different areas and studies of the reproduction and production characteristics of herring in support of the fishing industry. In the process, long term monitoring programs of the stock size, fish size, catch, and age structure were initiated that have continued to present and produced one of the longest and most comprehensive data series in the eastern Pacific. The extensive data sets have provided the basis for the development of sustainable harvest strategies based on a well documented scientific understanding of herring biology and the factors that impact stock productivity. Sound scientific advice has provided fisheries managers with the tools to implement sustainable harvesting strategies. Good communication, mutual trust and respect among fisheries scientists, fisheries managers, fishermen and processors has facilitated the sustainable management of the fishery and allowed for implementation of difficult management decisions during periods of reduced productivity under changing environmental conditions. Despite the negative attitude of some stakeholders whose view of the fishing industry is as a strictly economic enterprise, a sense of shared stewardship between government and industry has developed over several decades and led to a co-operative partnership that has strongly supported ongoing scientific research on herring as a basis for better understanding of the biology and factors affecting long-term production. Ongoing dialogue among government, industry, and stakeholders at joint fora have facilitated fisheries management decisions and the mutual objectives of a successful fishery.

S18-5

An analysis of factors controlling the sustainability of fisheries for sockeye salmon over the past century on the west coast of Vancouver Island, British Columbia

Kim Hyatt[1] (presenting). [1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, B.C. Canada

Sustainable fisheries for Barkley Sound sockeye salmon on the west coast of Vancouver Island have been maintained for approximately 150 years despite annual variations in productivity that exceed an order of magnitude. By contrast, neighbouring Clayoquot Sound sockeye salmon fisheries persisted for roughly a century followed by a stock collapse from which both fish and fisheries have yet to recover. Here we employ a retrospective analysis of stock and recruit data to identify effects of harvesting, climate variation, habitat alterations and management actions as a complex of factors controlling the sustainability of these fisheries in the face of large magnitude environmental changes. The failure to successfully maintain fisheries for Clayoquot Sound sockeye salmon appears to be a consequence of low-resolution, stock assessment information and delayed decision "loops" affecting critical elements of both in-season and pre-season management. By contrast, the success of the Barkley Sound fishery has been based on an exceptional series of collaborations by resource managers and fisheries scientists to fashion effective pre-season and in-season management models dealing with a wide range of factors controlling decadal to centennial level variations in stock productivity.

S18-6
The Marine Stewardship Council Fisheries Certification Program
Jim Humphreys[1] (presenting). [1]Marine Stewardship Council, Seattle, WA, United States

The Marine Stewardship Council (MSC) is an international non-profit organization that manages an independent third party certification program for well-managed and sustainable fisheries. The MSC's fisheries standard was developed following international consultation, and encompasses three key elements: target stock health, impact of the fishery on the ecosystem, and the effectiveness of the fishery management system. Fisheries that are interested in participating in the MSC program voluntarily have their fishery reviewed and scored against the MSC standard by a team of independent experts working with an accredited certification body. The MSC has a prescribed methodology that must be followed in this process. In 2005, FAO developed and published minimum guidelines for ecolabelling of fish and fishery products from marine capture fisheries, and the MSC program works to ensure that the entire program meets those voluntary guidelines. Over 7% of the world's food fisheries are engaged in the MSC program, and over 100 fisheries are either certified or in full assessment in the MSC program. From these fisheries over 1200 product lines are using the MSC label on fishery products, which are being sold in 36 countries.

S18-7
The importance of scientific knowledge in securing long-term utilizationof fish resources
Jóhann Sigurjónsson[1] (presenting), Sigurdsson Thorsteinn[1]. [1]Marine Research Institute, Reykjavik, Iceland

It is well accepted that biological information is essential for successful management of fish stocks in addition to other important knowledge on the fishing operation in question. The required level of knowledge varies between fish species and the intensity of exploitation. This paper discusses three different cases of fish stock management in the Northeast Atlantic, the fishery for summer spawning herring (Clupea harengus) off Iceland, the Iceland cod (*Gadus morhua*) fishery and the pelagic redfish (*Sebastes* spp.) fishery in the Irminger Sea. The local summer spawning herring stock has been managed by adopted long-term harvest strategy based on optimum harvest level (F0.1), resulting in full recovery of the former depleted herring stock in the last 30 years and a resource that has given relatively stable yield, not sensitive to fluctuations in recruitment, operational factors or errors in assessment methods. The Iceland cod stock has been subject for intensive harvest for more than half a century and still constitutes the single most important fish stock exploited and managed by Iceland. The fishery has been closely monitored and studied for decades and the last 10 years it has been managed according to a well defined and adopted long-term harvest strategy developed by biologists and economists in cooperation with fishing industry representatives. The international fishery for pelagic redfish in the Irminger Sea is an example of an international fishery where the knowledge base is still non-satisfactory despite considerable scientific efforts in recent years and the stock is left in jeopardy demonstrating a management failure due to shortage of knowledge and lack of responsiveness of responsible international management authorities. The three examples discussed show how well founded biological knowledge of exploited fish stocks is important for successful management. It shows how moderately harvested fish stocks are far less vulnerable to over-harvest due to mismanagement or shortage of knowledge on critical aspects of the nature of the fish stock to be managed than overexploited fish stocks. And it shows how signals of over-harvest or shortcomings in knowledge need to be taken into account with precaution when determining management actions to be implemented.

S18-8
New Zealand lobster fisheries
Paul Breen[1] (presenting). [1]National Institute of Water and Atmospheric Research Ltd, Wellington, New Zealand

New Zealand introduced ITQs for its nine rock lobster stocks in 1990, retained essential input controls such as size limits, and reduced catches from the 1990 levels to address depletion. Over all stocks, catches are at 1990 levels, but effort is far less and CPUE far higher. However, individual stocks show variable histories, and this talk will discuss elements of management success. ITQs have been an essential component of those stocks that are well-managed, but are clearly not a sufficient component. Rapid management response to changing abundance is also an essential component, and the best success has resulted from ten years of management for two stocks with an operational management procedure (decision rule). Decision rules are now being developed for other stocks. Industry has been a critical component of success in some stocks: stock assessment relies heavily on industry-generated data. Government management of stocks lags behind stock fluctuations, so industry in two areas have adopted voluntary shelving of quota, based on decision rules, to manage their stocks.

S18-9
The restoration of Atlantic striped bass: the convergence of fisheries management, policy and science
Gary Shepherd[1] (presenting), Gary Nelson[2], Nichola Meserve[3]. [1]NOAA Fisheries, Woods Hole,MA, United States, [2]MA Div. Marine Fisheries, Gloucester,MA, United States, [3]ASMFC, Washington,DC, United States

The restoration of Atlantic striped bass stocks has been highlighted for several years as an example of a management success story. Prior to implementation of strict management regulations, high fishing mortality and exploitation patterns targeting small fish led to unsustainable catches and low spawning stock biomass. Based on scientific advice, management regulations altered fisheries to the extent that marginal year classes were allowed to prosper. Conservation efforts leading to stock restoration depended on the public acceptance of the benefits from a restored fishery. Stewardship of the restored striped bass resource has resulted in new management challenges. Success will depend on continued scientific monitoring of populations dynamics, identification of management objectives and involvement of user groups in both the scientific and management process.

S18-10
Georges Bank: an integrated fisheries management approach
Nadia Bouffard[1], Chris Annand[1] (presenting), Lisa Setterington[1]. [1]Fisheries and Oceans Canada, Ottawa, Ontario, Canada, [2]Fisheries and Oceans Canada, Halifax, Nova Scotia, Canada

Fisheries and Oceans Canada (DFO) has developed a new framework for fisheries management decision making throughout Canada called the Resource Management Sustainable Development Framework (RMSDF). This new Framework will help ensure a rules-based approach to decision-making that is more transparent, rigorous and systematic. The RMSDF introduces fisheries management policies and tools that implement the precautionary approach and the need to factor in ecosystem considerations when managing fisheries. There are three important drivers behind the development of the RMSDF. The first is international agreements and protocols that Canada has signed that affect how we manage fisheries. A second factor is the evolving domestic legislation and policy framework for the Government of Canada. The third driver is the growing number of requests to certify and to demonstrate that Canada's fish products are harvested sustainably to maintain existing markets. These market demands can help achieve sustainability objectives. The new policies and tools under the RMSDF include a policy to manage the impacts of fishing on sensitive benthic areas, a policy to help guide decisions regarding fisheries for forage species, a fishery decision-making framework incorporating the precautionary approach to guide management decisions, and a fisheries checklist to help DFO self-assess progress towards sustainability and to report externally on performance and progress towards sustainable management of fisheries. Examples of fisheries on the Atlantic coast of Canada that could be described as well-managed fisheries are the scallop and groundfish fisheries on Georges Bank. Some aspects of the RMSDF are already being used in these fisheries.

<u>S19. Who Holds the Cards: Government Versus Third Party Certifiers?? Setting the Standards for Sustainable Fisheries</u>
S19-1
Ecolabelling of fisheries: Canadian government response
Nadia Bouffard[1] (presenting). [1]Fisheries and Oceans Canada, Ottawa, Ontario, Canada

A growing number of Canadian fisheries are seeking eco-certification. Third-party certification assessments like MSC implicate Fisheries and Oceans Canada (DFO) in two significant ways: DFO holds most of the science and management information required to support assessments and it is the lead agency responsible for implementing measures or actions that are conditions of an assessment, both which can have resource implications. Two recent initiatives aimed at improving the economic and biological sustainability of fisheries in Canada are helping the Department to better respond to certification assessments. In April 2007, DFO announced the Ocean to Plate initiative to fisheries management decision-making. This initiative envisions working with all stakeholders, including government agencies and those involved in all levels of the seafood value chain, towards a common goal of a sustainable, economically viable and internationally competitive industry. Under this initiative, DFO is working on a strategy to be able to better respond to growing demand for the certification of fisheries that it manages. Along with the Ocean to Plate initiative, Fisheries and Oceans Canada has developed a new framework for fisheries management decision-making, called the Resource Management Sustainable Development Framework. Under this Framework, new policies and tools will help demonstrate sustainability and monitor progress towards sustainability. In this way, the Framework will help support efforts to certify fisheries. One such tool includes the Fishery Checklist, which is an internal Departmental assessment tool that covers the main subjects examined during a certification assessment. A summary of DFO's Ocean to Plate initiative and the Resource Management Sustainable Development Framework will be provided and how they allow the Department to better respond to certification assessments.

S19-4
Effectiveness of the MSC in promoting sustainable fisheries: role of corporate social responsibility

Cathy Roheim[1] (presenting). [1]University of Rhode Island, Kingston, RI, United States

The sustainable seafood movement has grown dramatically in the past ten years in its aim to entice the demand side of the market to reform poorly managed fisheries. Through their use of consumer guides to 'best environmental choices' in seafood and boycotts of species such as swordfish and Chilean sea bass, environmental groups have attempted to influence consumer choices. Ecolabeling, in particular by the Marine Stewardship Council, has grown significantly. Yet to date little formal analysis has been conducted on its market effectiveness and thus the creation of incentives to reform fisheries management. This presentation will present an initial analysis of the effectiveness of the ecolabeling by applying the theory of Corporate Social Responsibility (CSR) to analyze a) why major corporations globally ¬ all along the supply chain ¬ are supplying sustainable seafood to the market; and, b) why fisheries are undertaking the costs of certification.

S19-5
Confusing the public: current seafood certification methods
David Beutel[1] (presenting). [1]University of Rhode Island, Kingston, RI, United States, [2]Rhode Island Sea Grant, Kingston, RI, United States

Seafood lovers and chefs are confused about what is sustainable seafood. Their ethics tell them to "do the right thing" but they are confused about what seafood to serve and eat. We field numerous inquiries to this subject and have given public presentations to help clarify consumer thinking and to provide sources for information. Our experience with the reasons for consumer confusion, and suggestions for consumer education will be discussed in this presentation.

S19-6
The intersection of the sustainable fisheries and the demands of themarketplace and where certification programs play
Philip Fitzpatrick[1] (presenting). [1]Marine Stewardship Council, Seattle Washington, United States

I will present an update on the challenges confronting commercial buyers initiatives and efforts towards responsible and sustainable procurement practices of seafood. Provide overview of current and projected consumption patterns of sensitive and challenged seafood species will be reviewed and examples of major buyer initiatives stakeholders in the supply chain.

S19-7
The BC Sockeye salmon experience
Christina Burridge[1] (presenting). [1]BC Seafood Alliance, Vancouver, Canada

Three hundred thousand dollars, eight years, and two certifiers later, British Columbia sockeye has still not completed its Marine Stewardship Council assessment despite the best efforts of the client. This paper will use the example of BC sockeye to look at the implications of certification for client fisheries, for management agencies and conservation groups.

S19-8
Teaching the trendsetters: a chef-based sustainable seafood initiative
Megan Westmeyer[1] (presenting). [1]South Carolina Aquarium, Charleston, SC, United States

The South Carolina Aquarium's Sustainable Seafood Initiative (SSI) promotes the use of sustainable and local seafood in South Carolina's restaurants. The target audience of the SSI is high-end chefs, those who set the culinary trends and shape the market. The SSI scientific staff and advisors determine the sustainability of products by reviewing scientific studies and fishery management documents. A program, such as the SSI, that emphasizes local as well as sustainable seafood helps support local fisheries. These fisheries have achieved or are striving towards sustainability while competing with imports that are often not sustainable. A chef-based sustainable seafood program, such as the SSI, must balance the conservation ideals of the program with the reality that chefs face in the kitchen – limited availability of seafood that changes with the season. The most sustainable product option may not be available in all regions of the country or may only be available seasonally. Thus, a chef-based sustainable seafood program must help chefs determine their most sustainable options in the current marketplace and more sustainable products they could request from their wholesale seafood purveyors. The SSI has educated chefs to understand why seafood is seasonal and in some cases, that this seasonality is an artifact of management regulations that keep a fishery sustainable. This connection between seasonality and sustainability has helped chefs to educate their consumers, many of which are accustomed to having access to a variety of food products year round. The SSI minimizes seafood consumer confusion. Instead of educating a virtually endless number of consumers about a wide variety of seafood, which inevitably leads to confusion, the SSI helps a much smaller, targeted group of chefs make wise environmental decisions when sourcing seafood. This allows consumers to select an SSI Partner Restaurant, who presents a variety of sustainable seafood on their menu, without the need for the consumer to conduct further research.

S19-9

Legal aspects of seafood certification

Stephanie Showalter[1] (presenting). [1]National Sea Grant Law Center, Oxford, MS, United States

While direct government regulation is a key component of any fisheries regime, it is not the only management tool available. In recent years, a wide range of government agencies, nonprofit organizations, and industry groups have touted the benefits of indirect management strategies that seek to use consumer preferences to influence market choices. Two such strategies, environmental labeling and seafood certification, are growing in popularity due in part to the success of the dolphin-safe tuna campaign in the late 1980's and the more recent activities of the Marine Stewardship Council. Third-party certifiers seeking to develop labeling programs and fishermen hoping to participate need to be aware of the complex laws and regulations surrounding food labeling. In the U.S. environmental labeling schemes must comply with the regulations of the Food and Drug Administration, the Environmental Protection Agency, and other federal and state agencies. Labeling schemes can potentially run afoul of international trade laws designed to eliminate barriers to trade. Fraudulent conduct and improper use of certification marks can destroy consumer confidence in the third-party certifier's label. To protect its product and market share, a third-party certifier needs to vigorously investigate trademark infringements and pursue litigation as necessary. The presentation will discuss these and other legal issues that are likely to arise with respect of seafood certification.

S19-10

Economic factors affecting eco-label success at achieving sustainable fisheries goals

Kevin Athearn[1] (presenting). [1]University of Maine at Machias, Machias, Maine, United States

An eco-labeling program creates economic incentives that affect fishing behavior in both certified and uncertified fisheries. The ultimate effect on sustainability goals of reducing bycatch and preventing overfishing depend on various factors, including[1] supply and demand conditions for differentiated seafood products,[2] strictness and choice of certification criteria in relation to consumer demand and compliance costs, and[3] types of fishery management controls. Economic theory is used to generate hypotheses about the effects of these factors on eco-label success. The hypotheses suggest the types of programs and fisheries that are most and least likely to witness positive effects from eco-labeling.

S19-11

Consumer preferences for seafood information attributes

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Changes in consumer preferences have created an opportunity for developing differentiated and higher valued seafood products. Providing consumers with more information about seafood products at the time of purchase has been suggested as a way of differentiating seafood and promoting healthy fisheries. A discrete choice experiment conducted at high-end grocery stores in Portland, Oregon investigated consumer preferences for information about the quality, safety, origin and environmentally friendliness of seafood they consume. Results show that 'Sustainability Certification' was the most important information attribute influencing purchasing decisions, closely followed by 'Locally Harvested by Oregonians'. Also, significant relationships are identified between the information attributes and respondent characteristics. Overall, the study indicates an opportunity for local fishermen and the seafood industry to further develop 'local' brands while continuing the effort to market 'eco-friendly' seafood choices.

S19-13

Understanding consumer trends when cultivating new seafood markets: a workshop for seafood producers

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Commercial fishing is an integral part of North Carolina's coastal economy, contributing $65 million in ex-vessel value. Historically, the state's fishermen satisfied a strong demand along the East Coast for fresh, seasonal seafood. Since 1995, less expensive imports have taken significant market share from domestic processors. Many businesses are struggling to remain profitable. Product safety, bioterrorism threats, and the increasing demand for local or regional food products have recently made the public much more conscious about the origin of their food. Time-starved consumers are demanding wholesome seafood that requires little home preparation. To remain competitive, local seafood businesses must become consumer-focused. Companies must know how to discern consumer needs and product trends to compete in a global economy. The purpose of the workshop is to introduce market research tools for creating products and services consumers will value. Sourcing objective information about consumer needs will help mitigate financial losses in the marketplace. The market information and business tools provided in this workshop will provide seafood dealers with a foundation to make the transition from a production-driven enterprise to one that focuses on consumer needs. Our curriculum was designed as a model program for other coastal states to emulate.

S19-14

"Local catch": wallet-size cards inform or misinform consumers about North Carolina seafood choices?

Sara Mirabilio[1] (presenting). [1]N.C. Sea Grant Extension Program, Manteo, N.C. United States

In 2005, American consumer expenditures for seafood products increased by five percent over the previous year, with the biggest increases occurring in the restaurant ($1.7B increase) and home consumption ($1.6B increase) sectors (2005 Edition, NOAA's "Fisheries of the United States"). Specifically, demand is increasing for seasonal, locally harvested seafood due to greater food safety, enhanced nutrition, increased flavour and superior quality. In concert with this is growing clamour for sustainable seafood products. Whole Foods Markets, Bon Appetite food service company, and now even Wal-Mart, are making their niche appealing to sustainably minded customers that want to choose not only what is good for them but is good for the world ocean. What is universal, however, is a growing body of consumers cares about where their seafood comes from. Sea Grant has key roles to play in helping transfer technologies that keep the domestic seafood industry financially competitive and environmentally responsible and in enhancing the American public's awareness of differences in the quality, safety and nutritional benefits of different seafood products that will enable them to be informed buyers. North Carolina Sea Grant's "Local Catch" is a wallet-size card series that depicts the seasonality of 24 species of fish and shellfish commonly harvested in state waters. The primary goal is to help shoppers determine the freshest catch available in state markets and restaurants. Card information also includes descriptions of fishing gear used to target specific species. During development, questions arose regarding whether listed fishing practices were "environmentally friendly," and listed seafood, "sustainable." In trying to meet both consumer audiences' information needs, cards include statements that 1) the State of North Carolina employs environmentally responsible fisheries management and practices and 2) the N.C. seafood industry continues to work with researchers and government agencies to adapt gear to reduce bycatch, protect endangered species and maintain viable habitats. It now appears that in adding such text the targeted use became less defined. Local Catch cards are seen by some as pocket guides for certified N.C. fisheries, which the cards are not. The fundamental educational challenge is how to meet varying consumer preferences for seafood information while avoiding confusion in the marketplace.

S19-15

Decades of fisheries involvement - a tribute to Ralph Rayburn

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The passing of Ralph Rayburn on January 31, 2008 ended over three decades of his active involvement in fisheries affairs. Ralph dedicated his life to fisheries and served in a variety of professional positions which included Executive Director of the Texas Shrimp Association, Chief of Coastal Fisheries and Intergovernmental Liaison with Texas Parks and Wildlife Department and Associate Director and Marine Extension Leader with the Texas Sea Grant Program. Ralph represented the shrimp industry during the very contentious period of the sea turtle conservation conflict and did so with dignity and fairness. He later went on to serve with Texas Parks and Wildlife and was instrumental in establishing a shrimp management plan. Upon his death at Texas A&M University, Ralph was involved in a plethora of projects which reflected his strong commitment to fisheries conservation and management and the sustainability of the shrimp fishery.

S20. Cultured Aquatic Animals: Use and Implications for Stock Enhancement, Fisheries Management, and Species Diversity

S20-1

Hatchery reform in the Columbia River. application of biological principles to hatchery programs and the impact on large scale harvest and conservation goals

Peter Paquet, Chairman Columbia River HSRG[1], Andy Appleby[2], John Barr[3] (presenting), Lee Blankenship[4], Donald E. Campton[5], Mike Delarm[6], Trevor Evelyn[7], Dave Fast[8], Tom Flagg[9], Jeff Gislason[10], Paul Kline[11], Conrad VW Mahnken[12], Desmond Maynard[9]. [1]Northwest Power and Conservation Council, Portland, Oregon, United States, [2]Washington Department of Fish and Wildlife, Olympia, Washington, United States, [3]Nisqually Indian Tribe, Retired, Olympia, Washington, United States, [4]Northwest Marine Technology, Olympia, Washington, United States, [5]US Fish and Wildlife Service, Portland, Oregon, United States, [6]NOAA Fisheries, Portland, Oregon, United States, [7]Department of Fisheries and Oceans, Nanaimo, British Columbia, Canada, [8]Yakama Nation, Toppenish, Washington, United States, [9]NOAA Fisheries, Manchester, Washington, United States, [10]Bonneville Power Administration, Portland, Oregon, United States, [11]Idaho Department of Fish and Game, Boise, Idaho, United States, [12]NOAA Fisheries, Retired, Manchester, Washington, United States, [13]ICF Jones & Stokes, Vashon, Washington, United States, [14]Pacific States Marine Fisheries Commission, Portland, Oregon, United States, [15]University of Washington, Seattle, Washington, United States

The Congressionally-established Hatchery Scientific Review Group (HSRG) has provided a foundation for hatchery reform principles that should aid salmon hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals in the 21st century. The HSRG process has established principles based on goal setting, scientific defensibility, and adaptive management of hatchery programs. Tools to determine outcomes of proposed actions were developed and include a scientific framework for artificial propagation of salmon and steelhead, a benefit/risk assessment tool, hatchery operational guidelines, and monitoring and evaluation criteria. The foundation of the HSRG's evaluation is that conservation goals need to be met for key natural populations while at the same time continuing to contribute to harvest goals. In order for hatchery actions to effectively address conservation goals, harvest reforms are also necessary. The key to controlling genetic risks due to straying and the resulting fitness loss is to manage hatchery broodstock and the natural spawning escapement such that the natural habitat (and not the hatchery environment) drives the adaptation and productivity of the naturally spawning population. This is achieved by operating either (a) well-integrated programs where the proportion of hatchery-origin fish in the natural escapement is less than the proportion of natural-origin fish in the hatchery broodstock; or (b) well-segregated programs where the contribution of hatchery fish to natural spawning is kept very low. Implementation of genetic guidelines for broodstock and spawning escapement management may also reduce ecological risks. Additionally genetic risks have to be addressed not only on the local level but on a broader regional/ecosystem scale. Hatcheries need to be used as a component of an integrated strategy that incorporates other management tools including harvest reform in the context of current and future habitat changes. This presentation highlights the issues and concerns when hatcheries are used to address management goals, and the large scale results of applying conservation principles to hatchery operations.

S20-3

Impacts of supplementation: genetic diversity in supplemented and unsupplemented populations of summer chum salmon in Puget Sound

Maureen Small[1] (presenting), Ken Currens[2], Thom Johnson[3], Alice Frye[1], Jennifer Von Bargen[1]. [1]Molecular Genetics Laboratory, Washington Department of Fish, Olympia, WA, United States, [2]Northwest Indian Fisheries Commission, Lacey, WA, United States, [3]Washington Department of Fish and Wildlife, Port Townsend, WA, United States

Genetic diversity in supplemented and unsupplemented populations of summer chum salmon in Puget Sound Supplementation, where wild-origin fish are used as hatchery broodstock and their offspring allowed into wild spawning areas, is a tool used to support salmonid populations at risk of extinction. Managers seek to increase census size and boost effective population size (Ne) while minimizing risks of drift and inbreeding from hatchery intervention. Here we document impacts of five to ten years of supplementation on endangered summer-run chum salmon in Hood Canal (HC) and Strait of Juan de Fuca (SJF) in Washington State and compare them genetically to unsupplemented summer and fall-run chum salmon from HC and South Puget Sound. Microsatellite allele frequencies separated collections into four run-timing and geographic groups. Similar to patterns prior to supplementation, HC and SJF summer chum genetic relationships followed a metapopulation pattern of isolation by distance, suggesting that supplementation minimally impacted population structure. In most supplemented subpopulations, there were no effects on diversity and Ne, but high variance in individual pairwise relatedness values indicated overrepresentation of family groups. In two subpopulations, hatchery impacts (decreased diversity and lower Ne) were confounded with extreme bottlenecks. Rebounds in census sizes in all subpopulations suggest that general survivorship has improved and that possible negative hatchery effects will be overcome.

S20-4

Genetic evaluations of Great Lakes hatchery programs: concepts and case studies of domestic broodstocks and andromous salmonids

Kim Scribner[1] (presenting), Meredith Bartron[2], Kevin Page[3]. [1]Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan, United States, [2]USFWS-Northeast Fishery Center, Lamar, PA, United States, [3]Ohio Department of Natural Resources, Hebron, OH, United States

Supplementation is increasingly used in fish management efforts in the Great Lakes to restore, repatriate, or enhance populations. Retention of genetic diversity across all life history stages, throughout a hatchery system is an important goal of restoration hatchery and stocking programs. Diverse mating strategies used by hatcheries employ different numbers of males and females, varying sex ratios, and strategies to mix gametes that affect levels of genetic diversity, coancestry, and concomitantly long-term fitness of hatchery stocks or natural populations. We highlight case studies involving lake trout and steelhead. We used microsatellite loci to examine different stages of the lake trout hatchery program to estimate loss of genetic diversity in broodstock adults and in progeny stocked. We identified key areas where changes in mating regimes and in the distribution of fertilized gametes and juveniles could be improved. Using steelhead, we determined summary measures of diversity including percentage unrelated offspring, coancestry, and effective population size for each of several mating regimes. Adoption of guidelines that decreases adult reproductive variance and promotes more equitable reproductive contributions of broodstock adults to juveniles will enhance management goals of maintaining genetic diversity and minimize probabilities of consanguous matings among stocked individuals when sexually mature.

S20-5

Development of a captive broodstock management plan for upper Missouri River pallid sturgeon

Edward Heist[1] (presenting), Melody Saltzgiver[1], Josh Geltz[1], Phil Hedrick[2]. [1]Southern Illinois University, Carbondale, IL, United States, [2]Arizona State University, Tempe, AZ, United States

Federally endangered pallid sturgeon from the upper Missouri River are morphologically and genetically distinct from pallid sturgeon throughout the rest of the species' range. There has been no natural pallid sturgeon recruitment in the upper Missouri for

several decades and the approximately 200 remaining wild fish are approaching the end of their lifespans. Captive propagation from wild-caught broodfish may be the only way to preserve this unique stock. Because of the difficulty in recapturing the few remaining fish in the wild, Gavins Point National Fish Hatchery has maintained several year classes of hatchery-reared pallid sturgeon from wild broodstock and some of these year classes are approaching maturity. We used a combination of hatchery spawning records, PIT tags that identify the broodstock parents of captive broodstock, and DNA microsatellite genotyping to identify parentage and relatedness for sturgeon that have either shed their PIT tag or for which no parentage information is otherwise available. We then developed a captive broodstock management plan to recommend future crosses and to determine whether sufficient numbers of wild parents are represented in the captive broodstock program to preserve the genetic variation present in wild upper Missouri pallid sturgeon for future sturgeon (and human) generations.

S20-6

Environmental factors affecting hatching, and larval survival of rainbow smelt: implications for possible stock enhancement

David Berlinksy[1], Lauren Wyatt[1] (presenting). [1]University of New Hampshire, Durham, NH, United States

Rainbow smelt, Osmerus mordax, is a native bait fish to the Northeast Atlantic. Declines in their population have been thought to be related to traditional causes, such as predation, competition, disease, and anthropogenic causes. We will explore how the early life stages of smelt are impacted by various abiotic conditions, sediment deposition, and periphyton growth. Smelt are tolerant of a wide range of environmental conditions and are a good candidate for culture. Practical culture methods have been developed for larval smelt, producing fertilization and hatching rates as high as 99% and 86% respectively. Implications of using nucleic acids to characterize nutritional condition will also be discussed.

S20-7

Managing integrated hatchery programs with the Proportionate Natural Influence (PNI) Concept

Craig Busack[1] (presenting). [1]Washington Department of Fish and Wildlife, Olympia, WA, United States

Salmon and steelhead hatcheries are typically sited on streams already containing naturally spawning populations. There is often opportunity for returning hatchery adults to spawn with natural-origin fish, and for natural-origin fish to be included in the hatchery broodstock. This genetic exchange is typically ignored in harvest augmentation programs. In supplementation programs, where the intent is to use hatchery fish to increase the number of natural-origin spawners, the genetic exchange is monitored and in some cases controlled, under the assumption that gene flow rates affect the rate and extent of domestication. Recent genetic models suggest that this is the case and provide guidance on how the rates can be regulated to achieve different levels of domestication, regardless of the intent of the hatchery program. The key statistic is called proportionate natural influence (PNI), defined as PNOB/(PNOB+PHOS), where PNOB is the proportion of natural-origin fish in the hatchery broodstock and PHOS is the proportion of hatchery-origin fish on the spawning grounds. This paper explores the derivation and properties of the PNI statistic. PNI is an estimator of zw*, the expected equilibrium value of a trait relative to a natural optimum. PNI is based on equilibrium behavior, makes assumptions about heritability and selection strength, and is biased, but is robust to all these potential shortcomings. Although it is a simple statistic based on a single-trait mathematical model incorporating a number of simplifying assumptions, but because it is also consistent with another quite different model it is unlikely that future research will invalidate its usefulness. To date it has been applied only to anadromous salmonids, but the concept can be used to manage any population in which there is interbreeding between hatchery-origin and natural-origin fish.

S20-8

A state's perspective on making optimal stocking decisions: reducing uncertainty by asking questions about ecological aspects of species leads to reduced potential for negative impact

Jeffrey Koppelman[1] (presenting). [1]Missouri Conservation Department, Columbia, Missouri, United States

A history of fish releases in Missouri will verify that, from past to present, there has been an evolution in thinking about goals of stocking. While the bread-and-butter fisheries (e.g. bass, bluegill, catfish) have not undergone marked changes in stocking protocols, other fisheries have. Restorative releases have especially been treated under developing processes of goal-defining, stake-holder involvement, and incorporating emerging information. Specialty fisheries have also been included under advanced-planning practices that incorporate specific objectives for preserving and enhancing current fisheries. The essential concept is that the coupling of genetic diversity and broodfish management can produce a result that is satisfactory to all involved if the effort is put into designing management plans that include this information. The mounting body of evidence that ecological genetics can and does lead to improved culture practices is a basis for agreement among users; the first step, however, is acknowledgment by all parties that such diversity exists and that it can be used efficiently and ethically. Case studies will be discussed that have led to this forward progress in fish-stocking practices in Missouri.

S20-9

Relatedness estimates, effective population sizes, and spawning guidelines in hatchery management: evaluation using case studies

Meredith Bartron[1] (presenting), Gregory Moyer[2]. [1]U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA, United States, [2]U.S. Fish and Wildlife Service, Warm Springs Fish Technology Center, Warm Springs, GA, United States

Risks associated with conservation hatchery programs include loss of adaptive genetic variation, increased inbreeding, and artificial selection to the captive environment. To minimize these risks, management recommendations include maximizing the number of individuals in a broodstock, spawning randomly, equalizing the reproductive contribution from all parental broodstock prior to release in the wild, and monitoring genetic variation within the broodstock. However, these recommendations may vary depending on an organisms genetic, demographic, and life history characteristics. Specifically, generation time and fecundity can vary greatly between species and result in different captive propagation strategies. Population sizes of the captive and wild groups can alter the focus of management between maintenance of genetic diversity and reduction of inbreeding. In an effort to convey the complexity of genetic issues surrounding the propagation of threatened and endangered aquatic organisms, we explore the theory underlining conservation genetic principles of hatchery management, evaluate conservation and management guidelines (including examples), and discuss recent advances in molecular techniques that allow for more accurate predictions of risks associated with conservation hatchery programs.

S20-10

Effects of broodstock management practices on effective population sizes of hatchery strains in Ontario

Chris Wilson[1] (presenting), Gord Durant[1]. [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

Maintaining the genetic integrity, representation, and adaptive potential of broodstocks is an essential element of hatchery management, in order to maximize the value and effectiveness of stocking as a management tool. As well as using sufficiently large numbers of founding adults and appropriate mating systems, effective population sizes of hatchery broodstocks must be maintained in order to minimize inadvertent inbreeding and/or genetic changes in response to hatchery conditions. Equalizing family numbers and using rotational line crossing breeding schemes are advisable and effective methods for maintaining the genetic integrity, diversity, and effective population sizes of hatchery stocks, while at the same time helping to minimize undesirable domestication effects. In Ontario, the provincial hatchery system maintains 15 strains of captive broodstock for three native and two introduced salmonid species; gametes are also collected from wild populations for eight strains of three native species and two introduced species. We used broodstock pedigrees to estimate effective population sizes for broodstocks which represent a variety of spawn collection and (wild spawn collection versus captive broodstocks, rotational versus single-line breeding). The results suggest that rotational line crossing has been very effective for minimizing inbreeding and maintaining the genetic diversity of broodstocks in Ontario, thereby helping to ensure their genetic integrity as well as their ecological and management value.

S20-11

Genetic marker-assisted restoration of the presumptive native walleye fishery in the New River, Virginia and West Virginia

George Palmer[1], Joe Williams[2], Mark Scott[3], Katherine Finne[4], Nathan Johnson[4], Daniel Dutton[4], Brian Murphy[4], Eric Hallerman[4] (presenting). [1]Virginia Department of Game and Inland Fisheries, Marion, VA, United States, [2]Virginia Department of Game and Inland Fisheries, Blacksburg, VA, United States, [3]West Virginia Division of Natural Resources, Beckley, WV 25801, United States, [4]Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, United States

The increasing importance of the walleye *Sander vitreus* fishery in the New River, Virginia and recent findings showing persistence of a presumptive native stock motivated a seven-year program of hatchery-based restoration of the native stock. Candidate spawners were collected from spawning areas, and DNA from fin clips was genotyped at two microsatellite loci. Candidates exhibiting alleles at the Svi17 and Svi33 loci that characterize the presumptive native stock were spawned. Their young were reared at four fish hatcheries in Virginia or West Virginia. Approximately 600,000 fry and 800,000 fingerlings were stocked in riverine sections of the New River in Virginia and West Virginia. Ages 0-3 walleye have become much more abundant at the upper New River spawning areas than prior to stocking. Catch rates in spring electrofishing samples have increased from 3 to 17 fish per hour in Virginia and from 1.2 to 26.6 fish per hour in West Virginia Walleye catch per net-night from fall gill net sets in Claytor Lake, Virginia increased from 0.2 in 2001 to 3.1 in 2006. Comparison of data from creel surveys in 2002 and 2007 showed increasing angler effort directed toward walleye from 10% to 30% and increasing catch. Native walleye allele frequencies increased from 16% and 14% at the two marker loci in the 1997 to 1999 genetic surveys to 46% and 58% in the 2004 to 2006 surveys.

S20-12

The genetic architecture of fitness-related traits in salmonid fishes: implications for stock enhancement

Moira Ferguson[1] (presenting), Roy Danzmann[1]. [1]University of Guelph, Guelph, Canada

The maintenance of genetic diversity in cultured fishes is seen as a key factor in promoting their adaptive potential after introduction into natural populations. The adaptive response will in part be determined by the genetic architecture (number, type and magnitude of gene effects) of fitness-related traits such as body size and maturation schedule. For instance, complex traits may evolve as a correlated suite during adaptation to new environments and yet the genetic basis of such adaptation is largely unknown. Studying the genetic architecture of fitness-related traits is especially challenging in salmonid fishes because they are the products of four whole genome duplications and subsequent chromosomal rearrangements. Through the construction of genetic linkage maps for Arctic charr, Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*), we have located chromosomal regions (quantitative trait loci, QTL) and putative candidate genes for fitness-related traits. We have detected multiple QTL with major effects for each trait indicating that rapid responses to selection are possible. Our data also indicate that QTL for the same trait map to homologous regions across species suggesting conservation of QTL location over evolutionary time. Moreover, several chromosomal regions have pleiotropic effects on multiple traits suggesting that correlated responses to selection are expected.

S20-13

Research Results From an Integrated Spring Chinook Hatchery on the Yakima River, Washington

David Fast[1] (presenting), William Bosch[1], Mark Johnston[1], David Lind[1], Curtis Knudsen[2], Douglas Neeley[3], Steve Schroder[4]. [1]Yakama Nation, Yakima Wa, United States, [2]Oncorh Consulting, Olympia Wa, United States, [3]IntSTATS Consulting, Olympia WA, United States, [4] Wasington Dept of Fish & Wildlife, Olympia wa, United States

The concept of the Cle Elum Supplementation and Research Facility (CESRF) was developed in the early 1990's to evaluate the efficacy of using hatchery reared salmon to rebuild natural populations. This design is similar to the current integrated hatchery concept of the Hatchery Scientific Reform Group, with hatchery fish intended to be similar to and a part of the overall natural population. The intent is to have the natural origin fish driving the adaptation and fitness of the overall population by using naturally produced adults for hatchery broodstock. Genetic guidelines include collecting broodstock over the entire adult run timing, and allowing at least half the returning adults to spawn in the wild. All juveniles were reared at low densities and cool temperatures (<55F). Research included comparing the survival of semi-naturally (SNT) fish reared with overhead and instream cover, underwater feeders and camouflaged raceways against optimum conventional treatment (OCT) juveniles reared in standard concrete raceways. No difference in survival of outmigrating smolts or returning adults was detected between the two groups. Further research compared the effect of growth modulation on smolt survival vs. rate of residualism. Reproductive success of hatchery and naturally produced spawners was also evaluated. An evaluation of domestication is currently occurring by using the returning hatchery adults as broodstock to determine if, when and how domestication would occur in a traditional hatchery population compared to the supplemented population and a control population that has no hatchery influence. Numerous juvenile and adult traits are being monitored for all three populations. The operation of the CESRF also produced enough returning adults to benefit harvest for both tribal fishermen as well as allow the first sport harvest of spring Chinook in the Yakima in over fifty years.

S20-14

Conservation aquaculture of northern leatherside chub

Eric Wagner[1] (presenting). [1]Fisheries Experiment Station, Logan, UT, United States

Northern leatherside chub (*Lepidomeda copei*) are native to streams of the Upper Snake River Basin and the Bear River (UT, WY, ID) currently listed as a 'species of special concern'. To prevent further declines, we have sought to develop protocols for captive rearing for potential repatriation efforts. Adults originating from Yellow and Deadman creeks, Summit County, UT, were used in several spawning studies. In the first, spawning substrate options were evaluated in both riffle and deeper water locations within a tank. Leathersides preferred medium cobble (2.1 – 4.8 cm, mean 3.1 cm) in deeper water, although some riffle spawning also occurred. In another test, higher velocities were preferred for spawning substrate (19 cm sec-1). Comparison of egg production between broodstock densities indicated that the total number of eggs and fry produced was not significantly higher at densities of 10/tank (2,888) than at 5/tank (1,420), although further replication may indicate otherwise. In contrast, the average number of eggs laid per spawning event was significantly higher in densities of 10 (144) versus 5 fish (83). Within each tank, the fish were given two spawning substrate options: either medium cobble or glass marbles on plastic mesh. The latter option was evaluated to potentially reduce the labor required to harvest eggs. Significantly more eggs were recovered from the rock substrate (8,870) than the marbles (894). Following a cohort of fish of known age produced in the lab, fish reproduced for the first time at 2 years of age. Eggs incubated at 24.5°C had hatching rates of 19.4% ± SD 29.4, which did not significantly differ from the percent hatched at 18.8°C (21.6% ± 28.2). Survival was significantly higher for eggs given a single formalin treatment of 1500 ppm for 15 min upon harvest (41.9 % ± SD 16.1%), than for eggs treated similarly on three consecutive days (one exposure each day; 0.0% ± 0.0% hatch). There was no significant difference in survival to hatching among eggs treated with 100 mg/L active iodine on either Day 1, 2 or 3 after harvest. Fry fed a probiotic diet (Artemia fed Lactobacillus sp.) did not significantly differ in growth or survival from fish fed Artemia alone or a Tetramin® ration. In another test, fry fed Artemia continuously over 7-8 h via an automated drip system had higher specific growth rates than fry fed the same ration manually four times per day.

S20-15

A conservation hatchery for the marine rearing of anadromous salmonids

Desmond Maynard[1] (presenting), Carlin McAuley[1], Mike Wastel[1], Deborah Frost[1], Bryon Kluver[1], Greg Baesler[2], Jeffrey Gislason[2], Jeff Hiendel[3], Paul Kline[3], Thomas Flagg[1]. [1]NOAA Fisheries Service, Manchester, Washington, United States, [2]Bonneville Power Administration, Portland, Oregon, United States, [3]Idaho Department of Fish and Game, Boise, Idaho, United States

NOAA Fisheries Manchester Research Station provides the marine rearing component for Snake River spring/summer chinook and sockeye salmon in ESA safety net programs. Marine rearing is thought to be a crucial factor in maintaining anadromous traits in Pacific salmon that spend the majority of their life at sea. Each year, freshwater conservation hatchery programs send smolting salmon to the marine facility located on Puget Sound for seawater rearing. At the marine facility the fish are reared in 6.1 m diameter circular tanks housed in a specially constructed protective culture building. The tanks are supplied with filtered, sterilized, and chilled seawater to provide a high quality rearing environment. All the effluent from these tanks is treated with ozone to protect Puget Sound stocks from any diseases out of basin stocks may carry. At the seawater rearing facility the fish are maintained at light rearing and loading densities, fed by hand and with automated feed delivery systems, given minimum handling, and provided prophylactic treatments as needed. Each spring visual inspection and ultrasound technology are used to determine the maturation status of individual fish. Fish displaying the first signs of maturation are rapidly returned to freshwater so they can complete their maturation process in a natural manner. The average inculture seawater survival of the 19 (BY 94-00) Idaho spring chinook groups for which data is complete was 56.74 + 5.0 % standard error. The mean survival of the 18 groups of Oregon fish from these broodyears was 69.63% + 3.7 % standard error. Through July 2007 the facility has provided 6,170 spring/summer Chinook salmon adults and over 1,000 sockeye salmon adults for Oregon and Idaho to use in their ESA recovery efforts.

S20-16

Use of multiple spawning techniques to increase genetic diversity in a Coho salmon broodstock program

Erick Sturm[1] (presenting), R. Bruce MacFarlane[1]. [1]NOAA/NMFS Fisheries Ecology Division, Santa Cruz, Ca. United States

Many stocks of Pacific coast coho salmon, Oncorhynchus kisutch, are listed as endangered or threatened by the Federal Government under the Endangered Species Act. The Scott Creek coho salmon are the southern most run of coho salmon in North America and are listed as endangered by both the Federal and California State Govermnments. A captive broodstock program was created by the National Marine Fisheries Service, Fisheries Ecology Division and the Monterey Bay Salmon and Trout Project, a local non profit organization, to prevent this particular run of coho from going extinct. All three runs of this population are at historically low numbers of spawning adults, all call fish spawned, wild and captive broodstock, at the MBSTP's Kingfisher Flat Genetic Conservation Hatchery are genetically screened at 18 microsatellite loci to ensure fish related at the half sibling level or higher are not spawned together. In addition to using spawning matrix we also use other techniques to ensure we keep the genetic diversity of our broodstock as high as possible. These other techniques include: 1) a preferential breeding order for all fish, 2) a cryopreserved milt bank to ensure we always have milt ready when a female is ready to spawn, 3) use of Ovaplant to speed up the final maturation of males and females, and 4) males are spawned a maximum of 4 times to ensure no one male's genetic signature dominates the genetic lineage of the next generation.

S20-17

Los Lunas Silvery Minnow Refugium: an endangered species breeding facility designed to minimize genetic changes during propagation

Kenneth Ferjancic[1] (presenting), Douglas Tave[1]. [1]HDR, Santa Fe, NM, United States

The Los Lunas Silvery Minnow Refugium was designed and is managed to spawn and propagate the Rio Grande minnow (*Hybognathus amarus*) an endangered species, under conditions that mimic those found in the Rio Grande. The design and management goal is to produce fish for augmentation and restoration that have minimal genetic changes via domestication, inbreeding and genetic drift. The outdoor refugium recreates the Rio Grande riverine habitats thought to be important in the life cycle of the silvery minnow. There is a 140-m long stream that meanders over a linear distance of 92 m: the width ranges from 2.4-6.4 m with a water depth which can be adjusted from 0.2-0.9 m. The stream has four sand bars which produce backwaters and plunge pools. Five ponds are connected to the stream which have controlled flow to produce variable velocities and hydraulic diversity. Surface area of the refugium is .11 ha with a water volume of 922,000 l (227,000 gal.). There are low-lying vegetated "overbank areas which become flooded as the water levels are increased. These areas function as egg collection, hatching and larval development areas with low velocity, cover and natural food present. The water supply is a recirculation system of 1,700 - 6,800 l (1 to 4 cfs) and makeup water (ground water) of 1-2% of total flow. The facility was completed in the spring of 2008 and the first fish are scheduled to be introduced in early summer of 2008.

S20-18

Ignorance is not bliss: hatchery rearing influences on salmonid stocking success force rapport between fisheries managers and hatchery staff in South Dakota.

Michael Barnes[1] (presenting). [1]South Dakota Department of Game, Fish and Parks, Spearfish, SD, United States

Four replicated experiments concerning the post-stocking survival and harvest of hatchery reared, and subsequently stocked, salmonids were conducted using feral, juvenile landlocked fall Chinook salmon *Oncorhynchus tshawytscha* and domesticated catchable rainbow trout *Oncorhynchus mykiss*. In the first study, Chinook salmon post stocking harvest and return-to-spawn were up to six-fold greater in fish that were hatchery reared at pre-stocking densities of 7.3 kg/m3 compared to fish reared to densities of 15.0 kg/m3. Rearing flows were evaluated in the second study, with post-stocking harvest and return-to-spawn elevated in salmon reared at flows double those typically used for the last five months of hatchery rearing prior to stocking. The third experiment is ongoing, but initial results indicate that landlocked Chinook salmon reared under partial covers return-to-creel at higher rates than those fish reared in uncovered circular tanks. Lastly, domesticated rainbow trout receiving a proprietary dietary yeast supplement during hatchery rearing survived significantly greater and experienced more angler harvest when stocked into put and-take lakes compared to trout fed a standard commercial diet. Some of these results have had unintended consequences on the assumptions of fisheries managers, particularly in relation to fish population estimates and stocking requests. The impact of hatchery rearing practices on the post stocking survival and angler harvest of stocked salmonids is forcing more reciprocal communication, interaction, and respect between fisheries management and hatchery staff in South Dakota.

S20-19

Fitness of hatchery Coho in the wild: discerning the effect of alternate captive breeding histories

Veronique Theriault[1] (presenting), Gregory Moyer[3], Laura Jackson[2], Gregory Huchko[2], Michael Banks[1]. [1]Oregon State University, Newport, Oregon, United States, [2]Oregon Department of Fish and Wildflife, Roseburg, Oregon, United States, [3]U.S Fish and Wildlife Service, Warm Springs, Georgia, United States

The use of hatchery fish to increase the size of extant wild populations is a common management strategy. However, in most cases the value of such programs is untested. Fish raised in the hatchery and subsequently released in the wild must reproduce successfully and produce viable offspring in order for such an approach to succeed. Accumulating evidence suggests that hatchery fish typically have lower fitness in the wild than wild fish, and that this decline can occur very quickly, following only a few generations in the hatchery. Here we present preliminary results of an experimental supplementation program for coho salmon, Oncorhynchus kisutch, on the Calapooya River, a tributary of the Umpqua River on the Oregon Coast. By reconstructing a 3-generation pedigree using molecular markers, we compare reproductive success in the wild (number of wild-born adults produced per parent) of fish raised in the hatchery. Our subjects have different histories in terms of their captive breeding: 1) captive-reared fish from two wild-born parents and 2) captive-reared fish from two multi-generation hatchery parents. Moreover, we compare the relative success of unfed fry releases compared to smolt releases in producing returning adults for both histories. Results presented here address important questions that currently undermine our understanding of the usefulness of hatchery supplementation for conservation and recovery. Although this project is specific to one hatchery program for coho in the Umpqua River, results will likely be of value in the design and application of supplementation programs across other species and further the field.

S20-20

Commercial channel catfish fry production : hatchery spawning replace natural pond spawning?

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US farm raised channel catfish Ictalurus punctatus, production relies almost entirely upon natural pond spawning, producing approximately 2 billion catfish fry annually. Catfish spawning is unpredictable and often varies between 10 – 80% depending on broodstock, farm management, and environmental factors. Maintenance of non-reproductive broodfish utilizes resources that could be invested elsewhere to improve production. The unpredictable and wide variation in reproductive performance is a limiting factor in the fingerling production under natural pond spawning conditions. The inability to identify spawning and non-spawning broodfish has hindered selection for reproductive success in genetic improvement programs in channel catfish. Superiority of hybrid catfish compared to the commonly grown channel catfish in research and commercial ponds in this decade will be presented. Higher growth rate, survival and processing yield coupled with lower feed conversion of hybrid catfish results in lower cost of production. However, producing commercial quantities of this superior genotype in the last 35 years has hindered its large scale application in the catfish industry. Advances in broodstock preparation and technological innovations in hormone induced spawning of channel catfish to produce Channel X Blue hybrid catfish production in commercial conditions is presently feasible. Natural and Hatchery spawning of channel catfish is compared under commercial conditions (Figure 1). Two of three criteria (Ovulation and Fry/Kg of female) to measure reproductive performance in artificial spawning of channel catfish have surpassed natural spawning. The potential of hatchery spawning to replace the traditional natural pond spawning of channel catfish will be highlighted. Improvements made in broodfish nutrition and husbandry, genetics, maturation and hormonal induction and other hatchery improvements will be presented to produce predictable and efficient fry production under commercial conditions.

S20-21

Use of recirculating aquaculture systems to increase production and quality of hatchery reared juvenile red drum for marine stock enhancement

Paul Wills[1] (presenting), Timothy Pfeiffer[2], Megan Davis[1]. [1]Harbor Branch Oceanographic Institute-FAU, Fort Pierce, FL, United States, [2]USDA-ARS, Fort Pierce, FL, United States

The abundance of economically important marine sportfish has declined in Florida's waters due to factors such as over-fishing and critical habitat disturbance. Hatchery production and enhancement stocking has traditionally been used in freshwater systems as a means of mitigating for effects such as this. In the past stocking of marine systems has had limited success. However, recent successes have been recorded with marine fish stock enhancement programs; red drum *Sciaenops ocellatus* in particular. Red drum is a very important marine sportfish fisheries in Florida with over 3 million fish caught annually (90% being catch and release).

Based on the success of their stocking program in Tampa Bay, the Florida Fish and Wildlife Conservation Commission (FWC)is developing the Florida's New Saltwater Fish Hatchery Initiative (HNI) to expand the FWC's saltwater fish stock enhancement program. Harbor Branch Oceanographic Institute at Florida Atlantic University (HBOI), Mote Marine Laboratory (MML), and HDR|Fishpro have partnered with the FWC to develop technologies to produce red drum juveniles in intensive marine recirculating aquaculture systems. The designs and performance information collected in the prototype systems at HBOI, MML, and at the FWC Stock Enhancement Research Facility (SERF), will be used to design the new intensive hatcheries being planned for Florida. The design for the prototype systems engineered and built at HBOI to rear phase I (25-50 mm SL) juveniles through phase II (60-100 mm SL), and phase II juveniles to phase III (>130 mm SL) will be presented. Information about performance of the prototype systems, and growth, FCR, health assessment and cost for production of phase III fish will also be presented.

S20-22
Production of juvenile and sub-adult cobia in recirculating aquaculture systems
Charles Weirich[1] (presenting), Paul Wills[2], Richard Baptiste[2], Marty Riche[1]. [1]USDA-ARS, Fort Pierce, Florida, United States, [2]Harbor Branch Oceanographic Institute-FAU, Fort Pierce, Florida, United States

Cobia Rachycentron canadum is a large migratory pelagic finfish species that is distributed worldwide in tropical, subtropical, and warm temperate seas except the Mediterranean and the central and eastern Pacific. Despite its large size, commonly exceeding 23 kg at maturity, and excellent food quality, annual US commercial cobia landings over the past ten years have not exceeded 200 mt, with the majority of fish harvested through recreational means. When available, cobia fillets are sold in Gulf and South Atlantic seafood outlets for approximately US $8.00/kg, indicating excellent consumer appeal. In addition, cobia exhibit exceptional growth rates, attaining a weight of 4-6 kg in one year. Primarily because of these two factors, coupled with the success of initial efforts to spawn and culture this species in Taiwan, interest in cobia aquaculture has increased greatly in the US in recent years. Although the principal culture system employed for the production of cobia currently is offshore net-pen rearing, establishment of land-based recirculating culture technologies for cobia could mitigate some concerns associated with permitting, effluent discharge regulations, and restrictions on the use of coastal waters. To investigate this topic experiments were initiated in 2007 using commercial scale recirculating aquaculture systems (RAS). To date two rearing trials have been conducted. In the first rearing trial, the effect of feeding different commercial diets on production of juvenile cobia (initial weight = 29 g) was evaluated. After a rearing period of 56 d, results indicated that feed type significantly affected production with fish fed the superior diet exhibiting a mean weight of 311 g, a specific growth rate of 4.2 %/d, and a feed conversion ratio of 1.17. Across-treatment survival was 98.5 %. In the second rearing trial juvenile cobia (initial weight = 322 g) were reared at different densities for 118 d. Although at the time of writing all data had not been entered and analyzed, across-treatment mean final weight and survival was 2.14 kg (range = 0.80-4.17 kg) and 99.4 %, respectively. Results of our work thus far clearly indicate that RAS culture of cobia has excellent potential for the provision of food animals and the same techniques could potentially be employed to produce fish for stock enhancement purposes.

S20-23
development of genetic identification tools to refine striped bass *Morone saxatilis* release stratigies and improve hatchery contribution
Michael Denson[1] (presenting), Wallace Jenkins[1], Tanya Darden[1], Jen Fountain[1], Forrest Sessions[1], Justin Yost[1].
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Since the development of hormonally induced spawning of wild striped bass in the 1960's state and federal hatchery programs throughout the US have expanded production to meet a growing need for stock enhancement to support recreational fisheries. Currently striped bass or its hybrids are stocked in over 400 reservoirs and numerous inland streams in 36 states with over 40 million fingerlings being released annually. Initially these stocking efforts were very successful however as reservoirs have matured and anthropogenic changes have occurred striped bass populations in some reservoirs have declined precipitously in spite of large hatchery contributions. Since very few of the fish released are marked prior to release it is difficult to interpret which stocking strategies bypass recruitment bottlenecks and are most likely to reverse this trend in declining abundance. Chemical batch marks have been used in an attempt to develop more robust release experiments however these marks have provided limited help in optimizing stocking strategies. The advent of more advanced genetic ID techniques offers the potential to allow testing of more sophisticated release strategies and tailoring hatchery output to yield higher contributions and survival. The Ashley River in Charleston, SC was chosen as a study site to test strategies which might offer high survival and could be used to test genetic ID methods. The location is an estuarine site from which juvenile striped bass have been extirpated but historically held a reproducing population and for which there was a long term data base on abundance. Fin clips were collected from all brood fish, and families produced were kept separate throughout the production process. Fish were then released seasonally at several distinct sizes ranging from 43 mm TL fingerlings – 232 mm TL juveniles. Prior to release, fin clips were collected from a sub sample of each group. Fin clips were archived and linked by stocking strategy and family. Fishery independent sampling (electro-fishing and trammel netting) was conducted monthly. Fishery results collected to date show that catch/effort has gone from 0 to a monthly average of 0.8, which is the highest among 5 coastal rivers in the state which are regularly sampled. Genetic methods were evaluated based on their potential utility for this application (ID) and it was determined that microsatellites would likely offer the most polymorphic and bi-parentally inherited mark. Staff surveyed the literature and found 22 potential public domain striped bass microsatelite loci to screen for variability among the brood stock samples. These loci of which 8-10 will be chosen for use as IDs represent a geographically diverse area, have high heterozygosity, meet Hardy- Weinberg equilibrium and should offer a tool for striped bass hatchery evaluations nationwide.

S20-24

Evaluation of recruitment bottlenecks using cultured red drum (*Sciaenops ocellatus*)

Wallace Jenkins[1], Theodore Smith[1], Karl Brenkert[1], Justin Yost[1], Tanya Darden[1], Michael Denson[1] (presenting).
[1]SCDNR, Charleston, South Carolina, United States

In South Carolina, stock enhancement research in recent years has focused on release of small juveniles (20-50 mm TL). In 1999, approximately 600,000 genetically marked juveniles were stocked in the Ashley River, Charleston, a site for which there is a long-term index of abundance. Data derived from fishery-independent surveys since 1992 showed that mean catch-per-unit-effort (CPUE) for the Ashley River typically ranged from 0.4 to 1.5 fish/net set whereas the average CPUE for the adjacent estuarine systems ranged from 2.0 to 4.0 fish/net set. Following stocking in 1999, the mean (± SD) CPUE in 2000 for the river was 1.73±3.73 fish/net set, much greater than the historic mean (0.81±0.36 fish/net set). In addition, the Ashley was the only estuary sampled in South Carolina in 2000 that showed an increase in CPUE relative to previous years. Analysis of captured red drum in 2000 showed that 90% of fish aged 11-16 months were of hatchery origin. Based on these results the next logical step seemed to be to evaluate stocking larval red drum to determine at what life stage recruitment was set. To examine this question larvae were stocked in the river during the normal spawning season three during successive years; 2004, 05 and 06 in increasing numbers of 17, 34 and 48 million larvae, respectively. Both fisheries-independent sampling CPUE and microsatellite analysis of tissue from captured fish were used to assess impact. Subsamples of estuarine-stocked larvae were also stocked in fertilized ponds to document larval viability. Genotypes were determined for; captive broodstock, larvae collected prior to each release, and samples collected from each year class (YC) by net and electrofishing surveys. Mean CPUE in the Ashley River for the 2004 and 2005 YC were monitored and compared to long-term means in the system as well as adjacent sample strata. Stocking larvae did not appear to provide a change in the long-term mean CPUE in either YC, which were also two of the weakest wild YCs on record. Microsatellite genotypes of field-caught fish in the Ashley River and adjacent strata were compared to all broodstock genotypes but no matches were detected for either the 2004 or 2005 YC despite excellent survival (~50%) to 30 days of the subsamples grown in fertilized ponds. Thus, stocking of larvae did not provide a measurable impact on juvenile population abundance in the first two years of stocking. The fact that no stocked larvae were identified in fisheries-independent samples from the Ashley River stocking suggests that larval recruitment associated with available broodstock production may not be the source of the bottleneck or perhaps much higher numbers need to be stocked to overcome natural mortality. Red drum recruitment to the recreational creel may instead be limited by poorly understood natural factors that affect survival of larvae. The results of 2006 stocking will be determined after fish recruit to the sampling gear and samples are analyzed in Fall 2007.

S20-25

Cannibalism in size-structured populations of common snook *Centropomus undecimalis*

Nathan Brennan[1] (presenting). [1]Mote Marine Laboratory, Sarasota, FL, United States, [2]University of Florida, Dep. Fish. Aquat. Sci. Gainesville, FL, United States

A key area of stock enhancement research, yet widely unstudied, includes understanding how and when density-dependent processes act in response to stocking activities. These can manifest as intra- and inter-specific competition or cannibalism among hatchery-reared and wild stocks. In this study I investigated the potential for cannibalism in snook rearing habitats by[1] examining allometric changes in snook morphology (snook size range 39-903 mm fork length [FL], n=426) to reflect ontogenetic differences in predation risk and cannibalism tendencies, [2] staged cannibalism scenarios in field enclosure trials (n=74) to measure relative cannibalism rates across different sized cannibals, and[3] used the above information, existing literature, and localized collections of snook stomach contents to provide input into a simplified age-structured model to estimate predation mortality from age-0, age-1, and adult (age-2+) snook age groups on an age-0 year class. Overall, small snook had proportionally enhanced features useful for avoiding predation and maximizing prey choices to accommodate for performance and competitive disadvantages of smaller absolute body sizes. Controlling for body size, enclosure studies showed higher mean cannibalism rates in smaller predatory snook (74-163 mm FL), compared to large predatory snook (218-332 mm FL), although rate differences were not statistically significant. Literature reviews and direct examination of snook stomachs in Sarasota, Florida, showed that cannibalism was directed at young-of-year snook, but infrequently detected in the field (about 1 in 1000). Model simulations revealed that cannibalism was controlled by density-dependent interactions of age-0 and age-1 age groups and could have a strong influence on structuring a cohort's abundance. Adaptive management approaches must be incorporated into stock enhancement programs and should consider natural variation in inter-annual recruitment prior to stocking.

S20-26

Florida's bass conservation center : past, present, and future

Nick Trippel[1] (presenting), Wes Porak[1], Rick Stout[2], Mike Matthews[2]. [1]Florida Fish and Wildlife Conservation Commission- Eustis Freshwater Fisheries Research Laboratory, Eustis, FL, United States, [2] Florida Fish and Wildlife Conservation Commission-

Richloam State Fish Hatchery, Richloam, FL, United States

The Florida Fish and Wildlife Conservation Commission's Florida Bass Conservation Center and Richloam Fish Hatchery has produced more than 6.5 million largemouth bass *Micropterus salmoides* since the 1960's. This hatchery recently received a $15 million renovation to increase production capabilities. We will provide a historical perspective of our agency's bass stocking programs and include the hatchery's new production goals. Early research on stocking of advanced size (~100-mm TL) bass indicated that pellet-reared bass had difficulty transitioning from artificial feed to live prey after being stocked. Studies showed feeding behavior and predation success of naïve pellet fed largemouth bass differed from experienced wild fish, and that learning of naïve bass occurred following limited exposure to live prey. These and other research findings are being incorporated into new hatchery protocols. New production goals include more than 1.5 million fingerlings (<35-mm TL) and up to one million advanced-size (~100-mm TL) largemouth bass. We will follow guidelines of our agency's new fish genetics policy to insure genetic conservation of wild populations. This includes protecting the genetic integrity of Florida bass *Micropterus salmoides* floridanus by genetically testing brood fish, and avoiding translocations of genes from bass populations in one Genetic Management Unit (GMU) into another as a result of state stocking programs. Pellet-reared bass will be fed live fish (e.g. mosquitofish *Gambusia affinis*) before being stocked, which should enhance their ability to capture prey and increase survival in the wild. Current research efforts are focused on creating genetic markers using microsatelite DNA technology to differentiate hatchery fish from wild bass, and developing an experimental artificial diet to avoid a liver disease and still yield acceptable growth rates. Other research plans include developing and evaluating different post-release strategies. To assess the success of these new stocking programs, pre- and post-stocking evaluation protocols will be developed and implemented.

S20-27

Evaluation of pre-release feed weaning on performance of juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)

Andrew Lazur[1] (presenting), Erin Markin[1]. [1]University of Maryland, Cambridge, Maryland, United States

In evaluating the technology for possible stock enhancement of Atlantic sturgeon, the ability of hatchery-reared fish to accept natural foods in released sites is an important question. The excellent recapture and growth of juvenile sturgeon observed over a three year period in a 1996 preliminary release study in the Chesapeake Bay suggests hatchery reared fish can successfully readapt from commercial diets to live natural foods. To further evaluate this capability, a closed pond study evaluated two juvenile size classes' ability to adapt to natural foods. Juveniles of two sizes were PIT tagged, divided into two treatments (a. weaned from commercial diet to natural foods prior to release and; b. released without weaning) and stocked into a 0.2 hectare pond supplied with natural foods. Differences in fish growth, survival and condition factor were measured after several months. Gut analysis is performed by lavage technique twice during the study to evaluate foods consumed. Authors will present the results and discuss implications for potential fish release programs.

S21. Research, Education and Management Needs Regarding Barotrauma

S21-1

Management implications of minimizing bycatch and reducing release mortality in the Gulf of Mexico reef fish fishery

Andrew Strelcheck[1] (presenting), Clay Porch[2], William Patterson, III[3]. [1]National Marine Fisheries Service, St. Petersburg, FL, United States, [2]National Marine Fisheries Service, Miami, FL, United States, [3]University of West Florida, Pensacola, FL, United States

The Gulf of Mexico reef fish complex includes 42 species of fishes. Red snapper *Lutjanus campechanus*, red grouper *Epinephelus morio*, and gag *Mycteroperca microlepis* are three of the most abundant and economically valuable species in this complex. All three species are subject to high fishing pressure and experience depth-related release mortality. Regulatory discards are a major and increasing source of fishing mortality in all three fisheries as management measures have become increasingly more restrictive. Minimum size limits are the primary source of regulatory discards, although other regulatory measures also contribute to bycatch and bycatch mortality. Losses due to bycatch have resulted in forgone yield, thereby lowering total allowable annual catch levels and estimates of optimum and maximum sustainable yields. In an effort to reduce bycatch and release mortality and reverse some of the negative effects of commonly used fishery management tools, managers have shifted emphasis in recent years to management approaches that reduce bycatch and bycatch mortality. These approaches include gear restrictions, lowering rather than raising minimum size limits, and individual fishing quota programs. This presentation examines the biological implications of these and other management approaches when reducing reef fish bycatch to the extent practicable.

S21-2

Laboratory and field studies on the effects and survival of red grouper and red snapper following rapid decompression from depth

Karen Burns[1] (presenting), Nancy Brown-Peterson[2]. [1]University of South Florida, Department of Marine Sciences, St. Petersburg, FL, United States, [2]University of Southern Mississippi, GCRL, Hattiesburg, MS, United States

Depth induced mortality resulting from injuries sustained during rapid decompression from depth is an important factor that seriously impacts survival of undersized reef fish returned to the sea in compliance with minimum size regulations. Laboratory and field studies were conducted to compare the effects of barotrauma on red grouper (*Epinephelus morio*) and red snapper (*Lutjanus campechanus*) under various conditions. In the laboratory, necropsies were conducted on acute mortalities from headboats to quantify and evaluate injuries between the two species from fish caught at various depths. Fish hyperbaric chambers were used to compare survival rates and depth related injuries between the two species at simulated depths of 21, 27, 43, and 70 m. Histological studies on swim bladders from 138 red grouper (205-766 mm FL) and 62 red snapper (123-674 mm FL) were performed in conjunction with scientists at the University of Southern Mississippi to investigate differences in swim bladder morphology. Comparisons revealed red grouper have a larger swim bladder in relation to total body size than red snapper. The red grouper swim bladder membrane is thinner and swim bladder ruptures are larger than those of red snapper however rupture healing rate in survivors is identical. Swim bladders heal sufficiently to hold gas within 2 days. Gas resorption and secretion areas are different leading to difference in percent of swim bladder hemorrhaging. Data from laboratory studies were interpreted in light of field results obtained from a 17 year tagging study conducted off both coasts of Florida. Tag recaptures were used as a proxy for survival. Fish were tagged by researchers, recreational, recreational-for-hire, and commercial fishers at depths ranging 6-82 m. Gear types included J and circle hooks, commercial long-lines and commercial reef fish traps. Treatments included venting and not venting tagged fish before release at all depths fished. Fish at shallow depths (less than 10m) were also treated as a control to determine if venting was in itself harmful to fish due to injury from the venting tool or injection of pathogens. Although venting enhanced survival in both species, morphological and physiological differences between the two species determined the depth at which venting was necessary and the fish's ability to survive rapid decompression.

S21-3

Sink or swim indicators – which factors can best predict survival or mortality of discarded red snapper?

Sandra Diamond[1], Matthew Campbell[1] (presenting). [1]Texas Tech University, Lubbock, TX, United States

Size limits are often used as a management tool to limit landings of important fishes, but deep water fishes frequently suffer from barotrauma due to their rapid ascent from depth, and may not survive being caught and then discarded. Outward signs of barotrauma include stomach eversion, bug-eyes or opthalmia, protruding intestines, gas leaks from the scales, and tight air bladders. Physiological effects include disorientation, reduction or loss of reflex behaviors, and an inability to swim or respond appropriately to stimuli. Blood chemistry may also be affected, with changes in blood cortisol, lactate, and osmolality caused by the stresses of capture and barotrauma. Although many of these symptoms have been measured in discarded fish, the links to mortality and survival are not clear cut. Red snapper, an important commercial and recreational species in the Gulf of Mexico, is an example of a species that has relatively high discard rates, but may not survive discarding. We have performed a series of cage and tagging studies in the field and behavioral and physiological experiments in the lab on red snapper to determine which factors are the best predictors of survival and mortality. Data show that fish with opthalmia and protruding intestines survive less often than fish with everted stomachs or tight bladders. Immediate ability to swim below the surface reflects short-term survival, but is not necessarily an indication that fish will survive over the long term. Simple behavioral tests may be the best predictors of fish survival from discarding due to size limits.

S21-4

Releasing gravid female rockfish. Is it an effective management tool? Developing a collaborative barotrauma research project with the fishers of Port Orford

Stephen F Theberge Jr[1] (presenting), Selina Heppell[2], Jennifer Bloeser[3]. [1]Oregon State University, Astoria OR, United States, [2]Oregon State University, Corvallis, United States, [3]Pacific Marine Conservation Council, Portland, OR, United States

The live fish fishery in Southern Oregon has dramatically increased in recent years, but the ecology and long-term sustainability of our nearshore fish stocks has not been well-studied. As a precautionary measure to contribute to annual replenishment of stocks, some fishermen have proposed to release female rockfish that are obviously pregnant. This project investigates potential survival and contributions that released females could make to nearshore rockfish populations through a cooperative tagging and recovery effort with the fishermen of Port Orford. We are also gaining valuable information about the effectiveness of different release methods. We are working collaboratively with fishermen throughout the research project: pre-study assessment, study design, training, data recovery and review, and presentation of results. Fishermen are tagging and releasing fish, and recording tag recoveries or bringing tagged fish back to port. Working with Sea Grant, NMFS, NGO and industry collaborators, we have identified target reefs and fish species, developed tagging protocols, and identified realistic tagging and data collection methods that can work during regular fishing operations. The fishermen are the driving force developing this collaborative research project, with researchers providing guidance and advice instead of explicit direction. Our project is a model for other collaborative barotrauma research efforts.

S21-5

Developing practical and effective release methods for releasing barotrauma-impacted fish

Stephen F Theberge Jr[1] (presenting). [1]Oregon State University, Astoria, OR, United States

Developing practical and effective release methods for barotrauma-impacted fish are a challenge, especially in the Pacific

Northwest. The Pacific Northwest is home to over 60 species of rockfish who are often caught in water deep enough to cause barotrauma issues. The different rockfish species vary in their ability to adjust buoyancy and survive the trauma. The location of their swim bladder varies from species to species. The ocean conditions are often rough and dangerous. Some of the vessels encountering rockfish are trolling and unable to stop to release fish. Based on current science, different release methods have advantages and disadvantages that must take into consideration the fishers experience levels, the fishing methods and vessels being used and the depth and species of rockfish being caught.

S21-7
The potential for recovery in black rockfish (*Sebastes melanops*) following recompression
Alena Pribyl[1] (presenting), Steve Parker[2], Carl Schreck[3]. [1]Oregon State University, Corvallis, OR, United States, [2]National Institute of Water and Atmospheric Research, Wellington, New Zealand, [3]Oregon Cooperative Fish and Wildlife Research Unit (USGS-BRD), Corvallis, OR, United States

Overfished species of rockfish (*Sebastes* spp.) from the Northeast Pacific experience high bycatch mortality due to "barotrauma," induced from the rapid change in pressure during capture. As a result, "catch and release" techniques may not be effective for some species. Field experiments show that it may be possible for rockfish to recover from barotrauma if quickly recompressed prior to release. However, no work has followed the physiological recovery of rockfish after recompression or determined if it is possible for rockfish to survive barotrauma in the long term. We induced barotrauma in adult black rockfish (*Sebastes melanops*) from a simulated depth of 35 m with subsequent recompression. Following recompression, rockfish were slowly acclimated to surface pressure and transported to recovery tanks. Blood and selected tissues (eye, heart ventricle, head kidney, liver, rete mirabile, and gonad) were sampled at days 3, 15, and 31 post-recompression to evaluate the cellular-level response during recovery. No mortality from barotrauma occurred during the duration of the experiments. Results showed that damage due to barotrauma at the macroscopic level consisted of swimbladder damage, and at the histological level only rete mirabile damage was present. Results from blood plasma analyses will also be presented.

S21-8
Field evaluations of barotrauma incidences and treatment at a smallmouth bass tournament in northwestern Ontario
Vivian Nguyen[1] (presenting), Marie-Ange Gravel[1], Steven Cooke[1]. [1]Carleton University, Ottawa, Ontario, Canada

At a competitive smallmouth bass angling event on Rainy Lake in northwestern Ontario, we evaluated the incidences of barotrauma as well as the physiological and behavioral consequences of barotrauma on tournament-caught fish. We found that 76% of fish had at least one sign of barotrauma, whereas 32% of fish showed signs of severe barotrauma. A subset of these fish were classified into two groups (n = 10, severe barotrauma; n = 12, no barotrauma) and affixed with external radio transmitters. Physiologically, all tournament fish had elevated levels of blood glucose and lactate; however, the highest levels were found in fish with severe barotrauma. Behaviorally, fish with severe barotrauma took longer to leave the release site (> 2 km) than fish with negligible signs of barotrauma. Mortality differed between the two groups and was as high as 40 % for telemetered fish with severe barotrauma. In the following year, we used identical techniques to assess "fizzing" as a method to alleviate distended bladders. We included three treatment groups: fish with barotrauma and not fizzed (BNF; n = 8), fish with barotrauma and fizzed (BF; n = 9), and fish with no barotrauma and fizzed (NBF; n = 10). There was no evidence that fizzing affected survival or compromised the behaviour of smallmouth bass. However, we observed that both fizzed fish with and without decompression displayed a greater movement than decompressed fish without fizzing. Our work shows that the incidence of barotrauma in tournaments can be high and that an integrative approach is necessary to elucidate the consequences of barotrauma in wild fish.

S21-9
Post-release survival RD&E in Australia, with particular reference to barotrauma issues.
Ian Brown[1] (presenting). [1]Department of Primary Industries and Fisheries, Brisbane, Queensland, Australia

Investigations into post-release survival of line-caught fish began in Australia during the late 1990s with studies in Queensland comparing mortality rates of two tropical reef species caught on baited hooks and lures, and in West Australian estimating hook-related mortality in tailor (*Pomatomus saltatrix*). At the time, interest among Australian fish researchers in the issue of post-release mortality was stimulated by the likelihood that increasing minimum legal size limits would further increase already high release rates in the recreational fishery. A significant study undertaken in WA to estimate the effects of depth, venting and hook type on C&R mortality of dhufish (*Glaucosoma hebraicum*) and snapper (*Pagrus auratus*) led to the establishment of a national programme to promote and research a code of best practice for enhancing the survival of released line-caught fish. This programme first commissioned a report to review research information and identify Australian fish species likely to be most at risk from C&R mortality. A suite of projects, coordinated by a national steering committee, was then developed to address C&R issues in many of the key species and to disseminate the results of this work to the fishing community. The initiative was funded by the Australian Government's Fisheries Research and Development Corporation. Although much of the work focused on hook-related mortality, a number of projects addressed the problem of barotrauma and associated release methods. In Queensland we investigated the incidence of barotrauma in a suite of six key coral-reef species and compared the effectiveness of venting and shot-releasing using short-term field experiments and a long-term angler-based study. A later study into optimal releasing practices for the large iconic samson fish (*Seriola hippos*) in WA used the same experimental apparatus. Northern Territory researchers investigated the effects of barotrauma in another large iconic species, the black jewfish (*Protonibea diacanthus*), but using necropsies to quantify internal soft-tissue injury. Other projects have focussed on publicising the results of these investigations nationally in print and visual media, and conducting broad-based surveys to judge the effectiveness of the publicity campaigns.

S21-10

Will anglers adopt fish venting practices?

John Stevely[1] (presenting), Charles Adams[1]. [1]Florida Sea Grant, Gainesville, United States

The effectiveness of bag and size limits depends on the survival of released fish. Due to barotrauma, special procedures are required to increase survival of fish caught from deeper waters. Fish venting, releasing gas from the ruptured swim bladder that is trapped in the body, may improve survival of fish suffering from barotrauma. However, for fish venting to be effective, anglers must be familiar with proper venting procedures and be willing to adopt these procedures. The Florida Sea Grant Marine Extension Program conducted a multi-faceted educational program to familiarize anglers with fish venting. Part of the educational program consisted of providing anglers with free sample venting tools. A mail survey was then conducted to evaluate whether anglers were indeed venting fish. Results were very positive. Sixty eight percent of the survey respondents reported they had vented fish. Almost two-thirds (62%) of negative respondents indicated that the reason that they had not vented fish was because they had not yet had the opportunity to go fishing in waters sufficiently deep enough to make fish venting necessary.

S21-P-1

Performance of a fish descender hook in the Gulf of Mexico red snapper fishery

Matthew Campbell[1] (presenting), Tiffany Hedrick[1], Sandra Diamond[1]. [1]Texas Tech University, Lubbock, TX, United States

Catch and release management of fisheries depends on high rates of post-release survival of discarded fish particularly when discard rates are high. For the Gulf of Mexico red snapper fishery, various studies have shown a high degree of mortality upon release, particularly from deep water and at high seawater temperatures. Reducing thermal and barotrama stress by releasing fish at the depth of capture rather than at the surface could potentially increase post-release survival. A fish descender hook was tested at two depths (30 and 60 m) and two seasons (fall and summer) to assess the efficacy of deployment of the gear in the recreational red snapper fishery. Preliminary results show deployment of the gear to be relatively easy but it requires training. Analysis of gear failure rates showed that gear failure was significantly associated with larger fish, more active fish, and fish exposed to shorter surface handling times (MANOVA $p < 0.02$). Predation occurred most frequently with surface-released red snapper and with red snapper unintentionally released at the surface due to gear failure. Film footage of fish released at depth using the descender hook showed that red snapper released at depth were also preyed upon, but at a lesser rate than surface-released subjects. Most frequent predators observed included Atlantic bottlenose dolphin and greater barracuda.

<u>S22. Restless Lake Trout</u>

S22-1

Experiments in lake trout population dynamics

Kenneth H. Mills[1] (presenting), Sandra M. Chalanchuk[1], Douglas J. Allan[2]. [1]Fisheries & Oceans Canada, Winnipeg, Manitoba, Canada, [2]Limno Tech Enterprises, Winnipeg, Manitoba, Canada

We will summarize more than 30 years of experiments in lake trout population dynamics conducted in small lakes at the Experimental Lakes Area (ELA), northwestern Ontario. First, baseline population characteristics, using long-term mark-recapture studies will be summarized for 9 populations that were monitored from 9 to 31 years. Second, we will describe and compare impacts of experiments on lake trout populations: acidification, pulse exploitation, endocrine disruptor (EE2), and nutrient addition (from cage aquaculture). We will then describe and compare recovery of these populations after the experiments were terminated. Lake abundance decreased during all the experiments except the nutrient addition experiment, where abundance increased. Except for the population exploited at the lowest level, approximately 20%, there was no immediate increase in lake trout recruitment to compensate for the decrease in abundance. The primary population response to decreased abundance was increased growth and condition (or relative weight). This was followed by decreased age-at-maturity and a gradual increase in recruitment, leading to increased abundance. Moderate eutrophication, caused by cage aquaculture, increased lake trout annual survival, growth, and condition. Recruitment increased, partially due to decreased age-at-maturity.

S22-2

Taxonomy of *Salvelinus namaycush*

Noel Alfonso[1] (presenting). [1]Canadian Museum of Nature, Ottawa, Ontario, Canada

The lake charr, *Salvelinus namaycush* (Walbaum 1792) was described as Salmo *namaycush* based on specimens from “Hudson Bay lakes, Canada”. There are no types known. The lake charr has been described under fifteen specific names and two subspecific names. A deepwater form of lake charr characterized by a deep body and a high fat content is recognized as S. *namaycush* siscowet (Agassiz 1850). Another deepwater form, lacking the deep body and high fat content of S. n. siscowet, was described by Hubbs (1927) as S. *namaycush* huronicus. Recognition of subspecies and variation at a sub-specific level is important in documenting rapid postglacial changes in populations and in biodiversity conservation. I define the subspecies as any genetic form showing reasonable geographical (although not on the basis of clinal variation) or ecological consistency, distinguishable in all available characters by high constancy (95 % of individuals). Morphological and genetic variation in lake charr is strongly influenced by ecological and other environmental factors. Species and sub-specific definitions can help in understanding the mechanisms that result in the diversity of forms and ecological niches of the lake charr.

S22-3

Life history differentiation between deep-water and shallow-water forms of lake trout in large lakes of North America

Nancy Nate[1] (presenting), Michael Hansen[2], Charles Krueger[3], Mara Zimmerman[3], William Taylor[1]. [1]Michigan State University, East Lansing, Michigan, United States, [2]University of Wisconsin Stevens Point, Stevens Point, Wisconsin, United States, [3]Great Lakes Fishery Commission, Ann Arbor, Michigan, United States

Lake trout (*Salvelinus namaycush*) readily diversify in morphology to exploit diverse habitats (depth) in large lakes of North America. Morphological diversity of lake trout in the Laurentian Great Lakes was greatly reduced when stocks collapsed in the 19th and 20th centuries. To provide more realistic expectations for rehabilitation of lake trout morphotypes in the Great Lakes, we examined life history attributes of deepwater and shallow water forms of lake trout from unperturbed large lakes in North America (Great Slave Lake, Northwest Territories; Lake Mistassini, Quebec) and Lake Superior during 2001–2006. Humper, lean, and siscowet morphotypes were differentiated from standardized photographs of specimens. Back-calculated lengths at age were determined from 1310 otolith thin sections. Growth, body condition, mortality, and maturity were compared among morphotypes and lakes using likelihood-ratio tests. Preliminary results suggest life history attributes differ significantly among morphotypes and lakes. For example, growth differed significantly between lean and siscowet lake trout in Great Slave Lake and between lean and humper lake trout in Lake Mistassini. We suggest that these measures from undisturbed populations should help to clarify objectives for stock restoration better than relying solely on similar measures from disturbed stocks in Lake Superior.

S22-4

Is assortative mating promoting the adaptive divergence in lake charr morphs in Great Bear Lake, NWT?

Craig Blackie[1] (presenting), Paul Bentzen[1]. [1]Dalhousie University, Halifax, Nova Scotia, Canada

Speciation can occur through several deterministic and stochastic mechanisms. For speciation to proceed, reproductive isolation must occur, and this process can be enhanced through positive assortative mating between phenotypically similar individuals. Among salmonid fishes, the lake charr (*Salvelinus namaycush*) is believed to be an exception in that they do not construct redds (nests), show sexual dimorphism, or display antagonistic spawning behaviour. We have found a unique exception to this pattern as part of an ongoing project investigating the adaptive divergence of lake charr in Great Bear Lake, Northwest Territories, Canada. Lake charr in this system can be generally grouped into invertebrate and fish eating morphs that differ greatly in phenotypic traits related to foraging style. We investigated the hypothesis that morphs segregate during spawning and that this segregation is associated with differences in sexual dimorphism between morphs. We examined fish from multiple spawning sites from three geographically isolated arms of Great Bear Lake and combined phenotypic and genotypic analyses to assess reproductive segregation. Using phenotypic data including body shape, fin length, and qualitative assessments of colouration (redness) we showed that sexual dimorphic patterns differed between morphs. Within the smaller invertebrate eating morph, male and female phenotypes differed; males had longer paired fins and a greater occurrence of red colouration. Conversely, no phenotypic differences were noted between males and females of the larger piscivorous morph. Hierarchical cluster analysis indicated spatial segregation where individuals grouped to spawning area based on phenotype. Multilocus microsatellite data showed significant differentiation between morphs and suggested that gene flow among spawning areas appeared to be largely occurring within morphs. Our results show a unique pattern of sexual dimorphism among salmonid fishes and certainly an exception in lake charr. The differences between male and female phenotypes in the smaller morph may represent an example of sexual selection for ecologically relevant traits; a theoretically attractive yet rarely documented phenomenon in nature.

S22-5

Genetic population structuring of lake trout in Great Bear Lake, Northwest Territories

Kimberly Howland[1] (presenting), Craig Blackie[2], Paul Bentzen[2], Melissa Lindsay[1], Ross Tallman[1]. [1]Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Canada, [2]Biology Department, Dalhousie University, Halifax, Canada

Lake trout populations in Great Bear Lake have been managed on a geographic basis under the assumption that stocks are localized and that there is little movement between areas. The differential use of this resource by stakeholders in various regions of the lake along with recent increases in development have however led to questions regarding the degree to which lake trout move between management zones and the extent to which localized impacts effect trout populations throughout the lake. Because of stakeholder concerns and logistical issues associated with using tagging methods in a large lake, we utilized molecular genetic methods to

estimate population structure and gene flow within and among management zones. Microsatellite DNA analyses show population structuring by geographic area suggesting a low degree of mixing among the different regions of Great Bear Lake. There is further genetic sub-structuring within management zones due to the presence of multiple reproductively isolated lake trout morphs. Mixed stock analysis is being used to examine the relative contributions of different lake trout morphs to the fishery within management zones. In addition, our molecular data is being used to investigate whether past and present lake trout harvest has caused population bottlenecks in particular areas of the lake. The implications of these results to management of the lake trout fishery on Great Bear Lake will be discussed.

S22-6

Ontogenetic niche partitioning of lake trout morphotypes in Great Slave Lake

Mara Zimmerman[1] (presenting), Stephanie Schmidt[2], Charles Krueger[3], M. Jake Vander Zanden[2], Randy Eshenroder[3]. [1]Michigan State University, Lansing, MI, United States, [2]University of Wisconsin-Madison, Madison, WI, United States, [3]Great Lakes Fishery Commission, Ann Arbor, MI, United States

Lean and siscowet lake trout morphotypes coexist in two lakes, Lake Superior and Great Slave Lake. This study tested whether changes in niche partitioning could explain morphological and buoyancy differences between morphotypes. Shape, buoyancy, diet, and stable isotope data from Great Slave Lake determined whether morphological and buoyancy differences exist between small and large lake trout and whether ontogenetic changes in morphology and buoyancy correlate with shifts in depth or diet. The morphology and buoyancy of lean and siscowet-like morphotypes differed in small (<43 cm) and large (>43 cm) trout. An ontogenetic shift in both forms from benthic to pelagic feeding was supported by isotope and diet data. These data were consistent with the interpretation that lean trout moved to shallow water with increased size whereas siscowet-like trout remained in deep water but changed buoyancy and morphology with increased size. Expression of the siscowet phenotype likely depends on a deep-water pelagic food web characterized by vertical migration.

S22-7

The reproductive biology of siscowet lake trout and the role of genes and the environment in determining the siscowet phenotype

Frederick Goetz[1] (presenting), Shawn Sitar[2], Charles Bronte[3], Dan Rosauer[1]. [1]University of Wisconsin-Milwaukee, Milwaukee, WI, United States, [2]Michigan Department of Natural Resources, Marquette, MI, United States, [3]U.S. Fish and Wildlife Service, New Franken, WI, United States

A variety of lake trout (*Salvelinus namaycush*) morphotypes were historically present in the Laurentian Great Lakes. A deepwater morphotype, the siscowet, is common in Lake Superior where they make up most of the lake trout biomass. This fish is characterized by a short convex snout, high fat content in flesh and viscera, deep body, and a short, thick caudal peduncle. These and other metrics distinguish it from the other principal morphotype, the lean lake trout. The siscowet is a deepwater form found at depths >80 meters, as opposed to lean lake trout that are more restricted to shallower water. Microsatellite analyses indicate that there are population genetic differences between lake trout morphotypes that suggest reproductive separation and perhaps a genetic basis for the differences in morphology and physiology. However, since the morphotypes also inhabit different environments, it is unclear whether genetics or the environment is ultimately responsible for these differences. We have initiated 2 projects that seek to determine the mechanism for genetic isolation (i.e. type of reproductive isolation) and the control (i.e. genes or environment) responsible for the differences observed between lean and siscowet lake trout. A reproductive life history analysis is being conducted to determine the annual ovarian and testicular maturational cycle of siscowet and lean lake trout in Lake Superior. Reproductively mature male and female siscowet and lean lake trout are being sampled monthly at two sites in Lake Superior from May until November. Morphometric data, tissue, and blood samples are being collected to determine total length, weight, age, gender, lamprey wounding, gonadosomatic index, gonadal histology, circulating gonadal steroids, and pituitary gonadotropin levels. Sampling to date indicates that, within a population, siscowet reproduction is synchronous and occurs at a similar time of year as that observed with lean lake trout. In a genetic study, we have raised siscowet and lean lake trout from fertilized eggs under identical environmental conditions. After one year, there are statistically significant differences in growth, morphometry (truss analysis) and lipid content between siscowets and leans raised communally under identical conditions, strongly suggesting that morphological and hysiological differences are genetically defined in these morphotypes and manifest phenotypically at a relatively early age.

S22-8

Vulnerable *Salvelinus*

Ross Tallman[1] (presenting), Kimberly Howland[1]. [1]Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada

The genus *Salvelinus* has shown considerable vulnerability to effects of manmade activities. In general, the genus has exhibited a greater number of population reduction, collapses and extinctions than any other group of harvested freshwater fishes. For example, lake trout in the Laurentian Great Lakes and in Great Slave Lake have had well doscumented fishery collapses. Similarly, Dolly Varden in the Big Fish and Rat River, Arctic charr in the Sylvia Grinnell River and Bull Trout in Western Alberta have had

significant declines or extinctions in association with over-fishing and other man-made disturbances. We hypothesize that the relatively "slow" vital rates exhibited as well as the apex predatorial position that *Salvelinus* often occupy in the ecosystem makes this genus vulnerable to over harvesting compared to other species.

S22-9

Climate-driven changes in seasonal habitat use by lake trout in a small boreal lake

Paul Blanchfield[1] (presenting). [1]Fisheries and Oceans Canada, Winnipeg, MB, Canada, [2]United States Geological Survey, Cook, WA, United States

Small boreal lakes are thought to be some of the most sensitive aquatic ecosystems to climate change. Consequently, the cold-water fish communities in these lakes are likely to be the most revealing in terms of understanding the sensitivity and adaptability of fish species to a changing climate. Lake trout (*Salvelinus namaycush*) is a coldwater species that is widespread in the small boreal lakes of the Canadian Shield. Acoustic telemetry was used to continuously monitor the depth distribution of lake trout in Lake 373 at the Experimental Lakes Area (ELA), located in the boreal forest of north-western Ontario. Lake trout depth distribution and water temperature data were collected over two climatically different years. Annual differences in habitat use indicated less use of productive shallow water habitats in climatically warmer conditions. Seasonal changes in the pelagic distribution of lake trout were primarily associated with temperature-mediated changes in the timing and depth of thermal stratification. Results suggest that persistent increases in temperature and longer stratification patterns could challenge the fitness of many lake trout populations.

S22-10

Lake trout past, present and future: prospects and adaptive potential for an Ice Age species in a warming world

Chris Wilson[1] (presenting), Jenni McDermid[2]. [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada, [2]Wildlife Conservation Society, Thunder Bay, ON, Canada

As an archetypal Ice Age coldwater species, lake trout are expected to fare poorly under climate change scenarios. Long-term persistence of lake trout populations will depend on adaptation of populations to changing ecological and thermal conditions as well as available habitat. Currently, very little is known about differences in thermal tolerances or adaptive potential among evolutionary lineages and regional populations of lake trout. As the adaptive potential of populations is thought to co-vary with population size, lake trout in smaller lakes (≤1000 ha) may face significant challenges for adapting to rapid climatic shifts. As the ability to respond quickly to selection pressures depends on expressed variation at genetically-controlled traits, populations in larger lakes and/or zones of secondary postglacial contact may be better able to respond to shifting selective pressures. Although available data are sparse, it is expected that life history and ecological traits will show more plastic responses than metabolic traits such as oxygen consumption and thermal tolerance, which may be under more stringent genetic control. Research is urgently needed to identify selective pressures on different life stages, heritability of adaptive traits, and potential rates of adaptive responses among geographic and ecological forms.

S22-11

Effects of climate and temperature on life history characteristics of lake trout

Jenni McDermid[1] (presenting), Brian Shuter[2], Bill Sloan[2], Nigel Lester[2]. [1]Wildlife Conservation Society, Thunder Bay, ON, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

thought to result from climate differences between northern and southern populations. Multivariate statistical techniques were applied to lake trout populations across Canada to summarize life history variation and associate these patterns to climate variables. Results of these analyses found significant associations between life history and climate. It was not simply the net thermal input that was associated with life history variation, however but also the length and severity of winters. In addition to the marked difference between lake trout populations at the northern and southern extremes, considerable local life history variation also occurs. Some of this variation may be attributed to differences in thermal ecology. A series of common garden experiments were conducted on young of year (YOY) lake trout from southern Ontario to identify population-specific differences in growth and temperature tolerance/preference. Differences in thermal ecology resulted in growth being optimized at different temperatures. Furthermore, an inverse relationship was observed between growth rate and temperature preference when YOY lake trout were reared at a common temperature. The results of these studies suggest that the vulnerability of lake trout to climate change will likely vary at both broad and local geographic scales.

S22-12

Life history variation among lake trout ecotypes in Great Bear Lake, Northwest Territories: Implications for stock assessment and management

Kimberly Howland[1] (presenting), Louise Chaverie[2], Ross Tallman[1], William Tonn[2]. [1]Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Canada, [2]Department of Biological Sciences, University of Alberta, Edmonton, Canada

Phenotypic variation of lake trout has been documented in a number of large lakes in North America. In most cases morphological differences have been associated with adaptation to different depths. Recent studies of lake trout in Great Bear Lake however suggest the presence of sympatric morphs in shallow water, a situation that may be promoted by the year round low water temperatures that occur throughout the lake. In this study we used a combination of traditional and geometric morphometric analytical techniques to quantify and group shallow water morphs and look at differences in their distribution and life history characteristics throughout Great Bear Lake. We were able to identify at least four different lake trout types which occur in different proportions for each lake region. Preliminary analyses also suggest differences in both size at age and age at maturity of different morphotypes. We discuss the importance of accounting for differences in the biological characteristics and distribution of lake trout morphs with respect to future assessment and management of the fishery.

S22-13

Restless indeed: Seasonal migrations of lake trout (*Salvelinus namaycush*) to brackish- water environments of coastal Nunavut

Heidi Swanson[1] (presenting), Karen Kidd[1]. [1]University of New Brunswick, Saint John, NB, Canada

Among members of the family Salmonidae, lake trout (*Salvelinus namaycush*) are considered to be one of the least tolerant of saltwater. Despite this, there have been sporadic anecdotal and published reports of their presence in coastal brackish habitats in the Canadian Arctic. Recent physiological work has also shown that the gills of lake trout retain some of the osmoregulatory functions common to other salmonids. As part of a study on anadromous Arctic charr (*Salvelinus alpinus*) conducted from 2002 to 2007, approximately 2800 lake trout were tagged in a short stream that flows to the marine environment of Hope Bay, Nunavut (68°N/107°W). Approximately 3% of these fish were later caught in the marine environment and/or were recaptured in subsequent years in a fish fence that intercepted anadromous Arctic charr. Stomach content analyses revealed that these migratory lake trout were feeding on a variety of marine prey items, including capelin (*Mallotus villosus*) and Pacific herring (*Clupea pallasii*). Of 36 lake trout captured in a study of 2 coastal lakes in 2006, 3 were migratory and could be discerned from their resident counterparts by significant differences in stable isotope ratios of carbon, nitrogen, and sulfur. A 2-source mixing model ($\delta34S$ was used as a tracer) showed that approximately 75% of flesh tissue from these migratory lake trout was marine-derived. Otolith microchemistry analyses conducted on these 3 fish and a further 20 migratory trout captured in 2007 showed that the age of first migration varied widely, from approximately 6 years of age to 15 years of age. After the onset of migratory behaviour, both annual and sporadic (periods of > 1 year in freshwater) migrations were observed to occur. It thus appears that migratory and resident life history strategies can be employed by lake trout in coastal Arctic lakes and that migratory behaviours are quite flexible. These results are interpreted in the evolutionary contexts of partial migration and conditional life history strategies.

S22-14

Molecular genetic characterization and comparison of lake trout from Yellowstone and Lewis Lakes, Wyoming

Wendylee Stott[1] (presenting), Todd Koel[3], Kim Scribner[2], Philip Doepke[3]. [1]Great Lakes Science Center-USGS, Ann Arbor MI, United States, [2]Michigan State University, East Lansing MI, United States, [3]National Park Service, Yellowstone National Park WY, United States

Lake trout were introduced illegally into Yellowstone Lake in the 1980's and have caused a significant decline of the native cutthroat trout. Genetic methods were used to explore a possible source of lake trout for the introduction, to estimate the effective population size of the populations in Yellowstone Lake, and to compare genetic diversity of lake trout from Yellowstone National Park to historical samples from the Great Lakes. Lake trout from Lake Michigan were the original source of lake trout stocked into Lewis Lake within the park in 1889. Samples from Yellowstone and Lewis lakes are more closely related to each other than to hatchery strains used in the Great Lakes and to samples from Lake Michigan collected in 1948. The effective population size was calculated for samples collected before and after lake trout suppression intensified on Yellowstone Lake. Individual assignment tests indicated that the majority of lake trout from Yellowstone Lake came from Lewis Lake, but they also appear to have also been stocked from some other source not examined in this study; possibly nearby Shoshone or Heart Lakes.

S22-15

Collapse and recovery: a history of lake trout dynamics in Great Slave Lake.

Ross Tallman[1] (presenting), Chris Day[1], Kimberly Howland[1], George Low[1]. [1]Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada

The lake trout fishery in Great Slave Lake is a little documented case of overfishing and management practices to achieve a partial recovery of the fishery. The fishery initiated shortly after the Second World War along with the lake whitefish fishery. The stock was highly productive with up to 300,000 lbs removed each year but quickly declined to full collapse by the 1960s. Measures to ensure that viable sport fishery in the eastern Arm of Great Slave lake were imposed. The sport fishery in a closed commercial fishery zone has remained productive to this day. In the main basin of the lake the fishery has not recovered and remains suppressed as a by-cach fishery of the lake whitefish fishery.

S22-P-1

Supplemental stocking has variable impact on regional patterns of native genetic diversity in lake trout populations

Michael Halbisen[1] (presenting), Chris Wilson[1]. [1]Trent University, Peterborough, Ontario, Canada

Supplemental stocking has been practiced worldwide since fish culture began in the late 1880s. However, management agencies are changing their practices in response to recent studies indicating that stocking can lead to unintended, negative results such as genetic homogenization with non-native, stocked strains. Additionally, since traditional fish culture practices can produce stocked fish with lower fitness than wild fish, homogenized populations may have less survival potential under future environmental change. To evaluate how supplemental stocking has impacted native lake trout population structure we have developed a region-specific genetic methodology for detecting the impact from supplemental stocking in the Great Lakes region. We used microsatellite and mitochondrial DNA molecular markers to detect replacement of native genetic diversity through introgressive admixture with stocked fish. We have focused on three regions representative of the species-wide pattern of genetic variation. Regional categories correspond with both phylogeographic history and contemporary watershed connectivity. Our results indicate that stocked lake trout have contributed to or replaced some native populations, but that many native lake trout populations persist even after substantial stocking with non-native lake trout. These results not only provide useful information for management agencies, but also reveal some limitations in adaptive potential for both donor and recipient populations.

S23. Parental Effects and Their Consequences for Recruitment Dynamics and the Sustainability of Harvested Stocks

S23-1

Measuring maternal effects and their population dynamic consequences in a model system: implications for fisheries management

Stewart Plaistow[1] (presenting), Tim Benton[2]. [1]University of Liverpool, Liverpool, United Kingdom, [2]University of Leeds, Leeds, United Kingdom

Maternal effects arise when a mother's phenotype or the environment she experiences influences the phenotypes of later descendents. Such effects may act as a source of intrinsic delayed density dependence that can potentially influence patterns of population dynamics. This will depend upon the nature, duration and magnitude of maternal effects over time. Quantifying maternal effects within the time-frame of a standard grant is not possible in most natural systems, but it can be possible in model systems. In this talk I will describe empirical experiments using soil mite microcosms that were designed to measure both the persistence and magnitude of maternal effects in different environments over time. Our results show that when multiple traits are studied, maternal effects are still detectable in the life history of descendents three generations later. However, the nature of maternal effects was found to be context-dependent. In low food, maternal effects had little effect on descendent reproduction suggesting that maternal effect would diminish over time, whereas in high food maternal effects primarily influenced descendent reproductive traits suggesting that maternal effects would persist over time. This prediction was tested at the population level by comparing the transient population dynamics of replicated populations that were either set up with young eggs or old eggs (maternal effect) at a range of initial densities (food environment). Throughout the talk, I will highlight the potential implications of these findings for fisheries, and generally explore the utility of using model systems to provide us with data that may be relevant for policy-related issues.

S23-2

Maternal effects, age structure and population resiliency: managing for diversity in the face of uncertainty

Selina Heppell[1] (presenting), Wade Smith[1]. [1]Oregon State University, Corvallis, Oregon, United States, [2]Oregon state University, Corvallis, Oregon, United States

Truncation of age structure is a common response of populations to fishing, and is unavoidable if an entire stock is susceptible to fishing mortality. Researchers have speculated on the implications of lost age structure, yet it is not a consideration in most stock assessment models and "reference points" – status thresholds used to regulate harvest. Productivity estimates from deterministic models are not likely to change dramatically if fertility is age-dependent rather than biomass-dependent. This is because a) most young females in a population are below the 50% mature level and therefore contribute relatively few offspring anyway, b) relatively few fish reach the oldest age classes, even under natural mortality conditions, and c) per capita fertility has a low impact on population growth rate relative to annual survival. However, under variable environmental conditions, the potential value of a broad age structure becomes more apparent. Maternal effects on egg or larval quality are often coupled with variance in the timing or location of spawning. We show simulation results for black rockfish on the Oregon coast under variable ocean productivity regimes that are based on observed upwelling indices. An increase in the length of the spawning season, due to a mixture of early and late spawning females, can promote population resilience when larval survival is highly stochastic. Further analysis with simulated populations and evaluation of the relationship between age structure, environmental variance and recruitment patterns may elucidate why maternal effects are more prevalent in some species or families than others.

S23-3

Maternal effects in pike (*Esox lucius*) and their relation to the efficiency of harvest regulations: a modelling approach

Robert Arlinghaus[1] (presenting), Shuichi Matsumura[2], Ulf Dieckmann[1]. [1]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany, [2]International Institute of Applied Systems Analysis, Laxenburg, Austria

Age-structured population models are frequently applied to examine the impact of harvest regulations on population abundance and angling quality in recreational fisheries. However, most existing models estimate recruitment through an allometric relationship between size of the female and egg number. This perspective omits size-dependent maternal effects or other size-dependent mechanisms that may influence egg numbers and egg and larval quality. We developed an age-structured population model for pike (*Esox lucius* L.) and incorporated a specific empirically derived positive relation between the gondosomatic index (GSI) and length of females. We also assumed various scenarios of increasing egg sizes with increasing sizes of the females, coupled with assumptions about distinct survival probabilities of differently sized eggs. We investigated the implication of the various maternal effects for equilibrium population size, total catches and harvest, as well as catch per effort and harvest per effort, under different harvest regulations and size-selective exploitation levels. We show that accounting for the positive relation between GSI and size of the fish dramatically alters model predictions. In this case, under size-selective harvesting, equilibrium population size is lower compared to model runs that assumed a constant GSI for mature females. Modelling pike population dynamics in response to exploitation without accounting for the size-dependency of GSI systematically overestimated sustainable angling effort. Model results were relatively insensitive to assumptions about size-dependent egg survival probability. In terms of harvest regulations, inverse slot length limits (i.e. a combination of minimum and maximum size limits) outperformed low minimum-size limit regulations as evidenced by enhanced equilibrium population size, total catches and catch rates without substantially lowering harvest levels. In conclusion, traditional age-structured population models that lack incorporation of various kinds of maternal effects may provide misleading signals to fisheries managers, and put populations and angling quality at risk.

S23-4

Larger females yield larger and more robust offspring in European lobster (Homarus gammarus): implications for fisheries management

Even Moland[1] (presenting), Esben M Olsen[2]. [1]Centre for Ecological and Evolutionary Synthesis (CEES), University of Oslo, Oslo, Norway, [2]Flødevigen Marine Research Station, Institute of Marine Research, His, Norway

Effects of maternal size, age, condition or behaviour on the viability of offspring are well documented for a number of marine and terrestrial taxa. However, published accounts of maternal effects in decapod crustaceans are limited. The European lobster in the Skagerrak system is a popular target species in recreational and commercial fisheries. Historically the catches were substantial but over the past 30-40 years the stock has suffered a major decline and is currently red listed as near threatened. The highly likely importance of 'BOFF' (big old fat fecund) females in successful recruitment of marine populations has been underscored in a number of studies over the last decade. Large, old lobsters are rare in present day Skagerrak catches. Here, we report a study of the effects of maternal size on egg size, larval size and larval survival in a common garden experiment designed to measure yolk reserves. We studied eggs and larvae from berried females (n= 45) of 79 to 152 mm carapace length. Mean within female egg dry-weight increased by ≈73% from 1.02 to 1.77 mg (mean 1.46 ± 0.03 SE) with maternal size and reached a high, stable level in females > 110 mm carapace length. Within female variability in egg dry-weight decreased with maternal size. Mean larval size at hatching was positively correlated with maternal size ($r2=0.76$) and with mean egg dry-weight ($r2=0.92$). Mean observed sibling survival varied from 8.05 to 13.5 days (mean 11.44 ± 0.2 SE), with highest survival time observed around mean egg dry-weight. Our findings warrant strong advice to management authorities and point in the direction of a maximum legal size for lobsters in the Skagerrak system.

S23-6

Maternal effects on timing of parturition in rockfishes

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Rockfishes (*Sebastes* sp.) are long lived, viviparous livebearers that typically release a single large batch of larvae each year. Because the oceanographic conditions encountered by larvae exhibit marked temporal variability within a spawning season, parturition date has a vital influence on the survival of a female's spawn. Previous studies on continental shelf associated species have demonstrated a maternal effect on timing of parturition, with older/larger females releasing larvae earlier in the spawning season compared to smaller/younger females. Shelf species can be maintained alive in laboratory tanks, allowing females to release their larvae on a natural schedule. To extend the study of maternal effects to species inhabiting the continental slope, which as a group are difficult to maintain in captivity, we examined pregnant females from collections taken throughout the spawning period, estimating parturition date from precise staging of developing larvae. We found a similar pattern of earlier parturition with increasing maternal age or size for yellowtail and widow rockfish collected in 2005 from Cordell Bank. Chilipepper, in contrast, had later parturition dates for older females. Additional data on gestating females were available from the California commercial

fisheries database. Although staging was less precise, these data provided a time series extending from 1969-2006. Comparison of the timing of collections with stages of pregnant females suggested that aurora, sharpchin, and widow rockfish exhibited the expected pattern of older/larger females spawning earlier than younger/smaller females. Chilipepper and bank rockfish displayed the opposite pattern of older females spawning later than younger females, and five species exhibited no maternal effect. Differences in the direction and strength of maternal effects on parturition timing may reflect differences in life history within the speciose *Sebastes* complex.

S23-7

Artificial selection overriding natural selection: unlikely role of an annual fish in a complex play with a gigantic audience

William Bennett[1] (presenting), James Hobbs[1], Swee Teh[1]. [1]University of California, Davis, Davis, CA, United States

We evaluate the role of parental effects and selective mortality in the population collapse of the endangered delta smelt, Hypomesus transpacificus, endemic to the San Francisco Estuary, California. Unlike many such cases, delta smelt is a small (<80mm) and primarily annual species that is routinely subjected to entrainment mortality, or “harvest”, in facilities that pump massive volumes of fresh water from the estuary to supply California’s significant agricultural and urban demands. Entrainment mortality is highly controversial, because pumping restrictions to protect salmon smolts and delta smelt (in April and May) interfere with water allocation. By setting a “high-low” seasonal pattern of water-pumping, however, this policy also inadvertently imposes “artificial selection” by disproportionately entraining early versus late-spawned larvae. We evaluate the implications of this apparent artificial selection by[1] measuring variation in several key life history traits using specimens collected during routine fish monitoring in the estuary, and by[2] examining potential relationships between long-term trends in the mean length of adults that show a significant step-decline, with those for water-inflow and pumping intensity. Finally,[3] we examine patterns in selective mortality by estimating hatch-dates and size-at-age information derived from otoliths comparing the period “before” the population collapsed (1999-2001) with recent years (2005-2006) “after” the decline. Parental effects were observed over relatively small size and age ranges, with egg number and diameter, as well as larval size and yolk-sac volume scaling significantly with female length; these larger fish also spawn early, before pumping is restricted. The decline in average size of adults is highly associated with lower inflows (dry winters) that enhance entrainment. Patterns in selective mortality in the “before” period indicate that fish larger-at-age or with higher growth rates generally also had higher survival to the adult stage (in December): a pattern consistent with life history and recruitment theory. In contrast, however, patterns of survival in the “after” period were generally opposite, with survivors initially smaller-at-age and growing slower than average. Overall, these results suggest “artificial” size-selection systematically interfered with natural selection and played a significant role in the demise of delta smelt, providing an example with broad implications for other species and systems.

S23-8

The influences of maternal age of spawning,recruitment variability, and life-history pattern upon harvest reference points and fishery management

Paul Spencer[1] (presenting). [1]National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, United States

Marine fish stocks exhibit a wide variety of responses to oceanographic variability and harvesting, reflecting largely differences in reproductive biology and stock-recruitment relationships. For some stocks---i.e. Pacific rockfish (genus *Sebastes*) and Atlantic cod (*Gadus morhua*)---there is evidence that larval viability may be affected by the age of the spawner, thus potentially complicating stock-recruitment relationships. These maternal effects can be viewed as redefining the units of reproductive output from spawning stock biomass (i.e. eggs) to “viable larvae” (i.e. larvae remaining after mortality dependent upon spawner age is applied). For Alaska Pacific ocean perch (*Sebastes alutus*), this redefinition results in estimates of Fmsy that are similar but slightly reduced from those obtained using spawning stock biomass as reproductive output, and steeper reductions in sustainable yield with fishing rates higher than Fmsy. Simulated “cod-like” and “rockfish-like” populations were used to further explore how estimates of management reference points such as Fmsy and Fcrash (the F level where equilibrium yield is reduced to zero) may be affected by life-history pattern, recruitment variability, and exploitation. In these simulations, larval survival was dependent upon spawner age, and estimates of Fmsy and Fcrash were made using either total larvae (proportional to eggs and spawning stock biomass) or viable larvae. Over a range of harvest rates and levels of recruitment autocorrelation for each life-history type, estimates of Fmsy obtained when using total larvae were similar to those obtained when using viable larvae. However, estimates of Fcrash obtained when using total larvae were larger than those obtained when using viable larvae because of the pronounced truncation of age structure and decreased larval survival rates associated with the high fishing mortalities of Fcrash. This suggests that estimation of stock productivity at low stock sizes may be biased high if larval survival is dependent upon spawner age and this relationship is not reflected in the units of reproductive output utilized for stock-recruitment analyses and estimation of fishing rate reference points.

S23-9

Size-dependent reproductive success in wild zebrafish (*Danio rerio*)

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Understanding and predicting recruitment remains one of the challenges of fisheries science. It is however crucial for identifying sustainable management actions. Recently, the importance of parental impacts on reproductive output has been intensively discussed, but there are important methodological challenges to understanding the differential reproductive success of individuals in wild fish populations. In this study wild zebrafish (*Danio rerio*) were used as a model species to experimentally analyze size-dependent reproductive success. Three subpopulations were harvested size-selectively either for large body size, small body size or randomly, and various measures of reproductive output were compared across the three groups. Small fish spawned significantly less frequently and had lower number of eggs than large fish or randomly harvested fish. In addition, the hatching rate was significantly lower in eggs produced by small parental fish. However, neither larval yolk sac volume nor size of hatched larvae (body area-at-hatch) was related to parental body size. Thus the parental impact on reproductive success in wild zebrafish was observed at the egg stage. Especially the very small parents seemed to produce low quality gametes, whereas the differences between random size and large parents were negligible. If this trend of size-dependent reproductive success is ubiquitous in nature, truncating size distributions towards small sizes may have an impact on recruitment dynamics in exploited fish species.

S23-10
Population level expression of maternal effects depends on life-history context
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Researchers have proposed increasing the number of older mothers in rockfish stocks as a method to increase per-capita recruitment. This predicted outcome is based on the discovery of age-dependent maternal effects in several rockfish species: it appears that older and larger mothers routinely release larvae with one of several advantages over larvae from younger mothers. These advantages are expected to improve larval success, but it is unknown whether the improvements are sufficient to create significant increases in recruitment. To investigate this, I calculate recruitment using a multivariate stock-recruitment function developed specifically for rockfish populations with maternal effects. I show that increased recruitment due to maternal effects depends primarily on the rates of mortality that larvae face pre-settlement and post-settlement, and the magnitude of density-dependent mortality in the post-settlement stage. I find that to increase recruitment,[1] the advantage must resolve a problem the fish face---if survival is already high, improving survival does not ensure significant increases in recruitment---and[2] the advantage must have a net positive impact---if density-dependent mortality is high, the success of the few does not guarantee the success of the cohort.

S23-11
Variation in maternal investment when juvenile survival is density dependent
Stephan Munch[1] (presenting). [1]Stony Brook University, Stony Brook, NY, United States

Since the early 1970's, over a thousand studies have investigated the sources of variation in maternal investment in offspring. Although classical theory indicates that all mothers should produce offspring of the same quality, Venable (1992) showed that density- dependent juvenile survival substantially changes this result. Here I extend this density- dependent theory to cover age-specific patterns of reproductive allocation.

S23-12
Redtail surfperch reproduction in heated water
Karl Brookins[1] (presenting), Howard Horton[2]. [1]Hawaii, United States, [2]Oregon State University, Corvallis, Oregon, United States

Large gestating redtail surfperch (*Amphistichus rhodoterus*) migrate into estuaries months prior to parturition while estuarine males and young are uncommon; older surfperch (several species) parturiate earlier and larger females carry larger young; female A. rhodoterus are subjected to intensive estuarine-fisheries that include embryo mortality (embryo by-catch). Experiments were conducted to test the hypothesis that warmer temperatures would influence embryo growth, survival and parturition timing. The survival of A. rhodoterus embryos during mid-gestation was significantly decreased in heated tanks; embryo growth was not significantly different between treatments. Embryo growth significantly increased in heated water during late-gestation. Significant differences were found for the number of days until birth, the distribution of days to birth, and embryo wet weight during a parturition experiment. The mean weight of newborn young was 7.61g and 5.65g, and the average number of days to birth was 54 and 33 in the ambient and heated parturition treatments, respectively. Temperature was significant and female SL was not, as a regression variable explaining offspring wet weight from the parturition experiment. The effect of gestating female migration into estuaries is likely to be faster embryo growth, earlier parturition, smaller size at birth and exposure to estuarine-fishery mortality. While females gestating in cooler ocean waters are likely to contain slower growing embryos, parturiate later, release larger young at birth, and avoid estuarine-fishery mortality. Smaller young and estuarine-fishery mortality likely decrease growth potential of the stock. However, earlier parturition may be advantageous. Published Embiotocid parent-offspring relationships "parental effects", which influence population dynamics, can result from size related movements of gestating females between different temperatures (i.e. behaviour and environment) and not ontogeny alone.

S23-13

Warming rivers, migratory stress, and parental effects: the influence of changing adult salmon migratory conditions on offspring fitness

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Semelparous and non-feeding, Pacific salmon have a finite supply of energy to allocate among routine metabolism, reproductive development and swimming during their arduous upstream adult migration. It is unclear whether changing environmental conditions (increased temperatures and variable flows) experienced by migrating parents will cause energetic trade-offs that affect future recruitment through changes in offspring number or quality. We summarized 10 years of research examining wild populations of Fraser River sockeye salmon that differed in migration distance (range 100 to 1100 km), timing (early summer vs. fall), and environment (interannual comparison of river temperature and discharge conditions) to test the hypothesis that migratory stress exerts a parental effect on offspring fitness. Within population assessment of ovarian development during migration revealed no evidence of en route facultative adjustments affecting egg size or number. Instead, interannual variation in ovary investment associated with difficult migration conditions likely results from selection against maternal phenotypes with high ovarian investment. Maternal and paternal gamete origin significantly influenced offspring survival in all populations examined thus effecting future recruitment, but embryo viability was not consistently correlated with phenotypic variation in parental condition (i.e. energy status, disease status, stress, hormonal status). Moreover, extremely unhealthy spawn ready females (i.e. moribund) that would normally not spawn successfully in the wild still produced similar numbers of viable offspring compared to their healthy counterparts. Different performance measures were used as surrogates of offspring fitness to examine sub-lethal effects, including offspring size, hatch times, development rates, metabolic enzyme capacity, burst swimming ability, and schooling behaviour. Assessment of these performance measures provided valuable insight into general parental influence on offspring fitness, but it was difficult to link these effects back to adult migratory stress. Adverse migratory conditions can cause severe stress responses in adults (including mortality), but those adults that survive to successfully spawn appear not to have compromised gamete quality as a result of exposure to the current range of environmental stressors.

S23-15

The influence of paternal traits on offspring survival and recruitment in a nest-guarding fish, the smallmouth bass

Brandon Barthel[1] (presenting), David Philipp[1]. [1]Illinois Natural History Survey, Champaign, IL, United States

The smallmouth bass is a popular freshwater gamefish in warmwater systems across North America. Research suggests that angling during the species reproductive period can have negative consequences for recruitment, largely due to the vulnerability of males providing parental care to offspring. Male smallmouth bass aggressively defend developing broods in shallow nests constructed in the littoral zone for 4-5 weeks during the spring. Parental males have been shown to be exceptionally vulnerable to angling during this period, and substantial portions of broods are often devoured by nest predators when males are removed from their nests for even short periods of time (e.g. during catch-and-release angling). There has been extensive research into how a number of factors impact male reproductive success during the parental care period, but tracking success through independent juvenile life stages has been extremely challenging. We present the results of a study that has integrated direct visual observations of reproductive success during the parental care period with genetic paternity determinations of offspring collected during the second year of life in a natural population in Ontario. This study design has allowed us to determine which males sired the offspring that survived the first year and investigate whether the traits of parental males affect the likelihood that their offspring survive to this later independent juvenile stage. Traits evaluated include male age, size, reproductive experience, and the timing of nest construction and spawning. These results have clear management and conservation implications: if the offspring of certain males are more likely to survive and recruit into the adult population than others, then management actions that improve the odds that these males are able to successfully raise their broods should have a positive affect on recruitment and population persistence.

S23-16

Parental behaviour and offspring recruitment: implications for exploitation.

Joseph Parkos III[1] (presenting), David Wahl[1], Jeff Stein[1], David Philipp[1]. [1]Illinois Natural History Survey-Division of Ecology and Conservation Sciences, Champaign, IL, United States

Maternal and, to a lesser extent, paternal effects on offspring phenotype and subsequent performance are recognized as an important process affecting recruitment variation in fishes. The role that parental behaviours play in determining the probability of offspring recruitment, however, is relatively unexplored. We examine how the negative effects of exploitation on population persistence and growth rate can be more severe for species with parental care by reviewing what we know about exploitation of fishes with parental care behaviour, by examining the degree of vulnerability associated with different types of parental care behaviours, and by (presenting) empirical data on the effect of parental care behaviours on offspring recruitment. The largemouth bass (*Micropterus salmoides*) is an ideal model species for these questions because males provide extended parental care for their young, and nesting males are frequently targeted by a commercially important fishery. We used molecular markers to determine parentage of offspring in an effort to test if there is significant variation in brood-specific contribution to recruitment. We further used in situ measurements of mating success and parental care behaviours to assess if the observed differences in contribution are related to behaviour of parental males. We found the highest contribution to recruitment from broods that were both produced earliest in the spawning period and defended into free-swimming life stages. Based on our review and these patterns of nest-specific contribution to recruitment, we offer a general framework for managing exploitation of fishes with parental care.

S23-17

Evolutionary impacts of angling nesting bass

David Philipp[1] (presenting), Julie Claussen[1], Cory Suski[2], Steven Cooke[3], Brandon Barthel[2], Aaron Shultz[2], Jeff Stein[2], Joe Parkos[2], Frank Phelan[4], David Wahl[1]. [1]Illinois Natural History Survey, Champaign, IL, United States, [2]University of Illinois, Champaign, IL, United States, [3]Carleton University, Ottawa, ON, Canada, [4]Queen's University Biological Station, Lake Opinicon, ON, Canada

Species in the genus, *Micropterus*, the black basses, all exhibit extended male parental care, a behavioural trait that is critical for survival of their young and, hence, for successful recruitment. In the spring, male bass enter the shallows and construct a saucer-shaped depression in the substrate. Males then court and spawn with females, and after egg deposition is completed, the females depart the nest area, leaving the male to provide all parental care, which involves fanning the eggs for oxygenation and defending the brood against potential predators. Long-term studies of several populations of smallmouth and largemouth bass now demonstrate that recruitment (i.e. annual year-class strength) is directly related to the reproductive success of the population. In all populations of bass, however, there is great variation among individuals in their relative contribution to annual overall recruitment. A number of factors (e.g. mating success. male size and age, timing of spawning, etc) all contribute to that relative contribution level. In addition, it has been well documented that angling (both catch-and-harvest and catch-and-release) has negative impacts on the reproductive success for the captured individual. Unfortunately, the male bass that are the most capable of producing surviving young and having the greatest relative contribution to the year class, are also those individuals that are the most vulnerable to angling. As a result, angling for nesting bass results in selection against those males that are the most valuable for population level sustainability. Controlled, long-term selective breeding experiments over 20+ years have documented the heritability of bass to angling. In addition, field experiments assessing the long-term impacts of angling pressure during the nesting season demonstrate the level of behavioural change possible during this era of widespread angler-induced selection. The long-term impacts of angling bass during the reproductive season is presented in the form of a conceptual model, which then serves as the basis for recommendations on what management changes are needed to assure long-term sustainability of wild populations of black basses in the future.

S23-18

Taking the next step: Examining recruitment and population variation in largemouth bass when catch and release angling disrupts parental care

Jeffrey Stein[2] (presenting), David Philipp[1]. [1]Illinois Natural History Survey, Champaign, IL, United States, [2]University of Illinois, Champaign, IL, United States

Largemouth bass are a popular sport fish throughout North America, supporting an economically important recreational fishery and a booming interest in competitive angling. As catch and release angling has become a common tactic among conservation-minded anglers, research has focused on the impacts of angling to individual fish (e.g. physiological effects, changes in reproductive success). Any effects of catch and release angling of brood-guarding largemouth bass on recruitment dynamics have yet to be explored. Changes in recruitment driven by decreases in reproductive success during catch and release events potentially affect population size and may disrupt the sustainability of an important resource.We tested for changes in largemouth bass recruitment in response to simulated brood predation in eight small (approx one-third acre) ponds in 2007 and 2008. In four treatment ponds, swimmers manually reduced eggs in each nest by a target 50% to simulate brood predation during angling capture of the parental male. Recruitment was measured as number of YOY produced (standardized by egg score), and YOY biomass (g), condition factor (K), and mean total length (mm). Treated ponds showed a notable reduction in number of YOY produced and total biomass when compared to treatment ponds. We also examined standardized population assessments and creel survey results in over 70 Illinois lakes spanning 1991-2007 for patterns relating disturbance of parental care with poor recruitment. These two studies indicate that brood predation of largemouth bass eggs during the removal of a nest guarding parental male (e.g. during an angling event) may have important implications to largemouth bass recruitment dynamics.

S23-19

Genetic links between adult size and larval quality in a marine fish: Effects of parent phenotype on population replenishment

Darren Johnson[1] (presenting), Jessica Moye[1], Mark Christie[1], Mark Hixon[1]. [1]Dept. of Zoology, Oregon State University, Corvallis, Oregon, United States

Wild populations of fish may evolve in response to direct selection on traits such as adult size and growth rate. However, some traits may evolve indirectly through genetic correlations with traits that are under direct selection. In this study we evaluated the degree to which traits that affect the survival of larval fish (size at hatching and swimming performance) may evolve in response to selection on adult size in bicolor damselfish (Stegastes partitus) in the Bahamas. To estimate the genetic covariance between adult size and larval quality, we combined field demographic studies with quantitative genetic analyses. We compared the asymptotic size of adult males to the size and swimming performance of their larval offspring. Results from both natural breeding and a cross-fostering experiment indicated that size of the male parent was strongly and positively correlated with both the size and swimming performance of larval offspring. Based on this information, we can predict how quickly larval quality may change in response to selection on adult size (e.g. removing the largest 10% of adults would reduce average larval size by 0.107 SD per generation). Such a change is estimated to reduce the relative rate of post-settlement survival by a difference of 6% in one generation. Because the dynamics of many fish populations are sensitive to changes in survival of early life history stages, these results suggest that even moderate rates of selection on adult size can have substantial consequences for population viability.

S23-20
Maternal influences as a mechanism of population regulation in exploited marine stocks
Paul Venturelli[1] (presenting), Brian Shuter[1], Brian Shuter[2]. [1]University of Toronto, Toronto, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

Relations between offspring survival and maternal quality (both genotypic and phenotypic) have been documented extensively in fish. Growing evidence suggests that these maternal influences are sufficiently strong to affect the dynamics of stocks via harvest-induced changes in age and size structure. However, the relative importance of maternal influences among life history strategies and other influences on population dynamics (e.g. climate) remains largely unexplored. When, if at all, are population-level maternal influences relevant to fisheries policy and management? We incorporated size-related maternal influences into two population models in which a) life history was either periodic or opportunistic (e.g. cod-like or anchovy-like), b) harvest either targeted or protected larger females, and c) recruitment varied naturally in response to realistic patterns of climate. For each combination of life history and harvest strategy, we compared values for biological reference points and levels of extinction risk. Results suggest that both climate and maternal influences affect population dynamics, but that the relative strength of these effects depends on both the size selectivity of harvest and the life history of the species being harvested.

S23-21
Parental effects on stock rebuilding rates
Tara Marshall[1] (presenting). [1]University of Aberdeen, Aberdeen, United Kingdom

Parental life history traits, including growth, maturation, fecundity and offspring quality, affect the resiliency of stocks to harvesting. For data-rich stocks this resiliency can be expressed quantitatively by estimating r, the intrinsic rate of population growth, for individual cohorts. Previous research for collapsed (Northern Gulf of St. Lawrence) and a non-collapsed (Barents Sea) cod stocks indicates that the collapsed cod stock had low and even negative values of cohort-specific r which is consistent with negative population growth. Negative r cohorts were also subject to non-negligible levels of fishing mortality (F). However, the propensity of this cod stock to low or negative values of r is not considered in management. Using a model that estimates stock rebuilding time (in years) as a function of r and F, I examined parental effects on rebuilding rates for cod under two contrasting scenarios: poor parental condition (slow maturation + reduced fecundity + lower offspring survival = low r) and good parental condition (fast maturation + increased fecundity + higher offspring survival = high r). These two scenarios were evaluated under a range of harvesting scenarios, ranging incrementally from a closed fishery (F=0) through to a status quo fishery (F corresponding to the target reference point). It was possible to rebuild the poor condition stocks within reasonable time frames (< 10 years) when F=0. The imposition of even small amounts of F increased rebuilding times to the point that recovery could not be realistically expected. Stocks comprised of parents in good condition could be rebuilt within ten years while sustaining moderate levels of fishing. In nature, fluctuating environmental conditions or regime shifts can cause cohorts to vary between extremes of poor and good parental condition. The analysis clearly shows that to ensure long-term sustainability the target F experienced by the cohort over it's lifetime should not be in excess of cohort-specific r.

S24. The Changing Role of Aboriginal Communities in Fisheries Management

S24-2
Anishinabek/Ontario Fisheries Resource Centre; a cooperative model for fisheries information
Tom Whillans[1] (presenting), Ed Desson[1]. [1]Anishinabek/Ontario Fisheries Resource Centre, Ontario, Canada

Mistrust by Anishinabek communities in government collection and interpretation of data has been an impediment to the development of fisheries co-management in Ontario. In 1996, the Anishinabek/Ontario Fisheries Resource Centre (A/OFRC) became fully operational in serving as an independent source of information on fisheries conservation and management within traditional harvesting areas. The A/OFRC is a not for profit corporation controlled by a Board with equal representation from Native and non-Native Directors. The roles of the Centre are to report on stock status, evaluate stresses on fish populations and habitats, promote the use of state of the art science and technology, and provide a forum for information sharing and participation with stakeholders.The Centre's studies focus on the integration of western science and aboriginal traditional knowledge (ATK), and have led to management decisions for fisheries of concern. Working relationships between Native communities, other stakeholders and, both the Federal and Provincial government, have improved significantly as a result of the A/OFRC's involvement. The A/OFRC model can be readily adapted to other jurisdictions and resource management issues where high quality, independent information is desired.

S24-3

Community based fish habitat assessments: challenges and benefits from the perspective of a First Nation empowered research institution

Jennifer Simard[1] (presenting), Alexandre Litvinov[1]. [1]MERC, Timmins, Ontario, Canada

The Mushkegowuk Territory spans across the western Hudson and James Bay basin covering nearly a third of the province of Ontario. The southern area of the territory relies on resource extraction based economies such as mining and forestry whereas the northern area is relatively undeveloped with minimal infrastructure and consisting of remote access First Nations. Seven First Nations across the Mushkegowuk Territory identified the need to build capacity within the environment sector and supported the establishment of a non- for – profit, First Nation empowered research institution that could address community information needs. Minimal baseline data exists within provincial/federal governments for the far north, an area that has been subject to a recent increase in resource development projects and proposals including diamond mines, mineral exploration, and hydro electric power (dams and transmission lines). Crucial Indigenous Knowledge exists across the Mushkegowuk Territory and includes but not limited to species inventories, distribution, population status, and critical habitat. The Mushkegowuk Environmental Research Centre works with both Indigenous Knowledge and "Western" science. Research projects are identified by communities and methodologies are informed by Indigenous Knowledge. Challenges include access to existing western or academic information removed from the Territory, translation of technical information (Cree/English), as well as conflicts between traditional values and government approved fish conservation strategies. Community based fish habitat assessments benefit several community objectives such as preparedness for resource development proposals (Environmental Assessments), provincial/federal fisheries policy review, and respect for the uniqueness of each watershed associated with each First Nation.

S24-5

Building capacity through education for resource management

Dan Longboat[1] (presenting). [1]Environmental Studies Program, Trent University, Peterborough, Ontario, Canada

Natural Resources and Biodiversity are under tremendous threat. These threats range from habitat loss, exposure to toxins and contaminants, to global climate change, complicated by over-harvesting. To deal with this multiplicity of threats and their impacts upon the resource management demands a highly specialized knowledge set that necessitates a specialized educational format. The face of resource management is slowly changing. With the recognition of Indigenous rights and claims comes the need to include Indigenous environmental knowledge into management regimes. Indigenous environmental knowledge is a very highly specialized and localized knowledge system that serves to provide a greater depth of knowledge and understanding to natural processes. To help resolve the ever growing complexities of resource management, will now demand that resource managers have an even more extensive knowledge and skill set that enables an integration of these two distinct ways of understanding the world, specifically with regards to fisheries management. What does this new form of "education" look like? What makes it different than the present "resource management" education? Why do we as resource managers need it?

S24-6

Community fisheries in the Maritimes: Mi'kmaq First Nations and fishery management

Tony Charles[1] (presenting). [1]Management Science / Environmental Studies, Saint Mary's University, Nova Scotia, Canada

Mi'kmaq communities in the Canadian Maritimes have faced major opportunities and challenges relating to their fishing activity over the past decade, particularly in light of the Supreme Court's Marshall Decision and subsequent changes in how the fisheries are utilized and managed. This presentation reviews those changes and focuses on several specific cases of Mi'kmaq First Nations involved in fisheries. These communities – Acadia, Bear River, Lennox Island and Abegweit – have each taken their own path to building fishery involvement. They also are all participating in the Coastal CURA, a research and capacity building partnership of First Nations community-based fishery organizations and universities (www.coastalcura.ca). This participation is among the mechanisms that have helped to forge crucial links with non-aboriginal fishers and to develop the capability to address broader fishery management and policy issues.

S24-7

Aboriginal fisheries management in PEI, Canada: a tale of two regimes

Randy Angus[1] (presenting). [1]Integrated Resource Management, PEI, Canada

After the Marshall decision, the PEI First Nations sought to advance their participation in the livelihood fishery. However, the two

First Nations, Lennox Island and Abegweit, took a different approach to the development of their fishery management regimes. In the evolution of the development of the communal fishery, thetwo communities undertook a long-term planning process within their communities to determine the communities' visions for their fishery, and to develop Band-level management systems. Two systems developed, both successful in their overall approach. A review of these systems, and the continuing evolution of them, are presented.

S24-8

Distinguishing between owners and users: social identity in Kwakwaka'wakw clam management

Robyn Heaslip[1] (presenting), Evelyn Pinkerton[1]. [1]School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia, Canada

Recent decisions in Aboriginal law and the introduction of a treaty negotiation process in British Columbia have created avenues for First Nations and Canadian governments to work towards fisheries co-management. Co-management theory predicts co-management will be more successful where pre-existing indigenous institutions are articulated and incorporated. In this case study of Kwakwaka'wakw clam management, social identity acts as a basis for distinguishing between those with access rights to clam beaches in a given area (users) and those who hold management and exclusion rights (owners). Individuals hold many different social identities or affiliations with tribes, namima (clans), and families. However, the nature and sources of social identity have been impacted by the local historical context of colonialism including: prohibition on potlatching, imposition of Indian Band structures, residential schools, and centralization policies. Today treaty negotiations reinforce band membership as the social identity that is most salient in the eyes of the state and of governance structures set up under the Indian Act, affecting perceptions of identity both within communities and in Canadian society at large. Through their impact on concepts of social identity, both historical colonial polices and today's self-government initiatives create challenges and dilemmas for re-conceptualizing indigenous management institutions for co-management today. One of these challenges is establishing a new basis for distinguishing between dominant and secondary social identities.

S24-9

Changing skies: tribal governments, collaborative agreements and climate change

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This article overviews the history of intergovernmental agreements with Tribes in the U.S. to identify key factors in management relationships. It explores the political and institutional relationships between Tribes and other governments and the issues that arise from local practices and indigenous knowledge in juxtaposition with scientific inquiry as it is practiced and applied in external governmental institutions. The main focus of the paper moves into changes in those relationships and the exchange of knowledge under the skies of impending and existing climate change as the paper seeks to uncover factors that may be critical in future collaborative and co-management agreements.

S24-10

Synopsis of a thirteen year community based harvest monitoring program in the Mackenzie Delta, Northwest Territories; management of a Dolly Varden (*Salvelinus malma*) fishery in a changing environment

Steve Sandstrom[1] (presenting), Robert Charlie[2], John Carmichael[3], Lois Hardwood[4]. [1]Private Consultant, Port Sydney, ON, Canada, [2]Renewable Resource Board, Inuvik, NT, Canada, [3]Rat River Charr Monitoring Program, Aklavik, NT, Canada, [4]Fisheries & Oceans Canada, Yellowknife, NT, Canada

Anadromous Dolly Varden charr (*Salvelinus malma*) of the Rat River provide an important subsistence fishery for residents of two communities in the western Mackenzie Delta, Northwest Territories. Fishers from two adjacent land claim groups, the Gwich'in and the Inuvialuit, harvest Dolly Varden from this stock along the Beaufort coast during the summer, and later in the season, within the channels of the Delta, as the fish move upstream to the headwater spawning and overwintering site. Prompted by growing concerns about the status and health of the stock, a community-based Fishing Plan, and a research and monitoring program prescribed by that Plan, were put in place by the residents of Fort McPherson and Aklavik, the Gwich'in Renewable Resources Board (GRRB), the Fisheries Joint Management Committee (FJMC) and Canada's Department of Fisheries and Oceans (DFO). The program has continued annually since its inception in 1995, and consists of[1] extensive sampling of fish taken in the subsistence harvest by local fishers, and[2] periodic scientific assessment at the spawning/overwintering site. The combination of these two components, along with the full participation of fishers, has facilitated assessment of trends in the stock. Results from this program suggest that recent declines in stock size could be linked to climate warming trends in this region, as opposed to being a direct consequence of the subsistence fishery.

S24-11

"Better off if they never saw a fish": the treatment of Aboriginal people in the development of Canadian fishery policy in the Great Lakes

Victor Lytwyn[1] (presenting). [1]Historical and Geographical Consulting, Orangeville, Ontario, Canada

Since the establishment of Canadian fishery legislation affecting the Great Lakes in 1857, Aboriginal people have been marginalized in the fishing industry. William Gibbard, the first fishery overseer to patrol the upper Great Lakes, set out systematically to deprive Aboriginal people of their fisheries. He saw Aboriginal people as an impediment to progress in the fishing industry, and observed that they would be "better off if they never saw a fish." Gibbard's views echoed those held by senior bureaucrats in the Fishery Department, and policies were put in place that limited the participation of Aboriginal people in the Great Lakes fisheries. Despite promises made in treaties that protected Aboriginal fishing rights, the government simply ignored them and instead imposed harsh penalties against Aboriginal people. This paper will trace the development of Canadian fishery policy in the Great Lakes and discuss the impact on Aboriginal people.

S24-12
Strategic directions for a rights based fishery
Chief Isadore Day[1] (presenting). [1]Serpent River First Nation, Ontario, Canada

From time immemorial the First Nation communities along the North Shore of Lake Huron have profited from the rich fisheries in this area. Fishing was one of the most important aspects of their economic strategy, and was also an important cultural and spiritual activity. The right to fish has never been surrendered and was in fact upheld by the Robinson Huron Treaty. The Sparrow decision of 1986 and the Agawa decision in 1988 further reinforced the rights based agenda of the North Shore Fishery. The Anishinabek North Channel Fisheries Authority project was initiated in mid 2007 to focus on development of a rights-based fishery initiative to self govern fisheries in the North Shore area of Lake Huron. The project, while still in its infancy, has developed some essential principles which include a basis in Anishinabek law, an emphasis on the rights and responsibilities of the first nation communities involved, and a focus on policy development with culturally appropriate enforcement mechanisms. Subsistence, recreational, commercial and ceremonial fisheries are being included as part of this process. A fisheries model is being developed which will include a scientific component as well as a focus on indigenous knowledge, education, communication and administration. Future work will focus on the development of data sharing and licensing agreements and methods, sharing of oral history/indigenous knowledge, and discussion about how to protect the intellectual property rights associated with the sharing of such knowledge.

S24-13
The Saugeen-Ojibway Commercial Fishing Agreement - History & Challenges
David Latremouille[1] (presenting). [1]Saugeen First Nation, Ontario, Canada

The Saugeen-Ojibway are comprised of two aboriginal bands: the Chippewas of Saugeen and the Chippewas of Nawash, both of which are signatories to a commercial fishing agreement with the Ontario Ministry of Natural Resources. The commercial fishing agreement stems from the Fairgrieve decision in the 1990's stating that the "Saugeen-Ojibway have a collective ancestral right to fish for commerce and sustenance purposes in their traditional fishing grounds". The commercial fishing agreement serves to allow the Saugeen-Ojibway to monitor and manage their fisheries resources in a scientifically defensible fashion. This agreement was implemented in 1994 and has posed a variety of problems and issues for all parties involved.

S24-14
Nipissing First Nation and Lake Nipissing: Building and managing a modern commercial fishery
Richard Rowe[1] (presenting). [1]Natural Resources Department, Nipissing First Nation, Ontario, Canada

Nipissing First Nation has had a commercial fishery on Lake Nipissing, a large (87,400 ha) mesotrophic lake in north-eastern Ontario, since time immemorial. The walleye population of Lake Nipissing is fished heavily by anglers as well as Nipissing First Nation (NFN). Attempts by the Ontario government to reach a fishing agreement with Nipissing First Nation have been rejected for a variety of reasons; but mainly because of the one-sided, intrusive nature of these proposals to date. In 2004, Nipissing First Nation (NFN) decided to take a unique approach to fisheries management that does not involve a formal agreement with the Province. Because of environmental changes, a stressed walleye population and heavy use of the resource, NFN began to implement a formal fisheries management program for its commercial fishery. Formal fisheries management includes a fisheries law with commercial fishing regulations that are administered by NFN's fledgling fisheries department. While many aspects of NFN's commercial fisheries management are conventional such as index netting, quota-setting and daily catch reporting, innovative approaches are being used to assure a sustainable fishery with maximum compliance, autonomy and profitability. While autonomous sustainable management and modernization of the commercial fishery are very much a work in progress, Nipissing First Nation is inching closer to realizing its vision of a healthy Lake Nipissing, fished proudly and profitably by Nipissing First Nation fishermen, who are respected by all surrounding communities.

S24-15
Update on Wisconsin 1837 and 1842 Ceded Territory Inland Fisheries
Mark Luehring[1] (presenting), Neil Kmiecik[1], Joe Dan Rose[1]. [1]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI,

United States

Questions regarding the ceded territory walleye populations caused considerable social unrest and controversy in the 1980s. The need for more complete information on the status of the walleye resource and the impact of angling and spearing became apparent. In 1990, a federal/tribal/state committee known as the Joint Assessment Steering Committee was established to provide an assessment of the status of northern Wisconsin's fishery. Specifically, the committee was directed to determine whether the tribal off-reservation treaty harvest was depleting walleye population and to provide information on the current health of the walleye fishery. Chippewa spearing has not harmed the walleye resource, and the fish populations in the ceded territory are healthy. However, the fishery still sees extensive pressure through combined effects of angling, tribal spearing, and habitat degradation. Therefore, continued assessment and development of a current, comprehensive database on walleye in northern Wisconsin lakes is clearly needed. Annual population surveys continue to be performed in cooperation by the Great Lakes Indian Fish and Wildlife Commission, the U.S. Fish and Wildlife Service, the Wisconsin Department of Natural Resources, the Sokaogon Band of Chippewa, and the St. Croix Band of Chippewa. Update reports on the work of the Joint Assessment Committee are published and released to keep the public apprised of the findings of the joint effort. By sharing the burden of data collection, the cooperating agencies have been able to build a considerable data bank on northern Wisconsin's walleyes.

S24-16
Tribal Nmé (sturgeon) Stewardship in the Big Manistee River, MI and the establishment of streamside rearing for lake sturgeon
J. Marty Holtgren[1] (presenting), Stephanie Ogren[1]. [1]Little River Band of Ottawa Indians, Manistee, MI, United States

Although lake sturgeon were once abundant in the Big Manistee River, MI the population is now only a fraction of its former size. In 2002, the Little River Band of Ottawa Indians implemented a strategy to manage the population through the use of a stewardship plan. The Tribally authorized plan, "Nmé Stewardship Plan for the Manistee River and 1836 Reservation" used both cultural and biological criteria for establishing goals for restoration. A cultural context group consisting of Tribal members and Tribal government staff was formed to develop the plan. A primary goal of the plan was to restore the harmony and connectivity between Nmé and the Anishinaabe and bring them both back to the river. The plan advocated for research and restoration activities of Nmé. After three years of research that defined the biological attributes of the Manistee River population we implemented strategies for restoration. The first was a large-scale effort of improving habitat for sturgeon within the watershed, specifically minimizing the input of sand into the river. Secondly, the first portable streamside rearing facility for sturgeon was designed and operated for lake sturgeon. This presentation will detail the development of the Little River Band stewardship plan and the implementation of strategies for sturgeon restoration.

S24-17
Knowledge acquisition about mature lake sturgeon (*Acipenser fulvescens*) ecology on Kitigan Zibi Anishinabeg First Nation Community
Andre Dumont[1] (presenting), Linda Dwyer[1]. [1]Kitigan Zibi Anishinabeg First Nation, Quebec, Canada

Lake sturgeon has long been an important food resource for First Nations communities. Unfortunately this fish species have suffer due to human development and is now considered as threatened in our area. In order to better understand the lake sturgeon population which inhabits the Desert river watershed surrounding the territory of Kitigan Zibi Anishinabeg community, we are studying the movement and habitat utilisation of 18 radio tagged lake sturgeons since May 2006. Although this project is on-going, we have already obtained very important observations helping us to develop protection recommendations. Beyond the scientific value, this project achieves the objective of increasing awareness and participation for community members about vulnerable species and sustainable management issues.

S25. Social and Economic Dimensions of Ecosystem-Based Fisheries Management
S25-1
Social science and ecosystem based fisheries management at NOAA: what have we done, where are we going?
Kristy Wallmo[1] (presenting). [1]National Marine Fisheries Service, Silver Spring, MD, United States

Ecosystem management is widely acknowledged as a holistic approach to natural resource management that considers interactions between physical, biological, and human components of an ecosystem as well as one that promotes ecosystem health and sustainability. Although no universal definition of an ecosystem approach to management (EAM) exists, many scientists agree that monitoring and adaptive management, ecological integrity, ecological boundaries, accounting for uncertainty, balancing diverse societal needs, and the consideration of future generations are important principles that EAM should address. The NOAA definition of EAM addresses many of these principles in defining the approach as one that is adaptive, geographically specified, takes into account ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives. This definition implicitly requires a multidisciplinary perspective to guide both the implementation of EAM and the research agenda that will inform decision-making. This paper will explore the use of social science in NOAAs ecosystem management approach, focusing on social science research at NOAA that addresses adaptive management, uncertainty and balancing societal objectives. Current challenges and future directions for incorporating social science research into NOAAs ecosystem approach to fisheries management will be identified and discussed.

S25-2

Incorporating the increasingly important artisanal fishery sector into fishery management

Ayeisha Brinson[1] (presenting), David Die[1]. [1]University of Miami/RSMAS, Miami, FL, United States

Artisanal or small-scale fisheries are found throughout the world in both developed and developing countries. These fishers have very different motivations and behaviors than recreational or industrial fishers. They are not necessarily motivated to maximize their revenues or catch the largest fish. Instead, artisanal fishers may fish to maintain their cultural identity or to maintain their independence. Artisanal fishes may be vulnerable to poverty and subjected to high risk in the fishing sector. Decision makers need to incorporate the artisanal sector into formal fishery management for a variety of reasons. Artisanal fisheries may be increasingly important in the future as fishery resources are depleted and fishers' actions are constrained by the inherent uncertainty of fishery populations. Traditionally artisanal and industrial fishers had complex competition. As artisanal fishers begin to exploit highly-valued species, e.g. billfish there may be increasing competition between the artisanal and recreational sectors. Fishery management should account for these fisheries and work towards increasing the resilience of both the fish populations and fishers who exploit the resource. If fishers' resilience is increased and their vulnerability to poverty is decreased, then there may be a reduced impact on fishery resources.

S25-3

New directions in the management of Commercial fisheries: Changes occurring in the NE USA

Barbara Rountree[1] (presenting). [1]USDOC/NOAA, Woods Hole, MA, United States

Inappropriate incentive structure under open access fisheries management has produced complex layers of regulation that, in many cases, are not effective from a conservation perspective, and virtually never effective from an economic perspective. Traditional management regulations have addressed economic incentives that result in inefficient exploitation and frequently over-exploitation of the resource. One emerging trend is the introduction of ecosystem based management to better address resource sustainability. Another is the growing interest in collaborative approaches to management which provide greater opportunities for stakeholder groups to participate in the process. The use of limited access privilege programs (LAPPs) offers both incentive for collaborative management while also addressing economic incentives. Examples are presented of commercial fisheries off the Northeast coast of the U.S. in which collaborative management has been successful. The application of LAPPs in two of these fisheries (the surfclam/ocean quahog fishery, and the tilefish fishery) are highlighted and discussed.

S25-4

Recreational fishing and tourism a changing landscape

Eric May[1] (presenting). [1]University of Maryland Eastern Shore, Princess Anne MD, United States

Tourism represents one of the most significant components of the nation's economy, especially in estuaries along the Atlantic Coast. Historically, many of the communities began as fishing villages, and supported a robust recreational and commercial fishery. As the area developed the demand for recreational fishing appears to have declined. Ocean City is one such community, where with intense development has came a decline in the demand for and use of recreational fishing facilities. Since 2004 the Maryland Department of Natural Resources and the University of Maryland Eastern Shore have been conducting surveys of the recreational angling public, the results of these studies suggest that the typical angler is middle aged, white, and depending on the nature of the recreational angling has a high school degree (shore based angling), or a bachelors degree (boat based angling either in the Maryland Coastal Bays or for the off shore billfish and tuna fishing). Previous studies in the area have suggested that recreational fishing is important to the local economy, however surveys of tourists coming to the region suggests otherwise with over 90% of the tourists not interested in fishing as part of their stay and none coming to the region for fishing alone. Is then the landscape changing for recreational fishing? This paper explores the Ocean City situation with other communities along the Atlantic and Pacific coasts to determine if there are similar patterns that have evolved, and what it may mean to the future of recreational angling and to resource agencies that will have to adapt to the new situations.

S25-5

Facing the climate future in Arctic Alaskan fisheries

David Fluharty[1] (presenting). [1]University of Washington, Seattle, Washington, United States

The Bering Sea and increasing the Arctic Ocean and their marine living resources appear to be undergoing more rapid change than most other regions. Human uses in these arctic seas are also undergoing considerable stresses ranging from changes in the subsistence hunt for marine mammals to the large scale fisheries for pollock. The Alaskan arctic ecosystem presents an opportunity to examine climate impacts and responses on living marine resources and their management. Management institutions at the federal and state level are developing proactive management strategies to mitigate impacts of management actions under high levels of uncertainty. Preliminary analysis shows the potential for significant social and economic impact. However, management institutions appear to have a robust ability to respond in ways supported by multiple stakeholder interests.

S25-6

The role of fisheries heritage in historical ecology: a case study from the Albemarle Sound Region, North Carolina

Anne Garland[1] (presenting). [1]University of Maryland Eastern Shore Living Marine Resources Cooperative Science Center, Princess Anne Maryland, United States

Historical Ecology provides for long -term understanding of the interplay between humans and their environment. Ecological change can inform decisions we make about the future. Archaeology and history record human response in which environmental change can be understood. As social, physical and natural scientists share concepts, they can effectively address environmental change. Local information about changes in the environment, culture, and history can serve as a basis for public policy which can assist in specific solutions. Community stakeholders work, as part of the integrated team, to plan, develop and implement shared concepts. This paper focuses on fisheries heritage about the socio-natural systems of the Albemarle Sound through historical documentation and oral history. Oral history about socio-natural conditions are from interviews of fishermen in the Albemarle Sound. This preliminary study demonstrates historical and archaeological sources, which are potentially available in the Albemarle region, to assist community policy within a changing landscape. Urban development along the vast waterways and wetlands has progressed rapidly in the last decade with rising waterfront property values. This is replacing past emphases on farming and wetland conversions. With the funding of historical ecology about the Albemarle Sound, the rich heritage of this region can better inform policy about its altered socio-natural systems and how to better plan for affects on fisheries management.

S25-7

The evolution of fisheries values from marine ecosystems of the U.S.

Ussif Rashid Sumaila[1] (presenting), Jackie Alder[1], Gakushi Ishimura[1], William Cheung[1], Lisa Dropkin[2].
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We provide an estimate of the value of the commercial, recreational and non-market values derived from the marine ecosystems of the United States. That is, the part of the large marine ecosystems within the country's EEZ adjacent to contiguous USA and Alaska. Particular attention is given to ocean bottom habitat (for example, seamounts and deepwater corals). We determine a measure of 'worth' useful to regulators, the scientific community, civil society and other interested parties. The ultimate goal is to provide scientific information to assist society in evaluating the ecological, economic and social tradeoffs and consequences under different policy scenarios, by identifying the flow of existing and potential values provided by US marine ecosystems.

<u>S26. Fisheries Management for Ecosystem Health</u>

S26-1

Metrics of ecosystem health: comparing the African and Laurentian Great Lakes

Norine Dobiesz[1] (presenting), Robert Hecky[1]. [1]University of Minnesota Duluth, Duluth, MN, United States

Management and research objectives of the Great Lakes Fishery Commission are guided by three vision statements. One vision statement identifies the need for healthy great lakes ecosystems but does not define what constitutes a healthy ecosystem or describe how it might be measured. Evaluating the success of initiatives supporting this objective requires a method to assess the state of health of ecosystems. To address this need, a sequence of four workshops is under way, bringing together experts on large lakes and inland seas, to identify quantitative indicators of ecosystem health. The ecosystems being evaluated include five Laurentian Great Lakes (Superior, Huron, Michigan, Erie, Ontario), three African Great Lakes (Victoria, Tanganyika, Malawi), and the Baltic Sea. These ecosystems are similar in size and complexity and experience a range of environmental stresses. During the first workshop we identified four categories of metrics: trophic structure, exploited species, habitat alternation, and catchment changes. Here we describe the metrics used and compare them across ecosystems, then show how the trends document changes in ecosystem health. Based on these trends, systems experiencing the least amount of change were Lake Superior and Lake Tanganyika while Lake Victoria, Lake Ontario, and the Baltic Sea experienced almost three times more change.

S26-2

The small scale perspective: Value, resilience, fishing patterns, and the need for open access

Jeppe Kolding[1] (presenting), Paul van Zwieten[2]. [1]University of Bergen, N-5020 Bergen, Norway, [2]University of Wageningen, 6700AH Wageningen, Netherlands

Inland fisheries in Africa (and many small-scale fisheries in general) are the 'social security system' - a common good. They often serve as the 'last resort' when everything else fails, and for this they have been seriously undervalued. In spite of common belief, the non regulated, non-selective, adaptive fishing patterns are healthier and far more ecosystem conserving than current management strategies. Small scale fisheries, by their nature, are regulated by the natural production and display a high degree of resilience. The immense pressure from outside to adapt to modern management thinking and economic theory will, under present conditions, not only have negative social effects, but also biological.

S26-3

Managing the fisheries of Lake Victoria: How Successful are the Initiatives undertaken by LVFO

Oliva Mkumbo[1] (presenting), Brian Marshall[1], Fiona Nunan[1], Levi Muhoozi[2], Taabu Munyaho[2], Robert Kayanda[3], Rhoda Tumwebaze[4], Albert Getabu[5]. [1]Lake Victoria Fisheries Organization, Jinja, Uganda, [2]National Fisheries Resources Research Institute, Jinja, Uganda,Tanzania Fisheries Research Institute, Mwanza, Tanzania, [3]United Republic of,[4]Department of Fisheries Resources, Entebe, Uganda, [5]Kenya Marine Fisheries Research Institute, Kisumu, Kenya

Lake Victoria supports the world's largest inland fishery with an annual catch of nearly one million metric tonnes, which generates more than US$ 600 million per year including US$ 340 million earned through exports that contribute almost 3% of the total GDP of the riparian countries. About 30 million people now earn their living from the fisheries and ancillary industries. The three important commercial species, the introduced Nile perch (Lates niloticus) and Nile tilapia (Oreochromis niloticus) and the endemic small pelagic (Rastrineobola argentea) are heavily exploited, while major changes to the ecosystem raise concerns about their sustainability. The demise of the fisheries would have lead to extensive social and economic disruption in the region and possibly cause irreversible damage to the ecosystem. The Nile perch stock in particular exhibit clear signs of overexploitation and a number of measures are being recommended by the Lake Victoria Fisheries Organization to ensure their sustainability along with the socio-economic benefits and the health of the ecosystem. This paper outlines causes and impacts of fishing pressure and the changes to the ecosystem as well as the institutional structures for managing the fisheries. These include a shift from a top-down command and control structure to a bottom-up co-management approach with all key stakeholders involved in the process. The successes and challenges of this management system are also discussed.

S26-4

How relevant is the resilient concept to the management of fisheries resources in Malawi Lakes?

Daniel Jamu[1] (presenting), Friday Njaya[2]. [1]WorldFish Center, Zomba, Malawi, [2]Malawi Department of Fisheries, Mangochi, Malawi

This paper reviews status of Malawi's lake fisheries and outlines key management challenges that are being faced by both the Department of Fisheries and resource users in the country. Specific examples of the management challenges and approaches to address them are drawn from Lakes Malombe and Malawi (south east and south west arms). The policy goal for fisheries management in Malawi is to attain maximum sustainable yield. To achieve this policy goal, the Department of Fisheries is mandated to regulate exploitation of the fisheries resources in partnership with the resource users under different forms of co-management arrangements. This paper asserts that current management approaches have failed to deliver and sustain livelihood and economic benefits of the fishery to the people. Catches have stagnated, and the tilapia fisheries are either threatened or have collapsed. The paper proposes that a new management approach centered on the resilience concept can be more successful in preventing Malawi's lake fisheries from further collapse and failure to deliver benefits by nurturing and preserving features that enable it to renew and reorganize itself.

S26-5

Fisheries management in ecosystem restoration – experiences from stocking and intensified fishing in Finnish lakes

Jouko Sarvala[1] (presenting). [1]University of Turku, Turku, Finland

Species introductions and stocking of native species have been common fisheries management measures in Finland. In anthropogenically modified watercourses, fish stocking has been done to compensate for catch losses. More recently, stocking of piscivorous fish and/or intensified fishery has been used in eutrophicated lakes for improving the water quality. Here I review some case studies from Finnish lakes, in which either fish stocking or intensified fishing, or both, have been used for restoring ecosystem health. In Lake Pyhäjärvi the commercial fish catches mostly consist of whitefish and vendace, both species initially introduced but now self-sustaining. As an efficient planktivore, vendace controls the water quality, but fishery keeps its biomass low, minimizing the adverse effects. In the 1990s, vendace stock declined, other fish species increased, and water quality deteriorated. Intensified removal of coarse fish enhanced vendace recovery and improved water quality. The annual trout stocking is controversial because at high levels it can harm vendace recruitment. A sustainable commercial fishery, based on a vendace-dominated pelagic fish community, is the key element in maintaining the balance between the fish populations and water quality in Pyhäjärvi. In the heavily eutrophicated lake Köyliönjärvi, mass removal of unwanted fish and stocking of pikeperch was performed in order to improve water quality. Food consumption of the present pikeperch population was found insufficient to control the prey fish. In Lake Vesijärvi, mass removal of roach and smelt and simultaneous stocking of pikeperch reduced roach, improved water quality, and resulted in a reproducing pikeperch stock. In Lake Inari, whitefish and salmonid piscivores have been stocked as a compensation for water level regulation. Owing to the abundance of prey fish (vendace), high piscivore stocking rates in the 1980s resulted in a flourishing recreational fishery, but later the prey fish populations were reduced, and the stocked trout exhibited poor

growth and survival. Following the suggestions derived from a multispecies fish stock model, the stocking rules have been recently amended to allow better balance between piscivore and planktivore stocks.

S26-6

Fisheries management in the Great Lakes – what is it that we manage?

Tim Johnson[1] (presenting), David Bunnell[2]. [1]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, Ontario, Canada, [2]United States Geological Survey, Great Lakes Science Center, Ann Arbor, Michigan, United States

The fisheries of the Laurentian Great Lakes are a reflection of their physical, chemical, and biological makeup as well as the deep cultural and social roots that shape expectations and influence management actions. The fisheries have undergone broad shifts in design, species composition, and yield in response to changes in technology, social economics, and ecology. In general, fisheries management strives to maximise yield of desired stocks either through regulation of exploitation or improving recruitment to the fishery. While this objective remains largely unchanged, today's fishery managers are required to consider a much more holistic view of the ecosystem. We will briefly review past and current examples of Great Lakes fisheries, describing the rationale for action, the points of view considered, and the approach taken to reach a desired endpoint. We will illustrate how expectations are becoming increasingly specific, and how yields are becoming increasingly uncertain, amidst an increasingly complex ecological and political backdrop. We will demonstrate how fishery managers are gaining familiarity and expertise in a wide variety of disciplines such as modelling, habitat analysis, limnology, foraging theory, and epidemiology. We will close our discussion with a comment on the probable future environment that a fishery manager will occupy.

S26-7

Managing Lake Ontario fish communities and fisheries in a changing ecosystem: lessons learned and new challenges

Tom Stewart[1] (presenting), Steve Lapan[2], Gavin Christie[1]. [1]Ontario Ministry of Natural Resources, Picton, Ontario, Canada, [2]New York State Department of Environmental Conservation, Cape Vincent, New York, United States

We present a conceptual model of a science-based management decision process and use it as a framework to illustrate the challenges to managing the Lake Ontario fish community and fisheries. Major challenges to effective management are uncertainty in all aspects of the management process, rapid rate of ecological change, and the lack of scientifically defensible end-points describing healthy rehabilitated ecosystems. We present examples from management issues relating to Lake Ontario predator-prey balance, cormorants, eels, native fish, lamprey control, and commercial fisheries to illustrate our contentions and make recommendations to improve our science and management decision making.

S26-8

Percid management in Lake Erie: successes and the future

Jeffrey Tyson[1] (presenting), Roger Knight[1]. [1]Ohio Department of Natura Resouces, Division of Wildlife, Sandusky, Ohio, United States

Walleye and yellow perch in Lake Erie have both gone through periods of declining abundance. For walleye, the most recent declines in abundance have occurred from the 1980s through the late 1990s. For yellow perch, the most recent declines in abundance occurred from the 1980s through the early 1990s. In response to these declines, the four state and one provincial fisheries management agencies responsible for management on Lake Erie developed harvest strategies that revolved around quota management. These actions have promoted recovery of the percid populations in Lake Erie. In spite of state and provincial authority over fisheries management issues in Lake Erie, agencies adopted many fisheries management policies that mirror components of Magnuson-Stevens Fisheries Conservation Act. These components include management based on sound science, development of fisheries management plans, and mechanisms for promoting stock rebuilding. In the future, Lake Erie fisheries management agencies are considering alternatives for incorporation of ecosystem, socio-economic, and other considerations into fisheries management policy decisions.

S26-9

Exploring fishery management adaptations to a changing food web: the case of yellow perch in Lake Michigan

John Dettmers[1] (presenting), Brian Breidert[2], David Clapp[3], Pradeep Hirethota[4], Dan Makauskas[5]. [1]Great Lakes Fishery Commission, Ann Arbor, United States, [2]Indiana Department of Natural Resources, Michigan City, United States, [3]Michigan Department of Natural Resources, Charlevoix, United States, [4]Wisconsin Department of Natural Resources, Milwaukee, United States, [5]Illinois Department of Natural Resources, Des Plaines, United States

During the past 20 years, the Lake Michigan ecosystem has been changing, in part due to the invasion of dreissenid mussels and round goby (*Apollonia melanostoma*). Recruitment of yellow perch (*Perca flavescens*) declined precipitously during the 1990s in southern Lake Michigan, due in part to reduced zooplankton availability for early life stages of yellow perch. At the same time, harvest of yellow perch was high, leaving few adult females available for spawning. By 1997, managers reduced harvest of yellow

perch by implementing coordinated regulations across jurisdictions. These regulations included drastically reduced commercial harvest and limited sport harvest. This action allowed adult females to accrue to the population, such that by the early 2000s at least two stronger year-classes were produced. With continued judicious regulation of adult yellow perch harvest, adult females represent a considerable component of the adult population and measurable year-classes of yellow perch are occurring regularly. These coordinated management actions contributed to a very popular sport fishery that regularly catches yellow perch > 250 mm TL. Judicious management of harvest in the face of a changing ecosystem has set the stage for recovery of yellow perch in southern Lake Michigan and helped maintain a popular sport fishery.

S26-10

Walleye recovery in Saginaw Bay, Lake Huron as a function of ecosystem level changes

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Walleye were historically the dominant predator in Saginaw Bay's ecosystem, but collapsed during the mid-Twentieth Century. After the passage of the Clean Water Act in 1972, and implementation of a walleye fingerling stocking program, a population and sport fishery re-emerged by the mid 1980s. The emerging population however was largely hatchery dependent. Research suggested that natural reproduction and full recovery were limited by the availability of quality spawning habitat and predation by invasive alewives on larval walleyes. A recovery plan was developed and, among other things, called for increased stocking to elevate predation pressure on alewives. It was believed that high adult walleye densities could achieve a cultivation effect by suppressing alewives locally and benefiting their own reproductive success. Walleye recovery was sought also as a means to restore balance in Saginaw Bay's prey heavy/predator light ecosystem with an eye towards also benefiting other species such as yellow perch. Although stocking rates were increased, alewives collapsed in Lake Huron in 2003 due to profound food web changes probably stemming from dreissenid colonization of the lake. Alewife scarcity, along with some ideal spring climatic conditions, lead to an immediate explosion of walleye reproduction that same year and each year since. Strong year classes have resulted in substantial increases in abundance and sport fishery catch rates. Although the recovery plan correctly predicted the need for alewife suppression, it was achieved by ecosystem level changes that were not necessarily a direct function of management activities. Stocking has been discontinued, contingent on alewives remaining scarce. The prey base has predictably declined but an unintended consequence is that yellow perch survival has also greatly declined apparently as a result of increased predation pressure. As we approach full walleye recovery in the bay, new challenges now face fishery managers including growing demands for a commercial fishery, and increased by-catch mortality in the existing commercial fishery for other species. Walleye recovery in Saginaw Bay may have consequences for the fish community and ecosystem of the main basin of Lake Huron as well. Although walleye recovery in Saginaw Bay is a success story, its staying power will likely hinge on the future of alewives in the lake and bay.

S26-11

A perspective on lake trout in Oligotrophic lakes of North America: restoration in the Laurentian Great Lakes versus suppression in western lakes

Michael Hansen[1] (presenting), Ned Horner[2]. [1]University of Wisconsin - Stevens Point, Stevens Point, WI, United States, [2]Idaho Department of Fish & Game, Coeur d'Alene, ID, United States

Lake trout (*Salvelinus namaycush*) predominate in most lakes of northern North America and have been widely introduced elsewhere. In the Laurentian Great Lakes, lake trout were driven to near extinction through over-fishing, sea lamprey predation, and habitat degradation, but restoration of self-sustaining populations has been difficult despite large-scale stocking, restraints on fisheries, and habitat remediation. Lake trout have only been restored to self-sustaining status in Lake Superior and isolated areas of Lake Huron. Elsewhere in the basin, juvenile lake trout appear to originate from successful spawning, but stocks are still not self-sustaining. In contrast, in western lakes, lake trout reproduced widely after initial introductions in the late 1800s and early 1900s, increased dramatically after *Mysis relicta* were introduced and provided an abundant prey supply for juvenile lake trout that were previously prey limited. Lake trout spawn on abundant inshore habitat, so overwhelm fish communities that rely on adfluvial spawning. Consequently, lake trout now threaten populations of native bull trout and rainbow trout, and introduced populations of kokanee. Distribution of suitable inshore spawning habitat at least partly explains why lake trout reproduced widely in western lakes and some areas of Lake Superior, but failed to reproduce in other areas of the Great Lakes. Suppression of lake trout is now being pursued or considered in several western lakes, including Lake Pend Oreille, Idaho, where suppression is being pursued through purposeful over-fishing by contracted commercial fishing (trap nets and gill nets) and bounties for anglers. Prior to lake trout suppression on Lake Pend Oreille (1999-2005), the lake trout population increased exponentially 63% per year. During the first two years of the suppression program, the lake trout population declined 39% in 2006 and 43% in 2007. Simulation modelling suggests that the lake trout population can be suppressed to non-deleterious levels within a decade. Suppression will be more likely if both gillnetting and angling are employed. Unfortunately, suppression of lake trout may be too late to save kokanee, which declined to their lowest level on record in 2007. In contrast, bull trout will likely recover to levels where harvest can be considered. If undertaken in time, lake trout suppression may be successful for saving native species in lakes of western North America.

S26-12

The impact of sea lamprey (*Petromyzon marinus*) management on the structure of the Great Lakes fish community

Robert Young[1] (presenting), Paul Sullivan[1], Dennis Lavis[3], Terry Morse[2], Todd Steeves[1]. [1]Fisheries and Oceans Canada, Sault Ste Marie, ON, Canada, [2]US Fish and Wildlife Service, Marquette, MI, United States, [3]US Fish and Wildlife Service, Ludington, MI, United States

The Great Lakes fish community and its productivity have been significantly impacted by more than 160 invasive species. The invasion of sea lamprey (*Petromyzon marinus*) and the combined effect of high fishing rates extirpated or significantly reduced piscivores such as lake trout (*Salvenlinus mamycush*) in the Great Lakes, causing the fish community to switch from a piscivore controlled community to one dominated by non-native planktivores. Using a case history approach, we examine the impact of the sea lamprey control program has had on the rehabilitation of lake trout and other predators in the Great Lakes. Lake trout are classified as restored in Lake Superior and parts of Georgian Bay because of an integrated program of sea lamprey management, stocking and harvest management. A decrease in sea lamprey production due to a control program in the St. Marys River has resulted in significant decreases in lake trout wounding and mortality as well as increases in size and age structure of lake trout in Lake Huron. Sea lamprey control in lakes Erie and Ontario contribute to the reestablishment of lake trout and other salmonids. We also examine the unintended impacts of the lampricide control and barrier programs on burbot (*Lota lota*), native lampreys and stream fish communities.

S26-13

Magnitude of biomass response to experimental cormorant control versus regime shift in coastal fish of Lake Huron

Mark Ridgway[1] (presenting), Scott Milne[2], John Casselman[1]. [1]Ontario Ministry of Natural Resources, Peterborough, Canada, [2]Milne Technologies, Peterborough, Canada

The biomass structure and distribution of fish in the Laurentian Great Lakes shift from one state to another depending on introductions (invasions and stocking), community interactions and climatic conditions. An observer may be forgiven for assuming that the trajectory of fish and fisheries is 'one long experiment' with 'manipulations' occurring at fairly regular intervals. In this study, we describe the outcome of a large-scale cormorant egg-oiling experiment in the North Channel and Georgian Bay that reveals the productive capacity of nearshore fish biomass. We compare this outcome with a regime shift in pelagic fish biomass that occurred in the same area of the experimental work while the egg-oiling was underway. Fish biomass increased nearshore (< 5m) in response to egg-oiling at approximately 5 kg/ha in the North Channel and 2 kg/ha in Georgian Bay. The shift in pelagic fish biomass was based on the disappearance of alewife and replacement with cisco among other species. The magnitude of this change was much greater and occurred over a similar time frame as the biomass change nearshore. Combined, the cormorant egg-oiling experiment was the largest designed experiment in the Great Lakes while the regime shift was one of the most dramatic detected in the Great Lakes. The results provide an interesting comparison of change in biomass with one brought about directly through management actions (cormorant egg-oiling) while the other brought about by climatic conditions (severe winter) interacting with management actions (salmonid stocking).

S26-14

When habitat improvement, fisheries management and infrastructure collide: challenges to Great Lakes ecosystem protection

Phil Moy[1] (presenting). [1]University of Wisconsin Sea Grant Institute, Manitowoc, WI, United States

Constructed in 1910, the Chicago Sanitary and Ship Canal forms an aquatic link between the Great Lakes and the Mississippi River drainage. Today the canal is an important navigation corridor and carries waste and storm water away from Lake Michigan, Chicago's source of drinking water. Historically, sewage and later chlorinated effluent formed an effective barrier for the movement of aquatic organisms through this man-made corridor. Improvements in water quality since 1985 have allowed tolerant species of fish to recolonize formerly depauperate sections of the canal, yet summer high temperatures (39 ºC) and low dissolved oxygen concentrations (0 mg/l) still impact the fish community. The micro-pulsed, DC electric barrier constructed in 2002 to deter the movement of fishes between the Great Lakes and Mississippi River basins is effective in deterring fish but poses some safety and maintenance concerns and is not effective on all life forms. Separation of the canal from Lake Michigan will provide the surest means of preventing the spread of invasive aquatic species via this pathway. Recent interest in making the Chicago area waterways fishable and swimmable (reduced temperatures, increased dissolved oxygen concentrations and reduced bacterial counts) may be at odds with aquatic invasive species prevention efforts. In this paper I will discuss the current status of the barrier project, potential steps towards improving the effectiveness of the barrier and obstacles posed by existing uses and habitat objectives for the canal.

S26-15

Risk assessment in the management of Species at Risk

Marten Koops[1] (presenting), Antonio Vélez-Espino[1]. [1]Fisheries and Oceans Canada, Burlington, ON, Canada

The recovery of species at risk is intended to protect native biodiversity and ecosystem function. By the time a species is considered at risk, abundance or distribution is severely limited and the potential for loss is considered significant. The management of species at risk may interact with fisheries management, either directly due to a species at risk being a fishery or by-catch species or indirectly if recovery actions impact fisheries activities. Risk assessment has been used in fisheries management to help inform management of the risks associated with exploitation levels and population decline. Risk assessment can also be used to inform management decisions aimed at species conservation. These actions may include control or reduction of stressors, stock enhancement, habitat restoration or protection. Here we present a modelling approach and risk framework for the conservation, protection and restoration of species at risk. The objective of the modelling is to provide guidance on levels of allowable harm and recovery effort given the existing (observed or inferred) demographic condition of a population. The risk framework provides a means to evaluate how alternative management strategies regarding human-induced harm, restoration activities and recovery targets interact to affect the probability of recovering a species. This approach is demonstrated through application to Great Lakes fishes such as lake sturgeon (*Acipenser fulvescens*) and Atlantic salmon (*Salmo salar*).

S26-16
Connections between fisheries management and lower trophic levels in the North American Great Lakes: a review of the evidence.
Lars Rudstam[1] (presenting). [1] Cornell University, Ithaca, NY, United States

Freshwater fisheries in North American Great Lakes are mostly directed towards top predators. Classic cascading trophic interactions predicts that a removal of top predators should result in an increase in planktivore, a decrease in grazing zooplankton, and an increase in phytoplankton. The goal of fisheries management in the Great Lakes is to counteract this removal of top predators and to maintain high predator abundance for restoration, for control of nuisance forage fish (alewife), and for increased fishing opportunities. This is not a simple task. Increased top predators have been implicated as one cause for the collapse of Lake Huron alewife, and if true represents a failure of management to balance supply and demand, possible a failure to account for increasing natural reproduction of Chinook salmon. But the decline of alewife has not resulted in the expected increase in large zooplankton grazers. I will discuss to what degree fisheries management directed at top predators has had an effect on lower trophic levels, from forage fish like alewife and rainbow smelt to mysids, zooplankton, and phytoplankton using data primarily from Lake Ontario and other New York lakes. Alewife has declined in Lake Ontario where the main effect on zooplankton appears to be an increase in predatory invertebrates and subsequent decrease in smaller zooplankton susceptible to predation from these invertebrates. The linkage between planktivorous fish (be it alewife, rainbow smelt, or coregonids) and their zooplankton prey is far from linear and trophic triangles are common. This may prevent trophic interactions from cascading far down the food web. Trophic triangles and how they are affected by oligotrophication and increased water clarity associated with zebra mussel grazing are keys to understanding the coupling between fisheries and management aimed at top predators and the lower trophic levels typically invoked in discussions of ecosystem health.

S26-17
Metrics for ecosystem health: Are subsidized fisheries healthy?
Robert Hecky[1] (presenting). [1]University of Minnesota-Duluth, Duluth, MN, United States

The African Great Lakes have the two most productive lake fisheries in the world and a disproportionate amount of global freshwater ichthyodiversity. They have also warmed over the last century, and at an increasing rate over the last several decades. The consequences of this warming to the fisheries and fauna are uncertain but critical to the riparian people. In deep meromictic, Lake Tanganyika, warming has increased water column stability and decreased vertical mixing thereby reducing nutrient loading to the upper mixed layer. Observations since 1974 and even earlier document decreases in phytoplankton abundance and increase in dissolved Si, both indicative of declining primary productivity with negative implications for the pelagic fishery which accounts for >90% of all landings. However, fishing effort continues to rise and technologies have improved so that landings have increased during the warming period making it difficult to decipher any impact on fish productivity in response to warming. On shallow Lake Victoria, climate warming has been implicated in the eutrophication of the world's largest lake fishery, but increased phosphorus external loading is the direct cause with climate playing a minor role by increasing stability of seasonal stratification and accelerating onset of hypolimnetic deoxygenation.

S26-P-1
Implications of *Clarias gariepinus* (African Catfish) propagation in Cuban waters
Daniel De La Rosa Medero[1] (presenting). [1]Instituto Superior de Tecnologías y Ciencias Aplicadas, Havana, Cyprus

Introduced *Clarias gariepinus* in Cuban waters have contributed to increased aquaculture production, which has had positive economic and social benefits. However, because of its highly predatory nature, omnivoracity and prolificacy, C. gariepinus poses a great threat to native fish fauna, serious changes have occurred to natural food webs and it also has the potential to accumulate mercury (Hg) via biomagnification up the food chain uptu humans in a contaminated region. Our paper intends to introduce some aspects thad had been happened since its introduction in our freswaters systems.

S27. The Future is NOW for Distributed Data and On-Line Collaboration!

S27-1

National fisheries data summit: the next steps

William Fisher[1] (presenting). [1]Oklahoma State University, Stillwater, Oklahoma, United States

In 2006, the National Fisheries Data Summit convened in Salt Lake City, Utah to address topics pertinent to improving fisheries information systems and the ability to share data among organizations and to support the National Fish Habitat Action Plan (NFHAP). Eight-six professionals from state and federal agencies across the United States attended the summit. Participants discussed data and information needed for the NFHAP, data transfer standards, web services, geographic and data scaling issues, and mechanisms to integrate regional information systems. Key themes from the summit were the need to recognize the unique differences and needs of agencies in developing data information systems, the importance of developing sound goals and directions for shared information systems, flexibility for inputting and querying data at different geographic scales, and the need to establish data standards. Responses from participants were evaluated after the summit to outline the next steps needed to successfully integrate state and federal data systems for use in the HFHAP. These steps included: 1) outlining an implementation plan that includes a national coordinator and funding and focuses on a regional approach for the national data sharing; 2) defining a mission statement and best practices to promote data sharing; 3) defining marketing tools tailored to deliver messages to a variety of audiences including administrators, state directors, and other interested parties; 4) defining data standards for georeferencing, measurements, classification and other data system aspects; and 5) outlining model state database structures and associated software that can be used to integrate data for the NFHAP and other joint ventures.

S27-2

Managing water information in a distributed and diverse organizational environment: lessons from Ontario's Water Resources Information Program

James Britton[1] (presenting). [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

Working from a base within the Ontario Ministry of Natural Resources, the mandate of the Water Resources Information Program (WRIP) is to work with a broad range of stakeholders and partners to improve the quality and management of water-related information of interest to the Province. WRIP directly creates or improves data and works to establish and implement procedures to improve data standards, quality, access, distribution and processing methods. Partners include individual units within many Provincial ministries; regional and local governments; conservation and environmental groups; NGOs, federal governments and trans-boundary agencies. Individual partners come from many discipline areas from drinking water safety through wildlife management to drought management. Creating an information management framework within such a diverse and distributed environment has numerous challenges. These include variations in disciplinary and organizational methods, varied technological environments as well as limited resources in many organizations. This presentation discusses the approach taken by WRIP to improve water-related information management in the Province and evaluates which strategies appear to work well and those that fail. Specific focus will include the challenges of linking to specialized scientific disciplines, such as fisheries management.

S27-3

Great Lakes Habitat Initiative – a web-based tool for planning and implementing restoration and conservation projects

Michael Greer[1] (presenting). [1]U.S. Army Corps of Engineers, Buffalo, NY, United States

In March 2006 Mr. John P. Woodley, Jr. the Assistant Secretary of the Army for Civil Works announced the selection of the Great Lakes Habitat Initiative as one of five projects to be funded for analyses of complex water resources issues within large, multijurdictional watersheds. The Great Lakes Habitat Initiative resulted an implementation plan for the protection and restoration of wetlands and aquatic habitat that builds upon the recommendations of the Strategy of the Great Lakes Regional Collaboration released on December 12, 2005. The Great Lakes Regional Collaboration is comprised of representatives from state, local tribal and federal agencies, along with industry, business, and civic groups. To assist in the identification of projects that would bridge the gap between the regional needs identified in the Strategy of the Regional Collaboration and site specific actions that were being proposed we developed a basin-wide project database. In its final form the project database will be a web-based resource for project proponents to seek funding for their project and help resource managers identify already proposed projects that meet their particular needs. In addition Project Characterization Criteria (PCC) were developed to describe the outputs of projects in the database. The PCC is a lexicon of attributes that are used by habitat funding programs, based on feedback from a variety of public and private organizations, to evaluate a project's eligibility, benefits and to ultimately make funding decisions. The PCC are designed to collect information on three different aspects of habitat restoration projects: 1) ecological, 2) social and 3) economic. Each attribute is described or defined and often examples are given to further evaluate how a particular habitat restoration project addresses the attribute. The PCC includes quantitative measures (i.e. acres affected), as well as, qualitative characteristics (i.e. habitat connectivity).

S27-4

The conservation success index: A web-based tool to helpprotect, reconnect, and restore coldwater fisheries habitats

Jack Williams[1] (presenting), Amy Haak[1]. [1]Trout Unlimited, Medford, OR, United States

Native trout, char and salmon face mounting pressures including a growing scarcity of clean water, climate change impacts, broadscale energy development, and invasive species. Many of these species are listed pursuant to the US Endangered Species Act. These coldwater-dependent species also can serve to indicate the condition of broader aquatic communities because of their requirements for high quality water supplies, sensitivity to disturbance, and relatively broad distributions. The Conservation Success Index (CSI; http://tucsi.spatialdynamics.com) is a web-based tool developed to analyze the status of native salmonids and facilitate an improved understanding of broadscale management needs. We emphasize watershed-scale approaches that protect the best remaining habitats, reconnect fragmented stream systems, and restore mainstem and valley bottom habitats. We will describe case studies illustrating how the CSI has been used to provide a multi-scale description of likely impacts of climate change and public lands energy development to population persistence for cutthroat trout and how this information may inform management strategies that protect remaining genetic and ecoligical diversity. Impacts from these future broad-scale disturbances are likely to compound existing problems associated with habitat degradation and introgression from introduced salmonids. Although specificially develolped by Trout Unlimited to prioritize the organization's conservation work, and to assist our members in understanding broad-scale conservation needs, the CSI may be useful to other organizations and agencies as a fisheries management or environmental education tool.

S27-5

National Estuaries Restoration Inventory - establishing data partnerships to enhance project tracking

Marti McGuire[1] (presenting). [1]NOAA Restoration Center, St Petersburg, FL, United States

The National Estuaries Restoration Inventory (NERI) has been developed to track estuary habitat restoration projects implemented around the country. The objective of NERI is to provide information to improve restoration methods and to track acres of habitat restored toward goal of the Estuary Restoration Act of 2000. Project information contained in the inventory is searchable and project details can be accessed through various reports and maps. NERI's online tools can assist in increasing public awareness and promoting local participation in and support for restoration projects. Restoration projects typically involve multiple partners; therefore, information about a project can come from many sources such as the local project sponsor, state or local governments, non-governmental organizations, tribes, community groups, or federal agencies. The primary method by which projects are currently added to NERI is by importing information from existing data systems, with an initial focus on federal tracking systems. A benefit to this approach is that data in these existing systems are often continually updated due to annual reporting requirements. The use of web service technology allows for projects in NERI to be updated from the data source in near real time or any other appropriate frequency. One of the challenges of importing data from multiple sources is that it requires compatible definitions and protocols across the data sources. Just as a restoration project relies on partnerships to implement, data partnerships can be established to improve the accessibility of information about habitat restoration activities. A comprehensive evaluation of data definitions and protocols must be conducted in order to effectively compile disparate project information from multiple restoration programs. This talk will explore both the benefits and challenges of developing a clearinghouse of restoration project information using multiple data sources as well as give an overview of the technology that makes it possible.

S27-6

The Conservation Registry: promoting strategic conservation

Gina LaRocco[1] (presenting). [1]Defenders of Wildlife, West Linn, Oregon, United States

Defenders of Wildlife and many partners are currently developing the Conservation Registry, an online tool that will allow users (agencies, organizations, private landowners, etc) to record, track and map conservation projects occurring across the landscape, ranging from restoration projects and management plans to land acquisitions. It features a friendly, easy-to-use format for data entry and retrieval and uses Google maps technology. Although some agencies and organizations have existing databases, they are often agency or organizationally specific and do not display projects that other groups are doing. This database will act as both a synthesis tool, bringing in multiple types of project information from multiple types of sources, as well as a project management tool for those agencies and organizations that need it. In addition, the registry will help organizations and landowners understand the context in which they are working; help people determine the degree to which actions are taking place within priority conservation areas; aid policy-makers and investors in understanding where public and private money is being spent; help conservationists find partners, funding, and advice for projects; help everyone learn from the successes and challenges experienced by others doing similar projects; and demonstrate that it is possible and useful to integrate information across jurisdictions and ownerships. More information on background and development of the registry can be found at www.conservationregistry.org.

S27-7

Fish Passage Decision Support System - a tool for decision making

Jose Barrios[1] (presenting), Leslie Hartsell[1]. [1]U.S. Fish and Wildlife Service, Arlington, Virginia, United States

America's fish and other aquatic species are declining at alarming rates, primarily due to loss and fragmentation of aquatic habitat. Over the past decade the practice of barrier removal or bypass to restore fragmented streams has become an important habitat restoration practice. However, the process to identify and prioritize the removal of particular barriers can be difficult and complex.

There are several ecological, social, cultural, political and economic dimensions that must be considered during the decision-making process. This presentation describes an effort spearheaded by U.S. Fish and Wildlife Service (Service) to develop the Fish Passage Decision Support System (FPDSS) to assist fisheries scientists in the decision making process for prioritizing the removal of barriers. The FPDSS is a public on-line inventory of barriers and other important information essential to the decision-making process. This comprehensive inventory is complemented with geospatial capabilities and a user-friendly interface that allows the user to interact with the data. The FPDSS provides access to locations of barriers that prevent fish and other aquatic species from reaching historic spawning and rearing habitats, significantly assisting managers, scientist and stakeholders to coordinate large scale watershed projects, to integrate projects with current action plans and to obtain better judgment to make confident decisions. The Service continually cooperates with internal and external partners enhance the information and capabilities of the FPDSS.

S27-8
Finding, sharing and using distributed data -- Northwest Environmental Data-Network portal development
Thomas Pansky[1] (presenting), Eric Lowrance[1]. [1]US Department of Energy, Bonneville Power Administration, Portland, Oregon, United States

The Northwest Environmental Data-Network (NED) is working to improve the quality, quantity, and availability of regional information on fish, wildlife and their aquatic and terrestrial habitats. The NED Portal is part of a multi-pronged approach to meet this goal. It works with open standards protocols, such as web map and feature services, and houses centralized metadata records provided by data stewards. These records are searchable by keywords, time, geography or full text. Once you find data to answer a question, the Portal's map viewer pulls distributed data sets together into a single, scaleable view. NED's Technology for Data Discovery and Sharing Work Group analyzed data sharing recommendations provided to the NW Power and Conservation Council from SAIC consultants. SAIC completed a regional data needs assessment in 2003. The suggested approach -- to use industry standard protocols -- made sense. The NED Steering Committee, comprised of Federal, state, Tribal, and public interest groups, identified existing protocols and recommended using the nation's Geodata.gov Portal software for NED. The look and feel of the ESRI Portal Toolkit has been customized to meet regional needs. Two new communities of interest are under development.We are now focused on filling the Portal with metadata and data by identifying subject matter experts to steward their own data offerings, find related web map services, and help others who have fish, wildlife, and water data to publish in the NED Portal. The NED Portal is the country's first regional Portal. It sits between the national Portal and developing state Portals in a coordinated, federated system. It's ready to help you find, share and use distributed data.See the Portal at http://gis.bpa.gov/Portal/; read more about the NED project at http://www.nwcouncil.org/ned/Default.asp

S27-9
Implementation of a spatial catalog to characterize and identify habitats in the Gulf of Mexico (Gulf GAME)
Cristina Carollo[1] (presenting), Dave Reed[1]. [1]Florida Institute of Oceanography, St Petersburg, FL, United States

The Gulf GAME project is intended to support the Gulf of Mexico Alliance Governors' Action Plan, Identification and Characterization of Gulf Habitats Priority issue. In particular, the project will provide database infrastructure to the "identification, inventory and assessment of nearshore and offshore Gulf habitats to inform resource management decision". The aim of the Gulf GAME project is to develop an inventory of habitat-related data within the Gulf of Mexico. This will serve as a foundation to develop a spatial framework for ecosystem-based management associated with regulatory and planning programs and areas of governmental coordination. Eco-regions are spatial frameworks of ecological similarities and provide a powerful tool for use in environmental protection. The data inventory will have both a regional and local scope and will focus on gathering data and mapping coastal habitats from the estuaries onshore to the edge of the continental shelf offshore to a depth of 200 m. The synthesis of data in a GIS-compatible database will enable the overlay of diverse information in a way that permits transparent and intuitive visualization of habitats and marine resources (biological or other). Information gaps will be identified and maps produced; the initial focus being on seagrass beds, identified by EPA as being a critical concern. The availability of updated maps derived from a spatially organized database can allow rapid access to the information needed to enhance the understanding and protection of habitats and their associated marine resources. In addition, data mining of historical data (e.g. from reports and publications) and their subsequent inventory using metadata standards within an organized data management framework will benefit both researchers and decision makers. This effort is in collaboration with the Priority Habitat Information System (PHINS) partnership "to provide users with habitat information and foundation geospatial data supporting implementation of the Gulf of Mexico Alliance Governors' Action Plan."

S27-10
Managing observation and model data to support ecosystem science and management in the Chesapeake Bay
Howard Townsend[1] (presenting), Doug Wilson[2]. [1]NOAA Chesapeake Bay Office - Oxford Lab, Oxford, MD, United States, [2]NOAA Chesapeake Bay Office, Annapolis, MD, United States

The NOAA Chesapeake Bay Office (NCBO) works with multiple state, federal, and institutional partners focus NOAA's capabilities and activities for restoration and management in the Chesapeake Bay. One of NCBO's major goals is to enhance implementation of ecosystem-based management through improved coordination and assistance. The goal is accomplished by providing science-based information and tools necessary to facilitate ecosystem approaches to management in the region. In support of this mission, NCBO is developing systems for collecting, accessing, integrating, and delivering ecosystem data and information among a wide base of providers and end-users. Regional ecosystem data must cover wide spatial and temporal scales and a diversity of parameters across jurisdictional boundaries. NCBO interacts with resource managers to define their needs and works with them to identify and access data including: fisheries-independent and dependent monitoring data, environmental surveys /spatial assessment (including remote sensing), continuous real-time data streams, and data from empirical biological models, and then works with managers and partners to develop and deliver integrated products. This presentation will describe ongoing efforts to implement an NCBO information management system that will integrate the data collected, processed, and supported by NCBO with distributed data sets from partner agencies and institutions to produce information tools that enable ecosystem-based resource management decisions.

S27-11
Ontario's Fish Web Collaborative -- enabling the discovery of fish distribution data over the Internet using metadata, standard protocols, and web mapping services
Silvia Strobl[1], Craig Onafrychuk[1] (presenting). [1]Ontario Ministry of Natural Resources, Southern Science & Information Section, Peterborough, Ontario, Canada

For the Ontario Community of Practice that relies on fish distribution information to manage the fisheries resource, basic fisheries information is generally undiscoverable, uncoordinated, incorrect and unstandardized, often resulting in poor resource management decisions. Even for the public, answering simple questions on what species is in my lake requires extensive research and an understanding of the multiple scattered sources where this information might be found. The ultimate goal of the Fish Web Collaborative partnership is to provide one repository of fish data that is maintained by multiple organizations and served to the public through web mapping. To attain that goal this project proposes to assess the data holdings of several of the primary organizations that maintain fisheries information into a single agreed upon standard for fish distribution data in Ontario. Consultations with stakeholders will evaluate their business requirements and document current data holdings and their associated standards in a thematic metadata catalogue. This information will then be used by the project's multi-agency technical committee to develop consensus on a data model and data standard for the storage of fish distribution data in Ontario.

S27-SP-1
The U.S. Fish and Wildlife Service (FWS) and the Fisheries Information System (FIS)
Susan Wells[1] (presenting). [1]U.S. Fish and Wildlife Service, Fisheries and Habitat Conservation Branch of Fish and Wildlife Management, Arlington, VA, United States

The Fisheries Information System (FIS) is the primary reporting and tracking tool for the U.S. Fish and Wildlife Service (FWS) Fisheries Program. It is a powerful instrument which provides the Program with accountability, planning, budget justifications, program evaluations, internal communication, reporting, and outreach. The information gathered from FIS is used to showcase the Program and all the achievements the FWS field stations are accomplishing. FWS field stations are the end users of this system and benefit from the information that is extrapolated and presented to the public and constituents. FIS is a relational database comprised of different modules. Modules include the Plans Module, which guide the work of the FWS, the Populations Module, which contributes to identifying how the FWS is moving towards sustainable populations, the Accomplishments Module, Reports Module and the Fisheries Operational Needs (FONS) Module. All modules are intertwined to give the broad picture of the FWS Fisheries Program across the national landscape. It is how the FWS tells its story.

S27-SP-2
National Oceanic and Atmospheric Administration (NOAA) Restoration Portal
David Landsman[1] (presenting), Karla Trampus[1]. [1]NOAA Restoration Center, Silver Spring, MD, United States

The National Oceanic and Atmospheric Administration (NOAA) Restoration Portal http://habitat.noaa.gov/restoration/index.cfm> provides comprehensive information about restoration techniques; NOAA's restoration programs, projects, and activities; and access to restoration references. NOAA scientists and staff are able to easily add and modify content through a dynamic web interface, enabling an efficient and expedient means of providing meaningful information to the restoration community. Also, NOAA restoration references are maintained in a topic-specific database that facilitates targeted searches. Finally, the website includes the NOAA Restoration Monitoring Planner, an on-line tool for guiding restoration practitioners through the basic steps of developing a science-based monitoring plan. The Restoration Portal was developed through collaboration between NOAA's National Marine Fisheries Service, National Ocean Service, Office of Oceanic and Atmospheric Research, and the National Environmental Satellite, Data and Information Service.

S27-SP-4
ConserveOnline: an online community for conservation science and practice

Jonathan Adams[1] (presenting). [1]TThe Nature Conservancy, Bethesda, MD, United States

Access to timely, relevant information often determines whether a conservation project succeeds or fails, yet conservation information and knowledge is difficult to find and often unavailable to scientists and project managers. Information resources must be made more readily available to people engaged in conservation, particularly in developing countries, where the cost of obtaining information is high and the need for conservation action is often most urgent. Beyond accessing documents and publications, there is a need to enable conservation managers, scientists, and decision makers to more effectively interact, form networks, and collaborate. The mission of ConserveOnline, a free online resource developed by The Nature Conservancy, is to connect conservation practitioners to each other and to the information they need to achieve their conservation goals by providing tools for collaboration and dissemination of information. ConserveOnline is a neutral forum for shared problem solving and the free and open exchange of ideas, and is freely available to anyone engaged in conservation. ConserveOnline is now being substantially revised to focus on enhancing collaboration among widely dispersed conservation practitioners by enabling users to easily create common workspaces to facilitate collaboration around a common problem. ConserveOnline will also facilitate the publishing of conservation knowledge and practices in a variety of formats, in particular XML driven on-line, open access publishing.

S27-SP-5

The Federal Fish Passage Action Plan community of practice

Andrea Ostroff[1], Robin Schrock[1] (presenting), Robin Bruckner[2], Leslie Hartsell[3]. [1]US Geological Survey, Reston, VA, United States, [2]NOAA Fisheries, Silver Spring, MD, United States, [3]US Fish and Wildlife Service, Arlington, VA, United States

Initiation of the Federal Fish Passage Action Plan (FFPAP) sparked the need for participants to communicate and collaborate in an efficient manner. The US Geological Survey's National Biological Information Infrastructure (NBII), one of the federal partners working to implement the FFPAP, has provided the infrastructure and support to host the collaboration portal community. The tool facilitates document-sharing, versioning for creating and refining documents, conducting on-line discussions, and tracking tasks and timelines among participants. Most importantly, the collaboration tool archives the progress and developments of the community for current members to reference or new members to consult in the future. This eliminates high levels of email traffic and loss of information over time. Broader exposure of the FFPAP Community's efforts has greater benefit since it is linked to other established communities, which increases the networking potential with the NBII Fisheries and Aquatic Resources Community and other agencies, and may harness more expertise in the fish passage community. Use of the FFPAP collaboration tool will assist with information transfer, planning, budgeting, and advocacy of the FFPAP. Having this established means to share information and tools to consistently apply best practices across agencies will maximize the effectiveness of the Federal Fish Passage Action Plan.

S27-SP-6

Clearinghouse for dam removal information: a network approach to project data collection and dissemination

Paul Atwood[1], Robin Bruckner[2] (presenting). [1]University of California, Berkeley, CA, United States, [2]NOAA Fisheries, Office of Habitat Conservation, Silver Spring, MD, United States

The Clearinghouse for Dam Removal Information (CDRI) fulfills an identified need for a centralized public access point to formerly difficult-to-locate documentation and data on dam removal. Dam removal is increasingly considered as one means to minimize threat of catastrophic failure and to restore ecological health and natural fish passage to riverine ecosystems. The aging infrastructure of an estimated two million dams in U.S. rivers and streams suggests this trend will continue to develop. Although numerous studies and project files of dams both removed and considered for removal have been produced, the information is widely dispersed among government, consulting, and non-profit agencies. CDRI was implemented by the Water Resources Center Archives (WRCA) at the University of California in collaboration with a diverse group of experts from leading organizations invested in river restoration, dams, and dam removal. The project is a direct result of a two-year series of dialogues on dam removal conducted by the Aspen Institute. A resulting recommendation from the dialogues was to establish a clearinghouse for dam removal resources as a means to centralize and improve access to information on this nascent discipline. Project documentation is solicited and submitted by the user population and is immediately publicly accessible online. Articles and other formally published materials are included (only in full-text when copyright permission is granted), however users are encouraged to submit unpublished data, alternatives analysis, equipment and costs, presentations, images, and gray literature. Bibliographic entries are included for items that are under copyright restriction or otherwise can't be posted in full-text online. Copies of materials not available online can be requested from WRCA for a cost-recovery fee. In addition to the database, the website posts relevant news items and information about upcoming workshops and conferences. CDRI is available online at http://www.lib.berkeley.edu/WRCA/damremoval/

<u>S28. The Valley Rules the Stream: Integrating Ecosystem-Based Science into Stream Conservation and Recovery Planning</u>

S28-1

Classification and modelling of stream temperatures in Ontario

Cindy Chu[1] (presenting), Nicholas Jones[2]. [1]Trent University, Peterborough, ON, Canada, [2]Ministry of Natural Resources, Peterborough, ON, Canada

Successful management of streams ecosystems requires an understanding of the dynamic processes occurring within them. Temperature is a key variable in stream ecosystems that affects the growth, survival and distribution of stream organisms. Yet, the lack of broad-scale temperature data has limited our understanding of the patterns and processes affecting stream temperatures in Ontario. Continuous data from 90 sites throughout the Great Lakes Basin during July 2005 – September 2006 were used to classify and model the thermal regimes of streams in Ontario. Existing and newly developed temperature metrics were used to characterize the data for each site. The 90 sites clustered into 3 thermal regimes based on maximum weekly average temperature (°C) and spring rate of change (°C°d-1). The centroids of regime 1 had temperatures of 26.7 °C and warming rates of 0.20 °C°d-1, regime 2 sites warmed to 28.5 °C and had spring warming rates of 0.12 °C°d-1and regime 3 sites had temperatures of 24.4 °C with warming rates of 0.10 °C°d-1. There was a regional pattern in the thermal regimes with most sites in the north being regime 1, sites in the southern region of the study area being regime 2 but neither regime was limited to those ranges. Regime 3 sites were found throughout the study area. Discriminant function analysis indicated that percent riparian forest, mean annual air temperature, percent surface water and groundwater discharge potential influenced the thermal regimes at the sites. These findings provide a framework for thermal assessments elsewhere, can be used to develop a long-term monitoring network in Ontario and indicate which landscape and climate variables must be considered in water quality and stream management plans.

S28-2

Fish distribution in Wisconsin streams: estimating changes from the mid 1800's to the present with a GIS-based, watershed-scale, predictive model

Jana Stewart[1] (presenting), John Lyons[1]. [1]US Geological Survey, Middleton, WI, United States, [2] WI Department of Natural Resources, Madison, WI, United States

Very little is known about fish distribution in Wisconsin streams prior to European settlement. However, it seems almost certain that major changes have occurred since then because of the transformation of the Wisconsin landscape by agriculture, forestry, and urbanization. We used a newly developed, geographic information system (GIS)-based, watershed-scale, predictive model to quantify current relations between land cover and fish occurrence in Wisconsin streams. We then applied this stream model to land-cover data gathered by the first surveyors of Wisconsin during the mid 1800's, before major land conversion to agriculture, forest clear-cutting, or urban development, to estimate pre-European-settlement fish distribution patterns. The stream model estimated that stream baseflows were generally higher and summer water temperatures were lower in the 1800's than at present. Coldwater species such as trout and sculpins were more widespread and were common in regions where they are now rare, such as southeastern Wisconsin. In the mid 1800's, brook trout were predicted to occur in 25,200 km of stream (29 percent of 86,900 km in Wisconsin) versus 13,900 km (16 percent) today, a 39 percent decline. Conversely, warmwater species were less widespread in the past and have increased since then. Environmentally sensitive warmwater species have shown smaller gains than tolerant species because increases in water temperature over the last 150 years were often associated with declines in water or habitat quality. For example, the distribution of the sensitive carmine shiner increased 4,100 km, from 4,010 km (4.5 percent) in the pre-settlement period to 8,100 km (9 percent) now, whereas the tolerant green sunfish increased 19,500 km, from 5,150 km (6 percent) to 24,650 km (28 percent). The stream model is an exciting new tool that allows us to reconstruct the fish faunas of Wisconsin streams before they were heavily modified by human activities.

S28-3

Modeling fish assemblage responses to flow reduction in Michigan rivers

Troy Zorn[1] (presenting), Paul Seelbach[2], Edward Rutherford[4], Todd Wills[3], Michael Wiley[4], Su-Ting Chen[4]. [1]Michigan Department of Natural Resources, Marquette, Michigan, United States, [2]Michigan Department of Natural Resources, Ann Arbor, Michigan, United States, [3]Michigan Department of Natural Resources, Lewiston, Michigan, United States, [4]The University of Michigan, Ann Arbor, Michigan, United States

In response to concerns over increased use and potential diversion of its abundant freshwater resources, the State of Michigan enacted legislation in 2006 that required creation of an integrated assessment model to determine potential for water withdrawals to cause an adverse impact to its waters or water-dependent natural resources. As part of this effort, we developed a model to predict how fish assemblages in different types of Michigan streams would change in response to decreased base flows. The model used Michigan-based habitat suitability information (stream size, base flow yield, July mean temperature) for over 40 fish species to predict assemblage structure and characteristic fishes of individual river segments under a range of base flow reductions. We stratified river segments by size and temperature, ran the model for representative segments, and synthesized changes in abundance of individual species and the fish assemblage for segments within each strata. The strata-specific, fish response curves were used in policy negotiations to identify withdrawal levels resulting in adverse resource impacts (ARIs) to characteristic fish populations. The strata-specific ARI levels were applied to river segments statewide. Our model provides a framework for evaluating impacts of flow withdrawals on biotic communities across regional spatial scales.

S28-4

Examining the cumulative effects of headwater enclosures on downstream fish assemblages and water chemistry in stream

agro-ecosystems

Katie Stammler[1] (presenting), Robert Bailey[1], Nicholas Mandrak[2]. [1]University of Western Ontario, London, ON, Canada, [2]Fisheries and Oceans Canada, Central & Arctic Region, Burlington, ON, Canada

In intensively farmed areas, headwater streams are often enclosed to increase the efficiency of farming and reduce soil erosion. Enclosures involve burying open first or second order streams and replacing them with drain tiles installed below the soil surface. We wish to relate the degree of enclosedness of headwater streams in cultivated fields to the downstream ecosystem's structure and function in the Ausable River basin (ARB) in southwestern Ontario. Ten watercourses in the ARB with varying degrees of upstream enclosedness, but similar in natural variation, were selected for this study. Fish and benthic macroinvertebrate assemblages were characterized using standardized sampling protocols in July and November 2007 and May 2008. Water samples were collected monthly from July – November 2007 and March-July 2008 and analyzed for ammonia, nitrate and major ions (P3-, Ca2+, Mg2+, K+, Na+). Data from this field sampling enable us to test the hypothesis that enclosedness affects, among other ecosystem attributes, the diversity and composition of the downstream fish and benthic invertebrate community. Our findings will aid managers in Ontario in setting scientifically defensible regulations regarding stream enclosures and will significantly further our knowledge of the importance of headwater streams to downstream ecosystems.

S28-5

Response of headwater fish communities to natural and stressor gradients in southwestern Ontario, Canada

Adam G. Yates[1] (presenting), Robert C. Bailey[1]. [1]The University of Western Ontario, London, Ontario, Canada

Stressor gradients are an effective method of describing the varying magnitude and nature of the stressors to which freshwater ecosystems are exposed. But to be useful as a bioassessment tool, the environmental changes that the gradient depicts must correspond to predictable changes in aquatic organisms or communities. Our study addressed the effectiveness of stressor gradients as a bioassessment tool by answering two important questions: 1. Are changes in aquatic communities correlated with variation in the stressor environment? and 2. To what extent is the stressor environment correlated with the natural environment? We answered these questions by determining the degree of correspondence between stressor environment and fish communities of 164 rural headwater streams in southwestern Ontario. We also assessed the nature and magnitude of correlation between the stressor environment and the natural environment. Our results demonstrated that there is strong correspondence between changes in the stressor environment and the composition of the fish community, such that as the number and degree of stressors increases the fish community shifts from a small number of sensitive, cold water stenotherms to a community dominated by tolerant, warmwater species. However, our findings also indicate a significant amount of covariation between natural and stressor gradients. This covariation highlights the need to account for the natural environment when conducting bioassessment studies and applying the results to planning and management activities.

S28-6

Challenges and successes in recovering freshwater ecosystems in southern Ontario

Shawn Staton[1] (presenting), Nicholas Mandrak[1], Kari Killins[1]. [1]Fisheries and Oceans Canada, Burlington, ON, Canada, [2]Ausable Bayfield Conservation Authority, Exeter, ON, Canada

The success of recovery programs in the watersheds of south-western Ontario are critical for the conservation of freshwater biodiversity in Canada. An aquatic ecosystem approach to recovery planning is underway within watersheds of the Sydenham, Thames, Grand and Ausable Rivers that support rich communities of fish and mussel species at risk. Recovery strategies based on the best available science help direct recovery actions to mitigate threats to species and ensure their survival. The adaptive management principal is key to the long-term success of these programs. Targeted research and monitoring activities can allow constant refinement of recovery approaches and track ecosystem responses to habitat improvements. In addition, the identification of critical habitat is an important management tool that can provide additional insights. Specific examples from several recovery teams will be presented to illustrate these concepts. Highlights will include the establishment of quantitative monitoring programs for fishes and freshwater mussels that provide baselines to track changes in freshwater communities. The results of research to identify critical habitat for several fishes will also be presented.

S28-7

Hope for recovery or planned obsolescence: using relationship of stressor gradients and biota in agricultural streams to predict the recovery or demise of stream agroecosystems

Robert Bailey[1] (presenting), Adam Yates[1]. [1]The University of Western Ontario, London, Ontario, Canada

Bioassessment of streams has become much more than deciding whether to "pass" or "fail" a site (or how badly it fails). Environmental planners also want to predict what negative or positive effects different land use strategies will have on the component ecosystems of a landscape. In an agricultural setting, if we can characterize the nature and magnitude of agricultural activity, and the biota present at a site, we can build models relating the two that will enable us to predict a future state of the ecosystem from present, spatial correlations, given a change in land use. We built a multivariate model relating descriptors of both

the natural (e.g. catchment size, surficial geology) and stressor (e.g. extent of tile drainage, cultivation intensity) environment of 164 streams in rural southwestern Ontario to fish species collected at each site. We then turned these relationships into predictions as to what will happen to a stream ecosystem's biota if the stressor environment is either improved or degraded over time.

S28-8

It's a patchy world out there: how a multi-scaled approach can enhance recovery plans for endangered freshwater fishes

Mark Poos[1] (presenting), Donald Jackson[1]. [1]University of Toronto, Toronto, Ontario, Canada

The redside dace (*Clinostomus elongatus*) is an endangered freshwater fish typically found in large, deep pools of headwater streams. Current expansion of urban development has been attributed to the severe decline in this species, with 10 of 13 populations in the Greater Toronto Area, Ontario showing substantial losses. We developed a multi-model approach to help identify habitat requirements for this species at three spatial scales: patch level, site level and watershed/landscape level. Under a patch-based scale, we monitored the movement and habitat usage of two populations of redside dace, one undergoing urban expansion, the other not. For this approach we marked redside dace with color coded visual implant elastomer (VIE) tags and monitored their movement across twenty consecutive pools in a one year time period. Redside dace movement was calculated and patch occupancy was used to identify habitat usage. Under a site-based scale, we sampled stream characteristics across known redside dace sites within the past decade. Geomorphologic cross sections, substrate size, riparian buffer, flow and depth were all measured and used to build a predictive model. As redside dace are known to lay their eggs in nests of creek chub (*Semotilus atromaculatus*) and common shiner (*Luxilus cornatus*), the presence of these species were also used as a site-level predictor. We used logistic regression, artificial neural networks, classification trees and general additive models to develop our predictive model. Finally, under a watershed/landscape level we quantified stream geology, adjacent land use, slope and elevation. Unique habitat predictors were found at each spatial scale: including the presence of small distances between good patches, large deep pools at a given site, and lack of urban development across the watershed/landscape. This study highlights the utility of using a multi-scaled approach for developing recovery plans, as each scale identified unique characteristics. As the river continuum theory suggests, recovery plans should attempt to understand the spatial dynamics of impacts on fish habitat, as there are likely complex interactions in and amongst patches, sites and watersheds/landscapes; which would be important additions to recovery plans. The redside dace (*Clinostomus elongatus*) is an endangered freshwater fish typically found in large, deep pools of headwater streams. Current expansion of urban development has been attributed to the severe decline in this species, with 10 of 13 populations in the Greater Toronto Area, Ontario showing substantial losses. We developed a multi-model approach to help identify habitat requirements for this species at three spatial scales: patch level, site level and watershed/landscape level. Under a patch-based scale, we monitored the movement and habitat usage of two populations of redside dace, one undergoing urban expansion, the other not. For this approach we marked redside dace with color coded visual implant elastomer (VIE) tags and monitored their movement across twenty consecutive pools in a one year time period. Redside dace movement was calculated and patch occupancy was used to identify habitat usage. Under a site-based scale, we sampled stream characteristics across known redside dace sites within the past decade. Geomorphologic cross sections, substrate size, riparian buffer, flow and depth were all measured and used to build a predictive model. As redside dace are known to lay their eggs in nests of creek chub (*Semotilus atromaculatus*) and common shiner (*Luxilus cornatus*), the presence of these species were also used as a site-level predictor. We used logistic regression, artificial neural networks, classification trees and general additive models to develop our predictive model. Finally, under a watershed/landscape level we quantified stream geology, adjacent land use, slope and elevation. Unique habitat predictors were found at each spatial scale: including the presence of small distances between good patches, large deep pools at a given site, and lack of urban development across the watershed/landscape. This study highlights the utility of using a multi-scaled approach for developing recovery plans, as each scale identified unique characteristics. As the river continuum theory suggests, recovery plans should attempt to understand the spatial dynamics of impacts on fish habitat, as there are likely complex interactions in and amongst patches, sites and watersheds/landscapes; which would be important additions to recovery plans.

S28-9

Modeling habitat of the imperiled Eastern Sand Darter (*Ammocrypta pellucida*) at multiple scales to help guide recovery and repatriation efforts

Alan Dextrase[1] (presenting), Nicholas Mandrak[2]. [1]Trent University/Ontario Ministry of Natural Resources, Peterborough, ON, Canada, [2]GLLFAS, Fisheries and Oceans Canada, Burlington, ON, Canada

Factors that influence the distribution and abundance, and the viability of reintroduction, of the threatened Eastern Sand Darter (*Ammocrypta pellucida*) were examined in rivers of southwestern Ontario, Canada. The Eastern Sand Darter is a globally imperiled percid that has been extirpated from four of seven historically occupied river systems Ontario. Habitat data were collected at three spatial scales (site, reach and valley segment) in the Grand and Thames rivers for the development of models using a random, stratified design. Fish community data were collected by repeatedly seining 10 x 10 m sites. Eastern Sand Darter were continuously distributed within their occupied range (~150 river km) of the Thames River where suitable habitat exists (present in 87% of sampled reaches), but were more patchily distributed within their occupied range (~85 river km) of the Grand River (present in 45% of sampled reaches). Preliminary models relating habitat variables to Eastern Sand Darter occupancy (logistic models) and relative abundance (general linear models) were developed at the reach and site levels. Substrate size (presence of sand and fine gravel) and the presence of upstream sand were important variables in both rivers at all scales for both occupancy and relative abundance. In the Grand River, the presence of dams appeared to negatively affect the upstream distribution of Eastern Sand Darter and the degree of bank erosion had an opposite effect at the site and reach levels. The feasibility of reintroducing Eastern Sand Darter to historically occupied Ontario rivers will be assessed using the habitat models.

S28-10

Population dynamics of eastern sand darter (*Ammocrypta pellucida*): a threatened species on the lower Thames River, Canada

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Eastern sand darter (*Ammocrypta pellucida*) is listed as a threatened species under Canada's Species at Risk Act (SARA). Habitat destruction throughout its geographic range has made the species vulnerable to population declines and possible local extinction. To help protect Canadian populations of eastern sand darter (ESD), biological recovery teams mandated by SARA have identified knowledge gaps in scientific understanding of the life-history and population ecology of the species. Population modelling has been highlighted as one method that can help determine population fates and identify critical population habitat and life stages. An ideal location to intensively study eastern sand darter in Canada is the lower Thames River as local populations appear robust with calculated population densities of 0.30-0.49 ESD/m2. Here I discuss the creation of a population model that is calibrated using field and laboratory information collected from the lower Thames River over four years (2004-2007). Non lethal sampling methodologies were used to gather information on eastern sand darter life history parameters and habitat surveys were conducted to identify the role of habitat and watershed processes on population dynamics. I will highlight how the inclusion of this field information affected model estimates of population trajectories, and aided in identifying limiting life stages. These results may be used to guide management decisions on the protection of eastern sand darter and provide guidance as to the critical information needed to manage other similar species at risk with little life history information.

S28-P-1

Productive capacity of semi-alluvial streams in Ontario: the importance of alluvial material for fish, benthic invertebrates, periphyton and organic matter

Sarah Quesnelle[1] (presenting), Nicholas Jones[2]. [1]Trent University, Peterborough, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Canada

The natural flow regime is a key component of creating and maintaining in-channel and floodplain conditions critical for aquatic and riparian life. Changes in land-use and climate (e.g. urbanization, agriculture, damming and increased frequency of storm events and run-off) are expected to result in highly modified flow regimes leading to flashier and more powerful flows threatening fisheries resources and biological productivity of streams. Armouring of streambanks to reduce erosion and damming for flood regulation leads to lower recruitment of gravels into streams while larger peak flows increases transport capacity leading to a loss of gravels: critical habitat for aquatic biota. Semi-alluvial streams are characterized by having only a thin veneer of alluvium (e.g. gravels) on top of a non-erodable base (bedrock or cohesive clays) and are common across North America. Under this new low recruitment and high transport capacity scenario we are likely to see more sections of exposed clay or bedrock. What does this loss of gravels mean for benthic invertebrates, fish and productive capacity? This research examines the effects of alluvium loss on biological productivity of semi-alluvial streams in Ontario. Streams have been sampled for fish, benthic invertebrates, periphyton/bryophytes and coarse particulate organic matter across three disturbance gradients: low (0% loss of alluvium), medium (25-50% alluvium loss) and high (>50% loss of alluvium). Comparisons of abundance, diversity and biomass yield insight of the importance of different substrate types and the ability of gravels to support greater community diversity in comparison to simpler habitat such as clay or bedrock.

S28-P-2

Approaches to identifying critical habitat for Northern Madtom (*Noturus stigmosus*) in Canada

Amy Edwards[1] (presenting), Nicholas E. Mandrak[1], Shawn Staton[1]. [1]Fisheries and Oceans Canada, Burlington, Canada

The northern madtom (Noturus stigmosus) is a small (132 mm maximum total length), cryptic species, that can be found in small creeks to large rivers. It is a globally rare species and one of the most imperilled fishes in Canada. It was designated as Endangered by the Committee on the Status of Endangered Wildlife (COSEWIC) in 2002 and is currently protected under Canada's Species at Risk Act (SARA). The identification of critical habitat for Threatened and Endangered species is a requirement of SARA; once designated, critical habitats receive protection under the Act. In 2008, the Ontario Freshwater Fish Recovery Team investigated methods for the identification of critical habitat for the two largest populations in Canada: the Detroit River and the Thames River. Within the Detroit River, a large river connecting Lake St. Clair and Lake Erie, northern madtom are found near the mouth of the river where it connects to Lake St. Clair. Within the Thames River (the second largest watershed in southwestern Ontario) northern madtom are found in the middle reaches of the river, in a stretch approximately 30 km long. To define critical habitat for northern madtom, the recovery team considered several approaches, including home range size, available data on habitat characteristics at

northern madtom captures sites, and provincial stream valley segment data. The final results of these analyses will be presented as well as implications for conservation and management of the species.

S29. Sampling Approaches to Improve Understanding of How Headwater Drainage Systems Affect Fish Production

S29-1

From habitat units to landscapes: sampling headwater streams in Western Oregon

Robert Gresswell[1] (presenting), Douglas Bateman[2], Christian Torgersen[3], David Hockman-Wert[4]. [1]USGS NoRock, Bozeman, MT, United States, [2]Oregon State University, Corvallis, OR, United States, [3]USGS FRESC, Seattle, WA, United States, [4] USGS FRESC, Corvallis, OR, United States

Sampling headwater stream networks can be fraught with challenges, but there are also numerous opportunities to gain new insights into relationships between fishes and habitat characteristics. For example, because these systems a relatively small, it is possible to investigate large-scale variation of geologic, geomorphic, and climatic factors across regions by using individual watersheds as analytical units. At finer spatial scales, habitat units, geomorphic reaches, stream segments can be used as analytic units to investigate variation within watershed. In western Oregon, we have used spatially continuous data collection to assess spatial structure of coastal cutthroat trout. By studying movement at the watershed scale, it was possible to evaluate use of specific habitat patches and changes occurring among seasons and years. Individuals implanted with passive integrated transponder tags have been monitored with fixed and mobile sensors to obtain temporally- and spatially-continuous relocation information over a 4-year period. These data have provided new insights concerning patterns of habitat use and the watershed-scale processes affecting population-level growth and survival. Genetic information collected intensively in a single watershed and extensively for 27 watersheds across the region yielded important information concerning the effects of genetic and demographic isolation on genetic diversity and population persistence. This integrated approach for assessing relationships between salmonid distribution and physical habitat opens the door for continued methods development and innovation in the coming years.

S29-2

The production potential of stream fishes as affected by changes in water temperature driven by climate and land-use in the Delaware River basin

Jerry Mead[1] (presenting), Fredrick Scatena[1], Richard Horwitz[2], Yude Pan[3], Richard Birdsey[3]. [1]University of Pennsylvania, Philadelphia, PA, United States, [2]Academy of Natural Sciences, Philadelphia, PA, United States, [3]USDA Forest Service, Newtown Square, PA, United States

We developed empirically reach-based models of stream water temperature using measurements of water temperature and maps of watershed scale and reach scale land cover, surface geology, soils, climate. Our analysis indicated that riparian conditions rather than watershed conditions explained most of the variance in stream temperature. Two different sets of models proved robust; those for streams draining < 100 km2 that are not influenced by reservoirs, and stream with watersheds greater than 100 km2. For each of these classes drainage area we developed a model for the leaf on and leaf off season. These models were then applied to all freshwater streams within the Delaware River Basin to: a) determine how management strategies would effect water temperature considering issues of scale and water regulation; and b) assess the effects of climate change, land-use change, and water level regulation on the production potential of three native fishes (Brook trout, American eel, and the America shad, and four non-native fish species (Brown trout, Rainbow trout, Small mouth bass, and the common carp). For the smaller watersheds water temperature was explained by air temperature at the reach and watershed scale, riparian forest cover, day length, percentage of limestone, and impervious surface in the riparian zone. For streams with large watersheds, during the season when leaves were on plants, hill shade and forest cover in the riparian zone, and releases from reservoirs within 80 km upstream were correlated to water temperature. During the leaf off period, air temperature, percent surface that impervious in riparian zones above the reach, and the slope of streams with 80 km upstream of the reach. The simulated relative growth potential of fishes per length of stream will be presented for under current conditions. Additionally, we will compare simulated growth potential of fishes for the following scenarios; reforested riparian zones, global warming, and reforested riparian zones with global warming. The amount reforesting riparian zones could counter act global warming will be examined.

S29-3

A preliminary investigation of exported materials from headwater drainage features in forty sites located within Southern Ontario

Odum Idika[1] (presenting), David Barton[1]. [1]University of Waterloo, Waterloo, ON, Canada

The export of invertebrates, detritus and organic materials from intermittent and ephemeral headwater drainage features (HDF) were analyzed to determine their ecological contributions to permanently flowing systems downstream. Forty Sites within the Greater Toronto Area and Kitchener-Waterloo Region were selected to provide contrast in the soil type, vegetation, land-use and catchment area. Drift traps were installed at each site and emptied during and after each runoff event from late winter through summer 2008. Organic materials (living and detrital) were related to these landscape conditions. Given that little work has been conducted in these stream types, this paper will emphasize the sampling methods developed, their reliability and sources of variance. Finally, recommendations will be provided to those interested in sampling organic drift in intermittent streams in other ecoregions.

S29-4

Abiotic constraints to sampling and evaluating macroinvertebrate communities in headwater streams

Robert Danehy[1] (presenting), Russell Langshaw[1], Robert Bilby[2]. [1]Weyerhaeuser Company, Springfield, OR, United States, [2]Weyerhaeuser Company, Federal Way, WA, United States

Small stream size and high seasonal variability present sampling challenges for macroinvertebrates in headwaters streams different than those encountered in larger systems. We will present information on two separate headwater system research projects in Oregon; an evaluation of benthic macroinvertebrate communities across a range of forest stand conditions in the Coast Range and a study of macroinvertebrates drift distance in the Cascade Mountains. In both projects, streams were perennial and means of area, baseflow discharge, and travel time were 22.2 ha, 0.62 l•sec, and 94 min•100 m respectively. The first project required different benthic sampling techniques for June and August collections. While standard sampling with flow flushing nets was possible in early summer, insufficient flow made it necessary to isolate and excavate bed material at baseflow in August. It was possible to sample the entire flow of the stream for drift and operate the nets continuously, emptying them only once a day. However, not all streams maintained continuous flow through the 100 m sampling reach during this three month study. Results of both projects exhibited moderate variability between replicates and within treatments. Both data sets included taxa that were unique to individual sites. Our results reinforce the importance of full site reconnaissance, robust sampling designs, and analytical approaches.

S29-5

Ecological linkages between fishless headwaters and downstream fish communities

Elizabeth Green[1] (presenting), Mark Wipfli[1], Karl Polivka[2]. [1]USGS Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, AK, United States, [2]Pacific Northwest Research Station, USDA Forest Service, Wenatchee, WA, United States

Downstream transport of nutrients, detritus and aquatic invertebrates by headwater streams can vary widely at the landscape scale with potential consequences for fish and other consumers. We used observations and experiments to determine whether the quantity of drifting invertebrates originating from fishless headwaters can affect fish downstream. Specifically, we tested whether variability in prey transport from headwaters, associated with timber harvest of upland forests and geoclimatic regional classification, affects fish abundance, biomass, and growth. Sixteen streams were sampled in the Wenatchee River sub-basin, Washington, whose catchments fell into one of four climate and land use combinations. We measured the density and biomass of drifting invertebrates entering fish-bearing reaches from fishless headwaters, along with fish abundance and biomass associated with those estimates of drifting prey during two field seasons, 2006 and 2007. We also measured growth of individual fish over six weeks in these same reaches. We then manipulated invertebrate drift (blocked, supplemented, or control) from headwaters and measured downstream fish responses (movement, growth, abundance and biomass). There was no correlation between invertebrate drift density and fish biomass or growth in 2006. Drift manipulations showed higher fish growth in habitats receiving more headwater prey in 2006, but not in 2007, possibly due to low recapture success in 2007. Clarifying whether there are important trophic linkages between fishless headwaters and fish downstream will provide insight into how management of headwater forests and streams affects broader riverine ecosystem productivity.

S29-6

How important are fishless headwaters to downstream fishes and food webs?

Mark Wipfli[1] (presenting). [1]Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, AK, United States

Aquatic habitats that support fish receive nutrients, detritus, and invertebrates from many sources, including fishless headwater streams. These headwater streams typically account for 80% or more of the channel network within watersheds. Thus, through their sheer abundance, the nutrient and energy transport from headwaters could greatly influence food webs and fish communities further down in valley bottoms. In order to really understand the potential ecological importance of headwaters within the broader riverine ecosystem framework, it is crucial to understand how the quantity (and quality) of nutrient and food resources provided by these streams compares to other sources. Studies from parts of Alaska and the Pacific Northwest have revealed that fishless headwater streams are a reliable and year-round source of detritus and invertebrates for downstream fish-bearing habitats. And some evidence indicates that drifting prey originating from these headwaters is important for fish at small, local scales. At the basin-wide scale, however, their prey contributions seem to be relatively small compared to that provided by in-stream (localized production), marine (via anadromous fish runs), and riparian (terrestrial input) sources. Understanding the broader effect of headwater resource subsidies (nutrients, detritus, invertebrates) on downstream fish-bearing habitats, and the extent of the reliance on these resources by the receiving food webs, will provide much needed insight into the importance of the ecological linkages between these distant but fluvially connected systems.

S29-7

Possible controls on the production and flux of invertebrates from headwater streams

John Richardson[1] (presenting). [1]University of British Columbia, Vancouver, BC, Canada

Evidence is accumulating that small streams provide important subsidies to downstream environments and are unique habitats in their own right. The production of some invertebrate species can be very high in small streams, with two non-exclusive hypotheses that might account for this. First, organic matter, which is the primary energy subsidy to small streams is not as readily exported from small streams because of their relatively high hydraulic radius and low competence, allowing this resource to be more fully used in situ that might occur in larger streams. Sampling for numbers of emergent, adult aquatic insects based on emergence trapping indicates that headwater streams (narrowly defined) may have lower species richness but greater total numbers of individuals. Another hypothesis is that the typical absence of fish or larger, predaceous invertebrates provides greater availability of the local production within a given trophic level. The specific mechanisms contributing to the controls on production in small streams are not well defined, as most energy resources are donor-controlled, detrital-based subsidies. These small streams also appear to support greater invertebrate production than might be expected considering low summertime flows, perhaps because cool groundwater runoff generation maintains the temperature conditions amenable to growth and survival of many stream invertebrates. Many of the invertebrate species found in these small streams are poorly known and there is an urgency to document more about them. In general, the smallest, perennially flowing streams are difficult to sample, and we lack estimates of the productivity of those streams.

S29-8
Influence of riparian forest cover manipulations on terrestrial invertebrate inputs into headwater streams
Jered Studinski[1] (presenting), Kyle Hartman[1]. [1]West Virginia University, Morgantown, West Virginia, United States

Headwater streams and their biota rely on riparian areas for many essential products and services. Recent research has indicated that during summer, >50% of a brook trout's (*Salvelinus fontinalis*) diet can be composed of terrestrial invertebrates. Due to this strong terrestrial-aquatic linkage, it is important to understand the effects of riparian manipulations on terrestrial invertebrate inputs. West Virginia has developed best management practices to minimize the effects of riparian timber harvest on stream water quality. This project investigates how riparian forest manipulations affect the quantity and composition of terrestrial invertebrate inputs to headwater streams. During summer 2007, 640 pan traps were placed within treatment and reference sections on 8 headwater streams in central West Virginia. The treatments consisted of either a 50% or 90% basal removal. We expect that both quantity and composition to differ between the treatments and reference sections, with the greatest differences being between the reference and 90% basal removal sections.

S29-9
Cattle grazing regimes influence terrestrial and aquatic invertebrate prey that support trout populations in western rangeland headwaters streams: conceptual model, initial results, and challenges of sampling
W. Carl Saunders[1], Kurt Fausch[1] (presenting). [1]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Colorado Springs, CO, United States

Cattle grazing is known to degrade riparian zones and bank stability in western U.S. rangeland streams, resulting in erosion and siltation of aquatic habitats. However, when cattle are fenced away from streams, riparian vegetation and trout populations often increase rapidly whereas aquatic habitat recovers more slowly. Comparisons in two regions in Colorado and Wyoming indicate that resident trout biomass in streams managed intensively for grazing is about twice that in streams where cattle are free to graze season-long, although larger mobile trout may range widely among stream segments and be influenced by different factors. Accurate estimates of both size groups requires night depletion electrofishing and state-of-the-art estimators that can account for changes in capture probability with fish size. Riparian vegetation, input of terrestrial invertebrates to streams, and biomass of terrestrial invertebrates and macroinvertebrate shredders in trout diets are all 2-3 times higher at intensively managed sites than those under season-long grazing, providing a mechanism to explain the rapid trout biomass increase. These observations suggest that a new conceptual model that includes rapid regrowth of riparian vegetation and inputs of terrestrial invertebrates will be needed to understand how cattle grazing influences trout populations. Moreover, initial results indicate that regional precipitation that controls this riparian vegetation regrowth will strongly influence the timing, intensity, and duration of grazing needed to maintain sufficient vegetation to support terrestrial invertebrates that sustain trout populations in western rangeland streams.

S29-10
Appalachian brook trout dietary analysis and their linkage to riparian zone manipulation
Jonathan Niles[1] (presenting), Kyle Hartman[1]. [1]West Virginia University, Morgantown,WV, United States

Lotic salmonids frequently inhabit environments of low productivity, such as headwater streams. Consequently, the quality and quantity of food intake may play an important role in shaping salmonid populations. The most frequently cited source of energy for salmonids in such ecosystems is the aquatic macroinvertebrate community, which derives most energy from allochthonous sources in the surrounding watershed. Such sources of energy often result in stream communities low in productivity and thus offer limited resources to higher trophic levels, such as stream fish. However, recent publications have indicated that terrestrial invertebrates may play a dominant role over aquatic sources in providing energy to salmonids. Terrestrial prey has been shown to be more heavily exploited by Appalachian brook trout (*Salvelinus fontinalis*) than aquatic prey throughout a majority of the year. This concept implies that manipulating riparian zones to alter vegetative cover and resulting terrestrial insect communities may have substantial effects on salmonid populations. During summer 2007 we conducted a study to evaluate the effects of Streamside Management Zone manipulation upon headwater streams and associated biota (brook trout, terrestrial and benthic macroinvertebrates) by removing 50% and 90% of the basal area on 8 headwater streams in central West Virginia. Brook trout greater than 120 mm total length had dietary samples taken in the field via gastric lavage and identified to family. Comparisons were made in dietary composition between manipulated sites and upstream reference sites in order to determine the effect that canopy removal had on terrestrial invertebrate input and brook trout dietary compositions.

S29-11

Quantifying the factors that influence flow response to storm events in headwater streams

Les Stanfield[1] (presenting), Don Jackson[1]. [1]University of Toronto, Toronto, ON Canada

How climate, geology and land use specifically affect flow conditions in headwater streams is poorly understood and hampers decision maker's ability to manage impacts from development. In 2007, crest stage gauges and physical measurements of stream condition were used to quantify peak flow responses at 110 sites located on headwater streams on the north shore of Lake Ontario. Rain fall to each catchment was measured using spline procedures from 20+ rain gauge stations. The relationship between peak discharge and rainfall was quantified as a flashiness index and regressed to catchment attributes of drainage area, geology, slope and a land cover index. Residuals of this model were regressed against the area of tile drainage in each catchment to determine the degree to which this attribute independently explained flow condition. Finally, the flashiness index was compared to a hindcasted reference condition as a means of quantifying the degree of alteration in flow condition within the study area. This presentation will highlight the field procedures used and their reliability, the study findings and the implications of this study to protecting fish habitat in downstream reaches.

S29-12

Check Your Watershed Day: a community-based survey quantifying flow and fish barriers in headwater streams

Sarah Hogg[1] (presenting), Joyce Chau[2], Les W. Stanfield[3]. [1]Halton Region Conservation Authority, Milton, Ontario, Canada, [2]Citizens' Environment Watch, Toronto, Ontario, Canada, [3] Ontario Ministry of Natural Resources, Picton, Ontario, Canada

Accurate information about flow conditions in headwater streams is essential to inform planning decisions that may effect the future functioning of these systems. Efforts to model flow conditions in specific headwater catchments have been hampered by the inherent temporal and spatial variability of flow in these systems. 'Check Your Watershed Day' (CYWD) is a community-based approach for evaluating the flow conditions at accessible locations to provide a measure of relative discharge throughout a watershed during summer low flow. Field methods vary in recognition of the importance of data precision: volunteers collect data at small stream crossings and technicians collect data at larger stream crossings. This combined approach enables a low flow water budget to be developed for the entire watershed and provides the information necessary to rank the relative importance of headwater areas critical to maintaining fish habitat. The information collected also provides baseline information for future changes within a watershed as well as an inventory of potential barriers to fish passage. This paper describes the CYWD methodology and the results obtained from pilot projects in five watersheds in Southern Ontario. Suggestions for future applications of this data and the improvement of future events are also included.

S29-13

Quantification of processes within a headwater channel network

John Parish[1] (presenting), Shelley Gorenc[1], Mike Tilston[1], Jackie Thomas[1]. [1]Parish Geomorphic, Georgetown, ON, Canada

Over a two-year period, a series of sites have been subjected to regular monitoring from March to December. The purpose of the monitoring has been to quantify processes that are operative within small ephemeral channels. The upstream drainage areas of each of the sites were less than 20 Ha. All sites were situated within the same geology with slightly different land uses; ranging from agriculture to more natural conditions. The specific focus of the monitoring was on characterizing the flow and sediment regime. Each site included a temporary stream gauge, and a series of sediment traps. This monitoring was augmented by repeated cross-sectional surveys and sampling for TSS. Finally, this monitoring data was linked to several other stations further downstream. The results were intriguing in that proportionally more water is produce from these catchments than downstream areas. Also, while a substantial amount of the sediment within the channels is the product of the agricultural fields, there is evidence that natural scour and fill processes regularly occur. This finding alone, suggests that these channels, which tend to lack substantial definable form, have the ability to behave like much larger channels, with respect to channel dynamics and response to changes in flow and sediment regimes. This work has been a valuable contribution to our understanding and has been applied to management decisions regarding future land use scenarios.

S29-14

The consequences of habitat sampling choice on benthic macroinvertebrate metric and index estimation in coastal Louisiana streams

Michael Kaller[1] (presenting), William Kelso[1]. [1]Louisiana State University Agricultural Center, Baton Rouge, LA, United States

Bioassessment protocols stipulate consistency and efficiency in sampling to maximize consistency among practitioners, sites, and years such that deviations from expectations may be attributed to habitat or water chemistry alteration rather than sampling artifacts. Currently, biocriteria for surface water assessment in Louisiana have not been determined, and future protocols will need to incorporate the lessons learned by other states and federal programs, particularly the impacts of differences in benthic organism abundance among habitat types. We conducted an investigation into the differences in benthic macroinverterates among habitat types and the consequences of these differences to commonly or regionally used bioassessment metrics and multi-metric indices. In coastal Louisiana streams, benthic organisms live in 2 predominant habitats, woody debris and mineral benthic sediments, which we sampled independently and compared to each other and combined habitat samples. Not unexpectedly, macroinvertebrate community composition and resulting metrics and indices differed among watersheds sampled as well as seasons. Further, macroinvertebrates demonstrated considerable habitat specificity, with only 39% of taxa found in both habitats. Therefore, metrics and indices estimated from individual habitats were markedly different from each other, as well as combined habitat estimates. Surprisingly, the North Carolina coastal stream multi-metric index (NCBI-EPT) was more robust with regard to sampling than other indices, including an index developed in neighboring Mississippi (MBI-SQ). In summary, our data suggest individualized habitat sampling will incorrectly estimate bioassessment metrics and indices, and importing metrics and indices from other regions may not adequately detect stress without modification. Lastly, we suggest future protocols should use composite estimates from combined habitat samples to most efficiently and consistently estimate bioassessment metrics and indices.

S29-15
Fishless streams: natural and anthropogenic causes

Richard Horwitz[1] (presenting), Paul Overbeck[1], David Keller[1], Shane Moser[1], Thomas Belton[2]. [1]Academy of Nat. Sci. Philadelphia, PA, United States, [2]NJDEP, Trenton, NJ, United States

The presence, intermittent presence, or absence of fishes in headwater streams will have substantial effects, including community structure, nutrient biogeochemistry, and secondary production. Fish occurrence will be partly determined by channel form, which affects size and depth of pools and other extreme-flow refuges, and hydrology, which affects occurrence and duration of extreme flows. Other important factors include gradient, barriers (dams, cascades, etc.), substrate (affecting refuge habitats and subsurface flow) and water chemistry (causing chronic or episodic mortality). Thus, absence of fish may be caused by natural stream characteristics or by human disturbance. The effects of some factors, such as watershed and riparian land cover (e.g. forest or impervious cover), are difficult to predict, since they will reflect net effects of changes in shading, temperature, evapotranspiration, base flows, peak flows, channel widening, and pool deepening. We used new and existing data from headwater streams in New Jersey and adjacent states to analyze relationships among fish presence, drainage area, gradient and channel form (e.g. pool depths), as affected by land cover, dams, and measures of hydrology and geology. Relationships among intermittency, watershed and riparian land cover, gradient, and channel form were used to link processes at the watershed, reach and microhabitat scales which affect presence and absence of fish. Differences between fish assemblages in permanent and intermittent streams (e.g. proportion of mobile species) were used to assess the specific effects of intermittency on stream fish assemblages. These results provide a basis for distinguishing impairment from natural absence of fish.

S29-16
Spatial variance of headwater stream environments and fish assemblages

Beth Sparks-Jackson[1] (presenting), Michael Wiley[1], Paul Seelbach[2]. [1]Univeristy of Michigan, Ann Arbor, MI, United States, [2]Institute for Fisheries Research, Michigan Department of Natural Resources, Ann Arbor, MI, United States

Fisheries biologists need to understand the patterns, causes, and ecological consequences of spatial heterogeneity in rivers. Although rivers have historically been viewed as continuum, the identification of mesoscale units has recently garnered attention. Since rivers are networks with an overwhelmingly unidirectional flow of water and materials, ecological units likely form as a result of the branching pattern of river networks and discontinuities along the network, such as inline lakes/reservoirs. We explored the spatial variability of headwater streams with fine resolution sampling of five stream systems of varying size (73-341 km2), type (cold and stable to warm and flashy), and condition (minimal human impact to heavily impacted). We located multiple sites in each proposed unit (usually a river segment) with about 2-4 km between adjacent sites (n=57). At each study site we surveyed fish assemblages using depletion electroshocking and measured water chemistry, temperature, discharge, habitat characteristics, and macroinvertebrates. The pattern of variability of invertebrates and fish assemblages was similar and mirrored the pattern of stream discharge. If the discharge increased substantially from one site to another variability of biological assemblages was high. Uppermost sites were unusually different from the downstream neighbor and lacked fish in the most heavily impacted system. Fish assemblages were quite variable, especially in small headwater segments, but overall similarity within a segment was higher than similarity between segments. In moderate sized segments with invariable discharge fish assemblages were quite similar. Most of the discontinuities in fish assemblages occurred at stream junctures and were particularly marked if the sites differed in stream type or were separated by a dam. This research provides useful theoretical advances and practical approaches for resource managers. For example, understanding that the rate of change of fish assemblages varies with location suggests the sampling of small headwater streams needs to be of very high of resolution. Since mesoscale ecological units exist and are predictable in moderate sized streams, these units should serve as a guide for efficient sampling, the unit at which modeling occurs, and a real unit for understanding, communication, assessment, and management.

S29-SP-17

Ready, set, Check Your Watershed Day: a unique community-based approach to assess stream conditions

Joyce Chau[1] (presenting), Sarah Hogg[1], Les W. Stanfield[1]. [1]Citizens' Environment Watch, Toronto, Ontario, Canada, [2]Halton Region Conversation Authority, Burlington, Ontario, Canada, [3]Ontario Ministry of Natural Resources, Picton, Ontario, Canada

Community volunteers are a valuable asset when it comes to evaluating the flow condition of headwater streams. However, there are many challenges inherent to community-based monitoring. A common obstacle is the long-term commitment required by volunteers. Check Your Watershed Day is a unique and innovative community-based project that addresses these difficulties primarily by scaling down to scale up. By dividing the watershed into manageable sampling zones, and focusing on small streams at stream crossings (e.g. culverts), volunteers are able to measure stream flow assessment using low-tech methods. As well, monitoring is done in a social setting and is completed within a span of four hours.A vital concern of volunteers is that the collected data is valid and useful to managers. To ensure the scientific integrity of the data, a variety of quality control and assessment measures were evaluated during the 2007 surveys: the use of training videos, certification of crew leaders, data sheet verification by project staff, and a quality control study involving two volunteer crews and one professional crew. This poster will summarize the results of quality control and assessment measures and provide recommendations for others interested in community-based hydrology studies.

S29-SP-18

A comparison of crest stage gauges and pressure transducer as tools for assessing stage response in headwater streams

Les Stanfield[1] (presenting). [1]University of Toronto, Toronto, Ontario, Canada

Studying hydrologic conditions in headwater streams is hampered by the scarcity of permanent gauge data and the difficulties in measuring discharge in systems which are often intermittent. This study investigated the use of crest stage gauges (CSG) as a means of quantifying the stage response to storm events. Clear plastic tubes were coated with powder and installed in small streams on the north shore of Lake Ontario. At a subset of sites, pressure transducers were also installed to enable an independent measure of stage height at each site. Results for each rain event were compared to generate a correction factor for the CSG and confidence limits for the outputs. Using both approaches provided a backup system for the more expensive pressure transducers and helped identify outlier data. Details of the survey design and operational protocol for the crest gauges are discussed and implications for future use of both devices in monitoring studies will be provided.

S29-SP-19

A management tool for maintaining headwater functions in an urban setting

Shelley Gorenc[1] (presenting), John Parish[1]. [1]Parish Geomorphic, Georgetown, ON, Canada

Within the Greater Toronto Area (GTA), urban sprawl has moved northwards, away from Lake Ontario. As a result, within the last few years, the headwater areas associated with the regions major watercourses have been subjected to increasing development pressure. Traditional development and associated servicing would have meant the lost of numerous, small ephemeral drainage channels and replication of their function through storm sewers. Regulatory agencies have been concerned with the implications of this practice, but have not had the necessary scientific understanding to challenge this form of traditional development, nor an alternative management tool. Part of the challenge is that individually, these small systems do not seem to provide much ecological function, although cumulatively, their role can be of great significance. Through several applied research initiatives, the drainage density parameter has evolved as a prospective solution for this management challenge. Results have shown that, given similar geology and climate and to a lesser extent area and basin shape, headwater areas have relatively consistent drainage density values. Using these regional values, along with a standard deviation to account for natural variability, a target for maintaining open channels per unit area can be developed. These target values can be supported from a regulatory perspective, as they can be implemented and monitored. Results of the monitoring seem to suggest that flow regimes in the post development condition are not as extreme due to more natural storage, slower conveyance and some loss through evapotranspiration.

S29-SP-20

Landscape models to prioritize headwater restoration for watershed recovery

George Merovich[1] (presenting), J. Todd Petty[1]. [1]West Virginia University, Morgantown, WV, United States

Acid rain and mine drainage cause significant degradation to stream ecosystems throughout the central Appalachians of the eastern U.S. Because so many streams are impaired, an objective process is needed to identify priorities for restoration and protection. Therefore, we developed a hierarchical classification system to identify protection and restoration priorities given in-stream conditions in the Tygart Valley and Cheat River basins (8-digit HUC watersheds in north central WV). In-stream conditions were quantified using an integrated index that combined information on water quality, macroinvertebrate communities, and mining intensity. We constructed landscape models to predict in-stream conditions for stream segments where data were lacking. The segment-scale ("house" scale) integrated condition index was then compiled at the 12-digit HUC ("neighborhood" scale) and 10-digit HUC ("community" scale) scales, giving a comprehensive picture of aquatic resource conditions at three important spatial scales. We were then able to identify key protection and restoration priorities as a function of both segment-scale condition and watershed and sub-watershed scale context. First, the highest priorities for protection are high quality neighborhoods adjacent to low quality neighborhoods. Second, highest restoration priority is given to neighborhoods in poor-fair condition that are within communities of good-excellent condition. Within high priority 12-digit HUCs, the highest restoration priority is given to stream segments that maximize watershed scale restorability. Our hierarchical classification system explicitly identifies stream restoration and protection priorities within a sub-watershed context. This approach ensures that the benefits of restoration will extend beyond the stream reach alone. A similar process for classifying headwater restoration may be valuable in other heavily impacted regions where strategic approaches are needed to maximize watershed scale recovery.

S29-SP-21

Reference conditions for mid-Atlantic headwater streams

Camille Flinders[1] (presenting), Richard Horwitz[1], Paul Overbeck[1], Amanda Fierro[1], David Keller[1], Thomas Belton[2].
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The biological importance of headwater streams to downstream watersheds is well-known, but existing bioassessment protocols are often inapplicable. We collected fish, crayfish, and amphibians from sites in headwater streams (drainage area < 10 km2) across a gradient of land uses in northern and central New Jersey, and examined existing data from headwater streams in adjacent states to determine reference conditions and response to disturbance. The most undisturbed streams (>90% forest cover and no other known impairment) generally contained either brook trout or no fish. Undisturbed streams in the southern portion of the study area contained 1-2 minnow species or no fish, based on a small number of sites. Slimy sculpins were found in only one site; their absence from other sites may indicate impairment or restriction for unknown reasons. Undisturbed streams had the greatest abundance and diversity of aquatic salamanders, but thresholds for these measures were difficult to estimate because of the small number of species and high sampling variance. The Appalachian brook crayfish (Cambarus bartonii) was found only in relatively undisturbed streams. Its apparent restriction to these sites may reflect extirpation from other streams following establishment of non-native crayfish. Increasing disturbance of sites was correlated with increasing numbers of species, paralleling typical assemblage changes with increasing stream size. More undisturbed sites in the southern study area will be located and sampled to determine reference conditions in warmwater headwater streams.

<u>S30. Managing Impacts of Fish and Fish Habitat</u>

S30-1

Choosing our legacy--fisheries sustainability or ultimate collapse

William Taylor[1] (presenting), Kerry Waco, Nancy Leonard[1], Michael Schechter[2], C. Paola Ferreri[3]. [1]Department of Fisheries & Wildlife, East Lansing, MI, United States, [2]James Madison College, East Lansing, MI, United States, [3]School of Forest Resources, University Park, PA, United States

Fish are critical components of aquatic ecosystems providing essential goods and services that generate social and economic benefits. The future health of our fisheries depends largely on our willingness to strengthen the value, knowledge and actions of our citizens. Humans must perceive fisheries as socially, politically, biologically and economically valuable resources. Strengthened fisheries valuation should motivate society to ensure benefits from sustainable fisheries and associated ecosystem services. Enhanced communication among stakeholders is an essential component to achieving the desired stewardship and fisheries valuation. This is only possible through the incorporation of all jurisdictions and sectors related to the fisheries supply chain. The focus from fish production and harvest must be expanded to include the entire fisheries supply chain, from ecosystems to consumers. Only in considering all aspects of the fisheries supply chain will holistic decisions leading to sustainable fisheries resources be made. Understanding the social, political, economic, and biological underpinnings and measuring the degree to which a fishery is resilient are essential to having sustainable fish populations. Furthermore, to mitigate negative impacts on fisheries ecosystems the dimensions of the fisheries supply chain, its governance and its resilience need to be incorporated into the decision-making processes. Ignoring any of the above factors will lead us down an irreversible path of destruction and collapse for many fisheries and fish populations. Only through understanding the requirements and benefits of healthy fish, healthy habitats and healthy people will sustainability of fisheries ecosystems for current and thus future generations be ensured.

S30-2

Canada's legal, program and policy frameworks for managing impacts to fish and fish habitat

Patrice LeBlanc[1] (presenting).Fisheries & Oceans Canada, Ottawa, Ontario, Canada[1]

Canada's Fisheries Act, one of the country's oldest laws enacted by Parliament in 1868 under its Constitutional authority for "Sea-

coast and Inland Fisheries" provides the legal framework for the conservation and protection of fish and fish habitat in Canada. Through amendments, most notably those in 1976-77, the Fisheries Act now contains a range of powers, authorities and duties to regulate the impacts of human activities to fish and fish habitat as these relate to fish passage, flow needs for fish, killing of fish by other means than fishing, harm to fish habitat and pollution of fish bearing waters.In 1986, the Policy for the Management of Fish Habitat (Habitat Policy) was tabled in Parliament as a comprehensive and innovative policy framework to guide the programs responsible for the implementation of the provisions of the Fisheries Act for regulating impacts to fish and fish habitat consistent with the emerging concept of sustainable development. Over the years, programs responsible for the administration of the provisions of the Fisheries Act for regulating impacts to fish and fish habitat were given added responsibilities for applying the legal requirements of the Canadian Environmental Assessment Act (CEAA), the Species at Risk Act (SARA) and for Aboriginal consultations prior to making regulatory decisions under the Act. Despite its comprehensive set of legal, program and policy frameworks for managing impacts to fish and fish habitat, Canada, like other countries, continues to face challenges in finding the right balance between sustaining the integrity of its fish species and their habitats and the benefits they provide and maintaining the activities necessary for social and economic prosperity, in essence achieving sustainable development. This paper describes Canada's legal, program and policy frameworks for managing impacts to fish and fish habitat in support of their conservation and protection; identifies key challenges in implementing these frameworks and efforts to address these; and provides some insights into efforts to renew and improve the legal, policy and program frameworks required to managing impacts on fish and fish habitat in order to sustain the integrity of fish species and their habitats and the benefits they provide to Canadians while maintaining the activities necessary for social and economic prosperity.

S30-3
U.S. experience since 1996 implementing the "Essential Fish Habitat" program to conserve fish habitat
Thomas Bigford[1] (presenting). [1]NOAA/National Marine Fisheries Service, Silver Spring, Maryland, United States

Habitat conservation was a low priority in US fishery management until the 1996 amendments to the Magnuson Fishery Conservation and Management Act. Fishing effort, allowable take, rebuilding plans, and gear designs too often failed to consider the ability of habitat to support targeted species. That ecological naivete changed incrementally in 1996 when Congress mandated NOAA and the regional fishery councils to describe and identify essential fish habitat (EFH). The immediate effect was the first ever effort to assemble the best available information on the habitats of each life stage for each species in a commercial or recreational fishery. Existing knowledge often exposed major knowledge gaps on habitat preferences and relationships, a tolerable situation for pelagic species but hardly sustainable for hundreds of habitat-dependent species supporting premier fisheries valued in the billions. About $4.3M (US) in new 1998 funds aided implementation but continues to fall well short of research and management needs. Although still a second-tier consideration in most fishery management decisions, habitat is now accorded greater consideration than ever before. A larger role is likely as many stocks are overfished and some populations are stressed by habitat degradation or loss. Successes during the first decade of EFH implementation include an efficient EFH consultation process to minimize adverse effects (dictated in the 1996 amendments and explained in federal regulations), administrative tools to combine EFH reviews with pre-existing environmental procedures, and increasing attention on priority habitats at risk from specific gear types (cold-water corals that could be toppled by bottom gear) or other human activities (submerged aquatic vegetation affected by declining water quality and shore-side development). Much remains to be done, especially: research to fill key gaps in the connections between habitats and population health and how those populations might respond to habitat loss and gain; natural and social science knowledge to bolster conservation recommendations provided to action agencies during EFH consultations; greater insights on the utility of various mitigation techniques; relative impacts from natural and human events; and much more.

S30-4
The Mexican experience in implementing norms to regulate impacts to fish habitat
Felipe Amezcua[1] (presenting). [1]Instituto de Ciencias del Mar y Limnología, Mazatlán, Sinaloa, Mexico

Fisheries science in Mexico is relatively new. It began in 1923 after the Mexican revolution was finished as a strategy of the new government. But it was until the early 1940 when the fisheries research really started thanks to the creation in the late 1930 of Faculties of Science in the two most important universities of the country, and also to the Spanish Scientifics who arrive to Mexico as immigrants because of the Spanish Civil war. During that time the government idea was to boost the fishing activity in the sea, make list of the available marine species, and administrate the marine resources. Just until very recently, efforts have been made to study and regulate fresh water fisheries. Since then, the main problem has been the shortage of both fisheries scientist and authorities in the country that have been unable to study and patrol the 3,149,920 km2 that comprise the Mexican marine waters, and the continental territory of 1,959,248 Km² in which a great number of lakes and reservoirs are. The shortage of scientist has the consequence that studies on fisheries science are scarce. Therefore, the management policies for many species has been done through the extrapolation of the few results available, with the consequence that form many fishing grounds not even a list of the exploited species is available, with the consequence that most of the species are overexploited. If enough studies are available to establish proper management policies for some species, the problem remains, because poaching is common in Mexico, due to the shortage of authorities that can control this sort of activities. To target these problems the Mexican government has established two strategies. One is to fund research projects to gather socio economic and biological information from habitats where fisheries studies have never been made. Once the scientific studies are finished, the authority then will publish a norm or law. Then, the other strategy is to form local committees with people and authorities from each fishing ground, with the idea to make the population aware of the importance to follow the rules to conserve the resources, and then to make them in charge of the management of the fishing ground, and with the scientific advice from of the researchers that undertake the studies.

30-5

Fish resource protection mechanisms, their application and their effectiveness in Vermont, a small, rural state in the northeast US with an outsize reputation for environmental quality

Leonard Gerardi[1] (presenting). [1]Vermont Fish and Wildlife Department, St. Johnsbury, VT, United States

Among the fifty U.S. states Vermont is small, ranking 45th in area and 49th in population. It is also rural, escaping many of the challenges of urban and suburban development. It has no coastline on salt or estuarine waters. It can be viewed virtually as headwaters, mainly exporting water downstream rather than receiving if from upstream. Its fishery resources are principally freshwater, but do include anadromous and catadromous species. The Vermont Fish and Wildlife Department (VTFW), part of the State's Agency of Natural Resources (VTANR), plays a key role in the conservation, management and protection of Vermont's fishery resources and aquatic habitats. It does not administer any permitting programs affecting land and water use, but typically has standing in a range of state and federal regulatory programs that offer opportunities to avoid, minimize or mitigate the damaging impacts on fish, fish habitat and fishing. VTFW is a relatively flat organization. Its regional fisheries biologists participate as the first line of defence in host of proceedings affecting projects ranging from hydropower plants to lake bottom barriers for vegetation control. They coordinate as needed with other staff within VTANR, and with federal fish and wildlife resource personnel. Higher level staff involvement occasionally comes into play in more controversial cases. Vermont and VTFW have a reputation for rigorous review of jurisdictional projects and activities that have potential to affect fish and habitat, and for strong advocacy on behalf of these resources and their users. In this paper I review the Vermont experience, and the role of VTFW's biologists in advocating for and protecting fish resources, tools and strategies they employ, limitations to their effectiveness, successes they celebrate and frustrations they live with.

S30-6

What should science be providing to support policy and regulation of fish habitat, and how well prepared are we to provide it?

Jake Rice[1] (presenting). [1]Department of Fisheries and Oceans, Ottawa, Ontario, Canada

The landscape for policy and management of fish habitat is changing. The historic focus on evaluating environmental impact assessments for large projects, and issuing (or not) permits for small projects is being crowded by new expectations for habitat managers and policy makers. These new expectations placed on habitat managers and policy makers create the need for expanded support from a new blending of habitat and population sciences. Historical use of relative indices of habitat quality and expert opinion now must be augmented by much more quantitative science advice, to allow setting operational objectives for managing habitats, assessing the quality and quantity of critical or essential habitat, conducting risk assessments of projects and mitigation measures, making siteing decisions about marine protected areas and other spatial zoning measures, and many other tasks in which habitat managers and policy makers must participate. Science advice now must be able to quantify the relationships between habitat features and population status and productivity, as well with community properties such as resilience and vulnerability. This advice has to capture the uncertainty in the relationships and data sources, in forms that fit comfortably into risk assessments. Tools for forward projection of the habitat consequences of management options ar needed, as are tools for cost-benefit analyses of tradeoffs among different types of habitats for different groups of aquatic species. None of these analytical challenges is beyond the scope of modern statistical and modelling capabilities, and current ecological concepts. Few of them can be met by existing tools and data-bases however. Moreover, many of the conceptual approaches to aquatic habitat management have been imported from terrestrial habitat management. They may have served well for management of riverine and lacustrian habitats, and adequate for marine benthic habitats, but some of the fundamental conceptual starting points are being questioned for marine habitats more generally. The talk will develop the above points, and bring out both some promising opportunities and some difficult challenges for the science needed to support contemporary habitat management and policy.

S30-7

A better way to think about aquatic habitat: the science foundation for the National Fish Habitat Action Plan

Gary Whelan[1] (presenting). [1]Michigan Department of Natural Resources - Fisheries Division, Lansing, MI, United States

For the U.S. National Fish Habitat Action Plan to be successful, it is critical to periodically assess the status of the Nation's fish habitat and to have a method to determine the effectiveness of individual and groups of funded projects. A number of attempts have been made to examine the condition of the Nation's fish habitat, most recently by the Heinz Center. All of these attempts have been at scales that are not useful for watershed or system planners. Another difference between this effort and others is the focus on rehabilitating system processes and the true problems not just symptoms. The National Fish Habitat Board will use a system that classifies all of the Nation's waters from the mountains to the continental shelf. The system will provide for the vertical integration

of scoring and the horizontal comparison of systems, and will apply a set of condition variables to score the overall condition of the each system. The inland classification system will use a system similar to that used in the The Nature Conservancy/Aquatic GAP system and will have units ranging from very large landscape groups (World Wildlife Fund Freshwater Ecosystems) to individual reaches. The coastal classification system will use a system similar to NOAA/NatureServe CMECS system. One unique feature of this assessment will be the linkage between the classified units and condition scores of the tributary inland systems to the coastal systems. All classified units will be scored in Hydrology, Water Quality, Connectivity, Channel and Bottom Form, Material Recruitment, and Energy Flow. Scores for each classified unit will be averaged across processes and compared against the theoretical maximum and currently existing best systems within each group (Horizontal Scoring). Larger watershed and landscape units will have scores averaged over their composite units to provide system scores (Vertical Scoring). As individual and groups of projects change processes, the assessment will allow the tracking of system changes and will show the improvements/changes in the Nation's fish habitats, tracking the success of this unique National effort.

S30-8

Overview talk on the proposed DFO Centre of Expertise on Habitat Research

Robert Gregory[1] (presenting). [1]Fisheries & Oceans Canada, St John's, Newfoundland & Labrador, Canada

The complexity and variability of fish-habitat relationships over a wide range of temporal and spatial scales poses challenges for government regulators. Human activity has the potential to directly or indirectly affect fish habitat. The Department of Fisheries and Oceans has proposed that a Centre of Expertise on Habitat Research be formed which will provide a strategic and integrated approach for the identification of national and multi-regional priority areas for future habitat research and the provision of scientific advice in Canada. The emphasis of the Centre will be population-habitat linkages. Knowledge of these linkages is essential to understand the effects of anthropogenic and natural changes to habitat quantity and quality. The objectives of the Centre will include: human and natural influences (quantifying and calibrating effects of human-induced and natural changes to habitats and the aquatic resources, including sensitivity, resilience, intensity, duration and reversibility of effects); methodological tool development (specifically those that link population and community productivity to habitats); developing best practices for measuring habitat impacts (habitat assessment methods, identification of productivity surrogates, development of indices, models, and tools), assessing mitigation methodologies integrating ongoing surveying methods; and communications (information sharing across Canada).

S30-9

Assessing net change of productive capacity: moving from suitability to fish

Charles K Minns[1] (presenting). [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada

Efforts to achieve no net loss of productive capacity (PC) of fish habitat are failing in Canada, and elsewhere. These growing losses, particularly in freshwater, have a central role in ongoing global changes that threaten our future. Canada has a large share of global freshwater resources and hence a greater responsibility to help find solutions. For fish habitat, a preoccupation with habitat suitability, and other indices of that ilk, have diverted attention from self-sustaining fish populations, their productivity and their fisheries. Symptoms of the problem are reviewed and a remedial approach is offered alongside analogies from comparable conservation and protection arenas such as fisheries, biodiversity, and human society. The numerous symptoms include: net change (NC) of PC is primarily assessed by site or project; PC is erroneously assumed to be a linear function of habitat quality and supply; detection of NC at the site level is difficult and most assessment programs are ineffective; management agencies tend to be pre-occupied with few large projects although the aggregate impact of many small projects is likely greater; cumulative impacts only gain cursory attention; limited spatial and temporal attention spans result in an ever-shifting baseline; folklore and anecdote are often more influential than scientific evidence; many large-scale stressors causing net loss are ignored by management agencies; mitigation and compensation efforts are often species-directed rather than ecosystem-based. Current approaches to fish habitat management are analogous to managing fisheries one fisher and one catch at a time. The remedy has several key features: a total ecosystem approach is required; all habitat changes need to be tracked within a spatial framework specifying the total supply of PC; absolute development limits are necessary across spatial scales as there are limits to how compensation can offset losses and degradation; recognition that productive capacity: habitat quality-supply linkages are inherently nonlinear with thresholds presaging profound consequences; a much stricter legal framework with a reversed onus of proof to protect ecosystems and ecosystem services; and, adoption of a rigorous adaptive management approach. Some examples illustrate how implementation might be achieved.

S30-10

Implications of cumulative impacts to estuarine marsh habitat quality and fish and invertebrates resources

Mark Peterson[1] (presenting), Michael Lowe[1]. [1]University of Southern Mississippi, Ocean Springs, MS, United States

Salt marsh habitat has long been established as an important nursery for estuarine fishes and crustaceans (nekton). It has been presumed that these habitats are preferentially sought out within an estuary, suggesting avoidance of less suitable habitat types. This selection has important ramifications because habitat is the template on which population and community dynamics occur.

However, the linkage between vegetated estuarine habitat and production of ecologically- and economically-important nekton are being altered by development pressures and thus we are studying this linkage (function) while it is changing. Modification of estuarine landscapes can have direct and indirect consequences leading to reduced or eliminated access to favourable nursery habitat for nekton, which is predicted to reduce growth, increase mortality, and/or modify settlement patterns. Furthermore, cumulative impacts are more problematic because they are typically not immediately noted and build up over time to produce a more substantial impact to habitat. On a small scale, bulkheads and levees eliminate or significantly reduce access to intertidal marsh habitat, but these can accumulate to a larger area of impact that fragments the salt marsh landscape and reduced habitat connectivity for early life stages of nekton. However, the creation of habitat patchiness (non-continuous segments) caused by shoreline development has received little attention but has been hypothesized to contribute to reduced environmental sustainability. Herein, we review the literature on habitat alteration in estuaries trying to separate hypothetical from quantified impacts. We also provide a time line on the development of these two perspectives as a way of gauging our scientific and management responses to these perceived cumulative impacts. Because of these alterations, particular focus needs to be placed on the ecological value of habitat that has undergone some form of alteration versus that which is still natural or has recently undergone restoration in order to evaluate and predict estuarine resilience and sustainability in the face of an ever changing landscape. As with many other issues, managers and policy makers must make cumulative impacts an important item in their coastal management plans.

S30-11

Basin scale monitoring of river restoration: guidelines and case studies from the western United States

Phil Roni[1] (presenting), George Pess[1], Tim Beechie[1], Chris Jordan[1], Martin Liermann[1]. [1]Northwest Fisheries Science Center, Seattle, WA, United States

holistic basin or watershed approach not only to restoration but also to monitoring and evaluation. Monitoring restoration at a watershed scale requires more coordination among data collection efforts, as well as different study designs, sampling schemes, and sampling intensity than evaluation of individual projects. An additional challenge is linking site or reach scale responses of restoration to the response at a watershed or population level. Using completed and ongoing restoration case studies in the western United States, we demonstrate the key factors and challenges that need to be considered when designing watershed scale evaluation of numerous restoration actions. We also illustrate the different monitoring designs, sampling designs, and spatial and temporal replication needed to monitor a range of physical and biological parameters at a watershed scale. Notably, physical processes and populations of fish and biota require very different monitoring schemes at the watershed scale than at a reach scale. Finally, the case studies suggest that additional improvements in monitoring design and parameters are needed for successful implementation and evaluation of restoration at a watershed scale.

S30-12

Involvement of the Department of Fisheries and Oceans, Quebec Region in the analysis, mitigation and monitoring of a major highway construction project in the Réserve faunique des Laurentides, Québec

Alain Guitard[1] (presenting), France Pouliot[1], Simon Blais[1]. [1]Fisheries and Oceans Canada- Quebec Region, Mont-Joli/Quebec, Canada

Starting in the summer of 2006 and running until 2010, the Ministère des Transports du Québec is widening Highway 175, which traverses the Réserve faunique des Laurentides between Quebec City and the Saguenay/Lac St Jean region. This work stretches for over 150 km and requires construction of bridges and culverts, as well as river stabilisations, that will affect some 300 natural watercourses. Réserve faunique des Laurentides is noted for the richness of its natural waters and for its brook char (speckled trout), a game fish much prized by sports fishermen and generating 65,000 fishing days per year in this territory. Moreover, the region is a unique environment, with harsh climatic conditions, soils susceptible to erosion and subject to heavy precipitation. All of these factors tend to make fish habitat more sensitive to construction work, and minimizing its impact represents an important challenge. For this reason, the Department of Fisheries and Oceans (DFO) has been involved from the outset in analysing the many work sites to avoid or minimize fish habitat destruction, degradation or disturbance. DFO has issued and will issue to the Ministère des Transports du Québec authorizations under the Fisheries Act for all the work sites in this major project. These authorizations include numerous mitigation measures designed to minimize the effects on fish and their habitat, in terms of both the free passage of fish and conservation of such important habitat as brook char spawning grounds. Further, where habitat loss is inevitable, authorizations require compensatory measures. Concurrently with the analyses and authorizations, DFO is involved in environmental surveillance of work sites and monitoring of the effectiveness of the project mitigation and compensatory measures, jointly with other federal (Transport Canada) and provincial departments (Ressources naturelles et Faune, Développement durable, Environnement et Parcs, and Transports Québec). These concerted monitoring efforts will help to avoid much of the potential impact on fish habitat, in particular adjusting contractors' work methods so as to preserve habitat and maintain the free passage of fish. The purpose of this presentation is to describe DFO's role in the various approval and realization stages in the works of Highway 175 widening that affect fish habitat.

S30-13

Effects of habitat change on fishes – a review and meta-analysis

Tom Pratt[1] (presenting), Karen Smokorowski[1]. [1]Fisheries and Oceans Canada, Great Lakes Laboratory, Canada

Aquatic resource managers are continually faced with development proposals which, if allowed to proceed, would ultimately alter the physical structure and cover of fish habitat. To assess the weight of scientific evidence in support of management decisions, we summarized both the observational and experimental freshwater fish-habitat literature. We then extracted data, where possible, from experimental studies to undertake a more rigorous meta-analysis. We found relatively strong and consistent correlational evidence linking fish and physical habitat features, yet inconsistent evidence in the experimental literature. On the whole, large decreases in structural habitat complexity are detrimental to fish diversity and can change species composition. Increases in structural complexity showed increases, decreases, or no measurable changes in species and/or communities. Habitat alterations are most likely to affect individual species or community structure, and thus evaluating the extent of the effect on a biological basis depends on management objectives.

S30-14

Exploring how low-resolution data can work in high-resolution mapping tools – lessons learned from NOAA's Essential Fish Habitat Mapper

Michael Peccini[1] (presenting). [1]National Oceanic and Atmospheric Administration, Silver Spring, MD, United States

In creating an online tool to distribute existing GIS data that represents Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC), the National Oceanic and Atmospheric Administration has organized a set of regionally produced GIS datasets that represent a range of approaches to mapping habitat based management areas. This presentation will describe some of the challenges in producing high resolution GIS layers from source data that is limited in both spatial coverage and resolution. By putting existing GIS data in the context of high resolution imagery and simple query and analysis tools, this project has demonstrated the need to reevaluate how spatial data is created so as to allow for better integration with rapidly evolving technology. Lessons learned from this effort may assist in the future development of GIS data for use in the management of fisheries habitat.

S30-15

Evaluating the stability and performance of engineered fluvial habitat as a method to achieve 'no net loss' over the past 20 years in Seal Cove River, Newfoundland, Canada

Keith Clarke[1] (presenting), David Scruton[2], Curtis Pennell[1]. [1]Fisheries and Oceans Canada, St. John's, Canada, [2]Sikumiut Environmental Management Ltd. St. John's, Canada

The science of habitat compensation is still relatively young and there have been few studies that have monitored the effectiveness and stability of engineered structures over the long term. The first habitat compensation project in Newfoundland, under the auspices of the then new Policy for the Management of Fish Habitat, was conducted in 1987 for a 162 m reach of Seal Cove River. This reach was destroyed to accommodate highway construction and the compensatory habitat was designed to achieve 'no net loss' by the addition of rearing areas (pools) for larger brook trout (*Salvelinus fontinalis*), a habitat feature lacking in the original reach. An initial before/after assessment in 1990 indicated an increase in overall habitat area (23%) including pool area (134%), increase in pool/riffle ratio (223%) and increase in overall depth (29%). There was a 2.1 fold increase in fish biomass, reflecting a shift from young of the year to older age classes, and the habitat increase coupled with increased biomass suggested a 2.58 fold increase in the 'productive capacity' of the artificial reach. The evaluation was repeated in 1999, 2001 and 2007 and revealed that the habitat and engineered features remained stable, with pool/riffle ratio similar, overall depth of pools and riffles increased, and salmonid biomass remaining high (1.86 fold increase from the destroyed habitat). Fish biomass in pools with artificial undercut banks ('lunker' structures) was 2.6 times greater than in pools without. Local conditions that may have promoted the observed stability in both habitat and its subsequent biological functions are discussed.

S30-16

Getting beyond the leap of faith: translating habitat science into management advice

John Boreman[1] (presenting). [1]NOAA Fisheries, Silver Spring, MD, United States

Translating scientific information into management advice is often considered an art form. The information must be conveyed in a manner that is easily understood, relevant, timely, and technically correct. The scientist's job is made easier if the advice can be delivered in a universal information currency that both the scientist and the manager fully understand and are adept at using. Perhaps the best example is stock assessment advice that fishery scientists provide to fishery management councils, for which the currency is expressed as indicators or biological reference points. In this case, scientists and managers have had over 30 years to overcome communication barriers. Scientific advice to managers on potential impacts of human activity to habitats that support fishery stocks has had an even longer period of time to develop a universal information currency, but progress has been much slower. A principal reason for the slower development is the lack of adequate information on the connection between habitat types and productivity of fishery resources. Information that does exist is spotty and often not transferable to other habitats and stocks. Serious consideration should be given to using extant information to develop a body of theory that can be used to guide future research as well as management actions.

S30-17

The National Fish Habitat Action Plan – a national partnership to protect and restore fish habitat

Susan-Marie Stedman[1] (presenting), Thomas Busiahn[2], Christopher Estes[3], Janet Cushing[4]. [1]NOAA Fisheries Service, Silver Spring, MD, United States, [2]US Fish and Wildlife Service, Arlington, VA, United States, [3]AK Dept. of Fish and Game, Anchorage, AK, United States, [4]US Geological Survey, Reston, VA, United States

In recent decades, gains have been made in reducing pollution and degradation of aquatic habitats, but they have not kept pace with impacts of population growth and land-use changes. Conservation leaders saw a need to increase voluntary action to conserve aquatic habitats and to improve coordination across boundaries and jurisdictions. The National Fish Habitat Action Plan is an investment strategy to maximize the impact of conservation dollars. Signed by State and Federal leaders in 2006, the Action Plan is partnership-driven, science-based and non-regulatory, modeled after the North American Waterfowl Management Plan. With oversight by a national board, the Action Plan works through regional-scale Fish Habitat Partnerships to set strategic priorities; to implement projects to protect, restore, and enhance habitats; and to measure and communicate results. By 2010, partners in the Action Plan will assess and report on the status of fish habitats across the United States, and establish 12 or more Fish Habitat Partnerships in priority areas. Fish Habitat Partnerships already in place include include the Eastern Brook Trout Joint Venture, Western Native Trout Initiative, Driftless Area Restoration Effort, Southeast Aquatic Resources Partnership, and Matanuska-Susitna Basin Salmon Conservation Partnership. The Action Plan enlists non-traditional partners, such as local governments, corporations, and landowners, to contribute to healthy aquatic habitats. Several hundred individuals and organizations have joined the Partners Coalition to support the Action Plan. The Action Plan brings together an unprecedented partnership to conserve aquatic habitats for fish and other species.

S30-18

An integrated regulatory review process for regulating impacts to fish and fish habitat from placer mining in the Yukon

Steve Gotch[1] (presenting). [1]Fisheries and Oceans Canada, Whitehorse, Yukon, Canada

Since the Klondike gold rush of 1898, placer mining has been one of the principle economic mainstays of the Yukon. Today modern placer mining occurs on many historically mined watercourses, and due to the advent of gold recovery technology, is being practiced in a number of newly developed areas. Placer gold deposits are typically found within alluvial floodplains, occurring adjacent to, and in many cases beneath present-day streams and rivers. A large number of these watercourses provide habitat for a variety of resident (freshwater) and anadromous fish species, and as such, require careful planning and consideration when developing mining proposals. Many activities and processes associated with placer mining have the potential to result in the harmful alteration, disruption or destruction of fish habitat. In the past, the operation of mechanized dredges resulted in extensive localized disturbance of fish habitats which, without active restoration required many years to recover. In the Yukon, Fisheries and Oceans Canada administers the habitat protection provisions of the Federal Fisheries Act, and thus is principally responsible for ensuring that placer mining activities are carried out in a manner which achieves effective conservation and protection of fish and fish habitat resources, consistent with the principle of sustainable development. Between 2002 and 2007 Fisheries and Oceans Canada, in partnership with the Yukon Government the Council of Yukon First Nations and with support from the placer mining industry, developed a new integrated regulatory process for managing the effects of placer mining activities on fish and fish habitat resources. The resulting system effectively integrates a number of key regulatory principles including cause-effect / risk-based project assessment, industry-specific operational guidelines, watershed-wide fish habitat management planning, aquatic ecosystem monitoring, incorporation of First Nation traditional knowledge, proactive compliance and enforcement and an adaptive management system through which adjustments can be made over time. Overall this approach has been implemented with the objective to achieve conservation and protection of fish and fish habitat resources while facilitating a regulatory environment that enables the placer mining industry to continue operate in an environmental sustainable and economically viable manner into the future.

S30-19

Risk characterization and assessment of cumulative impacts on aquatic ecosystems

Roland Cormier[1] (presenting). [1]Fisheries and Oceans Canada, Moncton, NB, Canada

Risk characterization is but one step of a decision-making process for integrated management generally. Classic risk analysis decision-making includes:

1. Setting of management objectives based on spatial/temporal social, cultural, economic, regulatory and ecosystem profiles and consultations;
2. Identifying and characterizing the risk to both ecosystem and social components to set priorities for management;
3. Formulating of the assessment scope which includes setting indicators and identifying data sources;
4. Conducting the assessment of the identified risks taking into account the management objectives so to provide options for management consideration;

5. Developing management plans based on options provided in consultation with key stakeholders and regulatory agencies;
6. Implementing management plans where indicators are then used for monitoring the performance of the management plans in effectively achieving the initial management objectives;
7. Communicating to regulatory agencies, industry sectors, stakeholders and coastal communities from the perspective of policy, best management practices and stewardship.

In addition to ecosystem-based strategic planning, risk characterization can prove useful in communicating priorities to coastal or regional communities and management as well as identifying science knowledge gaps.

S30-20

Toronto Waterfront Aquatic Habitat Restoration Strategy – a strategic and integrated approach to managing the aquatic habitat in a large urbanized centre

Cassandra Bach[1] (presenting). [1]Toronto and Region Conservation Authority, Toronto, ON, Canada

The Greater Toronto Area occupies an extensive length of the coast of Lake Ontario. Historically, the shoreline and lands were used for commercial purposes with some areas for recreation. Degradation has led to substantive losses of important aquatic habitat. Recently renewed interest in revitalizing the waterfront has emerged. Significant efforts to revitalize the waterfront require effective coordination at all levels of government. Aquatic Habitat Toronto has been created to implement the Toronto Waterfront Aquatic Habitat Restoration Strategy and coordinate all three levels of government so that projects can be implemented in a time and cost effective manner. This presentation will showcase the planning process involving consensus based development of aquatic habitat on the Toronto Waterfront. The objective is to provide an overview of the research, monitoring, planning and ultimately implementation with respect to aquatic habitat within the highly urbanized Greater Toronto Area. The Toronto Waterfront Aquatic Habitat Restoration Strategy represents an integrated approach to adaptive management. The strategy is an effective tool for facilitating federal, provincial and municipal agencies in their respective review and approval process ensuring a sustainable 'no net loss' policy for development on the waterfront.

S30-P-2

Nutrients in the Upper Athabasca River monitoring to fit the need

Mark Spafford[1] (presenting), Preston McEachern[1]. [1]Alberta-Pacific Forest Ind. Inc. Boyle, Alberta, Canada

The Athabasca basin is one of the largest drainages in Alberta with an area of 155,000 square km. Resource development is the major land use activity and oil and gas development is extensive. The main users of water and sources of effluents discharged directly or indirectly to the Athabasca River in the upper basin are pulp mills, agriculture and municipalities. Nutrification has been identified as the largest threat to ecosystem integrity in the upper basin. The Northern River Basins Study, Provincial monitoring in the 80's and 90's, and the Environmental Effects Monitoring program (EEM) have all identified nutrients as the number one risk. EEM has given evidence of mild nutrification of local zones from pulp mills. In the basin nutrients from pulp mills account for approximately 10% of the total. No monitoring is conducted by the other nutrient contributors. A suggested alternative to EEM may be a basin wide approach that includes all contributors (point and non-point sources). The Athabasca Water Quality group was created in 2005 has begun the work to identify sources of nutrification, develop predictive tools to determine where and when risks are present, and encourage/enforce best practices with all sources of nutrients. This strategy is being adopted by Alberta to preserve and enhance water quality throughout the Province.

S30-P-3

Potential benefits of regional fish habitat compensation planning

M. Kerry Brewin[1] (presenting), Julie Dahl[2]. [1]TERA Environmental Consultants, Calgary, AB, Canada, [2]Fisheries and Oceans Canada, Winnipeg, MB, Canada

In Canada, Fisheries and Oceans Canada (DFO) are responsible for administering the Federal Fisheries Act and for the conservation and protection of fish habitat. When mitigation is unable to successfully prevent a harmful alteration, disruption or destruction (HADD) of fish habitat, proponents can be allowed to proceed with the activity expected to cause the HADD under a Fisheries Act Authorization. To ensure DFO's Habitat management Policy guiding principle of 'no net loss' policy is met, the Authorization generally includes conditions for a Fish Habitat Compensation Plan (FHCP). This normally requires a physical project be undertaken that results in the creation of new, or enhancement of existing, fish habitat. The process of getting a FHCP approved often varies between offices and regions (e.g. level of consultation with stakeholders and other regulatory agencies varies). The process typically involves the proponent proposing a physical project to DFO. If it is found to be acceptable, it is approved by DFO. While the process has its advantages, it also has disadvantages, particularly in regions where aquatic habitats are relatively pristine, limitations to productivity can not be readily identified, and the number of orphaned projects that need corrective measures is limited. One way of addressing the limitations of the existing system is to develop regional compensation plans that would identify and prioritize regional fish habitat compensation opportunities. This presentation will discuss some of the potential pros and cons associated with regional compensation planning, as well as discuss scenarios, and potential processes, where regional compensation plans could provide win-win benefits to proponents, regulators, aquatic resources, and resource users.

S30-P-4

The will to protect: an evaluation of fish habitat management and policy in Canada

John Werring[1] (presenting), Jeffery Young[1]. [1]David Suzuki Foundation, Vancouver BC, Canada

Fisheries and Oceans Canada has charted a new course for managing fish habitat in Canada. The Environmental Process Modernization Plan, adopted and implemented in 2004, seeks to refocus the department's efforts away from reviewing project development proposals on a case-by-case basis and toward streamlining the project approval process by applying a risk management approach to decision-making that ostensibly takes into account concepts of risk, uncertainty and precaution. In addition, the Department has moved away from using enforcement of the law (specifically the federal Fisheries Act) as a means to achieve compliance, arguing that education, training, stewardship and monitoring and auditing compliance effectiveness will achieve the same goal. his new approach reduces the onus on government to assess the likelihood of the impacts from myriad project activities across Canada on fish and fish habitat while giving greater control to project proponents to determine how habitat is identified, replaced, or protected. The department asserts that this approach will be more efficient while still protecting habitat. We disagree with this approach for several reasons but primarily we believe that compliance in the realm of fish habitat protection will only be achieved with greater enforcement, not less. This is confirmed by past audits of DFO's habitat management program effectiveness which have concluded that in order to achieve compliance there is need for greater enforcement presence in addition to increased monitoring. Solutions will be presented that we believe will result in better protection for fish habitat in Canada while at the same time help the Department to achieve its objectives of streamlining the project approval process and increasing the Department's overall effectiveness. These include: a discussion of alternative enforcement tools; and, suggested policies and regulations for improving habitat protection.

S30-P-5

Fish habitat management at Canadian Forces Base Gagetown

Andy Smith[1] (presenting), Shane Heartz[2], Steve Falconer[2]. [1]Department of National Defence, Oromocto, New Brunswick, Canada, [2]Fisheries and Oceans Canada, Oromocto, New Brunswick, Canada

Canadian Forces Base Gagetown was established in 1952 to provide a training area for the army in Atlantic Canada. Located in south central New Brunswick it encompasses over 1100 km2 of land area and includes 1618 km of watercourses, 44 water bodies and 1215 wetlands. Training activities include artillery, armoured, infantry, engineering, helicopter, air force and battle group exercises. Direct impacts to fish habitat due to related development and training have included channel diversion, culvert installation, removal of riparian vegetation and fording. Activities that have indirectly impacted fish habitat include land clearing, neglected roadways, lack of maintenance, and soil disturbance by military vehicles. The activities have resulted in significant impacts to stream hydrology and increased levels of sedimentation. Several programs, projects and partnerships have been initiated to address historic and ongoing impacts to aquatic environments and to manage fish habitat. These include protection of sensitive habitat, stream rehabilitation, improvements to infrastructure, environmental training of civilian and military personnel, project planning and review, and compliance monitoring. Annual monitoring programs are conducted on water quality, macro-invertebrates and fish populations. Through a unique partnership, the fish habitat management program at CFB Gagetown is implemented jointly by the Department of National Defence and Fisheries and Oceans Canada.

S30-P-6

Canada's approach to addressing the impacts of fishing on the ecosystem, including fish and fish habitat

Nadia Bouffard[1] (presenting), Lisa Setterington[1], Brett Gilchrist[1]. [1]Fisheries and Oceans Canada, Ottawa, Ontario, Canada

Fisheries and Oceans Canada (DFO) has developed a new framework for fisheries management decision-making called the Resource Management Sustainable Development Framework. Under this Framework, new policies and tools will assist in factoring in ecosystem considerations and will help demonstrate sustainability in those fisheries managed by DFO. The policies and tools involved in the Framework include a policy to managing the impacts of fishing on sensitive benthic areas; a policy to help guide decisions regarding fisheries for forage species; a fishery decision-making framework incorporating the precautionary approach to guide management decisions; and a fisheries checklist to help DFO self-assess progress towards sustainability and to report externally on performance and progress towards sustainable management of Canadian fisheries. The policy of managing the impacts of fishing on sensitive benthic areas is one way that Canada is addressing the impacts of fishing on the ecosystem. Marine benthic ecosystems are important components of the oceans environment as they provide habitat, support food webs and are a significant source of marine biodiversity. These areas also sustain many marine species that have an important role in social, cultural and economic role in the lives of many Canadians. The health and productivity of such ecosystems form a central part of fisheries management decision-making, including the consideration of target and non-target species along with the ecosystems of which they are a component as well as the impact of fishing on these ecosystems. This policy applies an ecosystem-based approach to the management of all Canadian fisheries and all fisheries within Canadian fisheries waters in order to mitigate or avoid impacts on benthic areas that are sensitive to fishing activity. The policy involves steps for data collection and identification of sensitive areas as well as a risk assessment framework for addressing the impacts of fishing in sensitive areas according to the level of harm these impacts may cause. This policy will be addressed through existing management planning processes, including stakeholder advisory processes for individual fisheries.

S30-P-7
Evaluating the origin of spawners utilizing an engineered stream at the Granite Canal Hydroelectric Project: What is the spatial influence of the new habitat within the reservoir system?
Curtis Pennell[1] (presenting), Brent Sellars[2], Keith Clarke[1], David Scruton[3]. [1]Fisheries and Oceans Canada, St. John's, Canada, [2]Newfoundland and Labrador Hydro, St. John's, Canada, [3]Sikumiut Environmental Management Ltd, St. John's, Canada

The Granite Canal Hydroelectric Development, located within the Bay d'Espoir - Upper Salmon Hydroelectric Generating System, Newfoundland Canada was developed to generate up to 40 MW of electricity. Construction of the project resulted in the destruction of salmonid habitat utilized primarily by ouanainche (*Salmo salar*) and, to a lesser extent, brook trout (*Salvelinus fontinalis*). Pre-development surveys suggested that the habitat destroyed was used extensively for spawning, particularly by ouananiche. To compensate for habitat losses, Newfoundland and Labrador Hydro (NLH) constructed a 1.6 km fish habitat channel, subsequently named Compensation Creek. As there was very limited habitat available for spawning in the tributary streams of the downstream reservoir, Maelpaeg Lake, Compensation Creek was expected to be utilized by large proportion of the ouananiche population. To test this hypothesis fish of spawning size were captured using fyke nets throughout Meelpaeg Lake in the summers of 2006 (238 ouananiche and 27 brook trout) and 2007 (379 ouananiche and 46 brook trout) and surgically implanted with a 23.1 mm PIT (passive integrated transponder) tag, additionally in 2006, 26 ouananiche and 9 brook trout were surgically implanted with radio transmitters. The entrance to Compensation Creek was monitored during the spawning season by a double gate loop PIT antennae, attached to a data logger. A helicopter survey of the lake and nearby rivers and streams was also conducted to determine possible spawning locations of the fish that did not enter the creek. Forty percent (n=96) of the ouanainche tagged in 2006 entered compensation creek in that fall. Ten percent of these (n=23) returned in 2007. Twenty nine percent (n=110) of the ouanainche tagged in summer 2007 entered the creek during the subsequent fall. Most of these fish spent on average 2 weeks in the creek before moving downstream towards Mealpeag Lake. These preliminary results suggest that Compensation Creek is functioning as designed and is providing spawning habitat for a large proportion of the reservoir's ouananiche population.

S30-P-8
The Saskatchewan protocol agreement: a cooperative approach to prioritizing and managing fisheries issues at power-generating facilities
Jackie Lukey[1] (presenting), Vincent Harper[2], Debbie Nielsen[3], Robert Wallace[4], Michael Pollock[5]. [1]Fisheries and Oceans Canada, Regina, Saskatchewan, Canada, [2]Fisheries and Oceans Canada, Prince Albert, Saskatchewan, Canada, [3]SaskPower, Regina, Saskatchewan, Canada, [4]Saskatchewan Ministry of Environment, Saskatoon, Saskatchewan, Canada, [5]Saskatchewan Watershed Authority, Saskatoon

Fisheries & Oceans Canada, SaskPower, Saskatchewan Ministry of Environment, and the Saskatchewan Watershed Authority have entered into a protocol agreement. The agreement provides an organized framework for communication, a forum for interagency collaboration, a set of guiding principles, and a management structure for assessment and decision making. The purpose is to identify areas of concern regarding fish and fish habitat associated with SaskPower facilities and then to establish a process to develop, prioritize, and propose workable solutions to address these concerns. Under the agreement, a set of evaluation criteria was established and best available information was used to prepare a prioritized list of issues and opportunities for all of SaskPower's hydro-electric and thermal generation facilities and operations. The criteria comprise five areas: socio-economics (First Nations, recreational, or commercial fishing), fish population status, species-at-risk, fish kills, and impact to fish habitat. An action plan was developed and approved in late 2007 to begin the process of addressing, mitigating, or resolving each of the issues on the list. The ultimate goal is to address each of the areas of concern to ensure SaskPower is in compliance with the federal Fisheries Act.

S30-P-9
Protecting fish and fish habitat on provincial transportation undertakings in Ontario
Cynthia Mitton-Wilkie[1] (presenting), Jamie Dougall[1], Gareth Goodchild[2], Stuart Niven[3], Stephen Casselman[4], Bob Bergmann[4]. [1]Ontario Ministry of Transportation, St. Catharines, ON, Canada, [2]Fisheries and Oceans, Peterborough, ON, Canada, [3]Fisheries and Oceans, Burlington, ON, Canada, [4]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

The Ministry of Natural Resources (OMNR) is responsible for the management of Ontario's fisheries. The Ministry of Transportation (MTO) is responsible for planning, designing, constructing, operating and maintaining Ontario's Provincial transportation network with a view towards protecting the environment. These three agencies have formed a partnership and developed the MTO / DFO /OMNR Fisheries Protocol for the Protection of Fish and Fish Habitat on Provincial Transportation Undertakings (2006). The Protocol ensures that all MTO projects protect fish and fish habitat, including species at risk. This is achieved by clearly defining roles and responsibilities for each of the agencies, implementing a quality assurance and quality control program, and establishing a committee to oversee the implementation and continuous improvement of the Protocol. The Protocol also outlines a streamlined process whereby MTO has the responsibility and accountability to self screen for the likelihood of projects resulting in the harmful alteration, disruption, or destruction of fish habitat. This Protocol could serve as a model for other jurisdictions.

S30-P-10

Perspective on a habitat area-production approach for assessing the productive capacity of fish habitat

Robert Randall[1] (presenting). [1]Fisheries and Oceans Canada, Burlington, ON, Canada

Gear comparison surveys were conducted in 2006 and 2007 at four Great Lakes Areas of Concern (AOCs, degraded areas identified by the International Joint Commission) as a precursor to early detection monitoring recommendations. Historically, boat electrofishing has been used to survey the littoral fish communities at Areas of Concern. Additional gears were used to determine total species richness, including invasive species, in two areas of Lake Ontario (Hamilton Harbour, Bay of Quinte), the St. Marys River, and the Detroit River. The supplemental gears, depending on the survey area, included gill nets, fyke nets, trap nets, minnow traps, beach seines, boat seines, and a bottom trawl. The efficacy of the fishing gears was assessed by comparing cumulative catch curves. Although gear efficacy depended on the survey area and habitat, the results confirmed that boat electrofishing (active) was effective for measuring richness; however, significantly more species were detected if passive gears were added (e.g. trap nets). Results are being used to identify a multi-gear protocol for assessing invasive fish species in near shore habitats. In addition to a gear protocol, a strategy for surveying coastal areas and interconnecting channels (location, frequency) of the Great Lakes will be discussed.

S30-P-11

The application of a risk based approach to the management of development impacts on fish and fish habitat in Canada

Nicholas Winfield[1] (presenting), Abdelhafid Chalabi[1], Lonnie King[1]. [1]Fisheries and Oceans Canada, Ottawa, Ontario, Canada

Fisheries and Oceans Canada plays a major role in regulating the impacts of development activities on fish and fish habitat in Canada. The Fisheries Act contains legal tools to conserve fish habitat in both marine and freshwater habitats. The Oceans Act calls for the development and implementation of plans for the Integrated Management of all activities or measures affecting estuaries, coastal and marine waters. Fundamental to managing human-induced impacts is the need to have a common approach to assess how human activities impact on aquatic ecosystems. Activity-based “Pathways of Effects” models were developed to support departmental review of development proposals for effects on fish and fish habitat at the site level. These models have also aided in the identification of appropriate mitigation measures; the development of guidelines and best management practices; the assessment of alternative design options and as a communications tool to stakeholders. New initiatives are exploring the “Pathways of Effects” models as a foundation to assess the impacts of human activities occurring at broader spatial and temporal scales. In considering cumulative effects, for example, specific endpoints or valued ecosystem components must be determined, rather than discrete effects. Information gathered from such analyses serves as the foundation for understanding ecosystem condition and may provide useful information to guide marine and freshwater planning initiatives by establishing ecological thresholds.

S30-P-12

Green shores: a voluntary rating and certification program for sustainable shore development

Brian Emmett[1] (presenting), John Readshaw[2], Harriet Rueggeberg[3], John Harper[4], Gretchen Harlow[5]. [1]Archipelago Marine Research Ltd, Victoria BC, Canada, [2]Sandwell Engineering, Vancouver BC, Canada, [3]Lanarc Consultants, Nanaimo BC, Canada, [4]Coastal and Oceans Resources Inc, Victoria BC, Canada, [5]Canadaian Wildlife Service, Delta BC, Canada

The current approach to fish habitat assessment is often narrowly focused and does not fully consider the broad range of impacts of foreshore development on the coastal environment. The Green Shores project (www.greenshores.ca) promotes sustainable use of coastal ecosystems through development planning and design that incorporates consideration of the diverse ecological features and functions of the coastal environment. A key thesis of the Green Shores program is that the design and development community as well as local government are best positioned to implement sustainable shore designs, but lack effective enabling tools.
The Green Shores project has four key components:

1. A shore development rating and assessment tool modeled after the LEED® Green Buildings rating system.
2. Support for local government planning, including a review of existing bylaw language and ordinances that reflect Green Shore principles. This includes the development of example language for use in Official Community Plans, Development Permit Areas and zoning bylaws.
3. Partnership with developers and local government to assess and refine Green Shore program tools and build an inventory of conceptual designs for Green Shore developments.
4. An active outreach program for development professionals, local government and community groups. This presentation will introduce the pilot Green Shores rating and certification system and review the application of the rating system to several shore development projects on the British Columbia coast. In addition the role of the Green Shores project in the development of local government bylaws and regulations for shoreline management will be summarized.

S30-P-13

Cottages impact fish habitat in the canadian shield

James Atkinson[1] (presenting), Tracy Allison[1]. [1]Fisheries and Oceans Canada, Peterborough, Ontario, Canada

Haliburton County within central Ontario is found on the Canadian Shield, a rugged forested area with rocky outcrops and shallow soils. Watersheds draining mainly south to the Great Lakes have created hundreds of oligotrophic lakes. These pristine, wilderness lakes adjacent to the population centers of the Golden Horseshoe (Greater Toronto Area) have attracted cottagers/camp owners for over 100 years. In the last 25 years as lakes to the southeast of Haliburton have reached capacity, development has accelerated in Haliburton putting pressure on roads, building permit management, water quality and fish and wildlife habitat. For the past 10 years, Fisheries and Oceans, Canada (DFO), has been helping to regulate the development of lakeshores by using the Fisheries Act to actively manage fish habitat in Ontario. Cottage development has now leveled off after reaching a peak in 2005. The DFO strategy since 1997 has been to promote the fish habitat objective of the Fisheries Act. Recently because of the work load in reviewing projects for habitat impacts and because of public acceptance of Fisheries Act policies and procedures, DFO has initiated a risk management approach that allows projects with a low risk of habitat destruction to proceed following a generic set of mitigation guidelines and procedures. In this paper, I look at almost 100 cottage lake shore projects carried out in the last 5 years and assess two aspects: 1. cottagers compliance or non-compliance with direction; 2. success or failure in achieving “no net loss” of fish habitat; The projects are assessed using a photographic record and evaluated by an experienced fish habitat biologist according to accepted criteria.

S30-P-14

The development of a replacement class screening as a regulatory and planning tool to guide the sustainable development of oyster aquaculture in New Brunswick, Canada

Sophie Bastien-Daigle[1] (presenting). [1]Fisheries and Oceans Canada, Gulf Region, Moncton, New Brunswick, Canada

Ensuring the conservation and protection of fish habitat in the coastal zone is proving to be inherently challenging because of the myriad of regulators and stakeholders interacting there, in a complex web of legitimate uses and conflicts. The development of innovative management regimes are thus required in order to protect fish habitat and other ecological resources while allowing sustainable development. The industry and regulators have long recognized the need to bring consistency and timeliness to the environmental review process of oyster aquaculture works, particularly in N.B where the industry has been expanding. They recommended that the review of these projects be built around a comprehensive procedure covering environmental review and management, site selection, design criteria and operating conditions. As a result, the Province of New Brunswick, Transport Canada (TC) and DFO initiated the development of a class screening report for the oyster aquaculture industry in 2002. The class screening report identifies measures that are known to reduce or eliminate the likelihood of adverse environmental effects for a “class” of project. TC and DFO opted for that approach to streamline the review of water column oyster aquaculture projects, improve the consistency of mitigation measures, adequately capture potential cumulative environmental effects, reduce conflict with other users and meet multi-agency regulatory requirements. This paper describes the general analytical approach used to evaluate various management options to guide towards sustainable resource use and development for oyster aquaculture.

S30-P-16

A user based methodology for assessing stream crossing barriers to fish passage: a path to prioritize mitigation efforts

George Peabody[1], Simon J. Mitchell[1] (presenting). [1]Meduxnekeag River Association Inc. Woodstock, New Brunswick, Canada

Over the years, much research has been done to evaluate the effect that culverts in fish-bearing streams may have on fish populations. The primary physical factors that impede fish passage are fairly well documented and include outlet drop, excessive velocity, and insufficient water depth (Baker and Votapka 1990; Votapka 1991; Fitch 1995; Stein and Tillinger 1996). Some important biological considerations include fish species, size of fish, condition of fish, life history requirements, and movement timing (MacPhee and Watts 1976; Baker and Votapka 1990; Bell 1991; Stein and Tillinger 1996). Determining the barrier status of a culvert can pose some interesting challenges because of the dynamic nature of the setting, both from a physical and biological standpoint. We developed and subsequently implemented a volunteer-based culvert assessment tool. Our assessment tool relies on some basic measurements and observations that are repeated at multiple stream crossings within the Meduxnekeag watershed to create an overall picture of stream crossings in the watershed. The assessment tool was developed for administration on a portable computer (paper is also an option) and included geographical (GPS) and pictorial references. The results of this study reveal that the majority of stream crossings within the Meduxnekeag watershed are in good condition. There are a number of stream crossings that require attention, mainly as a result of two factors: inhibiting fish passage and contributing to sedimentation. Stream crossings that exceed the threshold for perched heights and are located within the lower portion of subwatersheds, meaning that the stream crossing is inhibiting fish passage to the remainder of the subwatershed are a priority. Other stream crossings that require remedial attention generally have an issue with the diversion ditch and or introduction of sedimentation as a result of poor road conditions.

<u>S31. Urban Aquatic Habitat</u>

S31-SP-1

Great Lakes Areas of Concern – limits to restoration

Kelly Montgomery[1] (presenting). [1]Toronto and Region Conservation Authority, Toronto, ON, Canada

The Toronto and Region Remedial Action Plan (TORRAP) has always adopted a watershed based approach. With its size, complexity of governance and the 3 million plus people living in this fast growing area, the ultimate success of this RAP will be no small feat. A lot has changed since the Stage 1 (1988) and Stage 2 (1994) Reports. Stage 1 defined this Area of Concern (AOC) to include the waterfront and the adjacent drainage basins; Stage 2 established very ambitious targets for restoration of this large area. Setting the bar high is important; however it is essential that we be realistic when determining what is achievable. Establishing unrealistic targets makes those targets obsolete as it is necessary to show progress otherwise people become frustrated with the process and can begin to disregard them. Restoring conditions in AOCs becomes even more challenging when those conditions are continually changing and being influenced by larger issues. The dramatic changes to the ecosystem of Lake Ontario in the last few years as well as the rapid urbanization within this area creates significant challenges to restoring environmental conditions as they were envisioned during the development of Stage 2. The RAP program is designed to focus on the endpoint; with the objective of working on a problem, fixing it so that the action can be completed or “delisted”. This process lends itself best to dealing with point source problems, whereas the issues impacting this AOC stem from non-point sources; often there is no clear-cut fix. For this AOC, continual vigilance and action are the solution to bring about environmental improvement. However, the RAP program needs to have an endpoint; this area cannot continue to be an AOC indefinitely. The difficulty for those involved in the TORRAP is where to set the limits of restoration.

S31-SP-2

Restoring wetlands in the Hamilton Area of Concern

Tys Theysmeyer[1] (presenting). [1]Royal Botanical Gardens, Burlington, ON, Canada

Project Paradise a component of Hamilton Harbour Remedial Action Plan began in 1993. It was created to connect Royal Botanical Gardens with community partners with similar goals concerning the restoration and stewardship of our wetlands. Initiated in 1994, the project is based on addressing the major marsh stressors that led to the decline of these wetlands and restoring them to a self sustaining state. An innovative restoration initiative, Project Paradise includes a range of conservation projects, but is dependent on the Fishway, the first carp barrier/two-way fishway structure on the Great Lakes. Numerous achievements have been made to date, including significant reductions in pollutants, exclusion of non native carp and significant recovery of plant, fish, and wildlife populations.

S31-SP-3

Baseline environmental monitoring in support of aquatic habitat Toronto

Rick Portiss[1] (presenting). [1]Toronto and Region Conservation Authority, Toronto, ON, Canada

Baseline environmental monitoring data has been assembled in order to provide the agency partners; Fisheries and Oceans Canada, Ontario Ministry of Natural Resources, Toronto Region Conservation, City of Toronto, with pre-construction environmental data for major in water works associated with the Toronto Waterfront Redevelopment projects being carried out by WATERFRONToronto. This information can be used to track and evaluate the design features and structures that are part of the construction projects. This baseline data can be compared to an ongoing monitoring program and be used to evaluate and add insight into the designs that are being recommended by the Aquatic Habitat Toronto as outlined in the Toronto Waterfront Aquatic Habitat Restoration Strategy. This data is used to provide informed decisions related to these mitigation measures. This in turn can provide a better understanding of trends and overall impacts of the designs and will allow for adaptive management to be used in the design of future phases of the Toronto Waterfront Redevelopment and the associated aquatic habitat.

S31-SP-4

The fish communities of the Toronto Waterfront: summary and assessment, 1989 – 2005

Jason Dietrich[1] (presenting). [1]AMEC Earth and Environmental, Cambridge, ON, Canada

Fish community metrics collected for 16 years (1989 – 2005), using standardized electrofishing methods, throughout the Greater Toronto Region Waterfront were analyzed to ascertain the current state of the fish community with respect to past conditions. Results that continue to indicate a degraded or further degrading environment include: an overall reduction in fish abundance, a high composition of benthivores, an increase in invasive species, an increase in generalist species biomass, yet a decrease in specialist species biomass, and a decrease in cool water thermal guild species biomass in embayments. Results that may indicate a change in a positive community health direction include: no significant changes to species richness, a marked increase in diversity in embayments, a decline in non-native species in embayments and open coasts (despite the invarsion of round goby), a recent increase in native species biomass, fluctuating native piscivor dynamics, increased walleye abundance, and a reduction in the proportion of degradation tolerant species. This presentation will provide an overview of the current state of fish communities on the Toronto Waterfront and trends that have been observed over the 16 year study period.

S31-SP-5

Variation in thermal habitat characteristics in 18 small coastal embayments of Lake Ontario: effects of basin morphometry, connectivity with the open lake, and weather

Shidan Murphy[1] (presenting), Nicholas Collins[1], Susan Doka[2]. [1]University of Toronto At Mississauga, Mississauga, ON, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, Canada

Our study focuses on how embayment bathymetry and orientation, with respect to winds and the open lake, differently expose them to coldwater intrusions from episodic upwellings and lake-embayment exchange. From temperature logger records from the ice-free seasons of 2006 and 2007 in 18 small embayments along the northwest shore of Lake Ontario and from the open coast, we are calculating a variety of indices of thermal habitat quality, including both indicators of temperature level and temperature stability on several time scales. Through multivariate ordination we will characterize the patterns of thermal regime variation within and among embayments. By combining our results with weather and water level measurements we hope to define how exchange between embayments and the open lake is controlled. We expect that thermal variations within embayments will be driven by weather and water-level changes that control nearshore upwellings and rates of water exchange between embayments and the open lake. Although we want to understand those connections, we will pay special attention to among-embayment variation, which we expect to be generated by differences in bathymetric characteristics of embayments and the sizes and compass orientations of their connections to Lake Ontario. This work will be useful in constructing or beneficially modifying warmwater embayments so the responses of warmwater fishes to various design characteristics of constructed embayments can be predicted and considered before the final design decisions are made.Our study focuses on how embayment bathymetry and orientation, with respect to winds and the open lake, differently expose them to coldwater intrusions from episodic upwellings and lake-embayment exchange. From temperature logger records from the ice-free seasons of 2006 and 2007 in 18 small embayments along the northwest shore of Lake Ontario and from the open coast, we are calculating a variety of indices of thermal habitat quality, including both indicators of temperature level and temperature stability on several time scales. Through multivariate ordination we will characterize the patterns of thermal regime variation within and among embayments. By combining our results with weather and water level measurements we hope to define how exchange between embayments and the open lake is controlled. We expect that thermal variations within embayments will be driven by weather and water-level changes that control nearshore upwellings and rates of water exchange between embayments and the open lake. Although we want to understand those connections, we will pay special attention to among-embayment variation, which we expect to be generated by differences in bathymetric characteristics of embayments and the sizes and compass orientations of their connections to Lake Ontario. This work will be useful in constructing or beneficially modifying warmwater embayments so the responses of warmwater fishes to various design characteristics of constructed embayments can be predicted and considered before the final design decisions are made.

S31-SP-6

Factors affecting northern pike (*Esox lucius*) home range, size and habitat use in perturbed environments

Ian Barrett[1] (presenting). [1]Niagara Peninsula Conservation Authority, Welland, ON, Canada

Northern pike ecology has been studied extensively throughout its native range, however little emphasis has been given to the study of northern pike in perturbed urban areas. The purpose of this study was to use radio telemetry to assess factors affecting northern pike movement, home range and habitat use in the Toronto Harbour. Twenty seven adult northern pike were captured from three habitats, implanted with radio tags and released. Fish were manually tracked 3-5 days per week between October 2000 and October 2001. Home ranges were calculated using an animal movement extension of ArcView GIS. Kernel estimates of home range at 95% ranged from 10.5-194.4 hectares. Home ranges for fish from highly perturbed habitat were significantly larger than the home ranges for fish from artificial and natural habitat areas. Using data collected during associated fish community monitoring, a weighted average biomass of forage fish, competitive piscivores and ration were calculated for individual home range area. Significantly more ration was available in the natural and artificial habitat areas than in the highly perturbed habitat. Similarly, significantly more northern pike biomass was present in the highly perturbed habitat areas than in other habitat types. Northern pike movement rates ranged from no apparent movement for up to 12 days to >4km in <19hrs. Northern pike in the highly perturbed habitat areas had significantly greater mean daily displacements than did conspecifics from the other habitat areas. Northern pike association with vegetation has been well documented. Approximately 95% of 893 northern pike relocations in the Toronto Harbour were associated with submerged vegetation, with northern pike preferentially selecting low and medium macrophytes densities. Dissolved oxygen concentrations were significantly higher in July than any other month for which data was collected. These data indicate that northern pike home range, movement and habitat use in the Toronto Harbour are influenced by ration and piscivore biomass, submerged macrophyte area, depth and temperature. To better manage northern pike populations in the Toronto Harbour, rehabilitation efforts should expand to include the protection and creation of deepwater, submerged macrophyte areas and develop connections between them rather than focusing on shallow-water spawning and nursery habitats.

S31-SP-7

Effects of land based storm water controls on waterfront aquatic habitat

Bill Snodgrass[1] (presenting). [1] Toronto Water, Toronto, ON, Canada

Toronto's Water Pollution Solution is a long-term plan to protect our environment and sustain healthy rivers, streams and other water bodies. The goal of the WWFMP is to reduce and ultimately eliminate the adverse impacts of wet weather flow on the built and natural environment in a timely and sustainable manner and achieve a measurable improvement in the ecosystem health of the watersheds. The health of the watersheds will in turn affect the health of the ecosystem downstream, the Toronto Waterfront. The Master Plan was developed with the recognition that wet weather flow will be managed on a watershed basis accompanied by a hierarchy of solutions starting with "at source", followed by "conveyance", and concluding with "end of pipe". The 2006 workplan focused on controlling discharges from combined sewer overflows and stormwater outfalls, a priority directed by City Council and respecting the Mayor's vision of a clean, green and beautiful waterfront.

The benefits of the plan include:

- Clean waterfront beaches that are healthy for swimming
- Eliminating discharges from combined sewer overflows
- Protecting City infrastructure from stream erosion
- Restoring degraded local streams
- Improving stream water quality
- Reducing algae growth along the waterfronts and in streams
- Restoring aquatic habitat

All of these benefits will improve the aquatic habitat of the Toronto Waterfront, this presentation will discuss the effects of these land based storm water controls on waterfront aquatic habitat

S31-SP-8

Assessment of urban fish habitat renewal, the Lake Ontario experience

Susan Doka[1] (presenting). [1]Fisheries and Oceans Canada - Great Lakes Lab for Fisheries and Aquatic Sciences, Burlington, ON, Canada

In Areas of Concern (AOCs) in Lake Ontario, both fish populations and fish habitat has been identified as impaired. These AOCs include Hamilton Harbour in the east, Toronto Harbour in the central lake, and the Bay of Quinte in the west. Two of these areas, Hamilton and Toronto, are highly populated urban centres. A scientific assessment of these AOCs is using a combination of stratified surveys, time series information, spatial analysis, habitat classification, and population modelling of fishes and their habitats. The final goals of the assessment are to help set synergistic and quantifiable targets for fish populations and fish habitat to be used as delisting criteria whereby the embayments may become Areas in Recovery. In some areas quantifiable targets have not been set, while in others, quantified targets have not been robustly set or have not been reconciled with other related targets. For example, targets for macrophyte cover have been set without considering fish populations, aquatic communities, or overall habitat goals. Also, nearshore and offshore fish population targets may be incompatible with habitat availability. Assessment is also helping with habitat restoration and compensation options for development activities, especially in Toronto Harbour. These are being evaluated using field work and modelling to assess their effectiveness at reaching the goals and targets identified for the system. Fish habitat classification schemes, validated by field date, are used to assess changes. The schemes help identify areas that are currently important to local fish production based on the fishes present in each area and their habitat requirements. The results may be used in fish habitat management plans by protecting important areas, and may also help set fish habitat targets by linking habitat supply with population dynamics. Habitat supply analysis will help guide restoration efforts by determining future gains or losses in habitat overall, thereby providing scientific advice to inform habitat management, urban aquatic planning, and restoration activity choices.

S31-SP-9

Waterfront Toronto's commitment to revitalizing fish Habitat in Toronto's Inner Harbour

Pina Mallozzi[1] (presenting). [1]Waterfront Toronto, Toronto, ON, Canada

Waterfront Toronto's vision is to put Toronto at the forefront of global cities in the 21st century by transforming the waterfront into beautiful, sustainable new communities, parks and public spaces, fostering economic growth in knowledge-based, creative industries and ultimately: re-defining how the city, province and country are perceived by the world. This is being undertaken with strong commitments to both sustainability and design excellence. As part of the implementation of its network of over five kilometers of waterfront public spaces including new parks and boardwalks Waterfront Toronto in partnership with Aquatic Habitat Toronto are fostering innovative approaches to both enhancing fish habitat in Toronto's Inner Harbour and raising awareness through demonstration of the opportunities which exist in an otherwise perceived non-existent ecosystem. Spadina Head of Slip, a new 700 square metre wooden deck cantilevered over the lake, will be the first initiative in the implementation of Toronto's Central Waterfront Master Plan. This initiative is accompanied by habitat compensation which has been designed to be synergistically integrated into the aesthetics and function of both the site and the structure. This presentation will explore the collaborative process being undertaken in the revitalization of Toronto's Central Waterfront ecosystem through the citation of the Spadina Head of Slip example.

S31-SP-10

Nearshore fish habitat creation at Tommy Thompson Park

Ralph Toninger[1] (presenting). [1]Toronto and Region Conservation Authority, Toronto, ON, Canada

Toronto and Region Conservation has led the restoration and enhancement of nearshore habitats along the Toronto waterfront. Tommy Thompson Park, a man-made peninsula in east Toronto that extends 5 km into Lake Ontario, is a case study on how a site that functions as a biological centre of organization can further be enhanced through nearshore habitat restoration. Through extensive planning and consultation a strategic natural area enhancement plan for terrestrial and aquatic habitats has been developed and is being implemented. Species specific essential habitats that target a range of life stages of fish, herpetiles, shorebirds, waterbirds and mammals and biological communities have been created and enhanced. Projects include fish spawning habitat, amphibian pools, in-water and shoreline structural habitat, waterbird habitat, coastal wetland development and invasive species management. A range of monitoring projects have been undertaken including underwater camera surveillance, breeding surveys, radio-telemetry, vegetation mapping, electrofishing and fish entrapment. The results show intriguing trends and document changes in the flora and fauna community. This case study documents one of the most significant changes to the nearshore community within the Toronto waterfront.

S31-SP-11

Toronto Waterfront Aquatic Habitat Restoration Strategy – a strategic and integrated approach to managing the aquatic habitat in a large urbanized centre

Warren May[1] (presenting), Laud Matos[2]. [1]Ministry of Natural Resources, Aurora, ON, Canada, [2]Fisheries and Oceans Canada, Burlington, ON, Canada

The Toronto Waterfront Aquatic Habitat Restoration Strategy (TWAHRS) is an integrated resource planning approach that strategically creates and improves aquatic habitat on the Toronto waterfront in response to the Toronto Waterfront Revitalization Initiative and the Toronto Waterfront Revitalization Corporation’s (WATERFRONToronto) long-term business plan. It is a proactive approach to address the needs of urban re-development, while strategically targeting the cumulative improvement of aquatic habitat and fisheries resources as an integral part of creating a more livable and sustainable waterfront for the people of Toronto. Aquatic Habitat Toronto made up of Canada’s federal Department of Fisheries and Oceans (DFO), the province of Ontario’s Ministry of Natural Resources (OMNR), the Toronto and Region Conservation Authority (TRCA), and the City of Toronto to work cooperatively with WATERFRONToronto in order to successfully implement TWAHRS. TWAHRS is a collective effort to improve service to Canadians by working with project managers at the early planning stages of projects, ensuring more timely, coordinated, and cost-effective environmental assessments and regulatory reviews, using science to support sustainable waterfront development.

S32. Freshwater Fishes of Canada: Changes since 1973

S32-1

Overview of the changes in the composition of the Canadian freshwater fish fauna since 1973

Nicholas Mandrak[1] (presenting). [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, Canada

This is the 35th anniversary of the publication of the seminal Freshwater Fishes of Canada by Scott and Crossman. The freshwater fish fauna of Canada, and our understanding of it, has changed substantially since 1973. In 1973, 181 species were established in Canada; whereas, at least 210 species are currently known to be established. The composition of the fauna has changed as some species have become extirpated (2 species) and some species have been only recently discovered (13 species), while others have invaded Canadian waters and become established (6 species). As fish taxonomy has evolved, some species have been synonymised (3 species), while others have been newly described (10 species). The greatest changes in the fish fauna have occurred geographically in the Great Lakes basin and taxonomically in the Cyprinidae.

S32-2

Changes in the taxonomy of Canadian fishes since 1973 and the “Common and scientific names of fishes from the United States, Canada, and Mexico”

Joseph Nelson[1] (presenting), Héctor Espinosa-Pérez[2], Lloyd Findley[3], Carter Gilbert[4], Robert Lea[5], Nicholas Mandrak[6], Richard Mayden[7], Larry Page[4]. [1]Department of Biological Sciences, the University of Alberta, Edmonton, Alberta Canada, [2]Instituto de Biología, Universidad Nacional Autónoma de México, México, [3]Centro de Investigación en Alimentación y Desarrollo, Guaymas, Sonora, Mexico, [4]Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611, United States, [5]California Department of Fish and Game, Monterey, California, United States, [6]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, Ontario, Canada, [7]Department of Biology, Saint Louis University, St. Louis, Missouri, United States

Scott and Crossman's book "Freshwater Fishes of Canada", published in1973, generally used common and scientific names from the 1970 (3rd) edition of "A list of common and scientific names of fishes from the United States and Canada", by Bailey, Fitch, Herald, Lachner, Lindsey, Robins, and Scott. Bev Scott and Ed Crossman separately served on the "Committee on names of fishes", a joint committee of the American Fisheries Society (AFS) and the American Society of Ichthyologists and Herpetologists (ASIH). Major changes in the taxonomy and higher classification of Canadian fishes have occurred since 1973 as reflected in the 2004 AFS/ASIH list (6th edition). Changes in some species such as Rainbow Trout demonstrate the principle that common names are more stable than scientific names. The "Committee on names of fishes" arose as a result of an AFS resolution in 1933. The first list was published in 1948. Choosing common names is often an involved process, as shown in the history of choosing Chinook (Salmon) over king and spring for *Oncorhynchus tshawytscha*, with key involvement from W. E. Ricker in 1952. The Principles (criteria) governing the choice of names was published in 1954. We are preparing the seventh edition for publication in 2010.

S32-3

Canadian fishes at risk: status assessment, legal listing, and the communication of science

Jeffrey Hutchings[1] (presenting). [1]Dalhousie University, Halifax, NS, Canada

In partial fulfilment of its international obligations under the Convention on Biological Diversity (1992), Canada's parliament passed the Species at Risk Act (SARA) in 2002. SARA provided legal recognition of the Committee on the Status Endangered Wildlife in Canada (COSEWIC), the independent arms-length science advisory body responsible for assessing the status of species at risk (species that are Extirpated, Endangered, Threatened, or of Special Concern). Since 1980, when the first fish species was assessed, 105 Designatable Units (roughly equivalent to Distinct Population Segments in the United States) of fish (69 of which are wholly freshwater species) have been assessed as being at risk. Following vascular plants, fishes (notably freshwater species) are the most second-most endangered taxonomic group of organisms in Canada. In addition to providing an overview of Canadian fish species at risk, the current Chair of COSEWIC will: 1) summarise the species-assessment and legal-listing decision processes; 2) identify listing biases (notably for marine fishes); and 3) discuss strengths and weaknesses of the assessment and listing processes as they pertain to the communication of science to society and to government decision-makers.

S32-4

Identifying Canadian freshwater fishes through DNA barcodes

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Fish identification can be problematic, especially when phenotypic variations overlap between species and when morphological character have been degraded or express differentially during ontogeny. The goals of DNA barcoding focus on the assembly of reference libraries of the mitochondrial cytochrome c oxydase I gene for known species in order to develop molecular tools for species identification. A total of 652-bp have been obtained for 1360 individuals belonging to 191 species from the Candian Freshwater fish fauna including 86 genera and 28 families. The nearest-neighbour distance between species averaged 7.5%, which was 30-fold higher than the mean within species distance of around 0.3% and 13-fold higher than the mean maximum intraspecific distance of around 0.6%. Among the set of 191 species, nine species (5%) included several distinct clusters and 15 species (8%) exhibited barcode sequences and lineages that were shared or overlapped with those of other species. This study has shown the efficacy of COI barcodes for diagnosing North American freshwater fishes since most species examined here corresponded to a single, cohesive array of barcode sequences that were distinct from those of any other species.

S32-5

Phylogeographic influences of postglacial recolonization of freshwater fishes across dynamic spatiotemporal landscapes

Chris Wilson[1] (presenting). [1]Ontario Ministry of Natural Resources, Peterborough, ON, Canada

Our understanding of historical events and recolonization history of freshwater fishes in Canada has grown substantially over the past several decades, and has benefited enormously from advances in genetic tools and techniques. Genetic tools have provided tremendous insights into the identity, history and relationships of species and populations, allowing us to see into their evolutionary and ecological past. Phylogeographic analyses have enabled the resolution of relationships among intraspecific populations dating back across millenia, and have provided valuable insights regarding the number and location of glacial refugia used by different species, as well as the timing and duration of recolonization events. In many cases, species persisted in multiple refugia, and had varying degrees of intraspecific secondary contact during recolonization that were otherwise difficult or impossible to resolve. Secondary contact among colonizers also resulted in interspecific hybridization and introgression, particularly in dynamic glacial landscapes such as southern Quebec. Many freshwater species in Canada bear strong genetic signatures of Pleistocene glacial and interglacial events, with differences in species ecology and their interaction with postglacial environments resulting in qualitatively different patterns among species. In several cases, coalescent analyses of genetic data have enabled inference of historical demographics across ecological and evolutionary timescales. This wealth of genetic information has helped inform and augment previous data sources such as morphometric analyses, physiology, parasitology, and geological records, and has helped provide a richer understanding of historical events and processes in the history of species and populations across dynamic postglacial landscapes.

S32-6

Comparison of taxonomic and functional richness across Canadian freshwater ecoregions: a freshwater fish perspective

Yorick Reyjol[1] (presenting), Marco A. Rodríguez[1], Pierre Magnan[1], Nicholas E. Mandrak[2]. [1]Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, Ontario, Canada

Species traits are becoming increasingly important in studies of macroecology. Compared to taxonomic approaches, approaches based on species traits (typically, descriptors of life-history, ecomorphology, and ecophysiology) enable one to move from a descriptive approach to a more deterministic one, in which ecological patterns become easier to interpret in terms of evolutionary history. Trait-based approaches also allow for prediction of ecological patterns that do not depend on the taxonomic identity of the set of species considered. This study examined patterns in freshwater fish taxonomic and functional diversity at a Canada-wide scale, using a database including more than 50 traits and 200 species. The traits were descriptors of life-history (e.g. age or length at maturity, fecundity, egg diameter), ecomorphology (e.g. fin lengths, maximum body height, occurrence of a lateral stripe, occurrence of barbels), general habitat preferences (e.g. thermal range, position in the water column), and feeding preferences (feeding location, feeding type, and diet). Our results indicated that taxonomic diversity followed a latitudinal gradient, decreasing from south to north. Maximum taxonomic and functional diversity was observed in the Great Lakes-Upper St. Lawrence and English-Winnipeg Lakes ecoregions. Our results are discussed in the light of both climatic (species-energy theory) and historical factors, as the last glacial maximum (20,000 years BP) is known to have had significant effects on the Canadian freshwater fish fauna.

S32-7

Homogenization and differentiation of Canada's freshwater fish fauna: a comparison between 2000 and 2005 faunal surveys

Eric Taylor[1] (presenting). [1]University of British Columbia, Vancouver, BC, Canada

Homogenization (or differentiation) of fish faunas refers to the increasing (or decreasing) faunal similarity between geographic areas owing to the combined effects of introductions of exotic species and extinction or extirpation of native species. An analysis of native and exotic fishes' distribution in Canada in 2000 indicated the presence of 48 exotic species and a significant signal of faunal homogenization (similarities between provinces increased by an average of 1.3%) since historic times. By contrast, analysis on a smaller scale within the province of British Columbia indicated a signal of significant faunal differentiation among aquatic ecoregions (similarities decreased by an average of 4.9%). New data collected in 2005 provided an opportunity to assess trends in faunal composition between 2000 and 2005. Several changes were evident between fish faunal lists prepared in 2000 and again in 2005. First, several taxonomic revisions resulted in three new native species being recognized and new biogeographic data indicated over 30 distributional changes both to native and exotic taxa. After accounting for these changes through time, the 2005 data indicated a slightly increased level of faunal homogenization (average of 1.7% vs. 1.2% in 2000, $P > 0.1$) between Canadian provinces. Similar changes in faunal composition were observed in British Columbia and the data indicated a significant decline in pairwise similarity between ecoregions in 2005 (4.8%, $P < 0.015$) compared to 2000 (3.5%). The time series of taxonomic and distributional data provides a valuable tool to track changes in faunal composition and regional relationships which, in the current context, appears to illustrate continuing erosion of biogeographic patterns of native fishes diversity via faunal homogenization and differentiation.

S32-8

Morphological, genetic and life history variation in alternative ecotypes in Canadian Arctic fishes.

Ross Tallman[1] (presenting), Kimberly Howland[1]. [1]Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada

Since 1977 it has been hypothesized that many Arctic salmonoid fishes have alternative ecotypes. Typically, one form is relatively sedentary and the other undergoes long migrations to and from the sea. In other cases such as in lakes, multiple ecotypes have been found. We describe the morphological, life history and genetic distinctiveness in these ecotypes as determined since 1977. We examine the consequences to life history traits based on the model that longer distance migrants will have delayed maturity, increased fecundity and faster growth than the more sedentary types. The model is relatively accurate for broad whitefish, Dolly Varden charr and Arctic charr but does not fit well for other species such as inconnu. Morphological distinctiveness of ecotypes based on life style is also evident but not always a definitive as expected. In two species, the broad whitefish and inconnu genetic differentiation between ecotypes based on DNA and rearing in common garden environments is demonstrated.

S32-9

Changes in the Prairie Provinces and North Western Ontario Fishes

Doug Watkinson[1] (presenting), Bill Franzin[1], Ken Stewart[2]. [1]Fisheries and Oceans Canada, Winnpeg, Mb, Canada, [2]University Of Manitoba, Winnpeg, Mb, Canada

In the last 35 years the fish fauna of the Prairie Provinces and North Western Ontario has changed substantially. Sampling has redefined the distribution of many of the native species and new species have appeared some from human-made introductions and others from northward dispersal of species native or introduced into the Hudson Bay Drainage upstream of Canada. The total number of species in the watersheds has increased from 94 species in 1973 to 115 species. This talk is an overview of these changes in fish species composition, taxonomy, and distribution. A brief discussion of new fish species that may be present in the Prairie Provinces and North Western Ontario in the next 35 years will be included.

S32-10

Fish populations and communities of Lake Ontario, Bay of Quinte, and Upper St. Lawrence River: 50 years of change

John Casselman[1] (presenting). [1]Queen's University, Kingston, ON, Canada

Over the past 50 years, fish populations and community structures of Lake Ontario, Bay of Quinte, and upper St. Lawrence River have changed substantially. Long-term monitoring of fish, fisheries, and environmental conditions provides the insights. Water-temperature changes, particularly after the regime shift of the late 1970s and associated winterkills, were primary factors, along with water-level stabilization. Phosphorus declines commencing in the late 1970s and dreissenid invasions in the early 1990s had significant effects. Early on, heavy fishing was a major factor; however, environmental and habitat changes and species invasions have become primary influences. Since the early 1970s, thermally ill-adapted small-bodied invaders (alewife, white perch), as well as large-bodied fish (lake trout, walleye, lake whitefish), have shown extreme changes in abundance, the latter peaking in the early 1990s; some native species (deepwater sculpin, sturgeon) have reappeared. Invasion of round gobies in the late 1990s altered inshore fish abundance. Global warming explains the substantial increases of centrarchids in inshore waters (basses, black crappie) and the increasing appearance of hybrid esocids (grass pickerel, pike, muskellunge) because of extreme and rapidly changing environmental conditions. Recent appearance of a new strain of VHS caused substantial die-offs of large, mature muskellunge and, to a lesser extent, freshwater drum and gobies. Since the 1970s, pike have declined, but not as precipitously as the catadromous American eel, now officially endangered. All these dynamics are now better documented and understood because of long-term monitoring, based on a fish-community approach that began in the late 1950s and was expanded in the 1970s

S32-11

Lampreys in Canada: changes since 1973

Claude Renaud[1] (presenting), Margaret Docker[2], Nicholas Mandrak[3]. [1]Canadian Museum of Nature, Ottawa, Ontario, Canada, [2]University of Manitoba, Winnipeg, Manitoba, Canada, [3]Fisheries and Oceans Canada, Burlington, Ontario, Canada

In 1973, nine species of lampreys were treated in Freshwater Fishes of Canada. Two more lamprey species occurring in Canada have since been described (Lethenteron alaskense Vladykov and Kott, 1978 and Lampetra macrostoma Beamish, 1982), although the AFS only recognizes the latter. In the past 35 years, changes in taxonomy have also been proposed. Scott and Crossman were following the 1970 AFS list and Bev Scott was a member on the Names Committee. Subsequent AFS lists in 1980, 1991 and 2004 have tinkered with lamprey taxonomy, for example, synonymizing the genus Entosphenus with Lampetra and changing the scientific name of the American brook lamprey from Lampetra lamottei to L. appendix. For its upcoming edition in 2010, the AFS is considering a return to Entosphenus and recognition of it and Lethenteron as monophyletic groups distinct from Lampetra. Furthermore, recent molecular investigations have proposed that adult feeding ecology may not be a species-level characteristic (at least in some members of Ichthyomyzon), and if ongoing experiments demonstrate that this is the case, it will significantly alter the way we treat lampreys taxonomically. The distribution maps in Freshwater Fishes of Canada (which used an innovative mixture of shading and points) have remained relatively unchanged except for the recorded presence of northern brook lamprey in Manitoba and chestnut lamprey in Saskatchewan, Ontario and Quebec. Another new development since 1973 is the awareness of the urgency to conserve biodiversity at the national level; the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) only began in 1977. Both Bev Scott and Ed Crossman were founding members of the COSEWIC Freshwater Fishes Species Specialist Subcommittee from its inception in 1979 until they retired from it, fittingly together, in 2002. Despite a number of new developments in the intervening years, Freshwater Fishes of Canada remains a resource of enormous importance to lamprey biologists in Canada and beyond.

S32-12

The continuing loss of cisco diversity in the Laurentian Great Lakes

Tom Pratt[1] (presenting), Nick Mandrak[1]. [1]Fisheries and Oceans Canada, Great Lakes Laboratory, Canada

Cisco populations in the Laurentian Great Lakes were at a time of tremendous flux when Freshwater Fishes of Canada was written and, unfortunately, the concern about the possibility of tremendous diversity losses noted then was subsequently realized. Of the eight species identified in Freshwater Fishes of Canada, only five species remain extant and of those only two species (*Coregonus artedi* and *C. hoyi*) are commonly found across their historical range. Both *C. johannae* and *C. reighardi*, last collected in Lake Huron in 1952 and 1985, respectively, are considered extinct, while *C. alpenae* was synonymized with *C. zenithicus* and both *C. kiyi* and *C. zenithicus* have suffered serious range constrictions over the past 35 years in the Great Lakes. Lakes Ontario and Erie remain nearly devoid of any ciscoes, while conversely lakes Superior and Nipigon contain the most intact cisco fauna. Recent survey data may indicate a stabilization of the remaining populations and, coupled with interest in cisco re-introduction, provides some hope that the remaining diversity of this group can be maintained.

S32-13

Diversity and taxonomic uncertainty in the cisco complexes of Canadian lakes

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Outside of the Great Lakes basin, populations of two or more morphotypes of ciscoes (*Coregonus* spp. subgenus *Leucichthys*) have been found sympatrically in many Canadian lakes – many more than identified prior to 1973. These morphotypes are typically identified based on jaw morphology, gill raker count and gill raker length, indicating resource partitioning among types. However, there have been few detailed systematic and taxonomic studies conducted on these populations. As a result, there is much uncertainty as to their identity and evolutionary origin leading to much debate over whether the multiple types recently evolved sympatrically in each lake, or dispersed from a single origin (e.g. Great Lakes). Examples of this phenomenon occur in White Partridge Lake, Ontario and Lake Athapapuskow, Manitoba. In White Partridge Lake, two cisco morphotypes were first identified in 1961 as two species – Cisco (*C. artedi*) and Shortjaw Cisco (*C. zenithicus*) with gill raker counts ranging from the low 30s to high 40s. Recent genetic analyses failed to find differences between the putative Shortjaw Cisco in this lake and Cisco. Sampling conducted in 2007 revealed an even wider range of gill raker counts from 26 to 48. In Lake Athapapuskow, three morphotypes were identified in 1970 with gill raker counts ranging from 24 to 49. Sampling in 2000 confirmed the presence of three morphotypes with gill raker counts ranging from 22 to 47. These three types were considered to be Shortjaw Cisco and two forms of Cisco. The uncertainty in the taxonomy of cisco complexes in all lakes in which they are found makes identifying appropriate conservation units difficult and highlights the need for a taxonomic revision of the subgenus Leucichthys.

S32-15

Diversity of the mottled sculpin species complex (Teleostei: Cottidae): How many species are there and where do we go from here?

David Neely[1] (presenting), Michael Blum[2]. [1]California Academy of Sciences, San Francisco, CA, United States, [2]Tulane University, New Orleans, LA, United States

Sequence variation at the mitochondrial cytochrome b and nuclear ribosomal S7 loci were used to test monophyly of, infer phylogenetic relationships between, and examine diversity within members of the mottled sculpin species complex (Cottus spp. cf. bairdii). The complex was not recovered as a monophyletic group in any analysis; some populations from eastern North America currently allocated to Cottus bairdii were consistently recovered with members of the banded sculpin complex (Cottus sp. cf. carolinae) and vice versa. Remarkably high levels of differentiation among drainages and between geographic regions suggest that the current species-level taxonomy is grossly inadequate to describe the observed diversity within the group. Major phylogeographic breaks correspond to geographic features, drainage divides, and/or paleodrainages and are generally congruent with both patterns of morphological differentiation and zooogeographic patterns observed in other co-distributed aquatic taxa. "Real" mottled sculpins are restricted to portions of the Ohio River drainage, adjacent portions of the Great Lakes and tributaries, and portions of the upper Susquehanna River drainage. We provide evidence for recognition of several taxa currently in synonymy of Cottus bairdii, and for additional undescribed diversity within the complex.

S33. Success Stories in Prevention and Control of Undesirable Introduced Aquatic Organisms

S33-1

Forecasting invasion pathways: using gravity models to predict angler movement

Andrew Drake[1] (presenting), Nicholas Mandrak[2], Harold Harvey[1]. [1]Department of Ecology and Evolutionary Biology, Toronto, Ontario, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, Ontario, Canada

Consistent with increases in human population and economic growth, the relative importance of abiotic factors (e.g. dispersal pathways) contributing to the introduction and spread of aquatic invasive species (AIS) has increased. Modeling approaches that forecast the likelihood of human-mediated invasions often consider propagule pressure (e.g. the number of introduced migrants) as a primary determinant of invasion success. We used a production-constrained gravity model to describe angler movement, a

relatively unknown AIS pathway. The model determined relative frequency and magnitude of angler movement according to the propulsiveness of angler origins (e.g. angler populations) and attractiveness of destinations (e.g. lake and fish community characteristics), based on data (n = 2947) from an angler survey conducted between February 2006 and 2008. The results of our study allowed destination waterbodies to be categorized according to the relative risk of introduction, prioritizing management action (e.g. outreach materials; increased monitoring and enforcement) at risky endpoints, such as those receiving many vectors, from several origins. The results of this study implied that modeling approaches designed to forecast vector movement can identify the relative risk of introduction within a spatial network of endpoints, a vital first step to prevent future AIS introductions while using management resources efficiently.

S33-2

Introduced topmouth gudgeon in the UK: delayed management response results in expensive eradication strategies

Gordon H. Copp[1] (presenting), J. Robert Britton[2], Rodolphe E. Gozlan[2]. [1]Cefas, Lowestoft, Suffolk, United Kingdom, [2]Bournemouth University, Bournemouth, Dorset, United Kingdom

Following introduction into Europe in the 1960s as a contaminant of fish imports from Asia, the topmouth gudgeon *Pseudorasbora parva* has since successfully spread throughout the continent. The species was introduced into the UK in the mid-1980s via a consignment to a fish farm in Southern England and subsequent requests to eradicate their population using a rotenone approach were declined due to the potential for collateral damage on native fishes in the adjoining river catchment. Fish movements off the site also continued, increasing the potential for *P. parva* to spread to waters across the UK. The net result of these activities has been an increasing distribution of *P. parva* in UK waters; it is now estimated that their infestation of all suitable UK inland waters will occur in approximately 40 years unless tighter control and eradication measures are adopted. In light of evidence of their high impact potential to native fish stocks, an eradication decision support tool for *P. parva* has recently been developed and risk assessments undertaken. The economic impact component of the assessment, which accounted for eradication costs, but not impacts to local and national economies, estimated that annual losses begin at ≈£300 (U$600) million, decreasing to £250M after 10 years, to £150M after 15 years, and reaching zero at 20 years. The scale of these eradication costs demonstrates the economic consequence of the delayed management response to *P. parva* introduction in the UK. In doing so, it also reveals the requirement for more proactive and rapid responses to future non-native fish introductions in UK waters.

S33-3

Trying to get ahead of the curve: risk analysis of barramundi *Lates calcarifer* for Florida aquaculture

Jeffrey Hill[1] (presenting), Scott Hardin[2]. [1]University of Florida, Ruskin, Florida, United States,[2]Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, United States

Barramundi *Lates calcarifer* (Latidae) is a valuable fishery and aquaculture species in Australia and Southeast Asia and there is increasing interest in culturing barramundi for food in North America, including Florida. The main impediment to food fish aquaculture in Florida is a lack of profitability due to high production costs, low farm-gate prices, and competition from wild-caught or imported product. However, barramundi has a high sale price and other characteristics favorable to profitability. Nevertheless, there is concern over ecological and economic effects if barramundi were to escape or be released into open waters. This large (up to 200 cm TL and 60 kg), predatory fish is native to tropical freshwater, estuarine, and marine habitats from northern Australia to the Persian Gulf region. Based on temperature requirements and suitable spawning and nursery areas, it is likely that barramundi could become established in Florida. Potential impacts include predation on or competition with native species and effects on important recreational and commercial fisheries. Possession of barramundi has been restricted in Florida since 1982 and its culture requires a conditional species authorization on an aquaculture certificate from the Florida Department of Agriculture and Consumer Services. To date, the barramundi industry in Florida is small with current commercial production located at a single facility. This facility began a recreational fee-fishing operation for barramundi in 2006 to augment economic returns. Due to concerns over the promotion of a restricted, nonindigenous species as a sport fish, new rules were enacted to prevent future operations from beginning fee-fishing for barramundi. A summary of the biological and ecological data on barramundi was produced to provide background material for a formal risk analysis by the Florida Fish and Wildlife Conservation Commission. This material was reviewed by agency personnel, and a risk analysis committee was appointed to conduct a risk assessment and to recommend risk management options. The risk analysis committee consists of state and federal agency personnel and university scientists, as well as industry and public stakeholders. The risk analysis is ongoing and should be completed in early summer 2008. The aim of this process is to proactively evaluate risk and implement appropriate regulations prior to the expansion of barramundi aquaculture in Florida.

S33-4

Early observations on an emerging Great Lakes invader, *Hemimysis anomala*, in Lake Ontario

Maureen Walsh[1] (presenting), Brian Lantry[1], Kelly Bowen[2], Joceyln Gerlofsma[2], Ted Schaner[3], Richard Back[4], Jennifer Questel[4], Roberta Cap[5], Garry Smythe[5], Michael Goehle[6], Bryan Young[6], Marc Chalupnicki[7], James Johnson[7],
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Hemimysis anomala, a Ponto-Caspian mysid, is an emerging Great Lakes invader that was discovered in both Lakes Michigan and Ontario in 2006. Similar to the native mysid, *Mysis relicta*, *Hemimysis* exhibits a diel vertical migration pattern, but generally inhabits shallower and warmer waters than M. relicta. Without basic information on distribution, habitat use, and biology of *Hemimysis* in the Great Lakes, its' potential effects on Great Lakes' foodwebs cannot be predicted. In response to the discovery of *Hemimysis* in Lake Ontario, researchers and managers formed a working group to discuss research priorities for the species. Several agencies conducted research during summer 2007 to better understand the distribution and basic biology of *Hemimysis*, and develop and refine sampling gears and strategies. *Hemimysis* presence was confirmed at sites spanning both the northern and southern shores of Lake Ontario, indicating widespread invasion; at one site near Oswego, NY, over 20,000 individuals were collected in one sample. *Hemimysis* occurred frequently in alewife diets and may play an important role in the nearshore foodweb in Lake Ontario.

S33-5

Aquatic alien invasive species early detection network for the St. Lawrence River

Geneviève Bourget[1] (presenting). [1]Ministère des Ressources Naturelles et de La Faune du Québec, Rivière-du-Loup, Canada

The St. Lawrence River watershed is at high risk from aquatic invasive alien species (AIAS). Early detection is very important to counter the potential impacts of AIAS. In 2007, for the first time in St. Lawrence River, the Québec Ministère des Ressources naturelles et de la Faune set up an early detection network to report new and emerging AIAS. To reach that goal, we coordinate, train and support 156 commercial fishers for detecting AIAS. The network spans on a 300 km long river stretch, with a wide variety of fish habitat and salinities and where 8 commercial ports are found. Fishing gears are very effective for catching fish ranging from 10 to 2000 mm. During the first year, fishermen sampled an estimated 2 500 000 fish. More than 150 specimens being suspected to be AIAS were collected. Four AIAS were identified: Chinese mitten crab (*Eriocheir sinensis*), Round goby (*Neogobius melanostomus*), Gizzard shad (*Dorosoma cepedianum*) and for the first time in St. Lawrence River the Blueback herring (*Alosa aestivalis*). The early detection network is very effective to collect and identify AIAS in an area with high potential of establishment. This presentation summarizes the network first year and perspectives.

S33-6

Early detection of invasive fish species at Great Lakes' Areas Of Concern

Christine Brousseau[1] (presenting), Robert Randall[1], Lisa O'Connor[1]. [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada

Areas Of Concern (AOCs), degraded areas identified by the International Joint Commission as a precursor to early detection monitoring recommendations. Historically, boat electrofishing has been used to survey the littoral fish communities at Areas of Concern. Additional gears were used to determine total species richness, including invasive species, in two areas of Lake Ontario (Hamilton Harbour, Bay of Quinte), the St. Marys River and the Detroit River. The supplemental gears, depending on the survey area, included gill nets, fyke nets, trap nets, minnow traps, beach seines, boat seines and a bottom trawl. The efficacy of the fishing gears was assessed by comparing cumulative catch curves. Although gear efficacy depended on the survey area and habitat, the results confirmed that boat electrofishing (active) was effective for measuring richness; however, significantly more species were detected if passive gears were added (e.g. trap nets). Results are being used to identify a multi-gear protocol for assessing invasive fish species in near shore habitats. In addition to a gear protocol, a strategy for surveying coastal areas and interconnecting channels (location, frequency) of the Great Lakes will be discussed.

S33-7

Residual ballast water and introduced aquatic species: from potential problem to policy in five years

Sarah Bailey[1] (presenting), Chris Wiley[2]. [1]Fisheries and Oceans Canada, Burlington, ON, Canada, [2]Transport Canada, Sarnia, ON, Canada

At least 180 aquatic nonindigenous species have become established in the Great Lakes, with activities associated with transoceanic shipping putatively responsible for the introduction of ~65% of invasions since 1959. Although regulations requiring vessels to exchange low-salinity or coastal ballast water for mid-ocean saltwater were put into place for the Laurentian Great Lakes nearly 20 years ago, the rate of invasion does not appear to have decreased. Numerous hypotheses have been formed to account for this trend, including regulatory exemption of ships carrying residual ballast. A multidisciplinary research program was conducted to evaluate if residual ballast water carried by transoceanic vessels posed a risk of introduction of aquatic invasive species to the Great Lakes. Results of the study confirmed that unmanaged residual ballast water and sediments were a potential vector for aquatic species introductions. Canadian regulations and industry practices were rapidly modified to immediately reduce risks associated with residual ballast. A similar success story is now unfolding in regards to spread of aquatic nonindigenous species via ballast water transported by domestic commercial vessels. Communication between academia, government and industry remains a key factor in the successful management of aquatic nonindigenous species introductions.

S33-8

Success of the Joint Ballast Water Inspection Program for ocean-going vessels entering the Great Lakes

Chris Wiley[1] (presenting), Sarah Bailey[2]. [1]Transport Canada, Sarnia, ON, Canada, [2]Fisheries and Oceans Canada, Burlington, ON, Canada

As a result of research conducted on invasion risks of residual ballast, Canadian and US agencies implemented various compatible, but differing, ballast water management policies between 2005-2007 to reduce the risk of species introductions associated with ships carrying foreign ballast and/or residual ballast waters. Current regulations are essentially uniform and require all ships to exchange full ballast, or to flush residual ballast, at sea to achieve a resulting salinity of at least 30 parts per thousand to reduce the abundance of low-salinity (high risk) taxa that might be later discharged from tanks into the Great Lakes. In 2005, Transport Canada, the United States Coast Guard, the St. Lawrence Seaway Management Corporation and the St. Lawrence Seaway Development Corporation entered into an innovative joint ballast water inspection program to monitor and enforce ballast water management. 100% of vessel documentation (ballast water reporting forms) is inspected and a risk assessment is conducted prior to vessel entry into the Great Lakes. In addition, approximately half of all vessels are boarded to ensure that water salinities on board measure 30 parts per thousand. The joint inspection group has tested the salinity of over 11,500 tanks on over 600 vessels. Compliance rates over the three year period have nearly doubled, from 44 to 85%; compliance for the Great Lakes region was effectively 100% in 2007 as waters of all non-compliant tanks were subsequently managed or retained after inspection. Comparison of the Great Lakes program with other regions indicates that the success of this program is largely due to the level of effort invested by the joint inspection program.

S33-9

Assessment and management of invasive spiny-rayed fishes in the Thompson River Watershed

J. Bruce Runciman[1] (presenting). [1]Fisheries and Oceans Canada, Salmon Arm, Canada

Non-native in areas west of the Rocky Mountains, yellow perch, smallmouth bass, largemouth bass and pumpkinseed (i.e. the “spiny-rayed fishes”) were introduced to British Columbia through a combination of government stocking activities, unauthorized introductions and local, inter-provincial and international trans-boundary dispersal. Though now well-established over much of the southern half of the province, these species were detected in the Thompson River watershed only after 1996. Subsequent collapses of trout fisheries in stocked headwater lakes in this watershed inhabited by spiny-rayed fishes were attributed to competition and predation between these introduced species and stocked sport fishes. Connectivity between occupied headwater lakes and downstream anadromous salmon populations posed risks of additional environmental, economic and social impacts. Lacking formal policy guidance, funding, assessment criteria or response plans, provincial and federal agency staff - in partnership with local First Nations and ENGO groups - initiated inventory, assessment, public education, enforcement and response planning for management of spiny-rayed rayed fishes in the Thompson River watershed in 2005. These efforts culminated in the fall of 2007 with the first chemical-based fish eradication treatment to be conducted in British Columbia since 1986.

S33-10

Fluridone eradication of the first Midwest hydrilla infestation, Lake Manitou, Rochester, Indiana

Doug Keller[1], Jeremy Price[1], Gwen White[1] (presenting). [1]Indiana Dept Natural Resources, Indianapolis, IN, United States

During a routine plant survey in August 2006, the monoecious form of hydrilla was found in Lake Manitou, a 735-acre glacial lake near Rochester, Indiana. This was the first known incidence of hydrilla in the Midwest. All public and private ramps were immediately closed; boats could not be trailered on and off the lake without intensive inspection. A multi-year course of treatment with fluridone at 6ppb over an exposure time of 180 days was initiated during the 2007 growing season by SePRO under contract to the Indiana Department of Natural Resources. The goal is to eradicate hydrilla plants along with any tuber and turion populations in the sediment. No viable hydrilla plants were found after the first year of treatment. Tuber sampling indicated significant depletion. Quantitative plant sampling indicated unanticipated severe effects on the native plant community. Future treatment regimes will be adjusted to minimize nontarget impacts without compromising hydrilla eradication. At least three years of treatment are anticipated to eradicate the plant at a total cost of over $1.5 million from state funding sources. No hydrilla has been detected in any of more than 70 lakes within 60 miles of Lake Manitou that have been surveyed from 2004-2007.

S33-11

Alien aquatic species and eradication in NE Mexico: some cases & lessons

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Alien species in aquatic systems are one of the big issues for eradication or control. NE Mexico has a few examples, not big, with varying degrees of success or failure. At least 6 cases from 5 areas are known to the writers. Three of the places are springs (approx. 1 ha) or spring systems (Cuatro Cienegas valley), one a natural lake (Chairel, 2,500 ha), and 1 a reservoir (Rodrigo Gomez, 300 ha).

None of this cases were treated with strict scientific controls. Alien species involved were algae, water hyacinth, hydrilla, arundo, typha, jewelfish, carp, and tilapia, in diverse combinations. One of the springs and the reservoir were sources of tap water. All were used for recreation. Success was complete at some stage, although recurrent for lack of persistence. The reservoir failed in 3 of the 4 stages, finally succeeding. The lake needs continuous work. In Cuatro Cienegas valley, success on eradication of the jewelfish was attained in 1 spring, not in others; one program was held for 4 years, a second project is going on. The arundo project is also going on in Cuatro Cienegas and elsewhere in Mexico, with partial success in chemical control, and research on natural parasites.

S33-12

Barriers and fishways as an ecologically sound tool for controlling invasive sea lampreys

Lisa O'Connor[1] (presenting), Thomas Pratt[1]. [1]Fisheries and Oceans Canada, Sault Ste. Marie, Ontario, Canada

The sea lamprey (*Petromyzon marinus*), an aquatic invasive species in the Great Lakes, is controlled by an integrated management program which includes the construction of low-head barriers that block adult sea lamprey access to spawning tributaries. Modified vertical slot fishways were constructed to provide non-target fish passage at three new low-head barriers to address habitat fragmentation concerns. We evaluated the performance of two of these fishways, Big Carp River and Cobourg Brook, by determining the attraction and passage efficiency for teleosts and the attraction and retention performance for sea lampreys. Between 2002 and 2005 a total of 2395 teleosts (> 100 mm) of 14 different species were tagged with passive integrated transponders (PIT) in two rivers tributary to the Great Lakes. Passage and attraction efficiency rates were estimated based on the number of tagged fish that approached the fishways and the number of fish that were passed over the barriers. Rates were estimated for two study periods: 2003 and 2005, in both streams. In 2003 attraction to the fishway entrance ranged from 79 to 94% while passage rates were low at 8 and 27% in Cobourg Brook and Big Carp River respectively. Experimental changes were made to the design of the traps and re-testing was completed in 2005. Attraction efficiencies ranged from 82 and 96% while passage efficiencies increased to 10 and 57% for Cobourg Brook and Big Carp River respectively. In addition to teleosts, sea lamprey attraction and retention rates were also tested. In 2003 attraction efficiency ranged from 80 to 72% and retention rates ranged from 75 to 87% for Cobourg Brook and Big Carp River, respectively. After the trap modifications in 2005, attraction ranged from 61 to 89% and retention ranged from 88 to 100% in Cobourg Brook and Big Carp River, respectively. Our study demonstrated that trap and sort fishways at low-head barrier dams can be an effective method of passing non-target teleosts, while maintaining a barrier to sea lampreys in two tributaries to the Great Lakes.

S33-13

Purple loosestrife biocontrol success in Ontario, 1992-2008: 16 years into the project

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In the 1980's and the 1990's, the non-native invasive wetland plant purple loosestrife (*Lythrum salicaria* L.) was being heralded in Canada as "The Beautiful Killer", and it became a most highly profiled invasive plant species for more than a decade throughout the provinces and states of temperate eastern North America. In 1992, two leaf-feeding beetles, Galerucella spp. were approved for importation and release in both Canada and the United States, as highly selective biological control agents for the plant. Beetle releases began in Ontario in 1992, and have continued, with more than 400 release sites being established in all major watersheds across the province to date. Releases and release programs have targeted watersheds and wetlands, and have involved widespread collaborations with individuals from academic institutions, governments, municipalities, non-profit organizations, conservation groups, anglers and hunters associations, the private sector and the public. Today, Gallerucella beetles can be found in virtually every watershed in southern Ontario, and in many of the more isolated watersheds of northern Ontario, as well. The beetles have fed on the plants to the point of control, without eradication. They have shown themselves to be cost-effective, and to provide passive, dynamic and sustaining control of the plant. The alarming effects of purple loosestrife on wetlands and watersheds in Ontario are being reversed with the introduction of these two natural predators. This paper will provide an overview of this highly successful biocontrol initiative.

S33-14

Specialty animal foods - new product made from invasive silver carp.

Duane Chapman[1] (presenting), April Braddy[2], Andrew Clarke[3], Ellen Dierenfeld[2]. [1]US Geological Survey, Columbia, MO, United States, [2]St. Louis Zoo, Saint Louis, MO, United States, [3]University of Missouri, Columbia, MO, United States

Silver carp (*Hypophthalmichthys molitrix*) are an invasive species of high importance in the Mississippi River basin. The Management and Control Plan for Bighead, Black, Grass, and Silver Carp in the United States recommends enhancement of harvest as a control method for silver carp. Models indicate that silver carp populations could be controlled through harvest, but inadequate markets exist to support a commercial fishery. Hence, development of silver-carp-based diets for zoo animals was initiated, as a possible applied end product. Environmental contaminants and nutritional values of carp were assessed. Whole silver carp were ground and formed into a "cake" using a cold gel set process, and proper supplements were added to a final product that was tested in feeding trials with piscivorous animals at the St. Louis Zoo. The total amount of saltwater fish used in the previous year in 43 zoos that replied to a survey was > 1,600,000 metric tons. Carp cakes have potential as an economical alternative to marine fish as

food in zoos, thus reducing harvest of marine fish and assisting in invasive species control.

S33-15

Management of the invasive European carp (*Cyprinus carpio*) through physical control at recruitment and migrational hotspots in the Murray-Darling Basin, Australia

Dale McNeil[1] (presenting), Anthony Connalin[4], Ivor Stuart[2], Dean Gilligan[3]. [1]South Australian Research and Development Institute, West Beach, SA, Australia, [2]Kingfisher Consulting, Diamond Creek, Vic, Australia, [3]NSW Department of Primary Industries, Narrandera, NSW, [4]Australia,Adelaide University, Adelaide, SA, Australia

Since the introduction and subsequent spread of carp throughout the Murray-Darling Basin during the 1970's, carp have become the most abundant and widespread of all large bodied fishes in the region. There is strong public concern that the impact this species has on the health and ecological integrity of rivers and wetlands presents one of the most significant pest species issues facing natural resource managers. Although longer term control options such as the daughterless carp project are well underway, strong community pressure has lead local catchment management authorities to develop programs to test the feasibility of physical control options in reducing the impacts of such large numbers of carp. This paper outlines current research into methodologies for the physical capture and removal of large numbers of carp through targeting spawning and migrational aggregations of adult fish. This has involved the application of carp specific trapping technologies to remove fish from river fishways and wetlands considered recruitment hot-spots for the species. The application of otolith microchemistry in identifying and targeting major recruitment sources for the carp population is also being tested as an assessment tool for identifying the project outcomes.

S33-16

The history of freshwater fish introductions in Nova Scotia: balancing prevention and promotion

Jason LeBlanc[1] (presenting). [1]Nova Scotia Department of Fisheries and Aquaculture, Nova Scotia, Canada

The freshwater recreational fishery of Nova Scotia has developed on a historical preference for salmonid species such as speckled trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*). The introductions of freshwater fish, both indigenous and non-indigenous, has a long history in Nova Scotia motivated primarily to develop recreational fishing opportunities and augment existing fisheries for native species. Rainbow trout (*Onchorynkiss mykiss*) were first introduced in 1899, brown trout (*Salmo trutta*) in 1924 and lake whitefish (*Coregonus clupeaformis*) from 1878 to 1908 in 31 lakes preceding later introductions of lake trout (*Salvelinus namaycush*) that took place from 1892 to 1963. Intentional releases of smallmouth bass (*Micropterus dolomieu*) occurred starting in 1942 while illegal introductions of chain pickerel (*Esox niger*) began in 1945. Atlantic salmon, speckled trout, brown trout and rainbow trout continue to be stocked through popular hatchery programs. In order of preference, 3 of the top 5 species and 43.2 % of angling effort is directed towards introduced species. The ecological risk associated with introductions differs among species and targeted educational programs have been developed both nationally and provincially and are often directed to specific watersheds where introductions of undesirable species are of particular concern. These programs focus on increasing public awareness of the potential impacts of illegal introductions and prevention of further occurrences. Conversely, where introductions of brown trout, smallmouth bass and chain pickerel have resulted in established populations or where continued introductions of rainbow trout have sustained fisheries, there are important economic benefits of maintaining a diversified recreational fishery. However, within the context of the current sport fishery of the province, there remains a perception of risk associated with introductions of certain species (particularly non-salmonids) and a difficulty balancing public perception of ecological risk, measurable or not, with sportfish promotion and economic benefit.

S33-17

Threats and Stop Aquatic Hitchhikers! Campaigns work to prevent introduction of aquatic invasive species

Douglas Grann[1] (presenting), Douglas Jensen[2], Nick Schmal[3]. [1]Wildlife Forever, Brooklyn Center, Minnesota, United States, [2]Minnesota Sea Grant, Duluth, Minnesota, United States, [3]U.S. Forest Service Eastern Region, Milwaukee, Wisconsin, United States

America's boaters and anglers need to be fully engaged in the aquatic invasive species (AIS) issue. In the U.S. there are 12.7 M boaters and 40 M anglers. If they are unaware of the AIS issue and do not know what to do, they pose great threats for the spread of harmful invasive fish, plants and other organisms. While research shows that they are part of the problem, the good news is that they are willing to be part of the solution. Several studies show that they are willing to take action with the understanding that our waters are too valuable to allow them to be invaded. To address this issue, Stop Aquatic Hitchhikers! Campaign partners teamed up with the Threats Campaign, led by Wildlife Forever, to extend the prevention message across the Upper Midwest to enlist an army of support in the battle against aquatic hitchhikers. Linking the Threats-Stop Aquatic Hitchhikers! together provides a unique opportunity to strategically promote effective multi-media targeting boaters, anglers as well as hunters. Combined efforts used television, radio and newspaper ads, billboards, dioramas at an airport, displays at rest areas, kiosks at retail and other outlets, outside ads on gas pumps, lawn banners, regulation booklets, watercraft inspectors, signs along roadways, signs at water accesses, windshield flyers, stickers and print materials. Through Wildlife Forever's expertise in marketing and media buys, the combined efforts generated some amazing numbers. In 2006, 125 million people were exposed to the campaign's messages. In 2007, 137 million people were exposed. The Threat Campaign partnership included the U.S. Forest Service and U.S. Fish and Wildlife

Service, and lake associations in addition to the state agencies and Sea Grant. So the question is: are the messages reaching the target audiences and do the messages work? Results of a 2006 survey led by Minnesota Sea Grant in MN, WI, and IA shows that not only is the campaign reaching the target audience, it is raising their awareness and empowering them to take precautionary actions at water accesses to prevent the spread of AIS. Based on their exposure to the campaign, 86% said it raised their awareness. Importantly, 97% said it WILL influence them to take action! Through this campaign partnership, we feel that it's really making a difference in help to protect our waters from the spread of harmful AIS.

S33-18

Early successes in reducing the risks of schools, science curricula and biological supply houses as pathways for spreading aquatic invasive species

Samuel Chan[1] (presenting). [1]Oregon State University, Corvallis, OR, United States

The distribution and use of live organisms by biological supply houses, science curricula, and schools is an important, but until recently, often overlooked and not well- studied pathway of national and regional scope for the introduction and spread of aquatic invasive species (AIS) that threaten our ecosystems, human health, and economy. We are learning that the release of organisms from schools into the wild, or teachers allowing students to take organisms home as pets after the completion of science projects, are not uncommon practices. This suggests that classroom release of live organisms is a practice that may be spreading invasive species and presents an opportunity for learning and intervention. In this "AIS in classrooms" pathway, organisms are distributed to teachers through a Biological Supply House (BSHs), often in association with widely- used science curriculum packages that are used in over a quarter of all classrooms in the USA. Many of the live organisms presented in the curricula and available through BSHs are documented AIS, for example, of 52 organisms distributed by three prominent BSHs in association with several popular learning kits, 19 are known invaders (including African land snails, red swampy crayfish, rusty crayfish, Brazilian elodea, American bullfrog, and mosquito fish). BSHs serve as distribution centers for these potential invaders, which are shipped outside their natural range for classroom use where some are released into the local ecosystem by well-intending teachers and students who are not aware of their potential harmful effects or humane alternatives for disposal. Teachers who want to get information on proper disposal of live organisms may look to BSH websites for species information, but of 19 BSH websites reviewed in a preliminary survey, only three sites offered information on proper disposal. Furthermore, there is little guidance available to teachers from the National Science Teachers Associations (NSTA), National Association of Biology Teachers (NABT) the National Academy of Sciences (NAS) and the National Research Council (NRC) regarding how to convey the social issues associated with euthanasia and the proper disposition of living organisms after completion of a class project. Early examples of local successes in addressing these "AIS in the Classrooms" pathways will be presented along with work being initiated to address the problem on a national scale.

S33-19

Some successes in aquatic invader prevention and containment: with special emphasis on the Great Lakes and Upper Mississippi River basins

Michael Hoff[1] (presenting). [1]U.S. Fish and Wildlife Service, Fort Snelling, MN, United States

We most often see documentation of our collective failures in aquatic invader prevention and containment programs. However, we have some reasons to celebrate our partnership efforts in prevention and containment of those species. From a prevention perspective in the Great Lakes, 40 species of invertebrates and fishes were predicted, 6-10 years ago, to invade. However, none of those species have yet been collected there. From a containment perspective in the Great Lakes Basin, relatively few or no inland lakes have been invaded by some key species that are established Great Lakes. For example no inland lakes in the U.S are known to contain ruffe, round goby, and tubenose goby. Round goby invaded the Illinois River system, via the Chicago Sanitary and Ship Canal, but have not yet been documented elsewhere in the U.S outside the Great Lakes. Thermal habitat for ruffe in the Great Lakes is greater in Lake Erie than elsewhere, but thus far the species has been contained from invading that lake. Ruffe are found in northern Lake Michigan, and had spread to northern Lake Huron, but no ruffe have been caught in the Lake Huron basin since 2003. Attempts to contain zebra and quagga mussels east of the 100th Meridian have been remarkably successful, until recently. Viral hemorrhagic septicemia has been documented in only a few inland lakes in Michigan, Wisconsin, and New York. Thus, we have been remarkably successful in our efforts to prevent species invasions, and contain species after establishment. Outreach programs have been our best tool in our efforts. However, more and better outreach is needed.

S33-20

AIS information coordination: recent progress and promise using on-line technology

Rochelle Sturtevant[1] (presenting). [1]NOAA GLSGN at GLERL, Ann Arbor, MI, United States

Efforts to increase coordination of AIS-related information have recently been boosted by the increased adoption of on-line technology. The U.S. Aquatic Nuisance Species Task Force commissioned and has just made public an on-line database of experts including both 'Tier 1' public responders and 'Tier 2' taxonomic experts for the Great Lakes region. When fully operational, this system should help to increase communications about findings of new invasive species to the individuals responsible for conducting risk assessments and rapid response. A system for the coordination of information for a rapid research response was piloted for

Hemimysis anomala on the Great Lakes in 2007. The system, which included a significant on-line component, was successful in providing access to summaries of the foreign literature on the species, providing recommended sampling protocols, disseminating voucher specimens throughout the affected region, and rapidly disseminating information on new sitings as well as negative sampling. Further, the system was successful in galvanizing early interest from sectors that traditionally operate along the waterfronts but are not traditionally involved in monitoring. NOAA has also recently rolled out 'GLANSIS' the Great Lakes Nonindigenous Aquatic Species Information System. When fully operational, GLANSIS will allow full public access to the latest information on the status of nonindigenous species in the Great Lakes basin.

S33-21

Keeping Our Lakes Great! Examples of cooperation to stop aquatic invasive species in Ontario

Francine MacDonald[1] (presenting). [1]Ontario Federation of Anglers and Hunters, Peterborough, Ontario, Canada

Successful efforts to address invasive species introductions have focused on specific pathways and key species of concern in Ontario. Cooperation between numerous stakeholders including all levels of government, industry, ENGOS and First Nations has been integral to this success; resulting in innovative approaches that have been both effective and maximized the use of limited financial and human resources. This presentation will highlight several initiatives, which exemplify this spirit of cooperation between individuals and organizations and the outstanding things that can be achieved when working together towards the common goal of invasive species prevention.

<u>S34. Native Species Restoration in the Great Lakes Basin and Connecting Waterways</u>

S34-1

Lake trout recovery in Lake Superior: a success of coordinated management

Steve Chong[1] (presenting), Shawn Sitar[2], Mark Ebener[3], Michael Hansen[4], Bill Mattes[5], Steve Schram[6], Don Schreiner[7].
Ontario Ministry of Natural Resources, Sault Ste. Marie, ON, Canada[1],Michigan Department of Natural Resources, Marquette, MI, United States[2],Chippewa Ottawa Resource Authority, Sault Ste. Marie, MI, United States[3], [4]University of Wisconsin Stevens Point, Stevens Point, WI, United States, [5]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI, United States, [6]Wisconsin Deptartment of Natural Resources, Bayfield, WI, United States, [7]Minnesota Department of Natural Resources, Duluth, MN, United States

In the late 1950's lake trout *Salvenlinus namaycush* populations in Lake Superior declined to near extinction due to sea lamprey *Petromyzon marinus* predation and over-fishing. The collapse of the lake trout fishery prompted agencies from around the lake to work collectively in an effort to restore lean lake trout populations in Lake Superior. Although restoration efforts focused on the restoration of the lean lake trout morphotype, the dominant form in the nearshore waters, two other recognized native morphotypes exist in the lake: the siscowet or 'fat' morphotype which is the dominant form in offshore waters, and the humper or banker morphotype which inhabits offshore humps. The main management actions taken starting in the early 1950's include the stocking of hatchery reared lean lake trout, the control of sea lamprey, and closure of the commercial fishery. Populations have since rebounded to near or above historical levels in most of the lake and the fish community objectives for lake trout are being met in most areas. Stocking has been reduced or suspended in most of the lake as the proportion of wild fish in the population continues to increase. Restoration has progressed to the point where a commercial fishery for lake trout has recently been opened in the Minnesota waters of Lake Superior. The restoration of lake trout as the dominant piscivore in Lake Superior is a success story; however the ongoing coordinated management of these populations into the future will be required in the face emerging issues such as global warming and the introduction new aquatic invasive species.

S34-2

Assessing potential spawning habitat to assist lake trout restoration in Lake Erie

Ann Marie Gorman[2], Patrick Kocovsky[1] (presenting), Tom MacDougall[3], Scudder Mackey[4], James Markham[5]. [1]United States Geological Survey, Sandusky, OH, United States, [2]Ohio Department of Natural Resources, Fairport, OH, United States, [3]Ontario Ministry of Natural Resources, Port Dover, ON, Canada, [4]Habitat Solutions, Inc, Chicago, IL, United States, [5]New York State Department of Environmental Conservation, Dunkirk, NY, United States

Lake Trout *Salvelinus namaycush* were once commercially harvested in Lake Erie, but were decimated by overfishing, pollution, and invasion of non-native species such as alewives Alosa psuedoharengus, rainbow smelt Osmerus mordax, and sea lamprey *Petromyzon marinus*. Total loss of native lake trout stocks occurred around 1965. Lake trout rehabilitation efforts began in the late 1970s and continue today, mainly focusing on stocking and sea lamprey control. Stocking has occurred mostly in New York waters and has focused on Brocton Shoal, a historical spawning reef. Despite these efforts, no known natural reproduction has occurred. The invasions of *Dreissena* spp. and round goby *Neogobius melanostomus*, may have hindered recovery. The lack of success has caused management agencies to shift their focus to basin-wide assessment of suitable spawning habitat to target future stocking efforts. To this end the Habitat Task Group of the Lake Erie Committee accepted the charge to seek and identify potentially suitable lake trout spawning habitat throughout Lake Erie. Our investigation will use a multi-scale approach, beginning with coarse-scale modelling and progressing to in-situ examination of substrate and water currents at specific sites identified as potentially suitable, to determine whether and where suitable lake trout spawning habitat exists in Lake Erie. Here we report on our efforts to date, which have included GIS modelling and preliminary examinations of potentially suitable sites, and future direction.

S34-4
Historical trends and current status of the coldwater fish community of Lake Simcoe, Ontario, Canada
Jake La Rose[1] (presenting), Brent Metcalfe[1], Campbell Willox[2]. [1]Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, Sutton West, ON, Canada,[2]Ontario Ministry of Natural Resources, Aquatic Science Unit, Sutton West, ON, Canada

The diverse fish community which inhabits Lake Simcoe is of considerable ecological and economic significance. The lake is the focus of one of Ontario, Canada's most intensive inland sport fisheries, with a large proportion of angling effort directed at the coldwater fish community. Lake Simcoe's coldwater fish community has undergone dramatic changes over the past few decades, attributed to accelerated eutrophication and coldwater habitat degradation. Long term fisheries monitoring projects conducted by the Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit (LSFAU), have documented recruitment failures in lake trout (*Salvelinus namaycush*) during the 1950s, lake whitefish (*Coregonus clupeaformis*) during the 1960s, and lake herring (*Coregonus artedi*) in the 1980s. Each event was followed by drastic declines in abundance for these species and their scarcity has persisted into the early 2000s. Lake Simcoe's lake trout and lake whitefish populations have been maintained through supplemental stocking. Monitoring conducted since 2001 has confirmed a limited amount of natural reproduction and survival by wild lake trout and suggests some successful reproduction by lake whitefish. We will review historical changes in Lake Simcoe's coldwater fish community and report on its current status.

S34-5
Lessons learned from 35 years of Lake Trout restoration in Lake Ontario
Brian Lantry[1] (presenting), Ted Schaner[3], Jana Lantry[2]. USGS Great Lakes Science Center, Ann Arbor, Michigan, United States[1],New york State Department of Environmental Conservation, Cape Vincent, New York, United States[2], [3]Ontario Ministry of Natural Resources, Glenora, Ontario, Canada, Canada

Before their extirpation in the 1950's, lake trout were the most abundant open water piscivores in Lake Ontario. Their collapse was linked to over fishing, predation from sea lampreys, and reproductive failure. Restoration of extirpated lake trout in Lake Ontario began in the early 1970s as a bi-national cooperative effort between state, provincial and federal agencies. After sea lamprey control was initiated in 1971-72, stocking of hatchery fish resumed in 1973, increased in the late 1970s, and peaked in the mid-1980s. By the mid 1990s adult abundance and population fecundity peaked, population targets set in the restoration plan were reached, and the first naturally produced juveniles were observed. Since that time, however, the abundance of adult fish has decreased substantially. Declines between 1998 and 1999 were linked to reduced juvenile survival combined with reduced stocking levels instituted in response to declining preyfish. Declines after 2004 remain unexplained. By 2007, the once abundant population of stocked lake trout of the mid 1980s and 1990s had declined to a level commensurate with the early years of the program that pre-dated effective sea lamprey control, dense stocking levels, and harvest regulations. In addition to what was learned from more than 35 years of management actions, observations further indicate that continuing change in the ecosystem at first enhanced restoration efforts (e.g. decreased contaminant and nutrient loading, and increased water and habitat quality) and then hampered them (e.g. accelerated invasive species colonization). At present, management agencies are revising the restoration plan and attempts to rebuild the population are underway, however, continued invasive species introductions and the lack of suitable prey alternatives to thiaminase rich alewives threaten the future of lake trout restoration in Lake Ontario.

S34-6
Movement of individual brook trout within and between tributaries to Lake Superior
Marilee Chase[1] (presenting), Thomas Pratt[2], Lisa O'Connor[2]. [1]Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada, [2]Fisheries and Oceans Canada, Sault Ste. Marie, Ontario, Canada

Brook trout (*Salvelinus fontinalis*) stocks in the Lake Superior basin were systematically degraded over the past century by habitat loss, over-fishing, and exotic species. Coaster brook trout, a migratory lake-dwelling ecotype, were diminished to the point where only a few viable populations now remain. Recent evidence suggests that anadromy in brook trout populations on the Atlantic coast may be influenced by differences in individual growth potential; therefore, in 2004 we initiated a long-term PIT (passive integrated transponder) tagging study in tributary streams along the north shore of Lake Superior, to investigate whether growth patterns influence brook trout movements. In-stream antennae were located near the stream mouths of the Cypress, Little Cypress, MacInnes and Jackpine Rivers to track the up and downstream movement of individual fish. Stream discharge and water temperature were also recorded. A discussion on the use of this technology to monitor anadromy in brook trout and the results to date will be presented.

S34-7
Opportunities for lake herring recovery in Lake Huron

David Fielder[1] (presenting), Lloyd Mohr[2], Richard Barbiero[3], Jeffery Schaeffer[4]. [1]Michigan Department of Natural Resources, Alpena, Michigan, United States, [2]Ontario Ministry of Natural Resources, Owen Sound, Ontario, Canada, [3]Computer Services Corporation, Chicago, Illinois, United States,[4]USGS, Great Lakes Science Center, Ann Arbor, Michigan, United States

Lake herring, also known as cisco, is one of several coregonine species that originally occurred in Lake Huron. Historically they comprised 50% of the coregonine harvest in Lake Huron yielding an average of 1.65 million kgs per year. Average harvest over the past 10 years has been less than 0.02 million kg. The decline is attributed to a combination of factors including increased abundance of invasive rainbow smelt and alewife, over fishing, and eutrophication. Lake herring persist today in Lake Huron but in greatly reduced abundance. It is theorized that on-going competition from alewife and rainbow smelt have been the central source of suppression. Lake herring mostly persist in the northern areas of Lake Huron, typically beyond the effective range of alewives in most years. Alewives collapsed in Lake Huron beginning in 2003 due to profound web changes possibly stemming from dreissenid colonization. This opened the pelagic planktivore niche. Lake herring are expanding in parts of Georgian Bay but remain extirpated in historically important areas such as Thunder Bay and Saginaw Bay. Recent examination of the main basin zooplankton community indicates shifts away from cladocerans to calanoid copepods, particularly Limnocalanus sp. Published literature indicates that such a shift would favor lake herring or at least not preclude their utilization of the niche. Recovery of a pelagic prey species is critical to the support of many main basin predators including lake trout and walleye and offers one possible means to support the popular, but presently depressed Chinook salmon fishery. Lake herring make a superior prey item over alewives because they are low in thiaminase (believed to be one cause of early mortality syndrome), they offer a larger body prey size, an energetically superior ration for large predators, and they also offer some sport and commercial value. Conversely, the current open niche leaves Lake Huron vulnerable to further exotic colonization. A lake herring recovery guide was recently established that called for conservation in the sport and commercial fisheries of the lake, as well as reintroduction (stocking) in areas currently extirpated to promote recolonization. Some pilot work has gone on to date. Great Lakes fishery agencies should collaborate on this and other efforts to seize the current opportunity for pursuing lake herring recovery to the extent possible under current ecosystem conditions.

S34-8

Resurgence of emerald shiners *Notropis atherinoides* in Lake Huron's main basin

Jeffrey Schaeffer[1] (presenting), David Warner[1], Timothy O'Brien[1]. [1]USGS Great Lakes Science Center, Ann Arbor, MI, United States

Emerald shiners *Notropis atherinoides* were formerly common in lakes Huron and Michigan, but declined during the 1960s as the exotic alewife Alosa pseudoharengus proliferated.They remained chronically depressed through 2004; however, we detected resurgence in emerald shiner density and biomass in Lake Huron during acoustic surveys/midwater trawl surveys conducted during 2004-2006. Emerald shiners were not found during 2004, but by 2006 spatial distributions had expanded, main basin density exceeded 500 fish/ha, and emerald shiners contributed more to pelagic biomass than alewives or rainbow smelt Osmerus mordax. Length frequency distributions suggested two consecutive strong year classes in 2005 and 2006. Resurgence of emerald shiners was likely a consequence of reduced alewife abundance. Return of this species may benefit native nearshore piscivores such as walleyes Sander vitreus; however, benefits to Pacific salmonids Oncorhynchus are uncertain because emerald shiners are smaller, still less abundant than historically important prey species, and they may be thermally segregated from salmonids because they inhabit warm surface waters.

S34-9

Use of decision analysis in the development of an action plan for restoration of American eel in the Upper St. Lawrence River and Lake Ontario

Alastair Mathers[1] (presenting), Rob MacGregor[1], Lorne Greg[2]. [1] Ontario Ministry of Natural Resources, Picton, Ontario, Canada, [2]ESSA Technologies Ltd. Richmond Hill, Ontario, Canada

Over that past 2 decades commercial catch records, passage at the Saunders Power Dam eel ladder, and other surveys have all shown a dramatic decline in the abundance of American eel (*Anguilla rostrata*) in the upper St. Lawrence River and Lake Ontario (USLRLO). Due to their complex life history and longevity, American eel are exposed to multiple sources of mortality at a broad range of spatial and temporal scales. These complexities, the ~25 jurisdictions involved in eel management, the availability of only very basic biological information, and a lack of information regarding spawning all provide tremendous challenges for local management of American eel. Approximately 40% of the eels leaving the Lake Ontario system on their spawning migration are killed during passage through turbines located at the two hydro electric generating stations located on the St. Lawrence River. The PrOACT approach was used to develop short term actions and a longer term strategy that would address objectives of: conservation and recovery of the USLRLO eel population, electric power generation, feasibility of implementation, socioeconomics, legal responsibilities and learning. Alternatives considered included spilling water during eel downstream migration, installation of 'eel friendly' turbines, diversion of eels to a bypass during downstream migration, trapping eels during their downstream migration and transporting them around dams, stocking and fisheries reductions. The consequences implied by each of the alternatives across the set of objectives were quantified in a model. The relative performance of each of the alternatives and the resulting action plan will be described in this presentation. Action plans to promote the recovery of American eel in the USLRO have been developed by both Ontario Power Generation and Quebec Hydro. Key components of the Action Plans include stocking, fisheries reductions, research into techniques to 'trap and transport' of eel during downstream migration and monitoring.

S34-10
Recovery of burbot *Lota lota* in Lake Erie
Martin Stapanian[1] (presenting), Larry Witzel[2], Andy Cook[3]. [1]U.S. Geological Survey, Sandusky, OH, United States, [2]Ontario Ministry of Natural Resources, Port Dover, ON, Canada, [3]Ontario Ministry of Natural Resources, Wheatley, ON, Canada

The burbot *Lota lota* made a dramatic recovery in eastern Lake Erie during 1993-2003, particularly in Canadian waters. Recovery during this decade accelerated under intense sea lamprey *Petromyzon marinus* control, and changes in water quality and food web structure. During a brief period when lamprey control was reduced, high populations of lake trout *Salvelinus namaycush* served as a buffer against sea lamprey predation on burbot. Recruitment of burbot declined suddenly after 2001, resulting in an increase in mean age through 2007. We examine the effects of abundance of the major predators of burbot eggs and larvae, density of adult burbot, and water temperature on recruitment of burbot. Large recruitment years were associated with low abundances of predators and adult burbot.

S34-11
The Black Sturgeon River dam: a barrier to the rehabilitation of Black Bay walleye in Lake Superior
Pat Furlong[1] (presenting), Rob Foster[1], Peter Colby[1]. [1]Ontario Ministry of Natural Resources, Thunder Bay, Canada, [2]Northern Bioscience, Thunder Bay, Canada

This presentation summarizes the results of a number of projects designed to define impediments to the recovery of the walleye population in Black Bay, Lake Superior. Detailed methods and results are included in the attached appendices. For many years Black Bay supported the largest commercial walleye fishery on Lake Superior with the vast majority of this harvest occurring during the spring near the mouth of the Black Sturgeon River. Construction of the Black Sturgeon Dam in 1960 was followed seven years latter by an abrupt and long term collapse of the walleye population. Since this collapse there are few reports of walleye in Black Bay but a small population still exists in the lower river annually congregating below the dam making them vulnerable to angling and poaching. Habitat surveys reveal limited spawning potential on shoals in the bay, areas reported to have been historical spawning grounds. The vast majority of quality river spawning habitat has been rendered inaccessible by the dam. Fisheries studies undertaken on the walleye below the dam reveal that the population uses both the river and bay on a seasonal basis and that the lack of suitable spawning habitat may have been a factor limiting population expansion. Comparison of genetic materials from historical samples collected prior to the population collapse in 1966 to samples collected from fish currently found throughout the Black Sturgeon River system, both above and below the dam, reveal that they are consistent with a single spawning population. A collective assessment of these results makes a strong case for the Black Sturgeon Dam being a major factor in the collapse of the Black Bay walleye population and its failure to recover over the past forty years.

S34-12
Walleye restoration on the Moon River, Georgian Bay: striking a balance
David Gonder[1] (presenting), Harry Taylor[1], Scott Finucan[1]. [1]Upper Great Lakes Management Unit, Ontario Ministry of Natural Resources, Owen Sound, Ontario, Canada

The Moon River is one of two outflow channels to Georgian Bay for the Muskoka River watershed and has largely been managed to facilitate hydro-electric production since 1938. The lower Moon River historically supported a large walleye spawning stock, originating from Georgian Bay. Walleye abundance on the spawning grounds in the lower Moon River has declined precipitously since assessment efforts were initiated in the late 1960's. A number of management actions have been implemented to halt this decline including reductions in walleye harvests in the area, rehabilitative stocking of fry and fingerling walleye and water quality studies. Water quality was not identified as a problem while these other management actions have not lead to any discernable recovery in the population to date. Large fluctuations in flows during the walleye spawning period have also been identified as a major contributor to the decline. Fluctuating flows have been difficult to deal with in the past due to competing interests of maintaining upstream lake levels and downstream hydro production and ecological needs. More recently, the formation of a Muskoka Water Management Plan has provided an opportunity for more equitable balancing of needs in the watershed. The formation of the Management Plan lead to a quantitative assessment and GIS analysis of the impacts of fluctuating flows on spawning walleye and deposited eggs in the lower Moon River. The collected data formed the basis for more fish friendly water management approaches on the Moon River, and an impending walleye spawning habitat rehabilitation project. Rehabilitation efforts for the Moon River walleye population provide a good case study for successes and failures in effectively balancing fisheries needs with other uses of water.

S34-13
Efforts to restore muskellunge to the Spanish River delta, Lake Huron, Ontario, Canada

Arunas Liskauskas[1] (presenting), Christine Selinger[2], Wayne Selinger[2], Seija Deschenes[2]. [1]Ontario Ministry of Natural Resources, Owen Sound, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Espanola, Ontario, Canada

The Spanish River delta, situated in the North Channel of Lake Huron, was an important area that provided spawning and nursery habitat for what was once a thriving muskellunge population. A long history of resource exploitation including timber harvest, mining, pulp mill effluent, commercial and recreational fisheries eventually resulted in the extirpation of this population by the early 1950s. Remediation efforts begun in 1980 eventually resulted in water quality and habitat improvements by the early 1990s. In spite of these improvements muskellunge remained absent, although a diverse fish community was present in the delta. Efforts to restore muskellunge to the Spanish River delta began in earnest with the stocking of muskellunge fingerlings and yearlings starting in 1996 and ending in 2003. Wild brood-stock from several native muskellunge populations found in the Lake Huron basin were used in the stocking efforts. Partnerships between government agencies, local industry and non-profit organizations were key to the restoration efforts. Ongoing monitoring of restoration efforts has recently revealed evidence of naturally produced young-of-the–year muskellunge, the first evidence of successful natural reproduction in the Spanish River delta in over 50 years!

S34-14

The development of muskellunge rearing techniques for fisheries restoration projects in Ontario

Allan Chamberlain[1] (presenting), Sasha Fernando[2]. [1]Sir Sandford Fleming College, Lindsay, ON Canada, [2]Hospital for Sick Children, Toronto, ON Canada

Prior to the 1990, muskellunge were pond reared in Ontario to the mid-summer fingerling stage 8-10 cm. In the early 1990s a number of unsuccessful attempts were made to intensively raise muskellunge to produce larger fish for stocking. In 1996, a conservation group, The Friends of the Spanish River, commissioned Chamberlain's Fish Culture Services to rear muskellunge for the Spanish Harbour Reintroduction Program. Over eight years 8902 fall fingerlings (17-20 cm) and 1660 yearlings (28-30 cm) were raised. This presentation outlines the development of the eight years of rearing by describing the modification to fish husbandry, naturalization process and system design. Also covered is the construction and rearing results of a new muskellunge culture facility built at Sir Sandford Fleming College in 2007.

S34-15

An overview of the Lake Simcoe Muskellunge Restoration Project

Jason Borwick[1] (presenting), Brad Allan[2]. [1]Ontario Ministry of Natural Resources, Aurora, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Midhurst, Ontario, Canada

The muskellunge (*Esox masquinongy*) is native to Lake Simcoe, Ontario, Canada and once supported a commercial fishery and exceptional sport fishery in the late 1800's and early 1900's, respectively. After significant over harvest, habitat loss and ecological change, the Lake Simcoe population of muskellunge was significantly reduced by the 1930's. A study published in 2000 determined that restoring the muskellunge to Lake Simcoe was a feasible management objective. The goal of the Lake Simcoe Muskellunge Restoration Project is to restore a self sustaining muskellunge population to Lake Simcoe through a long term restoration project including habitat enhancement and stocking efforts. Habitat surveys have shown that the lake can support a muskellunge population. Results of genetic analysis on several muskellunge populations throughout Ontario were used to determine an appropriate source of eggs. Stocking of fingerling muskellunge has occurred annually since 2005. Partnerships and significant funding commitments have ensured the early success of this long term restoration project.

S34-16

Parking on the water: evaluating the management and conservation of Great Lakes fishes through Aquatic Protected Areas

Kevin Hedges[1] (presenting), Nicholas Mandrak[1], Marten Koops[1], Ora Johannsson[1]. [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, Ontario, Canada

With a growing interest in precautionary approaches to natural resource management, Aquatic Protected Areas (APAs) are becoming more common on a global scale. APAs protect fishes and their habitats, helping preserve ecosystems and biodiversity, and can provide fisheries benefits through emigration and by buffering against over-exploitation. The literature is rife with debates regarding the effectiveness of APAs for fisheries management, and to a lesser extent conservation, with success potentially depending upon the life histories of target species and an APA's primary function (conservation or management). The purpose of this project is to determine how APAs have been used for the conservation and management of fishes in the Laurentian Great Lakes, and how effective such efforts have been. An inventory of past and present APAs has been constructed through interactions with various Canadian and U.S. organizations (governmental and non-governmental). Several types of APAs have been identified including numerous terrestrial parks (shoreline, islands or encompassing tributary streams), a few aquatic parks, fish sanctuaries and seasonal fishery closures, and de facto protected areas such as no-boating zones around military and industrial sites. The majority of areas providing habitat protection (parks) exist in perpetuity but were not specifically created to protect fishes and, therefore, their effects on fishes are not assessed or monitored, while fisheries-related regulations (fish sanctuaries and seasonal closures) lack permanent designation. Assessments of the effectiveness of individual APAs (primary literature, reports and personal communications) have been compiled to determine if APAs have been successful in the Great Lakes, if APAs have been more successful for conservation than management efforts, and whether success has hinged upon life history traits. A standardized evaluation of the APAs is being undertaken to further clarify appropriate uses of APAs and factors that impact their effectiveness in the Great Lakes. A GAP analysis is currently underway to determine species and habitats that are not incorporated in current APAs and to identify potential sites for future protection.

S35. Standard Methods for Sampling North American Freshwater Fishes

S35-SP-1

Standard methods for sampling North American freshwater fishes

Scott Bonar[1] (presenting), Wayne Hubert[2], David Willis[3]. [1]USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona, United States,U[2]SGS Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming, United States,[3]South Dakota State University, Brookings, South Dakota, United States

Standardization in industry, medicine and science has led to great advances. However, despite its benefits, freshwater fish sampling is generally unstandardized, or at most standardized locally. Standardization across large regions would allow for measurement of large-scale effects of climate or geography on fish populations; larger sample sizes to evaluate management techniques; reliable means to document rare species; easier communication; and simpler data sharing. With increased interaction among fisheries professionals worldwide, reasons for wide-scale standardization are more compelling than ever. The Fish Management Section of the American Fisheries Society in collaboration with the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management, National Park Service, USGS Cooperative Research Units and NBII Programs, National Fish and Wildlife Foundation, AFS Education and Computer User's Sections, and Arizona Game and Fish Department is developing a book of standard sampling methods for North America. Almost 50 United States, Canadian and Mexican fish sampling experts are authors. Standard Methods for Sampling North American Freshwater Fishes describes standard methods to sample fish in specific environments so population indices can be more easily compared across regions and time. Environments include ponds, reservoirs, natural lakes, streams and rivers containing cold and warmwater fishes. This book provides rangewide and regional averages; calculated from over 4000 data sets from 43 states and provinces; of size structure, CPUE, growth, and condition for common fishes collected using methods discussed. Biologists can use these data to compare fish from their waterbody to index averages. These methods were reviewed by 54 representatives from 33 North American agencies and by biologists from six European and one African countries. Final drafts were reviewed by an additional 36 sampling experts. Here we give an introduction to the AFS freshwater fish standard sampling program.

S35-SP-2

Standardized sampling of warmwater fish in small standing waters

Kevin Pope[1] (presenting), Robert Neumann[2], Scott Bryan[3]. [1]University of Nebraska-Lincoln, Lincoln, Nebraska, United States, [2]In-Fisherman, Baxter, Minnesota, United States, [3]Aquatic Consultants, Albuquerque, New Mexico, United States

We suggest standardized sampling techniques for routine monitoring and population assessment of warmwater sport and prey fishes in small (≤200 ha) standing water bodies. Gear recommendations are based on an objective of easily comparing primary indices of population structure and abundance (e.g. presence, length structure, condition, growth, and catch per unit effort) along spatial and temporal gradients in which fish communities are assessed. Given this objective, we recommend four gear types for sampling fishes in small, warmwater lentic systems: (1) boat electrofisher, (2) bag seine, (3) sinking experimental gill net, and (4) modified-fyke net. These recommendations are meant to facilitate comparisons of fish populations among warmwater and coolwater fishes in small standing water bodies and provide future opportunities to assess ecological processes in these systems on a broad geographic scale. These sampling techniques do not address all of the unique challenges of sampling warmwater fishes in small standing water bodies and are not appropriate for all sampling needs. Further, it is hoped that the guidelines presented will stimulate further research for greater understanding of fishing-gear selectivity, which ultimately will lead to improved procedures for standardization.

S35-SP-3

Sampling coldwater fish in small standing waters of North America

Nigel Lester[1], Paul Bailey[2] (presenting), Wayne Hubert[3]. [1]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada, [2]North Dakota Game & Fish Dept. Riverdale, North Dakota, United States, [3]University of Wyoming, Laramie, Wyoming, United States

This poster describes standard techniques for sampling coldwater fishes in small standing waters (i.e. lakes and reservoirs < 200 ha surface area), as documented in Chapter 6 of Standard Methods for Sampling North American Freshwater Fishes (S. Bonar, W. Hubert, and D. Willis, eds). To obtain a reliable index of species abundance, sampling should be conducted during summer when lakes are thermally stable and fish are not congregated due to spawning activity. Thermal stratification during summer implies that optimal temperatures for coldwater species vary with depth and therefore a depth-stratified sampling design is needed. Because target species vary in terms of their association with benthic and pelagic zones, a gear that can sample both habitats is needed. The recommended gear is a sinking gillnet with mesh bar size of 19, 25, 32, 38, 44, 51, 57, and 64 mm and corresponding monofilament diameter of 0.28, 0.28, 0.33, 0.33, 0.33, 0.40, and 0.40 mm. A standard gang is ~25 m in length (8 panels x 3.1 m). Net height is 1.8 m for benthic sampling and 6 m for pelagic sampling. Nets are set late afternoon and retrieved the following morning, so that the sample period encompasses both crepuscular periods. For sensitive populations, 2 hr sets during daylight may be used instead, so that fish are more likely to survive after capture. The gillnetting standards described here are compatible with standards proposed for sampling coldwater and warmwater fish in other types of North American waters (see other posters in this symposium). The North American gillnet (mesh size = 19 to 64 mm) differs from the European standard (mesh size = 6 to 55 mm). Selectivity of the North American net focuses on trout in the approximate length range of 190-650 mm total length. In contrast, the European net targets a wider length range of fish (60 – 550 mm). A different set of meshes was selected because management agencies in North America generally have objectives that target the length of fish typically harvested by anglers. If data on smaller fish are also needed, a net comprised of smaller meshes must also be used. North American standards have not been established for sampling small fish.

S35-SP-4

Sampling coldwater fish in large lakes

David Beauchamp[1], Donna Parrish[2] (presenting), Roy Whaley[3]. [1]US Geological Survey, Washington Cooperative Fish and Wildlife Research Unit, Seattle, WA, United States, [2]US Geological Survey, Vermont Cooperative Fish and Wildlife Research Unit, Burlington, VT, United States, [3]Retired, Costa Rica

We describe the standard techniques for sampling fish in large coldwater lakes as documented in Chapter 7 of Standard Methods for Sampling North American Freshwater Fishes (S. Bonar, W. Hubert, and D. Willis, eds). Large coldwater lakes are defined here as standing freshwater bodies with surface area > 200 ha that support coldwater fishes such as salmonids, coregonids, burbot, and associated species that are 200 mm or more FL (220 mm TL) and prey fishes of 50 mm FL or more (55 mm TL). These targeted fishes and lengths were selected to approximate the lengths that sport fishes recruit to fisheries and to the sampling methods used in the monitoring program and to reflect an index of nongame fishes that supply the prey base for piscivores. There are four standard gears identified for sampling coldwater fishes in large standing waters: (1) benthic gill nets, (2) hydroacoustic techniques, (3) midwater trawls, and (4) suspended horizontal gill nets. The use of a particular gear depends on the portion of the standing water that is to be sampled and the targeted fishes. For each of the four standard gears, we list specifications, operation, timing of sampling, and reporting of effort.

S35-SP-5

Sampling coldwater fish in rivers

Robert M. Hughes[1] (presenting), R. Allen Curry[2], Mark Mcmaster[3], David J. Zafft[4]. [1]Oregon State University, Corvallis, Oregon, United States, [2]University Of New Brunswick, Fredericton, New Brunswick, [3]Canada,Environment Canada, Burlington, Ontario, Canada, [4]Wyoming Game & Fish Department, Laramie, Wyoming, United States

We established standard sampling methods for fishes in large, coldwater rivers, most effectively and safely sampled from a boat or raft. Such rivers have wadeable riffles, bars, and shorelines, but are generally unwadeable, 10-100 mean wetted channel widths wide, with average summer temperatures < 20C. Waters are oligotrophic, but can vary in colour from clear to highly stained and low to high turbidity. Our methods focus on salmonids, cottids, and catostomids, but there are many other species that will be encountered in coldwater rivers. Effective sampling of fishes in coldwater rivers often requires the use of multiple gears or extensive sampling effort with a single gear. There are four standard methods to consider when establishing a standardized sampling protocol: (1) electrofishing by boat or raft, (2) seining, (3) gill netting, and (4) snorkeling. Electrofishing by boat or raft effectively captures fishes with minimal mortality or injury to the fishes. It allows long reaches to be sampled relatively quickly and most safely. Seining on beaches, riffles, or bars is an effective technique for collecting smaller individuals residing in shallow, obstacle-free habitats. It can be more efficient than electrofishing. Gill netting can effectively sample many different habitats and may be the only gear that can be employed in remote rivers with minimal access. With appropriate nets and short fishing times, gill netting can have minimal lethality for some species. Snorkeling can be effective in clear waters inhabited by larger, easily-identified fish. It is the preferred method in rivers with excessive obstacles for electrofishing and in situations where non-lethal sampling is required. Effective sampling will always depend on the river and study questions and safety training is essential. We recommend these four techniques singly or in combination as a standardized sampling protocol for coldwater fishes in large rivers.

S35-SP-6

Sampling warmwater and coldwater fish in two-story standing waters

Phaedra Budy[1] (presenting), Gary Thiede[1], Chris Luecke[1], Roger Schneidervin[2]. [1]Utah State University, Logan, UT, United States, [2]Utah Division of Wildlife Resources, Vernal, UT, United States

Two-story fisheries occur in lakes or reservoirs characterized by two distinct spatial strata, warmwater and coldwater. Due to both physiochemical differences between the two strata and the morphological, behavioral, and physiological differences between the fish species that occupy each stratum, a two-story system is complex in terms of sampling. The first step in designing a sampling regime is to identify the target species and sampling goals. The second step is to understand key physical and biological

characteristics of the system that may influence the distribution of fishes (e.g. lake morphology, thermal stratification, gradients in primary and secondary productivity). The upper stratum should be partitioned into (1) nearshore and slope zones, and (2) a pelagic zone. Sample the upper stratum using the standard methods for warmwater fishes in large standing waters using a minimum combination of gill netting and electrofishing. The lower stratum should be partitioned into the littoral and nearshore, slope, and the pelagic zone. Sample the lower stratum using standard methods for cold water fishes large standing waters using a combination of: (1) gill nets, (2) hydroacoustics, and (3) midwater trawls. To effectively sample both strata and to integrate CPUE across gear types, additional considerations may be warranted.

S35-SP-7
Converting non-standard fish sampling data to standardized data.
Jim Peterson, Craig Paukert

The ability to capture fishes and detect the presence of fish species varies by sampling method, fish species and size, and the physical characteristics of the habitats being sampled. Failing to account for differences in capture and detection when comparing locations with different physical characteristics, species, and among samples collected using different sampling methods, can introduce a systematic error or bias into the data. To incorporate new standardized sampling techniques, fishery biologists need a means for converting sample data collected using old methods (i.e., non-standard data) so they can be compared with data collected using new standardized sampling methods (i.e., standardized data). We propose two methods for converting non-standard data each with relative costs and benefits. The first method, paired-gear sampling, is one of the simplest approaches and involves the collection of fish samples using two different gears at approximately the same time and location to build models for adjusting the non-standard data. It requires relatively little data and additional sampling effort, but cannot be used to account for the biases associated with species and habitats. The second method, gear calibration, involves the collection of data using non-standardized and standardized and comparing catches to unbiased estimators of fish abundance, presence, and species richness using models. These models can be used to adjust catch data and account for biases due to sampling method, species, and habitat. However, calibration requires a greater amount of data and sampling effort to develop useful models.

S35-SP-8
Efficacy of the proposed North American gill net standard for monitoring fish communities in Ontario, Canada
Steve Sandstrom[1] (presenting), Nigel Lester[1], George Morgan[2], Tim Haxton[1]. [1]Ontario Ministry of Natural Resources, Bracebridge, Ontario, Canada[2],Laurentian University, Sudbury, Ontario, Canada

In the summer of 2007, we evaluated a gillnetting method that has been proposed for sampling fish communities in Ontario lakes. The method uses two types of nets: 1) a large mesh net that targets fish larger than 20 cm in length; and 2) a small mesh nets that targets smaller fish. The large mesh net has been proposed as a North American standard for sampling harvested freshwater species (Bonar et al, in press). The small mesh net is a new standard, developed in Ontario. Depth-stratified sampling with large mesh nets was conducted in 23 lakes where prior information about the abundance of lake trout or walleye was available. For both species, depth-stratified estimates of mean catch per net correlated well with prior estimates of fish abundance. Small mesh surveys were conducted in 15 lakes where other small fish assessment methods were planned (e.g. seine, fyke nets, Nordic gillnetting). Our results indicate that fish community composition can be described effectively using a combination of large and small mesh gillnets. Our surveys detected, on average, 61% of the fish community, but this detection rate could be substantially improved by a modest increase in sampling effort. Jointly, the large and small mesh nets span a mesh size range that is similar to the Nordic net, a standard that has been adopted in Europe. Our method (i.e. large and small nest nets) produced catches that were very similar to Nordic netting catches when sampling effort was the same. We recommend the proposed gillnetting protocol as an effective means of meeting Ontario fish sampling objectives, while ensuring our data are comparable to data collected by both North American and European standards.

S35-P-1
Sampling warmwater fish in large standing waters
Steve Miranda, Jeff Boxrucker, John Ney

Fish assemblages in large standing waters (i.e. lakes and reservoirs > 200 ha surface area) are moulded by the two distinct environments present, littoral and pelagic zones. Sampling programs should include methods and gears that that either alone, or in combination, and provide a representative sample of targeted species. Electrofishing, fyke netting, and gill netting protocols are discussed in Chapter 3 of Standard Methods for Sampling North American Freshwater Fishes (S. Bonar, W. Hubert, and D. Willis, eds) for collection of population data in warmwater lentic systems. Electrofishing is the primary gear for sampling littoral areas, typically targeting centrarchids. Flat-bottomed, heavy-gauged metal boats should be equipped with a deck and safety rail to accommodate two dippers, two anodes with electrodes arranged in a circular array, and a power supply capable of producing 60 Hz of pulsed DC current. Sampling is conducted by operating the boat slowly (1-3 km/h) along shallow (<3m) nearshore areas. Typically, diurnal samples are collected in spring (water temperatures ranging from 13 to 21ºC), however in clear water systems (Secchi visibility >3m), nocturnal sampling is recommended. Gill nets are recommended to sample open water species such as percichthyids, ictalurids, percids, clupeids, and esocids. The recommended gear is a sinking gillnet with mesh bar size of 19, 25, 32, 38, 44, 51, 57, and 64 mm. A standard gang is ~25 m in length by 1.8 m high (8 panels x 3.1 m each). Nets are deployed along the bottom, perpendicular to the bank at depths of 3-8 m and water temperatures are 20ºC or less set in late afternoon and retrieved the following morning, so that the sample period encompasses both crepuscular periods. Sampling is conducted in late summer through winter, depending on latitude, when water temperatures are 20ºC or less. Modified fyke nets are effective in sampling littoral species not adequately collected with electrofishing and gill nets, primarily crappies. The standard modified fyke net consists of a single lead and a trap consisting of 13-mm bar mesh netting. Nets are typically fished in late summer through winter (water temperatures <20ºC), set perpendicular to shore off points, aquatic macrophytes or other obstructions to fish movements that act as natural leads.

S35-P-2
Sampling warmwater fish in rivers
Christopher Guy, Scott Rogers, Patrick Braaten, Johannus Pitlo, David Herzog

This poster describes standard techniques for sampling warmwater fish in rivers, as documented in Chapter 5 of Standard Methods for Sampling North American Freshwater Fishes (S. Bonar, W. Hubert, and D. Willis, eds). Large warmwater rivers are complex ecosystems and often contain numerous species and habitats. We loosely define a large river as having a drainage area greater than 50,000 km2 and a stream order great than six. Further, these rivers typically have mean discharges greater than 1,500 m3/s. We define warmwater rivers as rivers that were naturally void of coldwater fish, such as salmonids and coregonids. Seven sampling gears (the bottom trawl and hoop net are divided into subcategories) were identified to provide the best representation of warmwater fish assemblages in large warmwater rivers based on numerous discussions among the authors and with fisheries biologists throughout North America: (1) bag seine, (2) large-mesh bottom trawl, (3) small-mesh bottom trawl, (4) boat electrofisher, (5) drifting trammel net, (6) "catfish" hoop net, and (7) "buffalo" hoop net. These sampling gears may not sample all species or work in all riverine habitats, but they provide a basis for standardization for sampling a wide array of fishes in large warmwater rivers.

S35-P-4
Controlling the spread of invasive species while sampling
Stewart Jacks, Roger Sorensen, Doug Jensen, Scott Smith, Steve Sharon, Ron Kinnunen, David Britton

Invasive species have had a huge impact on natural resource management. The economic cost of invasive species to Americans is an estimated $137 billion annually. The environmental cost is much greater and usually incalculable. Nearly half of the plant and animal species federally listed in the United States' Endangered Species Act are threatened or endangered primarily as a consequence of invasive species that directly prey on native species or out-compete them for limited resources. If our focus is limited to specific projects and tasks at hand we may overlook the broader ramifications of our actions and unintentionally contribute to the invasive species problem. This poster focuses on measures that should be taken to prevent, minimize, or control the spread of invasive species in the routine work we do as natural resource professionals. A fundamental responsibility of fishery professionals is to identify the points in our activities (e.g. gill netting in a lake and then moving to another lake to gill net) where proactive measures are necessary to stop the possible spread of invasive species. The movement of field gear/equipment can potentially provide a pathway for the introduction of invasive species. The most effective control method is simply to avoid moving gear and equipment from one location to another. If it is not possible to have multiple gear sets for different waters, it is critically important to decontaminate sampling equipment, boats, and other gear to a level that will eliminate most invasive organisms. Invasive species are a continuing challenge that will never go away. This poster provides a guide to the processes and procedures available to minimize the movement of invasive species during field activities. The techniques in this chapter will undoubtedly increase time and cost of field activities when implemented. However, time and cost applied in prevention is far more cost effective than removal of an invasive species. As stewards of the resource, it is our responsibility to first protect the resource during our activities and then educate the public of these threats as well.

S35-P-5
Length frequency, condition, growth, and catch per effort indices of common North American fishes
Mark Brouder, Scott Nonar, Alison Iles

Until now, summaries of freshwater fisheries data collected in a standard manner across North America have not been available. In this chapter, we provide Ecoregional and North American averages and distributions of several commonly used fishery indices for 15 common freshwater fish species found in North America. These summaries were developed from data collected using the standard sampling techniques described in this book. For each species * water body * sampling technique combination (e.g., largemouth bass * large standing waters * spring boat electrofishing) and when a sufficient number of datasets (N > 5) were available, we calculated the following summary data: (1) mean CPUE (> stock size: Gablehouse 1984), standard error (SE), and 5th, 25th, 50th, 75th, and 95th percentiles, (2) mean relative weight (Wr), SE, and 5th, 25th, 50th, 75th, and 95th percentiles for each stock density group (Gablehouse 1984), (3) length frequency as mean percentage and SE of each stock density group, and (4) mean back-calculated length at age, SE, and 5th, 25th, 50th, 75th, and 95th percentiles for each species * waterbody combination. The data presented in the tables represent a starting point for standard sampling comparison with regional and range-wide data. As standard sampling becomes more common in the future, more comprehensive data tables with larger datasets can be developed and thus, information regarding the efficiency of a particular sampling technique under a wide variety of situations will become available.

S36. Best Student Symposium

S36-1

Population genetic structure and invasion source of the exotic round goby

Joshua Brown[1] (presenting), Carol Stepien[1]. [1]University of Toledo, Toledo, OH, United States

The Eurasian round goby *Apollonia melanostoma* (formerly *Neogobius melanostomus*) invaded the North American Great Lakes in 1990. It quickly spread to become one of the most abundant benthic fishes in the lower Lakes. The round goby feeds upon dreissenid mussels, is prey to game fishes, and eats their eggs and young. We test the North American introduction's source population(s) and evaluate population genetic structure using mtDNA cytochrome b sequences and 7 nuclear microsatellite loci. We analyze relationships among 25 North American and 22 Eurasian locations (N=1158). Results define two taxa – *A. m. melanostoma* in the Black Sea and A. m. affinis in the Caspian Sea drainages. Both have expanded in Eurasia, with only A. m. melanostoma colonizing North America. Genetic diversity is high on both continents, indicating large number of founders. Analyses link the initial introduction site in the St. Clair River to the southern Dnieper River in the Black Sea. Allele frequency shifts and rare alleles define significant population structure throughout North America. The most common North American genotypes are also well-adapted to marine habitats, suggesting that the round goby may spread throughout our coastal estuaries.

S36-2

A genetic assessment of polyandry and breeding site fidelity in lemon sharks

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We here employ 11 microsatellite markers and recent litter reconstruction methods to infer mating system parameters (i.e. polyandry and breeding site fidelity) in a population of lemon sharks at Marquesas Key, Florida. 408 juvenile or sub-adult sharks were genotyped over eight complete breeding seasons. Using this information, we were able to infer family structure, as well as fully or partially reconstruct genotypes of 46 mothers and 163 fathers. Multiple litter reconstruction methods were used, and novel simulations helped define apparent bias and precision of at least some mating system parameters. For Marquesas Key, we find that adult female lemon sharks display high levels of polyandry (78% of all litters sampled) and stronger fidelity to the nursery site than do males. Indeed, few male sharks sired offspring from more than one litter during the course of the study. These findings were quite similar to previous results from another lemon shark nursery site (Bimini, Bahamas), suggesting conserved mating system parameters despite environmental variation. The finding of at least some breeding site fidelity in females supports the need for careful conservation of populations at each nursery.

S36-3

Limited access to cool-water refugia for adult up-river migrating sockeye salmon in the Fraser River mainstem, British Columbia, Canada

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Characterizing the influence of environmental conditions, such as water temperature and flow conditions, on migrating Pacific salmonids is central to understanding the basic migration biology of these species and is a prerequisite for effective fisheries management and conservation. Here, radio telemetry and individual thermal loggers were used to assess the temperature associations of adult sockeye salmon (*Oncorhynchus nerka*) during their migration through the Fraser River mainstem. Individual temperature profiles obtained from the thermal loggers revealed rapid and high magnitude changes in body temperatures as individuals transitioned between the marine environment and the Fraser mainstem (determined from telemetry receiver locations). Within the mainstem, individuals maintained mean body temperatures that were consistent with ambient river temperatures except in two regions where greater access to thermal refugia was available. Individuals within these regions where thermal refugia were accessible had a greater deviation between ambient and body temperatures with increasing ambient river temperatures. As the Fraser River continues to warm, changes in peak flow and temperature conditions will continue to have a profound influence on sockeye migrations. With growing evidence that exposure to high temperatures during the freshwater component of the migration contributes to mortality, understanding how individuals respond to environmental conditions is essential.

S36-4

Ecological futures for stream fishes along an intermittent Great Plains riverscape affected by drought and groundwater

withdrawal for irrigation

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Across the western Great Plains, groundwater pumping for irrigated agriculture is depleting regional aquifers that sustain stream flow for native fishes. Simultaneously, the region has undergone a multi-year drought that further reduced stream flow and increased water demands by agriculture. We surveyed fish habitat quantity and connectivity at the segment and basin scales during spring and summer 2005-2007 to investigate linkages between habitat drying and groundwater dynamics. Based on our empirical observations, along with historical groundwater and stream flow data , we constructed a linked regional and alluvial groundwater model to investigate how irrigation pumping and riparian evapotranspiration affect groundwater stage and fish habitats. Our model suggests that under the status quo of pumping, habitats for stream fishes are not sustainable into the near future. Based on minimum habitat requirements, we recommend reduced pumping to maintain habitat quantity above a conservation threshold that will allow persistence of fishes and critical habitats. Reduced water use mandated by an interstate compact may provide more habitat for native plains fishes in the future. Our ongoing research is aimed at optimizing habitat by recommending irrigation alternatives in areas of the aquifer that supply groundwater to critical refugia for plains fishes along the riverscape.

S36-5

Using fish otoliths to explore mercury bioaccumulation patterns in coastal fish populations in the Mobile-Tensaw River Delta, Alabama

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Mercury (Hg) is a harmful bioaccumulative heavy metal to which humans are exposed primarily through fish consumption. Using traditional tissue analysis techniques in conjunction with otolith microchemistry and dietary analyses we investigated seasonal and spatial trends of mercury accumulation in largemouth bass, *Micropterus salmoides*, and southern flounder, *Paralichthys lethostigma*, inhabiting the Mobile-Tensaw River Delta in coastal Alabama. Adults of both species were collected at sites across an upstream-downstream seasonal salinity gradient during spring and fall of 2005 and 2006. Size-normalized largemouth bass mercury tissue concentrations increased significantly from downstream to upstream locations with little seasonal variation. Southern flounder mercury tissue concentrations were uniform across the sample area and were lower than those of largemouth bass. Diet analysis indicated largemouth bass at downstream locations foraged on lower trophic levels than those upstream. Overall, largemouth bass foraged on higher trophic levels than southern flounder. Otolith microchemistry analysis showed Sr:Ca ratios may be useful indicators of salinity exposure which may correlate with lowered mercury accumulation in largemouth bass. Efforts to detect mercury directly in the otoliths of both species as a way to measure lifetime mercury accumulation trends have met with limited success.

S36-6

Comparison of prepositioned areal electrofishers and two-way resistance board weirs for assessing migrating stream fish populations

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Many species of freshwater stream fish are known to migrate seasonally for reproduction or other ecological functions. Quantifying lotic fish communities and their movement patterns provides critical information for management of streams and rivers. We compared catch efficiency and composition of stream fishes during the spring spawning period using two different techniques: (1) prepositioned areal electrofishing devices (PAEDs) and (2) two-way resistance board weirs. We deployed both gears concurrently at two sites in Valley River, a North Carolina mountain stream in the Hiwassee drainage, from March through July during 2006 and 2007. Total PAED catch by number was much higher than total weir catch; however, PAED total biomass was lower than weir total biomass, indicating that weirs sample predominately larger fish. Fish species richness and diversity were higher for PAED catch, while weir catch had higher species dominance. Catch in weirs was greatly reduced after a peak in fish spawning, and PAED sampling yielded higher fish mortality rates. PAEDs provided occupancy data of the community, while weirs described migration chronology for highly migratory redhorses (*Moxostoma* spp.). We conclude that PAEDs are the most valid approach to quantify fish communities, and that weirs should be employed when objectives concern migration.

S36-7

Intensive grass carp stocking effects on reservoir invasive plants and native fish populations

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Grass carp *Ctenopharyngodon idella* are a common biological control method for invasive aquatic vegetation. Effective control depends on stocking density and the fish's preference for consuming target vegetation. We evaluated a high density grass carp

stocking for control of parrot-feather (*Myriophyllum aquaticum*, a non-preferred food source) and the effects on native fishes. Lookout Shoals Lake, North Carolina, was stocked with triploid grass carp at a density of 100 fish per vegetated hectare. Parrot-feather biomass in the lake was significantly reduced three months after grass carp stocking, compared to biomass in in-situ exclosures. We evaluated the native fish community using seasonal shoreline electrofishing before and after grass carp stocking. Catch rates of largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus*, and redbreast sunfish *Lepomis auritus* were not significantly different after grass carp stocking, but yellow perch *Perca flavescens* catch rates were significantly lower. Total catch for all fish species at shoreline transects was not significantly different after grass carp stocking by number or biomass. The biological significance of fish distribution changes and long-term effects on lake biota remain undetermined. Our results demonstrate that intensive grass carp stocking can control an invasive, non-preferred plant and reveal associated changes in fish distributions.

S36-8

Parental care behaviour and muscle enzyme activities of nesting smallmouth bass across six lakes with a gradient of nest predator burdens

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Predation is often considered one of the greatest potential costs of reproduction. In large long-lived species with low risk of predation for parents, efforts are devoted to caring (i.e. defending broods from predators) for offspring and these investments can be costly. This study examined how nest predator burden affected nest-guarding behavior and anaerobic and aerobic capacities in a system with sole-paternal care (smallmouth bass). From snorkeler observations we assessed baseline and elicited (staged nest predator introduction) parental care behaviors, as well as nest predator burden in the presence and absence of the caregiver. Lakes were then classified according to predator burden: low, medium and high. The proportion of time performing each baseline parental care behavior varied with predator burden, where males from high predator burden lakes spent more time away from their nests and engaged in antipredator responses than fish in low predator burden lakes. Conversely, males from all lakes responded similarly to an introduced nest predator. Indicators of aerobic (cytochrome C oxidae [CCO] and citrate synthase [CS]) and anaerobic (lactate dehydrogenase [LDH]) capacities were measured in red and white muscle. Axial muscle LDH activity was lowest in the high predator lakes, while indicators of aerobic activity were similar across the predator burden gradient. Similarly, pectoral muscle enzyme activities were completely unaffected by nest predator burden. Our study supports that physiological indicators provide useful information to help elucidate the costs and consequences of reproduction and complex behaviours such as parental care in wild fish.

S36-9

The role of ecosystem size and disturbance in structuring stream food webs

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Ecosystem size has been found to have an important influence on community dynamics in a range of systems, however its effect on stream food webs is poorly understood. In contrast, the influence of flow-related disturbance on stream communities is well established but its effects are likely to interact with ecosystem size. Factors such as food and habitat availability vary both spatially and temporally within and between streams, so there is the potential for both stream size and disturbance to be key drivers of food web structure. The effects of these processes on New Zealand fish communities were investigated by analysing the abundance and biomass of fish faunas across gradients of stream size and disturbance for more than 60 sites over a 10-year period (and 25 sites for stream invertebrates). Analyses showed that the amount of fish biomass at a particular site was significantly affected by invertebrate biomass. In addition to this, both fish and invertebrate biomass were significant influenced by the level of disturbance at a site. However, these relationships were confounded by stream size. Further analysis revealed a relationship that combined all these factors to explain how food web structure changed across gradients of ecosystem size. This new relationship offers a potential tool for predicting how stream food webs may respond to changes in stream flows and emphasizes the importance of maintaining habitat area rather than setting minimum flow levels.

S36-10

Dietary fatty acid composition differentially impacts white bass oocyte composition and larval quality

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White bass *Morone chrysops* oocyte fertilization was improved by increasing maternal dietary n-3 highly unsaturated fatty acid (HUFA) content. Triplicate tanks of female white bass (n=5) were fed diets containing corn, canola, flax, or graded levels (0, 33, 66, or 100%) of squid oil as alternatives to menhaden fish oil. Oocytes were collected, fertilized using striped bass (M. saxatilis) milt, and survival was monitored through the onset of endogenous feeding. Dietary fatty acid composition affected oocyte composition and fertilization at 24 h post spawn. Oocyte fertilization was positively related to maternal n-3 HUFA intake ($p=0.002$, $R2=0.867$) and negatively related to 18:2n-6 intake ($p=0.0007$; $R2=0.918$). Correlation between larval survival and maternal n-3

HUFA intake was not statistically significant, but survival to 5 d post hatch was higher for progeny of marine oil-fed broodstock (77.1± 6.5%; mean ± SE) than those of broodstock fed plant oil diets (40.9 ± 9.1%).Oocyte fertilization was maximized within the 100% fish oil treatment. Although reproductive performance is improved by feeding fish oil, environmental and economical concerns exist regarding utilization of marine-derived products. Therefore, additional research defining specific fatty acid requirements is recommended to determine the balance among reproductive success, feed cost, and sustainability.

S36-11

Why saugeye are where they are

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Habitat provides the abiotic stage upon which biotic relationships are expressed, and therefore can dictate where a fish resides. Saugeye (*Sander vitreus S. canadense*) have been stocked in Ohio reservoirs since the 1970's and still little is known about their habitat preferences. Our recent telemetry work in Hoover Reservoir, Ohio has shown that saugeye avoid mucky substrate and prefer areas less than 5 m deep, with saugeye locations not tracking prey locations. To further investigate how prey may or may not influence saugeye, we created a growth rate potential (GRP) model. A GRP is a bioenergetic measure of habitat quality. Using a newly developed saugeye bioenergetics model, we combined spatially referenced prey biomass and water temperature to find potential growth of saugeye during the months of April through October in the top 15m of the water column. On average, saugeye growth potential was positive across seasons and throughout the water column, being limited neither by prey biomass nor water temperature. Coupling these GRP results with our data on saugeye locations, we conclude that saugeye are not selecting locations based on local prey abundance, but rather areas with preferred abiotic habitat features.

S36-12

Physiological and behavioural consequences of chronic stress during parental care in a wild teleost

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Parental care occurs in approximately 20% of fish families, including many commercially and recreationally valuable species. Natural and anthropogenic stressors during this period have the potential to negatively affect both the parental fish, and the offspring. However, the consequences of stress during parental care have never been examined in fish. We used intraperitoneal cortisol implants to elevate plasma cortisol during the first 120 hrs of parental care in wild largemouth bass (*Micropterus salmoides*). We then compared the physiology, parental care behaviour, and nest success of stressed animals to unstressed conspecifics. Individuals were blood sampled and analysis of plasma physiological variables focused on reproductive function, catabolic activity, tissue degradation, and ionic balance. Parental care behaviour was assessed every other day for the first 14 days of the parental care period and included measures of brood defense (vigilance, aggression towards potential nest predators), and general brood maintenance (egg fanning activity). Long-term monitoring continued for up to 30 days when the parental fish moved away from the nest area, and could be considered either reproductively successful (fry were motile) or unsuccessful (abandonment before fry achieved motility). Throughout the monitoring period, fish were also assessed for immunocompetence (resistance to Saprolegnia sp. infection). Understanding the consequences of stress during this time is critical for managers to predict how fish with diverse life histories will respond to anthropogenic activities.

S36-13

The influence of feeding level on the metabolic rate of largemouth bass: evidence of a compensatory response

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Despite their popularity, efforts to evaluate the accuracy of bioenergetics models (BEMs) predictions are often met with mixed success. Indeed, accuracy of BEM estimates has been shown to vary with feeding rate of fishes and may be associated with error in measuring fish metabolism. Metabolic rate of fishes is a key parameter in energy budget formulations and can have a strong influence on accuracy of model output. In addition to body mass and water temperature, factors such as salinity, starvation, pH, and season have been shown to affect metabolism in fishes but are generally not incorporated in parameter estimates. In this study, we tested the hypothesis that metabolic rate of age-1 largemouth bass (mean (SE) = 105.9g (1.77); n = 24) varies with feeding history. Different feeding regimes were applied to two size classes of fish—i.e. maintenance rations for larger fish and ad libitum rations for smaller fish—over a nine week period such that body mass was similar prior to metabolic measurements. After accounting for specific dynamic action (SDA), oxygen consumption was found to be significantly different ($p = 0.0003$) between the two groups of fish (n = 12/group). Fish that were fed maintenance rations consumed only 63% of the oxygen that ad libitum fish consumed (0.00230 vs. 0.00368 g O2•g-1•d-1), independent of body size ($p = 0.28$) or water temperature (constant 24°C). Incorporating feeding history into sub-models for metabolism in BEMs will improve their predicative accuracy and allow fisheries biologists to make better decisions regarding fish populations.

S36-14

Assessing genetic diversity and divergence levels of wild yellow perch and walleye populations and applications to improving broodstock

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We analyzed genetic divergence and diversity patterns of Yellow Perch and Walleye spawning groups across their native North American range using a landscape genetics approach, 14 microsatellite loci, and 2000+ individuals; in application to broodstock potential. Both broad and fine scale population structure are evaluated, focusing on the Great Lakes, Atlantic and Gulf coastal relict populations, Lake Winnipeg watershed, and upper Mississippi and Ohio River systems. Analyses include Fst analogs, distance trees, AMOVA partitioning, Mantel regression, Bayesian assignment, and Monmonier geographic networks. Walleye populations have greater genetic diversity and heterozygosity than do perch, as well as more distinct fine-scale structure. Greatest divergences separate Atlantic and Gulf walleye and yellow perch coastal groups from those in the Great Lakes. Populations in the Lake Winnipeg and Ohio and Mississippi River drainages are markedly distinct from all. Within the Great Lakes, primary genetic barriers separate the Upper from the Lower Lakes below Lake St. Clair, with divisions distinguishing Lake Superior and Lake Ontario populations. Spawning groups in eastern Lake Erie are genetically distinct from those in the west, and more closely allied with Lake Ontario populations. Thus, conservation management practices should evaluate genetic identity in broodstock selection and development.

S36-15

Density dependent growth and energy acquisition dynamics of central Appalachian brook trout

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Density dependent aggression, emigration, mortality, and, to a lesser extent, growth, have been identified in wild lotic salmonid populations. However, few studies simultaneously address multiple age classes when exploring density dependent growth, and fewer still consider sedentary versus mobile fish. Further, no explicit attempts to quantify density dependent growth have been attempted for brook trout (*Salvelinus fontinalis*) in Appalachia, where the species is strongly food limited and population densities are low. Brook trout growth, population density, and diet were intensely monitored over the course of two years at several sites within a watershed in eastern West Virginia. Estimates of consumption and estimated maintenance ration derived from a bioenergetics model provided estimates of excess energy intake. Tagging provided specific growth estimates for fish that remained in sites (i.e. sedentary fish). Young-of-the-year (YOY) brook trout exhibited density dependent growth, but the intensity of density dependence was strongly related to temporal variability, with increasing density dependence (i.e. decreasing slope and incrementally stronger relationships) as the year progressed. Age 1+ sedentary displayed density dependent growth, but only during periods of warm temperatures and poor feeding, when excess energy acquisition was also found to be density dependent. The strong influence of intra-annual temporal variability in density dependent processes offers a potential explanation of why studies elsewhere find contrasting evidence for density dependent growth in lotic salmonid populations. These findings have implications for quantifying the importance of stream reaches for brook trout, a species that is increasingly of conservation concern.

S36-16

Visual and chemical signalling in the round goby

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Chemical communication between sexes of a given species involves individuals of one sex releasing odours to attract a receptive mate. Using a lab flume, we determined if gravid female round gobies showed an increased attractiveness to reproductive male (RM) urine compared with non-reproductive male (NRM) urine in the presence of visual models (made of silicone) of each male type. We also conducted a dose response experiment to determine if different concentrations of NRM and RM urine released from a RM model exhibited similar responses from gravid females. Females spent more time at a nest with black (RM) rather than mottled (NRM) models ($F_{1,8}$ =9.293, P=0.016), whereas urine ($F_{1,8}$ =4.776, P= 0.06) and the model x urine interaction ($F_{1,8}$ =4.790, P=0.06) affected the time spent by females at the nest to a lesser degree. There was no significant difference in the relationship between time spent at a nest with RM model regardless of the RM urine concentration. Female attraction to a RM model declined with decreasing concentrations of NRM urine ($F_{1,2}$.=33.64, P=0.029, r^2 = 0.94). Our findings show that there is potential of using RM models with urine to lure females to traps in the field.

S36-P-1

Age and growth of the threatened spotted gar (*Lepisosteus oculatus*) from Rondeau Bay, Southwestern Ontario

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Spotted Gar (*Lepisosteus oculatus*), a species listed as threatened under the Canadian Species at Risk Act (SARA) were collected from several sites in Rondeau Bay, a shallow coastal wetland of Lake Erie. Using fine-mesh fyke nets, a non-lethal method of collection, 79 specimens were collected during May and June, 2007. The first pectoral ray was removed to age the fish. Rays were sectioned to a width of 0.75 mm, mounted on slides and growth annuli were counted. Specimens ranged in age from 3 to 10 years and from 515 to 761 mm total length. Length – frequency and length vs. age plots were created. Regression analysis of length vs. age data was calculated to be y=19.217x + 491.19 (R2 value of 0.22). Because the species is threatened, specimens could not be sacrificed to confirm sex, therefore, we attribute the high level of variability in our data to our inability to distinguish the sex of individuals. Our specimens were dominated by individuals in the 5 – 7 year age range, indicating strong year classes in years 2000 to 2002. Additional research is needed in to determine the long-term viability of this population, the largest of only four populations in Canada.

S36-P-2

Development, regulations, and outcomes of the Georges Bank Closed Area II scallop access fisheries, with reference to yellowtail flounder bycatch

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Closed Area II south of 41° 30’ was opened to the sea scallop (Placopecten magellanicus) fishery in 1999 after a five year closure and is now fished on a rotational basis. Georges Bank yellowtail flounder (*Limanda ferruginea*) are a bycatch during these openings. For each rotational fishery, a total allowable yellowtail catch is set based on the status of the Georges Bank yellowtail stock (currently overfished/overfishing occurring), and the target scallop catch is set to achieve a desirable level of scallop fishing mortality. Achievement of the yellowtail TAC triggered early fishery closure in 1999 and 2006, and the resulting scallop harvest was lower than the target. Comparing yellowtail catch rates during the 1999, 2000, 2004, 2005, and 2006 fisheries may suggest a solution to this problem. The highest mean catch/hr of yellowtail and the lowest mean catch/hr of kept scallops were observed in 2000, but despite this high bycatch rate, early closure was not triggered. In contrast, the lowest ratio of yellowtail catch to scallop landings was observed during 2006, but the ratio of yellowtail flounder TAC available to target scallop harvest was also lowest. Thus, both high yellowtail bycatch rates and a mismatch between the total allowable catches of the two species contribute to the early closure problem.

S36-P-3

Variation in ecosystem sensitivity to watershed urbanization between physiographic ecoregions in the southeastern United States

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The link between decline in stream biotic integrity and watershed urban land use is well established. However, much such work ignores potentially important variation in stream form diversity. Specifically, streams located within different ecoregions may respond differently to the same degree of land use change within a watershed. We explore how stream biota and physiochemical parameters respond to watershed urbanization between the Piedmont and Coastal Plain physiographic provinces using Maryland Biological Stream Survey (MBSS) data. At biological scales ranging from community-based approaches to responses observed by individual taxa, fish and benthic macroinvertebrates appear to be more capable of tolerating watershed urbanization in Coastal Plain streams relative to those in the Piedmont. Among-region variation in physiochemical responses to urbanization between provinces also were assessed as potential drivers behind the differential responses observed in the biota. Trends in such physicochemical parameters concur with those observed in biological responses. For instance, nutrient and chloride levels increased more rapidly per unit watershed urbanization in Piedmont streams relative to those in the Coastal Plain. Our findings highlight the importance of considering physiographic or ecoregion boundaries when examining ecosystem sensitivity of streams to land use change, particularly in the southeastern United States where the Coastal Plain-Piedmont physiographic boundary extends from New Jersey to Alabama and intersects multiple metropolitan areas.

C1. Lake Communities

C1-1

Landscape scale management for lakes: connecting lake landscapes to water chemistry and fishes

Mary Bremigan[1] (presenting), Kendra Spence Cheruvelil[1], Tyler Wagner[1], Patricia Soranno[1], Katherine Webster[2], Brett Alger[1]. [1]Michigan State University, East Lansing, MI, United States, [2]University of Maine, Orono, ME, United States

The importance of lake-landscape connections is apparent both to fisheries and water quality managers, but tools that provide an integrated framework for the management of aquatic ecosystems are still lacking. Such tools require quantifying linkages between in-lake and landscape features across multiple spatial scales and directly comparing findings for water chemistry to those for fishes. We ask, ‘Do water chemistry and fish response variables share similar relationships with hydrogeomorphic and anthropogenic landscape features spanning several spatial scales?' using datasets that include landscape, water chemistry, and fish population and/or assemblage metrics from up to 500 Michigan lakes and up to 2300 lakes in a six state region of the northeastern US. In Michigan, local and regional hydrogeomorphic features explained more variation among lakes in water chemistry (12% - 54% across variables) than in fish size at age (2-20% across species and ages). Across six states, maximum depth and catchment size best predicted total phosphorus, whereas lake area best explained fish species richness. Quantifying the relationships linking in-lake and landscape features and identifying the spatial scale at which lake variation occurs facilitates the design of lake assessment programs and the creation of synthetic management frameworks.

C1-2
Hydrogeomorphic and anthropogenic disturbance gradients in lakes: how have fish assemblages been altered?
Brett Alger[1] (presenting), Mary Bremigan[1], Kendra Spence Cheruvelil[1], Patricia Soranno[1], Katherine Webster[2]. [1]Michigan State University, East Lansing, MI, United States, [2]University of Maine, Orono, Maine, United States

Hydrogeomorphic features and anthropogenic disturbances affect fish assemblages but the relative importance of these variables is inadequately understood. Quantifying these linkages, across multiple spatial scales, is key to developing lake ecosystem assessment tools and management plans. Accordingly, we addressed two main goals. First, we classified lakes with similar hydrogeomorphic features. Second, within lake groups, we identified the most important anthropogenic influences on fish assemblages. We used fish assemblage, land use, and hydrogeomorphic data from ~500 lakes in Maine, New Hampshire, Iowa, Michigan, and Wisconsin. To build lake classes, we used classification and regression trees. We found lakes having similar fish species richness were best grouped by lake area and percent of forested land in the lake's local watershed. These results indicated that in addition to expected positive effect of lake area on species richness, land use/cover also influenced species richness, perhaps through nutrient loading or habitat modification. Being able to identify lake classes with high species richness and link them to hydrogeomorphic and anthropogenic factors, allows lake managers to make better decisions regarding lake conservation. Likewise, city managers and developers can use our lake classification design to make informed decisions about future land use near lakes with high species richness.

C1-3
Building on existing models of reservoir function: balancing complexity with critical components and connections
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Fisheries managers have traditionally focused on evaluating sport fish, anglers, and fisheries to meet management goals and objectives. However, food web interactions and watershed processes affect sport fish recruitment and system productivity. Further, characteristics of an individual reservoir may directly affect recruitment and reservoir potential as a sport fishery. Here, we build upon two existing models of reservoir function, namely the middle-out hypothesis and the coupled food web/landscape model, by considering the importance of (1) reservoir attributes, including reservoir type, productivity, morphometry, and watershed characteristics; (2) spatially and temporally mediated interactions between sport fish and their prey; and, (3) anthropogenic changes in land use and increasing competition for reservoir use. We explored these topics with a group of reservoir scientists and fisheries managers through a multi-day workshop composed of several small and large group discussions, facilitating concurrent brain-storming and thorough synthesis, respectively. Whereas each of the above aspects is important to understanding reservoir function, balancing complexity of existing reservoir function models with key components and connections that define reservoir function may allow sufficient detail to understand how reservoir and watershed attributes affect aquatic communities and provide new avenues for management and research.

C1-4
Relating species traits to habitat characteristics in coastal wetlands of the lower Great Lakes
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Habitat characteristics play a critical role in structuring fish assemblages. While species traits ultimately determine these habitat-species relationships, generally community ecologists determine relationships between species assemblages and habitat characteristics first and in some cases relate these relationships to certain key traits. However, a novel statistical technique, fourth-corner analysis, directly relates species traits to habitat characteristics. We tested associations between species traits and habitat characteristics in a novel wetland system. Fish and habitat surveys were conducted in 12 wetlands across the lower Great Lakes basin. Fish surveys were accomplished with the use of fyke nets and a boat electrofisher. An extensive literature search was completed to gather information on 42 life-history and biogeographical characteristics for 129 fishes. We predicted, a priori, specific species trait and habitat associations based on our literature search. The fourth-corner analysis was applied to five fish assemblage composition matrices: presence/absence matrices for all combinations of sampling methods; and, separate abundance

matrices for electrofishing and fyke netting data to determine the effect (if any) of sampling method. Results indicated that the environmental variables with the greatest significant relationships to the life-history and biogeographical characteristics were the area of the tertiary watershed, macrophyte coverage (% of open water, % of floating macrophytes), and geographical positioning. These results were consistent across all species assemblage matrices. Of the 49 predicted species trait and habitat associations approximately half were correct for each of the five fish assemblage composition matrices (49-53% correct predictions). However, 72-83% of the predicted species trait and habitat associations related to vegetative coverage were correctly predicted. This method provides a very important, causal, framework which may be incorporated into risk assessments for invasive species, and may be used to predict the effect of climate change on species distributions.

C1-5
Spatial structure of coastal fish communities in Lake Huron
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A large-scale study was undertaken from 2000-2005 to understand the effects of double-crested cormorants on coastal fish communities in Georgian Bay and the North Channel of Lake Huron. Hydroacoustic surveys of seven different locations were done in 400 km2 grids and covered roughly 4.7% of the total surface area of the Georgian Bay and North Channel basins. Additionally, quantitative electrofishing was performed in the same seven locations to assess the nearshore fish community. Hydroacoustic techniques yield spatially-explicit data on the density of different size classes of fish across a variety of habitats, while electrofishing yields information about species and individuals across both broad and fine spatial scales. We used global and local measures of spatial association to describe the spatial distribution of fish in Georgian Bay and the North Channel. At night, there are consistent patterns in spatial distribution across the study area, where the extent of spatial aggregation in small prey fish (<250mm) is greater than for larger fish (>500mm). Additionally, fish community structure differs markedly between the North Channel and Georgian Bay basins. Using these spatially-explicit techniques, we are able to infer broad-scale patterns of coastal fish distribution in the Lake Huron.

C1-6
Identifying energy sources supporting coastal fish: spatial differences revealed by stable isotope ratios
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The goal of our research is to identify energy inputs that support production of young fishes in coastal wetland ecosystem food webs using stable isotopes. We characterized the food web along the lower 35 km of the St. Louis River, MN, a coastal tributary that flows into Lake Superior, by measuring the carbon and nitrogen stable isotope ratios (δ13C, δ15N) of the major components of the ecosystem (primary producers, benthic macroinvertebrates, zooplankton and young-of-year fishes). Both fish and zooplankton data revealed a large isotopic gradient along the river, with increasingly enriched values toward Lake Superior, indicating a lake influence in the river food web. Across the ecosystem, planktivores (black crappie, white perch, rainbow smelt) were isotopically depleted compared to benthivores (rock bass), indicating the use of distinct carbon sources. The planktivores were likely consuming a mix of benthic (macroinvertebrates) and planktonic (zooplankton) organisms, which would account for the observation that the isotopic gradients observed along the river in these fishes (-28 to -23‰ δ13C, 9 to 10‰ δ15N; upstream to downstream) were smaller than the observed gradient in phytoplankton (-34 to -25‰ δ13C, 4 to 0‰ δ15N). The benthivores had unusually enriched carbon isotope values (δ13C >-20‰), suggesting the use of energy derived from either periphyton or submerged macrophytes. The data demonstrate that strong spatial heterogeneity exists in this food web, implying that the energy sources supporting fish production change rapidly in space and that the local food webs persist long enough to be detected with stable isotope techniques.

C1-7
Assessing nearshore small-fish community biodiversity in Lake Simcoe, Ontario, Canada
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In 2006, the Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, began developing a sampling method to monitor small fish biodiversity in the nearshore zone of Lake Simcoe, Ontario, Canada. This ongoing project seeks to assess trends in fish diversity through time. Long-term biodiversity monitoring of this kind will enable comprehensive reporting on the Lake Simcoe fish community. Additional objectives of this program include detecting the presence of new aquatic invasive species and measuring their impact on the fish community. Nearshore small fish sampling in 2006 and 2007 used multiple gear types to sample a range of nearshore habitats in Lake Simcoe. We will describe the diversity of the nearshore fish community, examine sampling effort levels required to adequately characterize the nearshore community, and compare the current state of nearshore diversity with assessments conducted 20 years prior. Preliminary results confirm the presence of many native and non-native fish species along Lake Simcoe's shoreline, including the recently introduced round goby (*Neogobius melanostomus*), and suggest substantial changes in abundance of some cyprinid species may have occurred over the past 2 decades.

C1-8
Spatial and temporal patterns in the food web of Hamilton Harbour
Jennie E Ryman[1] (presenting), Marten Koops[2], Michael Power[1]. [1]University of Waterloo, Waterloo, ON, Canada, [2]Fisheries and Oceans, Burlington, ON, Canada

Hamilton Harbour is an Area of Concern in the Great Lakes. Located at the western end of Lake Ontario the harbour is subject to contamination by treated wastewater and runoff from the cities of Burlington and Hamilton, wastewater from two large steel mills and the corresponding shipping traffic. The east of the harbour is characterized by steelmills, wastewater treatment plants discharge locations, and the Lake Ontario inflow, whereas the western end of the harbour has a stretch of natural shoreline, some artificial reefs and is connected to a large natural wetland. Stable isotopes (δ13C and δ15N) were used to document food web relationships both spatially and temporally within the harbour. An east to west increase of 1-2 trophic positions was evident in plankton, benthos and fish, reflecting the increase in productivity toward the west end. Carbon sourcing (littoral, pelagic) varied spatially among and within taxonomic groupings. Benthic invertebrates were more variable in their carbon use at the east and west end of the harbour but along the north shore used approximately 75% littoral sourced carbon during the summer. Isopods, amphipods and chironomids showed no consistent trends between sampling sites. There was a general trend toward increased reliance of littoral carbon sources during the spring to fall period, but variation among taxa with respect to the nature and speed of the shift from pelagic carbon sources. Twenty-one species of fishes were sampled throughout the harbour. All species relied more heavily on littoral carbon sources when captured along the north shore relative to the east or west sampling areas. During the summer channel catfish demonstrated the most pelagic carbon use (66.42 %) and gizzard shad demonstrated the most littoral use (59.82%). Knowledge of the spatial and temporal variability in dietary reliance on the littoral or pelagic food chains will be used to enhance ecosystem modelling of the harbour, thereby contributing to the remediation of aquatic habitats within the harbour.

C1-9
Fish community ecology of Cranberry Lake and Oswegatchie River, NY
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Cranberry Lake is a remote Adirondack lake located in northern New York. It has been subject to much environmental destruction due to human disturbance. Logging, dams and canal building have significantly restructured the physical and biological components of the ecosystem. The introduction of invasive species such as yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) have caused dramatic species shifts and has led to the decline of the native brook trout (*Salvelinius fontinalis*). We correlated detection of non-native species such as banded killifish (*Fundulus diaphanus*), northern pike (Esox lucius), black crappie (*Pomoxis nigromaculatus*), and rock bass (Ambloplites rupestris) with a decline of native species such as creek chub (*Semotilus atromaculatus*) and brook trout (*Salvelinius fontinalis*). The addition of non-native species can also be associated with the construction of canals which expanded fish migration paths, as well as the early successes of the fishing industry that lead to 'bait-bucket' introductions. Together with the Department of Environmental Conservation, SUNY ESF has established an extensive sampling program that spans back several decades. The fish collections have demonstrated changes in species dominance throughout a twenty-seven year period.

C1-10
Evaluating over-winter survival of gizzard shad (*Dorosoma cepedianum*) in Oneida Lake, NY
William Fetzer[1] (presenting), Tom Brooking[1], John Forney[1], Randy Jackson[1], Lars Rudstam[1], Tony VanDeValk[1]. [1]Cornell Biological Field Station, Bridgeport, NY, United States

Winter limits resource availability in temperate lakes, limiting northern distributions of fishes by altering age-0 recruitment. Gizzard shad (*Dorosoma cepedianum*) are at the northern extent of their range in Oneida Lake, NY, and over-winter mortality appears to be high. Here, we evaluate shad over-winter survival using a combination of experiments and field sampling during the 2005-06 and 2006-07 winters. Shad were exposed to three temperature-treatments of 1, 2 and 4ºC. Mortality rates of shad were two-fold higher in the cold conditions relative to the 4ºC conditions. Dry weight analyses of different tissues suggest shad rely disproportionately more on visceral than somatic tissues at low temperatures. Findings were consistent with an additional experiment and analyses of wild-caught shad. Temperature and dissolved oxygen profiles from locations throughout Oneida Lake (main lake, tributaries and marinas) indicated that marinas provide temperature refuges for age-0 shad when ice cover is inconsistent. Despite gizzard shad survival in the main lake, marinas may represent important refugia dependent on climatic conditions. A hydrodynamic model for Oneida Lake predicts reduced ice cover, and we suspect these refugia may provide additional, high-quality over-winter habitat for gizzard shad. This has implications for all trophic levels of the Oneida Lake food web.

C1-11

Fish community composition in tussock-forming aquatic macrophytes at two south Florida Lakes

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Altered hydrology in Florida lakes can exacerbate the formation of dense vegetation mats (i.e. tussocks) in littoral zones. Anoxia and hyperthermia associated with tussocks can provide quality habitat for small-bodied fishes utilizing the oxygen-rich surface layer, but reduce habitat for species that depend on oxygen within the water column. We sampled tussock-forming macrophyte species (i.e. cattail Typha spp. pickerelweed Pontedaria cordata, and torpedograss *Panicum repens*) at varying coverage levels (i.e. percent area coverage; 50-64%, 65-79%, and 80-95%) using enclosure samplers (i.e. block net, Wegener ring, and throw trap) dosed with rotenone at Lakes Istokpoga (2006) and Kissimmee (2007). Fish densities (number/m2) shifted with macrophyte types for various fish guilds. For example, stress-tolerant fish, comprised mostly of poeciliids and cyprinodontids (88% of total catch), were found at higher densities (28.1/m2) in torpedograss (an invasive exotic species) than other macrophytes. Conversely, centrarchids (7% of total catch) were most abundant in cattail (2.0/m2) and had the lowest density in torpedograss (0.5/m2). Aquatic macrophyte structural complexity, which affects prey abundance and predator avoidance likely drive differences in fish densities in this study. It is important to evaluate differences in fish densities between macrophyte species and coverage levels in order to make informed management decisions.

C2. Salmonids in Lakes

C2-1

Lipid mobilization and reproductive investment in lake trout, *Salvelinus namaycush*: stock specific patterns emerge from hatchery and field studies

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Organisms allocate available energy to growth and reproductive processes to maximize fitness. Stochastic environments, combined with tradeoffs between different components of fitness, lead to phenotypic plasticity. We completed a two year study where our objective was to quantify the degree of phenotypic plasticity involved in lipid mobilization and egg laying strategies in 4 separate stocks of lake trout. We used fish that originated from broodstock and that were raised in a common hatchery environment until sexual maturity. In year 1, we examined lipid mobilization patterns and reproductive investment in response to restricted food rations. In year 2, we explored how food rations affect reproductive investment and lipid mobilization patterns in different stocks. Results suggest that stocks show different rates of lipid mobilization and reproductive investment when exposed to low food rations. We found that some stocks were more sensitive to restricted food than others. The patterns observed in the hatchery made more sense when compared to field collections of three stocks. Egg size measured in hatchery compared favorably to field collections, and lipid content of fish provided insight into life history patterns observed in hatchery raised stocks. Our results suggest consideration of stock specific patterns in management practices is warranted.

C2-2

Hatchery and lake environments affect egg characteristics in lake trout *Salvelinus namaycush*

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Rehabilitation strategies for lake trout (*Salvelinus namaycush*) need to consider the spatial scale of population differentiation, the extent of adaptation to particular environments, and the relative roles of genetic versus environmental effects on phenotypic diversity. If populations are highly differentiated and local adaptation is suspected, the long-term success of hatchery supplementation and re-introduction programs will depend strongly on characteristics of the source population. Our objective was to evaluate how local adaptation and hatchery rearing influence egg size in lake trout. We collected lake trout eggs from 11 hatchery populations and 15 wild populations in the vicinity of the Laurentian Great Lakes. For each individual female we quantified average egg diameter and intra-individual variation in egg diameter. These traits were then compared among populations that differed in their origin (hatchery vs. wild) or lake characteristics (e.g. Great Lakes vs. inland lakes). An intriguing result was that intra-individual variation in egg diameter was consistently higher in hatchery populations than in wild populations and higher in Great Lakes populations than in inland populations. We present several hypotheses to explain these unexpected results.

C2-3

Feeding mechanisms of age-0 lean lake trout (*Salvelinus namaycush*)

Beth V. Holbrook[1] (presenting), Thomas R. Hrabik[1], Donn K. Branstrator[1], Allen F. Mensinger[1]. [1]University of Minnesota Duluth, Duluth, MN, United States

Extensive effort has been invested in rehabilitating lean lake trout (*Salvelinus namaycush*) populations in the Great Lakes following

the decimation of these fisheries in the late 1950s. Despite over fifty years of management intervention, Lake Superior is the only Great Lake where natural reproduction occurs and lake trout populations have rebounded. There is evidence that impediments to natural reproduction may be occurring during the first several months after lake trout eggs hatch in the spring. In order to better assess whether factors such as food availability or bioenergetic constraints are limiting survival, it is important to understand the foraging mechanisms of age-0 lake trout. We conducted a series of laboratory feeding trials to assess age-0 lake trout foraging behavior. Our methods included replicating the environmental conditions of Lake Superior by conducting the experiments in a temperature-controlled chamber at 8ºC and by simulating underwater light conditions with cyan LED lights ranging from 450-550 nm, the predominant wavelengths found at depths greater than 45 m in Lake Superior. The intensity of the LED lights was altered from 0 lux to 1900 lux to simulate a range of light levels and night-time conditions under which age-0 lake trout may forage. We also used three types of invertebrate prey in the foraging trials: amphipods (Hyallela spp.), mysids (*Mysis relicta*), and Daphnia magna. We discuss results on the: 1) foraging capability of age-0 lake trout under various light conditions, including complete darkness; 2) differences in reaction distance of age-0 lake trout in response to different species of prey; 3) foraging efficiency of age-0 lake trout at capturing different species of prey; and 4) the accuracy of model-predicted foraging rates compared to actual capture rates measured at various prey densities.

C2-4

The impact from dynamic postglacial events on regional lake trout population structure in Algonquin Park, Ontario

Michael Halbisen[1] (presenting), Glenn Forward[2], Chris Wilson[1,3]. [1]Trent University, Peterborough, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Whitney, Ontario, Canada, [3]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

The repeated cycles of glacial advance and retreat experienced during the Pleistocene epoch had a profound effect on both the distribution and genetic structure of North American fish species. The most recent re-colonization of lakes in previously glaciated areas occurred during a series of dynamic postglacial events that established diverse fish communities. Although lake trout (*Salvelinus namaycush*) are a common species in these lakes, little is known about how localized postglacial dispersal has patterned their regional population genetic structure. Therefore, we have evaluated twenty-seven lake trout populations from the Algonquin Park region of Ontario through molecular analysis of mitochondrial and microsatellite DNA variation. Our results indicate there were two distinct genetic clusters that corresponded to contemporary populations established by two major postglacial colonization events. The first lake trout to arrive dispersed from a Mississippian glacial refuge and established high elevation populations in the central and southern areas of the region. Lower elevation populations were later colonized by a second, Atlantic glacial lineage through the Fossmill outflow channel of proglacial Lake Algonquin. Future management strategies should limit genetic exchange between the two genetic clusters, particularly during the selection of source and recipient lakes for local strain stocking programs.

C2-5

Swimming speed and foraging behaviour of lake trout measured using multi-beam hydroacoustics

Scott W. Milne[1] (presenting), Erin S. Dunlop[2]. [1]Milne Technologies, Bergen, Norway, [2] University of Bergen, Bergen, Norway

Multi-beam hydroacoustics allow the in situ observation of swimming and foraging behaviour and give insights into the individual-level ecology of fish. In the summer of 2007, 16 adult lake trout in Lake Opeongo, Canada were surgically implanted with ultrasonic tags, subsequently released, and studied using mobile hydroacoustics. Tagged lake trout were located on 131 occasions, over 12 days, for a total of 11.7 hours of echogram observations. From these events, we observed and quantified the tagged individuals' spatial relationship to other similar sized fish targets (e.g. other lake trout), lake herring schools, and surrounding habitat. We found that all tagged lake trout were observed to spend at least a portion of their time in close proximity to the lake bottom, but interestingly, many made rapid vertical swimming events up into the water column. These burst vertical movements were often targeted at lake herring schools, providing evidence that lake trout are active foragers. Some of the tagged trout were also found to travel alongside or to actively swim towards other similar targets (e.g. other lake trout), whereas other tagged individuals were more solitary. This type of information, made available through the integration of acoustic technology, enables a fuller understanding of the ecology of aquatic predators and their prey and provides direct measurements needed to quantify the bioenergetics of lake trout in their natural environment.

C2-6

Habitat selection and the vertical distribution of cisco (*Coregonus artedi*) in Lake Opeongo, Ontario, Canada

Jan Moryk[1] (presenting), Mark Ridgway[2,3]. [1]Trent University, Peterborough, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Canada, [3]Harkness Laboratory of Fisheries Research, Algonquin Park, Canada

Understanding how pelagic organisms respond, through habitat selection, to stratification is important in determining the structure and productivity of lake ecosystems. This study examines, the seasonal use of the metalimnion by a pelagic planktivorous fish, the cisco (*Coregonus artedi*), and how seasonal changes in the metalimnion may or may not alter depth selection in cisco. Year-to-year temperature and hydro acoustic data sets were used to examine the variation in metalimnion formation and document the vertical distribution of cisco residing in Lake Opeongo (Algonquin Park). Age (via otoliths) and growth data were gathered from captured cisco. Initial results indicate that the vertical partitioning of the metalimnion by cisco is not random even at depth gradients as fine as 1 m intervals. The cisco within the metalimnion separate by size and partition the thermocline according to temperature preferanda. YOY cisco concentrate at depths that correspond to temperatures ranging from approximately 14°C-16°C whereas, larger and older cisco aggregate at a greater depth below the smaller and younger cisco. Larger cisco concentrate at depths corresponding to temperatures ranging from about 8°C-12°C. This study aims to answer three main questions; 1) How do seasonal patterns in the formation and time span of the metalimnion affect the temperature gradients selected by coregonines? 2) Do DVM patterns and variation change relative to the ontogeny and sex of cisco within the metalimnion? 3) Ulitmately, what hypotheses best account for the vertical distribution of cisco? (*Coregonus artedi*)?

C2-7
Status of lake whitefish (*Coregonus clupeaformis*) in Lake Champlain
J. Ellen Marsden[1] (presenting), Stephen J. Smith[2], Joanna Hatt[1]. [1]University of Vermont, Burlington, VT, United States, [2] USFWS Lake Champlain Fish and Wildlife Resources Office, Essex Junction, VT, United States

Lake whitefish supported the largest commercial fishery in Lake Champlain in the late 1800s; harvest in Quebec waters continued until the 1990s. Whitefish populations in the Great Lakes have declined in the past two decades, possibly linked to the invasion of dreissenid mussels. Diets have shifted to incorporate dreissenids, and condition factor has declined due to loss of the burrowing amphipod Diporeia. We examined whitefish population characteristics to determine whether similar changes may be occurring in Lake Champlain. Adult whitefish were sampled using gillnets in fall. Larval whitefish were sampled in spring with an ichthyoplankton net. In the first year, sampling was focused on historic spawning grounds and potential spawning areas identified by substrate. Spawners and larvae were sampled in high densities in one area, but none were found at traditional fall commercial fishing sites. Preliminary analysis indicates that the age structure is broad, condition factor is good, whitefish are growing well, and they do not consume zebra mussels. Diets are largely composed of gastropods, similar to diets reported in the 1930s. The apparent disappearance of historically important populations is being investigated further.

C2-8
Relating feeding habits and trophic position to changes in condition of lake whitefish
Kelly-Anne Fagan[1] (presenting), Marten Koops[2], Michael Arts[3], Trent Sutton[4], Michael Power[1]. [1]Department of Biology, University of Waterloo, Waterloo, ON, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, Canada, [3]National Water Research Institute, Environment Canada, Burlington, ON, Canada, [4] School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Alaska, United States

Lake whitefish, *Coregonus clupeaformis*, a commercially important fish, has experienced declines in condition in some areas of the Great Lakes. It has been hypothesized that trophic disruption has led to declines in the abundance of high quality food resources, specifically Diporeia. Spawning lake whitefish were sampled in 2004 and 2005 at six stations around Lake Michigan and one station each in lakes Superior and Erie known to vary in local abundances of Diporeia. Lake whitefish condition was characterized using dorsal muscle total lipid and the hepato-somatic index (HSI). Feeding habits and trophic position were characterized using stable isotope analysis (δ13C, δ15N). Mean total lipid levels were significantly different between lakes in 2004 and 2005, with high mean values of 38% and 35% in Lake Erie. Male HSI was found to be significantly different between lakes each year, with high mean values of 0.89 (2004) and 0.85 (2005) in Lake Superior. The condition of lake whitefish was best in lakes Erie and Superior, with low and high Diporeia abundances, respectively. The condition of lake whitefish in Lake Michigan varied among sites. The relationship between condition and isotopic signature was examined to test the hypothesis that condition in lake whitefish was associated with dietary contribution from high quality prey such as Diporeia.

C2-9
Characterizing basic movement and habitat use of lake whitefish (*Coregonus clupeaformis*) in Clear Lake, Maine
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Movements of lake whitefish (*Coregonus clupeaformis*) were studied in Clear Lake. Clear Lake is a small lake system (626 acres) which has maintained a robust population of lake whitefish and offered an opportunity to study movements on a daily to seasonal time frame. Vemco VR2 receiver units were deployed on Clear Lake for year round passive detection. Clear Lake has five receivers that have logged data year round since November 2004. Eleven lake whitefish were tagged at Clear Lake in November 2004, followed by 4 whitefish in 2005 and 14 in 2006. Movements, both vertically and throughout the systems have been used to identify key habitats. Such expansive and detailed monitoring would be nearly impossible with conventional mark/recapture methods. Results indicate a seasonal and diel pattern of movement in lake whitefish in Clear Lake. As the season changes from winter/spring to summer, lake whitefish follow a thermal layer to deeper waters only to return to shallower waters in fall and early winter for spawning. In the spring whitefish remain in shallow waters to feed until the water temperatures become too warm at which point they follow cooler temperatures and remain below the thermocline. The diel pattern of behavior shows an increase in vertical movements during daylight hours and a cessation of these vertical movements at night. This pattern is more visible during spring, summer, and fall seasons, while in winter the pattern seems to be intractable. The lack of this behavior during winter is hypothesized to be caused by the lack of light through the snow-covered ice.

C2-10

Long-term variability of Arctic cisco growth rates: evidence of environmental controls

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Arctic cisco (*Coregonus autumnalis*) are an important resource in northern Alaska. Subsistence users have expressed concern over declines in harvests and size of cisco from the Colville River. We measured otolith growth of 722 cisco captured in subsistence fisheries in the Colville River between 1986 and 2006 re(presenting) 24 year classes (1978 – 2002). There was a significant positive relation between otolith radius and fork length ($r2=0.85$, $P<0.0001$). Significant inter-annual variation in otolith growth was evident in the first 7 annual growth increments (one-way ANOVA for each annulus, $P<0.05$). Because the greatest growth rates occur in the first year, we analyzed first year otolith growth rates in relation to environmental variables using linear regression with each point weighted by sample size. First year growth was positively correlated with the winter Arctic Oscillation index (Nov-Mar, r2
=0.14, $P<0.05$), mean summer air temperature at Inuvik in the Mackenzie River Delta (May-Aug, $r2=0.17$, $P<0.05$), mean speed of east wind at Barrow, Alaska (July-Aug, $r2=.018$, $P<0.05$), and mean Mackenzie River discharge at Ft. Simpson lagged 2 years (April-June, $r2=0.29$, $P<0.01$). These results suggest that changes in the physical environment may influence cisco growth rates directly and indirectly as biologically mediated shifts in lower trophic level productivity.

C2-P-1

A model for the evolution of river-spawning behavior in lake trout

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Lake trout are highly adapted for complete lifecycles in freshwater lake ecosystems. Unlike other species of the charr genus, lake trout generally do not engage in complex mating behaviors that increase reproductive success in stream environments. Surprisingly, some Lake Superior lake trout migrate into tributaries in the fall to reproduce over riverine spawning habitat. Although these river-spawners are genetically distinct from lake basin-spawning lake trout, it is not clear whether their homing tendency and other characteristic traits are heritable. To facilitate planning for long-term breeding experiments, I developed a two-phase model to evaluate hypotheses on the evolution and heritability of river-spawning characters. Initially river-spawning lake trout would have diverged from basin-spawning lake trout as isostatic rebound lifted historical river-spawner habitat from the main basin of Lake Superior. A secondary period of behavioral reinforcement then would have followed during which characteristic differences in spawn timing and egg hatching could develop as the river-spawning lake trout adapted to mating under variable stream conditions. This model specifically predicts that many of their behavioral adaptations have some heritability, and it is supported by both historical mark-recapture studies and recent genetic analyses.

C2-P-2

Egg quality variation in wild and hatchery stocks of lake trout

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Organisms are predicted to produce higher quality offspring, at the expense of offspring quantity, in environments where conditions for offspring survival are poorer. In addition, egg quality (an index of offspring quality) has been shown to vary with maternal size or age within a particular environment for a variety of fish species. The relative contributions of environmental and maternal factors to variation in egg quality were examined in an iteroparous salmonid, lake trout. Egg size (dry mass) and lipid concentration (percent of dry mass) were measured for 18 wild populations and for 8 hatchery strains originating from these populations. Both egg traits showed very little interannual variation within populations. Egg size was positively related to maternal size and age, and varied significantly among populations for both wild and hatchery strains. Egg lipid concentration was a less variable trait than egg size, but also varied significantly among strains. In wild populations, egg lipid concentration was negatively correlated with egg size. Paired comparisons of egg quality between hatchery-reared broodstocks and wild females from their source populations indicated that the former generally produced smaller eggs with higher lipid concentrations. The implications for lake trout management are discussed.

C3. Sturgeon

C3-1

Age and growth of shovelnose sturgeon in the Missouri River

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Little is known about population dynamics of shovelnose surgeon *Scaphirhynchus platorynchus* in the Missouri River. Accurate age and growth information collected over a broad spatial scale will assist researchers in making management decisions in various hydrological zones (classified as river segments). In addition, shovelnose sturgeon have been identified as a surrogate species to pallid sturgeon S. albus, a federally endangered species. Identifying age and growth differences of shovelnose sturgeon between river segments and examining factors that drive these differences may guide restoration efforts for pallid sturgeon. A total of 2,602 shovelnose sturgeon pectoral fin rays were collected over a four year period from approximately 1,600 km of the Missouri River. Fin ray cross-sections were aged by two independent readers and a consensus was formed when discrepancies occurred. Length-at-age was back calculated to account for low sample sizes of age-1 and age-2 shovelnose sturgeon (Dahl-Lee method; Carlander 1969). The mean average growth for age-1 was 190-mm; second and third year growth rates decline to 92-mm and 68-mm, respectively. Significant growth variation was observed between river segments each year for age-1-3 shovelnose sturgeon. These differences are likely related to a variety of factors such as flow modification, natural environmental events, and habitat improvement projects. Our results indicate that growth of shovelnose sturgeon was related to temporal variation within segments and suggests that variation in water releases from dams and tributary influences play a large role in sturgeon growth.

C3-2

Wrong place at the wrong time: incidental take of endangered pallid sturgeon in a commercial caviar fishery

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We quantified the bycatch of endangered pallid sturgeon (*Scaphirhynchus albus*) in Tennessee's shovelnose sturgeon (S. platorynchus) caviar fishery by accompanying commercial fishers and monitoring their catch in April-May 2007. Fishers removed 327 live sturgeon from their gear in our presence, of which 93 were harvested; we also obtained the carcasses of 20 sturgeon that a fisher harvested out of our sight. Two of the 113 harvested sturgeon were confirmed pallid sturgeon based on microsatellite DNA analyses. Additionally, fishers gave us five, live pallid sturgeon that they removed from their gear. If the incidental take of pallid sturgeon (1.8% of all sturgeon harvested) was similar in the previous two commercial seasons, at least 169 adult pallid sturgeon were harvested by commercial fishers in the Tennessee waters of the Mississippi River in 2005 and 2006. While retrieving a gill net set the day before, a fisher we were accompanying retrieved a gillnet lost two days earlier. That ghost net caught 53 sturgeon; most of those fish were dead, including one confirmed pallid sturgeon.

C3-3

Spawning of pallid sturgeon in the Middle Missouri River

Justin Haas[1] (presenting), Dustin Everitt[1], David Adams[1], Aaron DeLonay[2], Gerald Mestl[1]. [1]Nebraska Game and Parks Commission, Lincoln, NE, United States, [2]United States Geological Survey, Columbia, MO, United States

Aquatic habitat in the Missouri River has been extensively altered or lost. This habitat alteration has affected most native fish species including the federally endangered pallid sturgeon (*Scaphirhynchus albus*). At the time pallid sturgeon were listed, it was not known if pallid sturgeon reproduction was still occurring in the lower Missouri River. The Nebraska Game and Parks Commission and the United States Geological Survey initiated a telemetry study in 2007 to confirm the spawning of pallid sturgeon in the Missouri River and if so, where. In the spring of 2007, five pallid sturgeon in reproductive condition, two females and three males, were implanted with Lotek Wireless combined acoustic radio tags and data storage tags. After tag implantation, fish were monitored through an extensive effort (daily) for possible signs of pre-spawning movement. After the fish began to move we switched to an intensive effort where a selected fish was monitored continuously. The two female pallid sturgeon were located hourly and habitat information collected. Both intensively tracked females exhibited upstream movement with a single apex, followed by intervals of slower downstream movement. The apex of upstream movement of one female was in the Missouri National Recreational River segment and the other in the upper channelized river. After both female pallid sturgeon began moving down stream they were recaptured using trammel nets and it was determined that both had spawned.

C3-4

Comparative examination of patterns of movement and spawning by pallid sturgeon and shovelnose sturgeon in the Lower Missouri River

Aaron DeLonay[1] (presenting), Kimberly Chojnacki[1], Sandra Clark-Kolaks[1], Emily Tracy-Smith[1], Diana Papoulias[1], Mark Wildhaber[1], Dustin Everitt[2], Gerald Mestl[2]. [1]U.S. Geological Survey, Columbia, MO, United States, [2]Nebraska Game and Parks Commission, Lincoln, NE, United States

In spring 2007 the U.S. Geological Survey with the Nebraska Game and Parks Commission studied the migration behavior and

spawning of sturgeon in the Lower Missouri River in response to flow and other environmental variables. Prior to spawning, 8 pallid sturgeon (*Scaphirhynchus albus*) and 176 shovelnose sturgeon (*S. platorynchus*) were captured and implanted with a telemetry transmitter and data storage tag (DST). Implanted sturgeon were captured in two study sections within the 160-mile length of river below Gavins Point Dam. Implanted sturgeon included both reproductive and non-reproductive males and females. The reproductive status of each individual was assessed during implantation. Crews extensively tracked sturgeon from late March through August, 2007. Systematic search efforts were conducted to document direction and distance moved, and to locate potential spawning habitat. Periodic efforts were made to validate spawning behavior and timing using DIDSON imaging technology and selective recapture of individuals. Following the spawning period all fish were targeted for recapture to reassess spawning success and to collect data storage tags. Two of 8 pallid sturgeon and 104 of 176 shovelnose sturgeon were recaptured. Both species spawned in the channelized and unchannelized portions of the Lower Missouri without modified flows out of Gavins Point Dam. All implanted pallid sturgeon females and >70% of shovelnose sturgeon females spawned. Limited results suggest that movement patterns of both species may be similar. Shovelnose sturgeon used tributaries extensively, while pallid sturgeon did not. Preliminary analysis indicates that migration behavior of males and females within a species may differ.

C3-5

Fine-scale movement of Gulf of Mexico sturgeon relative to critical habitat within Escambia, East, Pensacola, and Choctawhatchee Bays, Florida, following Hurricanes Ivan (2004) and Dennis (2005)

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Hurricanes Ivan (September 2004) and Dennis (July 2005) came ashore in northwest Florida over areas previously designated as critical habitat for Gulf sturgeon *Acipenser oxyrinchus* desotoi. Fifty-eight Gulf sturgeon were tagged with ultrasonic transmitters and released within Escambia, Yellow, Blackwater, and Choctawhatchee Rivers in June, July, September, and October 2005 to determine whether habitat patterns were similar to those observed prior to the hurricanes. Gulf sturgeon marine migration from these rivers into the Pensacola and Choctawhatchee Bay systems was monitored by underwater acoustic receivers stationed throughout each bay from October 2005 through June 2006 (study period 1) and from September 2006 through August 2007 (study period 2). During both study periods, the majority of tagged fish resided in the bays between November and April, with the exception of a few fish that were detected in near shore Gulf of Mexico. An atypical behavior was observed in one fish which was tagged in the Choctawhatchee River but remained in the upper portion of Escambia Bay for the entire summer (June - September) 2006 and returned again in June and July 2007. Several fish displayed the propensity to travel among different bays and rivers but the most notable included a fish that was tagged in the Choctawhatchee River in 2005 and migrated into the Apalachicola River in spring 2006 and then returned to the Choctawhatchee River in spring 2007. Santa Rosa Sound, the seaward arm of the Pensacola Bay system, supported 22 sturgeon for varying periods of time from November 2005 through April 2006 and 15 fish the following year (including11 fish from the previous year and 4 fish not recorded during the first study period). Several fish resided in Santa Rosa Sound for an extended period of time (up to 80 days), presumably to take advantage of the abundant food supply. Most of these habitat use patterns have been documented previously, therefore we concluded that the two hurricanes did not diminish or alter habitat use of Gulf sturgeon in the Pensacola and Choctawhatchee Bay systems.

C3-6

Status of gulf sturgeon in Florida waters: using age-structured population modeling techniques to reconstruct and project population trends and evaluate conservation targets

H. Jared Flowers[1] (presenting), William Pine[1], Steven Martell[2]. [1]University of Florida, Gainesville, FL, United States, [2]University of British Columbia, Vancouver, BC, Canada

Gulf sturgeon Acipenser oxyrhinchus desotoi is a US Endangered Species Act (ESA) listed “Threatened” species that was historically commercially harvested throughout its range in the northern Gulf of Mexico. Because of concerns over declines in population size due to overharvest, the fishery was closed in the mid 1980’s. The Apalachicola River, Florida likely supported one of the largest Gulf sturgeon population stocks, yet this population has shown little evidence of recovery as defined by the species’ recovery criteria under the ESA. To aid managers in evaluating the practicality of the current recovery criteria in terms of population size and time till recovery, we developed two age-structured population models. We first developed an SRA (stock reduction analysis) model using a time series of landings, biological information, and current population estimates for the Apalachicola River to estimate historic population biomass at the start of fishing. We then used this information to build a second model to evaluate tradeoffs of different management approaches currently being considered to expedite recovery for Gulf sturgeon in the Apalachicola River. Our findings suggest that there were about 20,000 individuals in the population prior to fishing and minimum population recovery time to this level will be in excess of 50 years from fishery closure, approximately double the currently listed target date.

C3-7

Effects of environmental factors and parental reproductive characteristics on dispersal time of larval lake sturgeon

(*Acipenser fulvescens*)

Yen Duong[1] (presenting), Kim Scribner[1], James Crossman[1], Patrick Forsythe[1], Edward Baker[2]. [1]Michigan State University, East Lansing, MI, United States, [2]Michigan Department of Natural Resources, Marquette, Michigan, United States

Rehabilitation of threatened fish species, including lake sturgeon (*Acipenser fulvescens*), is in part impeded by lack of knowledge of how environmental and genetic factors affect dispersal and survival during critical early-life history stages. Water temperatures and flow have been considered as major causes of variation in larval dispersal time. However, adult phenotype and timing and location of spawning can also influence larval dispersal. We estimated the relative importance of environmental factors (temperature and flow) and adult characteristics (body size, location and timing of spawning) on timing of larval dispersal. Biological attributes, spawning locations, and genetic samples were obtained from adult lake sturgeon spawning in the Upper Black River, Michigan during 2007. Larvae were passively captured dispersing downstream for 30 nights and were reared separately until fin clips could be taken. We employed parentage analysis using 12 microsatellite loci to assign larvae (N=1400) to adult spawners (N=203). Variation in larval dispersal time was partitioned into components attributed to environmental factors and parental reproductive characteristics. We will discuss the effects of behavioral plasticity and adaptive significance of dispersal time that is also tied to early life history traits, and discuss implications for management.

C3-8

Genetic diversity implications of lake sturgeon stream-side rearing

Luke Roffler[1] (presenting), Brian Sloss[1], Brad Eggold[2], Tom Burzynski[2], Ron Bruch[3]. [1]Wisconsin Cooperative Fishery Research Unit, University of Wisconsin-Stevens Point, Stevens Point, WI, United States, [2]Wisconsin Department of Natural Resources, Milwaukee, WI, United States, [3]Wisconsin Department of Natural Resources, Oshkosh, WI, United States

Rehabilitation of historic Lake Michigan lake sturgeon populations using stream-side rearing facilities (SRFs) is currently underway. The Wisconsin traditional hatchery (TH) method uses eggs from one female crossed with mixed milt of five males and all subsequent progeny are reared together (mixed families). The SRF approach uses a modification of this multi-male approach where the eggs are split into roughly equal lots and fertilized by one male each, after which female families are reared separately. Our objective was to determine if the two strategies resulted in realized genetic differences by comparing genetic diversity of TH and SRF progeny. Differences were observed between approaches the two (TH and SRF). We found all broodstock populations to be representative of their source populations, based on a G-test of allele counts. However, by the end of the rearing process, all facilities had lost the representative character of the original source population. This correlates with observed paternity-related bias in survival found consistently in each cross at each facility. Such bias can cause a loss of genetic diversity through lower than expected effective numbers of breeders. This study will assist in modifying spawning and rearing strategies for the maintenance of genetic diversity in lake sturgeon propagation.

C3-9

The St. Lawrence estuary Atlantic sturgeon (*Acipenser oxyrinchus*) fishery: managing a valuable resource towards a sustainable fishery

Guy Verreault[1] (presenting), Guy Trencia[2]. [1]Ministère des Ressources naturelles et de la Faune, Rivière-du-Loup, Qc, Canada, [2]Ministère des Ressources naturelles et de la Faune, Lévis, Qc, Canada

The Atlantic sturgeon (*Acipenser oxyrinchus*) has been exploited in the St.Lawrence estuary (Canada) for its flesh for decades. After a severe crash in late 60's, this non-regulated fishery recovered and landings peaked at record level (142 mt) in early 90's with signs of overexploitation. Lack of basic knowledge regarding population dynamics and habitat requirements have confronted managers striving to implement sustainable fishery management. Annual monitoring of the fishery and the sturgeon population was set up in 1994 in conjunction with progressive fishing restrictions. The fishery is now closely regulated with restricted seasons, individual quotas (tags), specific mesh size gillnets (20.4 cm), and maximum fork length (150 cm) for a mean annual landing of 49.2 mt (SD= 2.6). Annual size structure and CPUE were corrected for gillnet selectivity and allowed to estimate total mortality (Z= -0.12) and fishing mortality (F= -0.07). The management measures influenced fishers behaviour. Fisher selection is defined with a sigmoid function where probability for a sturgeon to be kept and tagged increases rapidly over 105 cm FL whereas gillnet selectivity decreases over the same size. Those two characteristics appear to be key components for sustaining the only remaining fishery for this species in North America.

C3-10

Bycatch mortality of sturgeon in the Northwest Atlantic Ocean

Tim Miller[1] (presenting), Gary Shepherd[1], David Secor[2]. [1]NMFS, Northeast Fisheries Science Center, Woods Hole, MA, United States, [2]Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, ML, United States

We performed statistical analyses to assess whether covariates (targeted species, surface water temperature, sturgeon length, and attributes of gear and its application) were correlated with mortality of sturgeon incidentally caught in gillnet and otter trawl

commercial fisheries. For each gear type, we fit a suite of nested logistic regression models to data collected between 2001 and 2006 by at-sea observers in fishing fleets off of the northeastern United States. We used likelihood ratio tests of the fitted models to determine whether the covariates were significantly correlated with sturgeon mortality. For gillnet gear (135 total sturgeon bycatch mortalities out of 465 sturgeon bycatch observations), sturgeon mortality was significantly correlated with soak time, water temperature, length of the caught sturgeon and mesh size. However, these relationships were significantly different by targeted species and whether or not tie-downs were used. For trawl gear, no covariates were significantly correlated with sturgeon mortality. The inability to detect significant associations of any covariates with mortality in trawl gear could be due to low statistical power; only 48 sturgeon bycatch observations (and only 3 mortalities) were available for trawl gear.

C3-P-1

A comparison of two transmitter implantation techniques in shovelnose sturgeon

Ben Neely[1] (presenting), Kirk Steffensen[1], Mark Pegg[2]. [1]Nebraska Game and Parks Commission, Lincoln, NE, United States, [2]University of Nebraska - Lincoln, Lincoln, NE, United States

Shovelnose sturgeon *Scaphirhynchus platorhynchus* are a benthic species native to the Mississippi River and Missouri River drainages. Population declines throughout their native range and their close phylogenetic relationship with the endangered pallid sturgeon S. albus have prompted researchers to observe shovelnose sturgeon behaviors and identify critical habitat types using telemetry. Telemetry transmitters are most often implanted surgically in shovelnose sturgeon with little or no documentation of alternate implantation techniques. We compared handling time and percent weight loss of shovelnose sturgeon that had transmitters implanted surgically (N=16), implanted gastrically (N=28), and not implanted (N=34). Implantation time was 35 seconds faster on average for gastric implantation versus surgical implantation (P<0.0001). However, there was no significant difference in percent weight loss between the three treatments (P=0.68). One gastric implantation mortality occurred during the 35-day observation period (day 32) and three gastric implantation mortalities occurred after the observation period ended (days 38 and 39). Two gastrically implanted tags were expelled during the 35-day observation period. Our results suggest that handling time for the transmitter implantation techniques used in this study do not affect short-term survival nor significantly influence growth.

C3-P-2

Population parameters and potential management scenarios of shovelnose sturgeon in the upper Mississippi River

Jeff Koch[1] (presenting), Michael Quist[1], Clay Pierce[2], Michael Steuck[3], Kirk Hansen[3], Gene Jones[3].
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Shovelnose sturgeon *Scaphirhynchus platorynchus* have become an increasingly important commercial species in the upper Mississippi River (UMR) due to collapsing foreign sturgeon populations and bans on imported caviar. Data regarding shovelnose sturgeon population parameters in the UMR are currently more than thirty years old; therefore, more recent information is needed for managing these populations. We began a project in the spring of 2006, in collaboration with the Iowa Department of Natural Resources (DNR) and the Wisconsin DNR to study the impacts of commercial harvest on shovelnose sturgeon populations in the upper Mississippi River. Over 1,500 shovelnose sturgeon were collected from eight study pools (i.e. Pools 4, 7, 9, 11, 13, 14, 16 and 18). Shovelnose sturgeon from upstream pools have the highest mean lengths, weights, and ages. Mortality estimates are also lower in upstream pools (i.e. Pools 4, 7, 9, and 11) compared to downstream pools (i.e. Pools 13, 14, 16, and 18). Modeling of potential management scenarios with current population parameters from our study suggest a 24-inch minimum length limit may prevent growth overfishing, but a 27-inch minimum length limit is necessary to prevent recruitment overfishing.

C3-P-3

Diet composition of juvenile shovelnose sturgeon in the Middle Mississippi River

Dawn Sechler[1] (presenting), James Garvey[1], Quinton Phelps[1]. [1]Southern Illinois University- Carbondale, Carbondale, IL/ north central division, United States

Shovelnose sturgeon populations are declining throughout their native range due to potential commercial overharvest and habitat degradation. To ensure shovelnose sturgeon populations persist in the Middle Mississippi River, a better understanding of sturgeon early life history is imperative. We quantified juvenile shovelnose sturgeon (total length (TL) range: 9-95 mm) diets from 2004-2007 to determine whether foraging behavior changed as a function of season and total length. Juvenile shovelnose sturgeons were collected from the Middle Mississippi River during the months of May-July of the above years. Each prey item was identified to genus and measured to calculate dry weight. Although, ephemeropterans, dipteran pupae, and megalopterans were consumed, chironomids comprised the majority of diet by dry biomass during all three years. For sturgeons >15 mm TL dry weight of chironomids and ephemeropterans were inversely related; smaller fish exhibited no such trend. During May-July of 2008, prey will be collected in order to quantify availability to determine whether observed foraging behavior is selective or non-selective.

C3-P-4

Development and application of a spatially explicit habitat model for juvenile pallid sturgeon

Bryan Spindler[1] (presenting), Steven Chipps[1], Robert Klumb[2]. [1]USGS South Dakota Cooperative Fish and Wildlife Research Unit, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD, United States, [2]US Fish and Wildlife Service, Great Plains Fish and Wildlife Management Office, Pierre, SD, United States

The pallid sturgeon *Scaphirhynchus albus*, is an endangered species native to the Missouri, and Lower Mississippi River. As part of a large-scale recover effort, juvenile pallid sturgeon are stocked into the Missouri River and monitored using standardized sampling protocols. Understanding the distribution and habitat requirements of juvenile pallid sturgeon represents an important part of the monitoring and assessment program. In this study, we developed a habitat assessment tool for pallid sturgeon that integrated information from known capture locations with physical habitat and prey availability parameters. We used discriminant function analysis to assess habitat differences between capture (n=25) and non-capture (n=49) locations from 2003-2006 in the Fort Randall reach of the Missouri River. Six variables successfully discriminated capture from non-capture locations and included 1) water depth >2 m, 2) water velocities < 120 cm , 3) variation in water velocity direction, 4) sandy substrates, 5) dipteran abundance and 6) ephemeropteran abundance. Classification functions were then used to predict pallid sturgeon occurrence in eight 3.2 km river segments. Percent of predicted habitat area ranged from 0.5 to 23%, indicating that habitat availability for juvenile pallid sturgeon is variable in the Fort Randal reach. The model developed here could be used to evaluate pallid sturgeon habitat in other areas of the Missouri River basin and help guide future pallid sturgeon stocking and habitat restoration efforts.

C3-P-5
Efforts to document spawning of shortnose sturgeon in the Penobscot River System, ME
Phillip Dionne[1] (presenting), Gayle Zydlewski[1], Michael Kinnison[1], James Wilson[1]. [1]University of Maine, Orono, Maine, United States

During the summer of 2006 the first confirmed endangered shortnose sturgeon captured in the Penobscot River in over a quarter century was netted by researchers from the University of Maine. Since then monitoring has led to efforts to develop population estimates and identify critical habitat within the system. These efforts involve the capture and tagging of sturgeon and have yielded over one hundred tagged individuals. A subset of these were also tagged with acoustic and/or radio transmitters allowing researchers to track the fish. It is currently unknown if sturgeon spawn in the Penobscot River. In the coming year, in addition to refining population estimates and distinguishing critical habitat, we will work to identify spawning habitat. Due to the delicate nature of dealing with endangered species, netting for spawning individuals is not permitted; instead efforts to document spawning will take place by tracking previously tagged sturgeon to spawning areas, or in the absence of such information, sampling when water temperatures approach those documented for spawning of the same species in adjacent river systems. Sampling will involve deploying an array of artificial substrates to capture spawned eggs that will adhere to the artificial substrates. These sampling techniques and preliminary results will be discussed and explained in relation to the challenges of this particular project. Additionally, the consequences of researching an endangered species and how the collection of data is regulated under the ESA will be considered.

C3-P-6
Assessing the spatial distribution of pallid and shovelnose sturgeon capture sites in the Lower Missouri river using geospatially enabled relational data
Kimberly Chojnacki[1], Sandra Clark-Kolaks[1], Emily Tracy-Smith[1], Aaron DeLonay[1] (presenting). [1]U.S. Geological Survey, Columbia, MO, United States

Multidisciplinary research is being conducted to investigate reproductive physiology, movement and spawning habitat use of Lower Missouri River sturgeon. Pallid (*Scaphirhynchus albus*) and shovelnose sturgeon (*S. platorynchus*) central to this effort were initially collected in two segments of the Missouri River from March 8, 2007 to April 19, 2007. The upper segment was located between river mile 756 and 727. The lower segment was located between river mile 685 and 648 (Blair, NE). A total of 86 pallid sturgeon and 2286 shovelnose sturgeon were collected using 544 gear deployments, 79 3.5-inch mesh gill nets, 238 2.5-inch mesh gill nets, 70 2-inch trammel nets, and 157 trotlines baited with worms. Using a relational database framework, data were recorded about each gear deployment, including habitat type, water quality, latitude and longitude. A related table was created to maintain data on all fish captured in each deployment. Using the database framework, fishing efforts, and number of pallid and shovelnose sturgeon captured were summarized by river mile. A geographic information system was then used to map the summary of pallid and shovelnose capture locations, normalized by fishing effort. This work provides visual representation of the spatial distribution of pallid and shovelnose sturgeon capture locations, which could be used in the future to focus field sampling efforts.

C4. Fish Conservation
C4.1-1
Beyond exhibits: fisheries conservation in zoos & aquariums
Cynthia Lee[1] (presenting). Toronto Zoo, Toronto, ON, Canada[1]

Inherent with a sustainable future is conservation. This fact is understood by the public and scientists alike. Less well known by these communities is the role of zoological parks and aquariums in conservation of both ecosystems and species. This presentation provides an outline of the endeavours and opportunities for the collaboration of zoos and aquariums with fisheries biologists. There are approximately 250 professionally accredited zoos and aquariums located throughout North America, with collections encompassing the major aquatic ecosystems on the planet - from pelagic marine to headwaters of the Rocky Mountains. Consider the opportunity to convey your conservation message through the education programming offered by zoos and aquariums. With access to over 140 million visitors annually, or by working with staff educators on curriculum or project-based programming, this is a resource that is available to you to increase your project's public awareness. Over the last five years, North American zoos & aquariums have supported over 3,700 cooperative conservation and management programs in fields as diverse as population genetics, animal behaviour, veterinary pathology, in situ conservation and animal nutrition. This presentation will offer examples and opportunities for AFS members to work with the professionals in the aquarium field – perhaps located right in your own backyard.

C4.1-2
Are crayfish in a pinch: investigating the influence of multiple stressors on crayfish decline
Brie Edwards[1] (presenting), Don Jackson[1], Keith Somers[2]. [1]University of Toronto, Toronto, Ontario, Canada, [2]Dorset Environmental Science Centre, Ontario Ministry of the Environment, Dorset, Ontario, Canada

Previous work on a small number of inland Shield lakes located in the Dorset area has indicated that several crayfish populations are in a significant state of decline. The purpose of this study was to evaluate the spatial extent and severity this trend, on a broad scale across central Ontario's inland Shield lakes. Additionally, we were interested in uncovering any environmental changes which may be linked to the observed changes in crayfish abundance. For instance, it has been recently hypothesized that decreasing lake calcium could be contributing to population declines in related taxa. In order to address these questions, one-hundred lakes were surveyed for crayfish abundance and a number of chemical and environmental parameters. Historical survey records from the early 1990s were then used to determine whether any significant changes have occurred. Our results indicate that many crayfish populations have declined significantly, and that the apparent loss of some populations has impacted the distributions of several crayfish species across the study region. Furthermore, we have found that the decreased availability of calcium in lakes, as well as changes in a number of other environmental characteristics, may be negatively impacting the abundance of these important biological indicators.

C4.1-3
Spatial patterns in the distribution and conservation of imperiled fishes in the Lower Colorado River Basin
Joanna Whittier[1] (presenting), Craig Paukert[2], Julian Olden[3]. [1]Kansas State University, Manhattan, KS, United States, [2]Kansas Cooperative Fish and Wildlife Research Unit, Division of Biology, Kansas State University, Manhattan, KS, United States, [3]University of Washington, Seattle, WA, United States

The Lower Colorado River Basin (LCRB) has one of the most imperilled fish faunas in the nation. Our objectives were to evaluate the spatial and temporal patterns in the distribution of imperilled species (species state or federally listed and threatened or endangered) and their association with protected habitats. Species data were summarized by decade (1970s-2005) using Aquatic Ecological System (AES) boundaries. This boundary classification is one level of a hierarchical classification system for freshwater systems. Of the 386 AES in the LCRB only 257 have records for fish species. From1970 through 2005, the proportion of AES with at least one imperilled species doubled. By 2005, half of the AES sampled contained >1 imperilled species. Less than 10% of AES with imperilled species have at least 50% of their area within a legally protected property. Protection of imperilled species may require protection of more habitats in areas of these species occurrences. Our results allow resource managers in the future to identify and focus conservation efforts on AES with increased numbers of imperilled species.

C4.1-4
Assessing anthropogenic threats to fishes in the Lower Colorado River Basin
Kristen Pitts[1] (presenting), Craig Paukert[1], Joanna Whittier[1]. [1]Kansas State University, Manhattan, KS, United States

Although anthropogenic activities often influence ecosystem processes and biotic communities, they are rarely integrated into conservation planning due to the difficulty in quantifying associated threats to biotic integrity. The objectives of this study are to first, create an ecological risk index by quantifying risk of anthropogenic threats at a landscape scale in the Lower Colorado River Basin, and second, determine the utility of an ecological risk index in assessing threats to native fishes. Anthropogenic stressors included in this study are dams, canals, land use (i.e. percent agriculture, percent urban), mining, roads, railroads, stream crossings, 303d listings, non-point discharge elimination system permits, water diversions, and hazardous sites and were identified from various sources including the National Land Cover dataset, National Dam Inventory, and other spatially referenced coverages. Density of each stressor was calculated for all 73,072 catchments found in the Lower Colorado River Basin. Various threat metrics (i.e. presence/absence of stressor, frequency with equal weighting, values based on literature) were used to assess a wide range of techniques in quantifying risk by catchment and watershed. Although cumulative risk values were highly variable, the various metrics consistently classified catchments near urban centers as high risk. Native, fluvial dependent fishes were more associated

with areas of low stressors scores (r2=0.31). An ecological risk index was a practical tool that can help managers identify areas that are in greatest conservation need and prioritize catchments for future conservation efforts.

C4.1-4b

Fish assemblages in Iowa's non-wadeable rivers: relationships with habitat and sampling methods

Travis Neebling[1] (presenting), Michael Quist[1]. [1]Iowa State University, Ames, IA, United States

Non-wadeable river systems are one of the most diverse aquatic ecosystems in Iowa; however, fish assemblages in these systems are virtually unknown. One of the primary reasons little is known about fishes in non-wadeable rivers is because few studies have investigated methods for adequately sampling fishes in these systems. Therefore the purpose of this study is to develop a sampling protocol for fish and habitat in non-wadeable rivers in Iowa. In 2007, ten sites were sampled on nine non-wadeable rivers. Sites were three or five km in length depending on stream order. Each site was sampled with boat-mounted electrofishing equipment, a modified Missouri trawl, and a bag seine. Habitat characteristics were also measured at each site using a protocol based on the Iowa Department of Natural Resources' wadeable streams physical habitat assessment and the U.S. Environmental Protection Agency's non-wadeable river protocols. A total of 12,021 fish from 66 species in 13 families were collected including 13 species of greatest conservation need and one state threatened species.

C4.1-6

Restoring a rangeland watershed & its endemic rainbow trout: Pine Creek, California

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The endemic Eagle Lake rainbow trout (ELRT, *Oncorhynchus mykiss aquilarum*) has been denied access to critical spawning and rearing habitat for over 50 years. Over 100+ years of modifications of Pine Creek watershed (e.g. overgrazing, timber harvest, passage barriers) have decoupled the ELRT from its stream habitat and brook trout (*Salvelinus fontinalis*) now dominate historic rearing areas in the upper watershed. Passage barriers were constructed on Eagle Lake tributaries to prevent ELRT from spawning in degraded habitat. Since 1950 the lake fishery has been maintained by artificial spawning. Offspring are reared in hatcheries and released into Eagle Lake. Since 1987 changes in grazing management, reconstruction of culverts, and other conservation projects have resulted in marked improvement of habitat, although ELRT have been not allowed to attempt their natural spawning migration. Their ability to migrate has been questioned, and concerns led to a petition for listing under the federal Endangered Species Act. We report on the second year of a study to[1] Track the migration of ELRT spawners in Pine Creek, and[2] Test the ability of ELRT to spawn and rear in a tributary of Pine Creek following temporary removal of brook trout in 2007.

C4.1-7

Reconstructing Sakhalin taimen (*Hucho perryi*) historical distribution and identifying causes for their local extinction

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Sakhalin taimen (*Hucho perryi*), the largest salmonid in Japan, has been listed as Critically Endangered in 2006 by IUCN. Although dramatic reduction in both population size and distribution range has been reported, the detailed global range of the species and causes for extirpations have not been investigated. We compiled a database of historical taimen occurrence by drainage throughout the Russian Far East and Japan. We constructed a classification tree to determine environmental factors shaping the historical taimen distribution and then applied the tree to predict the potential geographic range of the species. Sakhalin taimen distribution was most strongly influenced by a spatial autocorrelation term, indicating drainages inhabited by the species are highly contagious. Large and flat drainage basins with larger floodplains had higher probability of taimen occurrence. The boundary of the global distribution was clearly delineated by monthly precipitation contours of 54 mm to the north and 96 mm to the south. The taimen presence was predicted in many drainage basins that had previously no records of the species. We also modeled extant/extinct status of the taimen populations in Japan where detailed population survey data exists. The most significant factor differentiating 12 extant populations from 36 extinct populations was mean annual air temperature with the extant populations distributed exclusively in areas below 5.2 C. Extant populations were found in drainages with significantly lower elevations and in drainages with a smaller amount of area in agriculture compared to drainages where populations have been extirpated. The presence of lagoons in the drainage was found to be a characteristic of the seven most numerically stable populations in Japan. The implications of this study for taimen conservation will be discussed.

C4.1-8

Stocking with introduced silver carp as a tool for conserving native fishes in Ukraine

Igor Buzevich[1], Alexander Didenko[1] (presenting). [1]Institute of Fisheries, Kiev, Ukraine

Unaltered riverine ecosystems of the Dnieper River, which is the largest river in Ukraine, were degraded as a result of reservoirs construction. Newly formed fish communities are currently under high anthropogenic pressure, the most important aspect of which is commercial fishing. Economics of riverside communities are tightly bound with fish harvest which is increasing in intensity. Up to 90% of catches consist of native species (bream, roach, silver bream). Due to unstable hydrological regimes, reproduction and recruitment of native phytophilous species is poor. In addition, the high fishing intensity results in their overharvest, the majority of which falls on young age groups. Thus, there is a need for conserving the biodiversity of native fish fauna. This task can be realized by creating an alternative fish resource base, consisting of silver carp (Hypophthalmichthys molitrix), for which there is a vacant ecological niche. Currently, annual consumption of phytoplankton by this species in the Dnieper River reservoirs is 1.4% of its gross production. Silver carp does not spawn in the reservoirs and its number can be controlled. Presence of this fish stimulates commercial fishermen to use large-meshed gillnets resulting in decreased harvest of the smaller native fishes. Market price for silver carp is double that of the most abundant native species while effort (as man-hours) to catch it is almost seven times lower.

C4.1-9

Analysis of the saltmarsh topminnow (*Fundulus jenkinsi*) habitat and distribution along the northern Gulf of Mexico

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The saltmarsh topminnow, *Fundulus jenkinsi*, is federally registered as a Species of Special Concern in coastal areas ranging from Texas to Florida due to a lack of information of its ecology. Characterization of its habitat and distribution would support science-based data towards the development of a regional conservation plan. During the spring, summer and fall of 2007, 1080 Breder traps collected 436 F. *jenkinsi* from the marsh edge habitats in Terrebonne Bay, LA, Grand Bay, MS, and Weeks Bay, AL, but none were collected in Apalachicola Bay, FL. *Fundulus jenkinsi* were more abundant during the spring, in Weeks Bay, and in shallow marsh edge habitats characterized by less dense vegetation, high dissolved oxygen, low water temperature, low salinity, and gradual bank slope (Principal Component Analysis). No regional differences could be interpreted between estuaries. These results indicated that seasonal changes in dissolved oxygen, temperature, and salinity and vegetation density are correlated to *F. jenkinsi* abundance (R2 = 0.264). Conservation of marsh vegetation (i.e. Spartina and Juncus) in salinity between 2-20 psu should be considered in developing a regional conservation plan for F. *jenkinsi*.

C4.1-10

Habitat suitability of the Carolina madtom, an imperiled southeastern stream fish

Steve Midway[1] (presenting), Thomas Kwak[2], D. Derek Aday[1]. [1]North Carolina State University, Raleigh, NC, United States, [2]United States Geological Survey: North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC, United States

Warmwater streams in the southeastern United States support substantial aquatic diversity on broad spatial scales. Roughly 47% of the North American fish fauna, including the greatest number of endemic fishes – those most vulnerable to extirpation and extinction from localized impacts – is found in southeastern freshwaters. The Carolina madtom, *Noturus furiosus*, is one example of an imperiled, endemic southeastern catfish that is experiencing declines presumably associated with habitat loss. Presently, the Carolina madtom may be nearing extirpation in about half of its distribution (i.e. one of two Atlantic watersheds). We investigated Carolina madtom seasonal habitat use, focusing particularly on the occupancy of natural habitat as well as introduced, artificial cover. In three, 70-100-m study reaches in the Tar River basin of North Carolina, observed Carolina madtom (n=94) occupied microhabitats nonrandomly and most frequently in water 0.45-m deep with 0.12-m/s bottom velocity over coarse sand substrate (57% of locations). All occupied microhabitats included physical cover, with cobble used most frequently (35%). Our findings also demonstrate significant use of introduced artificial cover. Ongoing field research and analysis will focus on habitat suitability, and laboratory studies will be conducted to quantify preference for artificial cover.

C4.2-1

Prioritizing areas for the conservation of stream biodiversity in Maryland

Scott Stranko[1] (presenting), Ronald Klauda[1], Patrick Ciccotto[1]. [1]Maryland DNR, Annapolis, Maryland, United States

Higher proportions of North American stream dwelling species are imperilled compared to terrestrial species. Nearly 10% of the freshwater fishes historically found in Maryland, including the endemic Maryland darter (*Etheostoma sellare*), have become extirpated within the last 30 years and 90% of extant mussels are imperilled. We identified stronghold watersheds for rare, threatened, or endangered freshwater fish, amphibians, reptiles, and mussel species. These watersheds are being used as priority areas for conservation strategies such as pursuing land acquisition and easements, recommending zoning changes to local jurisdictions, and tiered aquatic life use designations. Protection guidelines are now being generated for imperilled species in stronghold watersheds using empirical relationships between species occurrences and habitat and landscape data from the Maryland Biological Stream Survey.

C4.2-2
Predicting future changes in Muskegon River watershed (Michigan, USA) game fish under land use alteration and climate change scenarios
Paul Steen[1] (presenting), Michael Wiley[2], Jeffrey Schaeffer[1]. [1]USGS Great Lakes Science Center, Ann Arbor, United States, [2] University of Michigan, Ann Arbor, United States

Future alterations in land use and climate have the potential to cause substantial changes in the composition of stream fish communities. Predictive distribution models are an important tool to assess the probability of these changes causing species gain, loss, or extirpation. Classification tree models predicting the probability of species presence were applied to the streams of the Muskegon watershed (Michigan, USA). The models were applied to three potential future scenarios: 1) land use change only, 2) land use change and a 3 °C increase in air temperature by 2100, and 3) land use change and a 5 °C increase in air temperature by 2100. The analysis indicated that the expected change in air temperature and subsequent change in water temperatures resulted in the decline of cold-water fish in the Muskegon watershed by the end of the 21st century while warm-water species were predicted to significantly increase in range. Changes in land use are expected to cause large changes in a few particular fish species such as *Sander vitreus* walleye and *Oncorhynchus tshawytscha* Chinook salmon, but are not predicted to drive the overall changes in fish composition. Through interpretation of the classification tree models, managers can develop plans about how stream environmental conditions should be altered to maximize the probability of species residing in particular stream reaches.

C4.2-3
Sculpin reintroductions in Minnesota's driftless region: growth and survival vary among habitats and source populations.
David Huff[1] (presenting), Loren Miller[1]. [1]University of Minnesota, Saint Paul, MN, United States

This research investigates the success and persistence of reintroduced populations of slimy sculpin (*Cottus cognatus*) in the driftless region of southeast Minnesota. Native populations were present in this region historically, but were likely extirpated through past land-use practices. Ten streams that previously lacked sculpins were stocked with a mixture of sculpins from three donor streams. Since the number and source populations of the reintroduced animals are known, and the origin of offspring are easily identified through genetic analysis, there is an opportunity to learn how genetically and ecologically divergent populations respond to reintroduction in various habitats. We compared the relationship of the source habitats to differential survival and habitats at the reintroduction sites and collected genetic samples from all translocated fish. Subsequent sampling of all adults in the stream indicated which individuals survived to spawn. Genetic testing of offspring determined parentage and ancestral source for fish produced naturally in the streams. The fitness of each source strain and interpopulation hybrids at each reintroduction site was inferred by comparing growth rates. We also determined unique source population differences in growth rates though laboratory-based growth studies. Analysis of microsatellites and mitochondrial sequences indicate a high degree of genetic distinctiveness and very low historical gene flow among the source populations. Laboratory growth experiments under common garden conditions showed differences in growth rates among source populations as well. There were straightforward relationships between the source and reintroduction site habitats. In some cases survival at the reintroduction sites differed among source strains based on habitat-matching among source and recipient sites. Source strain and interpopulation hybrids showed differential growth rates. Because these populations are both isolated and geographically close, they provide an ideal model to address general questions of interest to other freshwater fish reintroductions throughout the world. There is a need for studies such as this to provide guidance for managers and improve reintroductions as a tool for conserving imperilled species.

C4.2-4
Vulnerability of freshwater fish communities to human mediated impacts
Jenni McDermid[1] (presenting), David Browne[2]. [1]Wildlife Conservation Society Canada, Thunder Bay, ON, Canada, [2]Canadian Wildlife Service, Environment Canada, Gatineau, QC, Canada

As the human population continues to grow, our requirement for water, electricity, and other natural resources increases; consequently, development activities are expanding into previously unaltered ecosystems. The natural resource potential in northern Ontario is high; yet this region is globally significant as it represents one of the largest areas of essentially unaltered watersheds while still containing high biodiversities of fish. With human development activities targeting this area, the primary conservation concern for freshwater fish species is the lack of comprehensive baseline information including distribution, abundance, and life history information for fish species. This study examines freshwater fish communities in northern Ontario and their associated environmental variables using multivariate statistical analyses (PCA and CCA) on existing presence / absence fish data collected by the Ontario Ministry of Natural Resources. Furthermore, freshwater fish communities with greater vulnerability to human mediated impacts (e.g. logging, mining, and climate change) were identified from the effects of human activities on key environmental variables as observed in disturbed freshwater ecosystems. This type of analysis will aid in identifying planning criteria for human development activities in this relatively pristine area of northern Ontario prior to the expansion of the human footprint.

C4.2-5
Inbreeding depression in the endangered aurora brook trout (*Salvelinus fontinalis timagamiensis*): assessment and conservation options
Jenny Lynn Fortier[1] (presenting), Chris Wilson[1]. [1]Trent University, Peterborough, ON, Canada

The aurora trout (*Salvelinus fontinalis timagamiensis*), an endangered form of brook trout, was extirpated in the wild in the 1960's due to lake acidification. All aurora trout alive today are descended from nine founder individuals and several decades of captive breeding. Genetic analyses have shown aurora trout to have very little genetic diversity, which may indicate a limited ability to adapt to inevitable future environmental variation. To address concerns relating to potential inbreeding and reduced fitness owing to their lack of genetic diversity and population history, common-garden rearing experiments were conducted on aurora trout and wild-type brook trout to compare life history traits such as survivorship, growth rates, age and size at maturity, and female fecundity. Bidirectional mating crosses between aurora trout and wild-type brook trout were also conducted to determine whether facilitated gene flow (F1 and backcross progeny) could mitigate reduced fitness, and assess whether 'genetic rescue' is a plausible course of action for aurora trout. Results of both studies show evidence of inbreeding depression in aurora trout (reduced survivorship, growth, and fecundity), suggesting that genetic rescue via limited introgression with brook trout may be a viable option for restoring fitness and increasing the adaptive potential of aurora trout.

C4.2-6
Landscape mosaics and the aquatic ecosystem: improving fisheries management strategies for Species at Risk (SAR) in an urbanizing catchment.
David Lawrie[1] (presenting), Christine Tu[1], Mark Poos[1]. [1]Toronto Region Conservation Authority, Toronto, Canada, [2] University of Toronto, Toronto, Canada

There is an expectation that within the Greater Toronto Area, watersheds will be almost entirely built-out within the next 25-30 years. This urbanization constitutes a large portion of the total area of several watersheds' total area and the vast majority of redside dace habitat, an aquatic species at risk (SAR) sensitive to changes in flow regime and turbidity. While the protection of watercourses from direct physical habitat alteration is considered possible, understanding and protecting the fundamental ecological processes, dictated by landscape condition, are more of a challenge. For example, significant concerns exist for the assimilative capacity of smaller watercourses when utilizing standardized stormwater management practices that may not adequately address cumulative thermal, sediment, chloride and flow regime impacts to aquatic habitat. This study examined a small urbanizing catchment with the goal to understand the magnitude and pattern of response in biological communities to changes in stream hydrology, sedimentation and thermal regime. Patterns in community response were used to generalize threshold levels of response at which streams begin to degrade more rapidly; and better document the specific range of development impacts on the survival habitat of redside dace from the active construction phase through to land stabilization.

C4.2-7
Using meta-population dynamics to quantify extinction risks to the endangered fish the redside dace (*Clinostomus elongatus*)
Mark Poos[1] (presenting), Christine Tu[1], Donald Jackson[2]. [1]University of Toronto, Department of Ecology and Evolutionary Biology, 25 Harbord Street, Toronto, Ontario, Canada, [2] Toronto Region Conservation Authority, Ecology Division, Toronto, Ontario, Canada

Meta-population theory, which describes species movement across fragmented patches, has a long history of describing extinction risks to imperilled species. We apply the meta-population approach to examine two populations of the endangered minnow the redside dace (*Clinostomus elongatus*). The redside dace is found in stream habitats with pool type structures (i.e. low flow and high depth) and is thought to be in decline due to changes in flow regime related to an increasing urbanized landscape. We examine differences in meta-populations using a paired design of a currently urbanized and a non-urbanized stream in the Greater Toronto Area, Ontario, Canada. Sampling was conducted over a one year period with over five hundred redside dace tagged with visual implant elastomer tags (VIE) colour coded for pool location. We used the mark-recapture results (recapture rates > 25%) from over forty connected patches to quantify movement (e.g. immigration/emigration) of this species and to parameterize spatially explicit models. We demonstrate that populations of redside dace showed marked decreases in movement potential in relation to the more urbanized system, with decreased population sizes, lower number of quality patches and lower rates of patch occupancy. We show novel insights into the biology of this species and demonstrate how meta-population analysis can be implemented to quantify extinction risks of imperilled populations.

C4.2-8
From theory to the river: the supportive breeding program of an endangered Catostomid fish, the Copper redhorse (*Moxostoma hubbsi*)
Nathalie Vachon[1] (presenting), Pierre Dumont[1], Jean Leclerc[1], Francis Bouchard[2], Catherine Lippé[3], Louis Bernatchez[3]. [1]Ministère des Ressources naturelles et de la Faune, Longueuil, Québec, Canada, [2]Ministère des Ressources naturelles et de la Faune, Québec, Québec, Canada, [3]Université Laval, Québec, Québec, Canada

The Copper redhorse is an endangered species in Canada. Its distribution is now restricted to a section of the St. Lawrence River and few tributaries in Québec. Among multiple recovery actions, a supportive breeding protocol is applied since 2004 which aims to maximise the species genetic diversity. To maintain a minimal effective population size of 100, a partial factorial breeding design is used. Annually 500,000 larvae and 15,000 fall fingerlings should be stocked over ten years, with the objective of producing 1,000 fish reaching reproductive age. Each year, a maximum of 10 males and 10 females are used and the number of progeny per family is not equalised. Field surveys, 7–10 days following fall stocking, and genetic analysis confirmed that most juveniles captured were artificially produced and give indications of a slight improvement of natural reproduction. Some objectives of the program could not have been annually achieved (production of 100 families and number of fish stocked). In 2006, one family was largely overrepresented which could impact on inbreeding level and genetic diversity. Improving performances of this program is possible by using more spawners and increasing the knowledge pertaining eggs and fry survival (parental characteristics, rearing techniques, stocking stage).

C4.2-9
Tailored conservation scenarios for American eel in the major basins of New York State
Dawn Dittman[1] (presenting), Leonard Machut[1], James Johnson[1]. [1]Tunison Laboratory of Aquatic Science, Cortand NY, United States

American eel (*Anguillla rostrata*) have declined throughout much of its range in eastern North America. Formulation of strategies for effective eel conservation in New York State involved a comprehensive analysis of eel historical range, current presence and abundance reports, and limiting factors. We have applied this analysis to tailor scenarios of the most effective possible management actions for the major watersheds of New York. On the broad scale these strategies involve increasing the access of this catadromous species into historic habitats and increasing the probability of migratory survival to the ocean. We discuss the major basin differences in the eel situation and current best applied management/conservation scenarios for the five major basins, Susquehanna, Delaware, Hudson, Lake Ontario-St. Lawrence and Lake Champlain.

C4.2-10
Declining abundance and recruitment of American Eels at the extremities of the range
John Casselman[1] (presenting), Lucian Marcogliese[2], Rob MacGregor[3], Peter Thompson[4]. [1]Queen's University, Kingston, Ontario, Canada, [2]Ameliasburg, Ontario, Canada, [3]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada, [4]Department of Fisheries and Oceans, Sarnia, Ontario, Canada

American eels have declined dramatically in some regions over the past several decades, best documented in the upper St. Lawrence River-Lake Ontario (USLR-LO), where the species is now classified as endangered. Elsewhere, some believe this might be only a local problem and seek local explanations. If data are short-term or close to the source of recruitment (Sargasso Sea, Gulf Stream), decreases are either less apparent or deemed to be less of a concern. We examine changes in abundance at the extremities of the range for the St. Lawrence River system and its watershed and also for watersheds in the Gulf of Mexico, Caribbean, Florida, Atlantic Seaboard, and other remote regions (e.g. Newfoundland). We document that eel declines are common at various extremities throughout the range; some are as severe as in the USLR-LO system. These are associated with declining recruitment, since extent and dispersal of active immigration are density-dependent. Where recruitment data are long, near the sources of recruitment (U.S. Atlantic Seaboard), and decreases are less apparent, long-term changes in size and time of appearance of recruits indicate significant changes. Recent minor increases in recruitment in some locales can be explained by slight changes in oceanic effects and the North Atlantic Oscillation Index. If recruitment and abundance data are from the extremities of the range and long enough, declines are obvious, widespread, and consistent with overall reduction, emphasizing a need to be extremely concerned about the status of this panmictic species and that resource use is declining and threatened.

C4.2-11
Estimation of age-based biomass of American eel in relation to temporal variation of recruitment in Lake Ontario systems
Xinhua Zhu[1] (presenting), Yingming Zhao[1], Timothy Johnson[2], Alastair Mathers[2]. [1]Ontario Ministry of Natural Resources, Wheatley, Ontario, Canada, [2] Ontario Ministry of Natural Resources, Picton, Ontario, Canada

Lake Ontario system provides important freshwater habitats for American eel growth and maturation. Historically, the system supports important commercial fisheries for over one hundred years. The peak harvest was observed up to 250 metric tons in 1978. Since 1993, a dramatic decline in eel abundance and harvest occurred for all areas above the Moses-Saunders Power Dam, which directly resulted in the closure of commercial fisheries in Lake Ontario system. One of important issues for creating eel recovery plan is to understand eel population dynamics in the system. However, there are few population models to describe temporal changes in eel population biomass and related anthropogenic activities up to now. In this study, we applied maximum likelihood estimation to construct surplus production model of eel population biomass and effective fishing efforts, based on commercial sampling and independent surveys in eastern Lake Ontario during 1959-2005. Combined with the mixtures of statistical distribution, the derived biomass was partitioned into age-specific components to continue catch-age analysis over the time series. It has been found out that fishing effort increased 16-fold, resulting in a 9-fold increase in fishing mortality and an 89% decrease in lake-wide population biomass. Research surveys after 1985 indicated that continuous declines in both carrying capacity and intrinsic growth rate were significantly correlated with fishable eel density and population turnover rate through time.

C4-P-1

Fishes of Canada's National Capital Region

Noel Alfonso[1] (presenting), Brian Coad[1]. [1]Canadian Museum of Nature, Ottawa, ON, Canada

The National Capital Region of Canada (NCR) encompasses an area of 50 km radius centred on the Parliament Buildings in Ottawa. It is an ideal study area for biodiversity studies in widely varying landscapes including urban, protected park and farmed habitats. The fishes comprise 23 families with 84 species including 5 exotics. The collection database at the Canadian Museum of Nature houses 28,758 distributional and ecological records for the NCR. The origins of the native fauna are from three refugia, the Mississippian, the Atlantic and the Beringian. Population growth and development will inevitably constrain the natural diversity of fishes found in the NCR. Many species are at the northern limits of their range in this part of Canada and survival of populations for some species is delicately poised. Invasions of exotics and introductions are also threats. Distribution is often related to topography, with the Ottawa River being a major habitat for larger species, and the sparsely populated and hilly lake region to the north having a fauna substantially different from urban areas and flat farmland to the south.

C4-P-2

Movement and habitat associations of native and introduced catostomids in the Big Sandy River of Wyoming.

Diana Sweet[1] (presenting), Wayne Hubert[1]. [1]University of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, WY, United States

Bluehead sucker and flannelmouth sucker populations are declining throughout their native ranges in the Colorado River Basin. Reasons for declines include fragmentation of populations, loss of habitat, and hybridization with introduced white suckers and longnose suckers. The Big Sandy River in the Green River watershed of Wyoming contains populations of bluehead suckers and flannelmouth suckers and may become the focus of restoration efforts within the state. Research is underway on the ecology and population dynamics of both the native and introduced species in these two systems. This paper reports on one phase of the research, the movement patterns and habitat associations of native and introduced catostomid populations in the Big Sandy River. Using shore electrofishing gear, 22 bluehead suckers, 22 flannelmouth suckers, 21 white suckers, and 20 longnose suckers were captured from the Big Sandy River and surgically implanted with radio transmitters. These fish were tracked from September of 2006 through the winter and spawning seasons to determine resource use, important spawning locations, and movement patterns.

C4-P-3

A demographic based strategy for prioritizing juvenile salmon habitat restoration across a stream network

Michael Colvin[1] (presenting), Joe Ebersole[2], Jim Wigington[2]. [1]Iowa State University, Ames, IA, United States, [2]USEPA, Corvallis, OR, United States

Conservation of coho salmon populations has focused on restoring freshwater habitat to increase smolt production. Identifying where smolt production is sensitive to changes in juvenile coho demography across a stream network can help prioritize restoration efforts. Using observed data for a coastal Oregon stream, habitat unit dimensions were used to simulate a spatially explicit stream network. The stream network was seeded with parr using summer densities. Overwinter survivals were used to calculate stream network smolt production. We used stochastic simulation to evaluate smolt production sensitivity to increased summer parr densities and increased overwinter survival in mainstem and perennial tributary habitats. Increases in parr density and overwinter survival in mainstem habitats substantially influenced smolt production. Smolt production was most sensitive to changes in overwinter survival across the stream network. Overall results indicate that targeted restoration of mainstem stream habitats focusing on increasing overwinter survival are likely to confer increased smolt production at the stream network scale. While changes in parr density and overwinter survival in perennial and intermittent tributaries did not result in large changes in smolt production, these portions of the stream network provide valuable reserve habitat requiring continued protection.

C4-P-4

Conservation of American eel in tributaries of the Upper Delaware River

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American eels (*Anguilla rostrata*) in the Delaware River Basin may be an important contributor to the panmictic population of American eel; however, little data currently exists on the status and abundance of eel in the basin. In 2006, The Nature Conservancy and U.S. Geological Survey began a four year study of fish assemblages in tributaries to the Upper Delaware River (Neversink and Beaverkill Rivers, NY, and Big Flatbrook River, NJ) to measure abundance and biomass of American eel and their role in stream fish communities. At each study site, resident fish were collected at three near-bank seine-blocked sub-reaches using three successive passes with a backpack electrofisher. All fish were identified to species; lengths and weights recorded and returned to the study reach alive. Quantitative estimates of density and biomass for each species and the total community were calculated using proportional-reduction methods. American eel densities ranged up to 2120 fish/h, biomass ranged up to 175,770 g/h, and they constituted as much as 80% of the total fish-community biomass at sites throughout the three rivers. Efforts are being explored to relate the health and abundance of the basin's local eel communities to that of the overall American eel population.

C4-P-5

Detection of chemical alarm cues and learning capability in an endangered lake sucker

Stephanie Kraft[1] (presenting). [1]Utah State University, Logan, UT, United States

The June Sucker (*Chasmistes liorus*) is a lake sucker, endemic to Utah Lake, UT and federally listed as an endangered species. Historically the primary predator in Utah Lake was the Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*). Several nonnative piscivorous sport fish have since been introduced. A large scale stocking program has been instituted by The June Sucker Recovery Program, as directed by the USFWS 1999 recovery plan, with the goal of enhancing June Sucker numbers to levels where natural reproduction can sustain a viable population. This program has met with limited success, possibly due to high levels of predation on newly stocked fish. Fish in the super-order Ostariophysi, which contains the June Sucker (family Catostomidae), possess the ability to produce and detect chemical alarm cues, yet there has been little work confirming this in the family Catostomidae. I measured the behavioral response of hatchery raised June Sucker exposed to three combinations of conspecific alarm cue and predator odor. My data show that predator-naive June Sucker do not innately recognize predator odor, but they are able to detect and learn from conspecific alarm cues. These results suggest training fish prior to stocking may lead to improved survival.

C4-P-8

Artificial propagation of Danube salmon in Ukraine

Antonina Mruk[1] (presenting), Vasyl Ustych[1], Anna Zakharenko[1]. [1]Institute of Fisheries, Kiev, Ukraine

The problem is a sharp decline of population size of Danube salmon (*Hucho hucho* [L.1758]) in the Transcarpathian region of Ukraine, which began in 1960-ies. Currently, populations of Danube salmon in Ukraine are on the edge of extinction and is listed as an endangered species in the Red Data Book of Ukraine and Europe. A regional program aimed at conservation and rehabilitation of this species in its natural habitats has been started in 2005. There were evaluated current state and distribution of Danube salmon in Transcarpathian rivers as well as conducted complex study of its population and habitats. Experience of Danube countries demonstrated a possibility for artificial propagation of Danube salmon for its conservation. Solution of the problem can be formation of replacement and brood stocks. For the first time in 2006, there were taken sexual products from 4-year old brood fish caught in natural habitats, which were fertilized and incubated in Transcarpathian Aquaculture Laboratory. Hatched fry were grown in basins with the use of artificial and natural feeds. There was determined a possibility of Danube salmon growing in basins and it was found that young fish were quite sensible to fluctuations of water temperature. So, its elevation up to 25°C caused an increased mortality, which reached 70%.

C4-P-9

Ecological characteristics of Maryland's stream fishes and connections with abiotic variables for imperiled species management

Patrick Ciccotto[1] (presenting), Scott Stranko[1], Ronald Klauda[1]. [1]Maryland Department of Natural Resources, Annapolis, MD, United States

Effective fish conservation efforts typically rely on knowing the ecology of the focal species. The purpose of this study was to develop a detailed understanding of the importance of inherent qualities and external environmental factors in the distribution and status of Maryland's freshwater fishes. Species were assigned classifications according to 12 inherent ecological attributes and compared using univariate and multivariate analyses. The potential influence of external environmental variables on species presence was investigated using multivariate and logistic regression analyses on 23 abiotic variables. Limited natural geographic distributions were found to be the intrinsic ecological attribute most strongly associated with imperiled species. Certain abiotic variables were found to be related with individual species presence. Individual analyses were difficult for many rare species due to the limited number of occurrences however. Based on the limited distributions of these species, the most stringent protection efforts are currently recommended until sufficient information from within Maryland or adjacent states can be acquired.

C4-P-10

Application of forensic techniques to fish conservation and management: injury detection using presumptive tests for blood

Alison Colotelo[1] (presenting), Steven Cooke[1], Karen Smokorowski[2], Tim Haxton[3]. [1]Carleton University, Ottawa, Ontario, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Sault Ste. Marie, Ontario, Canada, [3]Ontario Ministry of Natural Resources, Kemptville, Ontario, Canada

The detection of injury on the skin of fish has generally been limited to gross macroscopic examination. This method has numerous limitations including subjectivity and a lack of quantitative analytical capacity. The uses of chemical enhancers can aide the detection and quantification of skin injuries in fish which can arise from fish interactions with humans and human infrastructure (eg. fishing, research, fishways, turbines). Presumptive tests for blood are commonly used in crime scene processing to characterize unknown stains as blood and detect blood patterns not visible to the naked eye. Many presumptive tests for blood exhibit a positive reaction through a catalytic colour change while others exhibit chemiluminescence and fluorescence characteristics. These positive reactions occur in the presence of an oxidizing agent (usually hydrogen peroxide) and are catalyzed by the haemoglobin present in the blood. This study examined several presumptive tests for blood and evaluated their usefulness for detecting injury. The evaluation was based on sensitivity, specificity, cost and ease of use. Several tests yield rapid results and do not require large pieces of equipment which makes them ideal for field use. Based on this synthesis and the direct evaluation of several tests for freshwater fish, we have revealed that these tools can be used to quantify the injury caused by a variety of handling processes and capture methods. The results of this study will be useful in a variety of fisheries research and management contexts.

C4-P-11

Management of anthropogenically derived hybrid populations: explicit recognition of assumptions

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Hybridization and introgression between native and introduced species is one of the most challenging issues currently facing fisheries managers. While recognizing we are simplifying arguments, we suggest two hybrid management paradigms have emerged. The first posits that as long as introgression is at moderate to low level, and the resulting hybrids are morphologically and ecologically similar to the native taxon, they should be considered a member of the parental species. The alternative view suggests that conservation efforts should be focused on native genomes that have evolved in response to localized selective pressures and hybridized populations are a conservation threat. We suggest that both management approaches are based on a few key assumptions about the nature and ultimate outcome of hybrid fitness and ecology. Although these assumptions are implicit in the arguments presented by both sides of the argument, neither camp has explicitly recognized the assumptions nor discussed the management implications of violations of those assumptions. In our poster, we present a framework that explicitly addresses various assumptions surrounding hybridization and the ecological outcomes each assumption would predict. We further suggest hybridization management actions should have clearly defined goals and be explicit about their assumptions.

C4-P-12

Protecting Species at Risk fishes through a community based management plan

Kari Killins[1] (presenting), Mari Veliz[1]. [1]Ausable Bayfield Conservation Authority, Exeter Ontario, Canada

The Old Ausable Channel (OAC) is an isolated portion of the Ausable River and is one of the most significant aquatic habitats in southwestern Ontario. A portion of the Ausable River was diverted from its original channel at the end of the 19th century. No longer part of a flowing river, the OAC is now a warm water, pond–like ecosystem that is fed by surface runoff, precipitation and ground water inputs. The channel supports a diverse warm water fish community, including three species at risk; the pugnose shiner, the lake chubsucker and the grass pickerel. The OAC provides critical habitat that is typically scarce and fragmented throughout the Canadian range of these fishes. Natural succession is occurring within the OAC. This has long-term implications for the species at risk fishes. Succession was one of the issues addressed in the development of a long term management plan for the OAC. A steering committee comprised of representatives from local agencies, universities and six local residential communities guided the two year planning process. The management plan has recommended 1) a study to identify the rate of succession and potential implications for fish species at risk; 2) enhancement of local wetland features; and 3) public education to protect existing habitat. The knowledge that local residents bring to resource management is critical to successful planning. Long-term implementation of projects recommended in the plan are more achievable through the commitment of local people. This poster will discuss the protection of the species at risk fishes as a result of a community based management plan for this unique ecosystem.

C5. Statistics and Modeling

C5.1-1

The advantage of explicitly incorporating predation mortality into age-structured stock assessment models: an application to Northwest Atlantic mackerel

Hassan Moustahfid[1] (presenting), William J. Overholtz[1], Jason S. Link[1], Megan C. Tyrrell[1]. [1]Northeast Fisheries Science Center, Woods Hole, United States

An Age-structured Assessment Program (ASAP) that explicitly incorporated predation mortality was applied to the Northwest Atlantic mackerel stock. Predator consumptive removals were explicitly modeled in the same way as fishing mortality, with a comparable set of time series, to produce estimates of predation mortality at age and year. Results from this analysis showed that incorporating predation into a mackerel stock assessment model notably altered model outputs. When excluding explicitly modeled predation rates, the model underestimated the magnitude and uncertainty in spawning stock biomass and recruitment. Further, predation mortality rates varied across time and were higher for younger fish. Predation mortality was higher than fishing mortality for younger fish, approximately equal for two year old fish, and lower for older fish (three years and older). Biological reference points for Atlantic mackerel differed considerably when predation mortality was included, particularly with higher estimates of BMSY with predation. Although there are several caveats to our model outputs, chief of which is the conservative estimates by exclusion of other mackerel predators, our results demonstrated the feasibility of executing such an approach with an extant tool. The approach presented here ultimately has the advantage of detecting and parsing out the impact of predators on prey relative to fisheries thereon, useful information for managers of small pelagic fisheries.

C5.1-3
Using linear models to validate recruitment indices
Justine Woodward[1] (presenting), Robert Latour[1], Mary Fabrizio[1], Christopher Bonzek[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

Assessing the relationship between estimates of relative abundance of fishes at different life stages remains one of the principal challenges faced by fisheries scientists. The paucity of concurrent monitoring programs designed to independently target juveniles and adults of the same species has been the key limiting factor. In Chesapeake Bay, however, multiple independent surveys are currently in progress to monitor the relative abundance of several life stages of fishes. In this study, linear regression analysis is used to examine the relationship between estimates of relative abundance for juveniles and adults of several estuarine dependent species, including striped bass (*Morone saxatilis*), Atlantic croaker (*Micropogonias undulatus*), and weakfish (*Cynoscion regalis*). Where necessary, the information used to derive recruitment indices was modified to increase the accuracy of the recruitment indices and to improve the linear relationship between estimates of juvenile and adult abundance. The results indicate that patterns in recruitment to the juvenile stage are reflected in subsequent age classes; however, species-specific information should be scrutinized when developing indices of relative abundance from research surveys. Additionally, these findings emphasize the importance of spatial and temporal dynamics of juvenile fishes with respect to assessing recruitment to the juvenile stage.

C5.1-4
Comparing a multi-species to species-specific assessments of hammerhead sharks (*Sphyrna* spp.) using production models
Christopher Hayes[1] (presenting), Yan Jiao[1], Enric Cortes[2]. [1]Virginia Tech, Blacksburg, VA, United States, [2]National Marine Fisheries Service, Panama City, FL, United States

A number of fish species have been assessed as a complex because of insufficient data available to conduct species-specific analyses. However, few studies have addressed the advantages and shortcomings of assessing the status of species as part of complexes or individually. Following the approach proposed by the Southeast Data, Assessment and Review (SEDAR) process for large coastal sharks (NMFS, 2006), this study assessed the status of the hammerhead shark complex (*Sphyrna* spp.) and compared it to those from individual assessments of scalloped hammerhead (S. *lewini*), great hammerhead (S. *mokarran*), and smooth hammerhead (S. *zygaena*) sharks in the western North Atlantic Ocean and Gulf of Mexico. The hammerhead shark complex was overfished, i.e. below the population size associated with maximum sustainable yield (MSY). Overfishing, or the exploitation above the level associated with MSY, occurred in 2005. The complex has a high probability of recovery within two to three decades, but the relatively faster-growing scalloped hammerhead shark probably would account for the majority of the recovery and could mask the continued decline of the slower-growing species in the complex, the smooth and great hammerhead sharks. This study thus provided a unique empirical example of comparing a complex-based assessment with species-specific assessments, illustrating the problems inherent in multi-species assessments and the need for conducting single-species assessments when feasible.

C5.1-5
From physics to fish to fishers: can the biology and people keep up with the computers?
Kenneth Rose[1] (presenting), Enrique Curchitser[2], Shin-ichi Ito[3], Salvador Lluch-Cota[4], Takashi Setou[5]. [1]Louisiana State University, Baton Rouge, LA, United States, [2]Rutgers University, New Brunswick, NJ, United States, [3]Tohoku National Fisheries Research Institute, Shiogama-city, Miyagi, Japan, [4]CIBNOR, La Paz, BCS, Mexico, [5]National Research Institute of Fisheries Science, Yokohama, Kanagawa, Japan

Until recently, water quality and NPZ (with physics) models and fish population models were developed separately. Zooplankton was included in the water quality and NPZ models mostly to provide a closure term for mortality of phytoplankton. Fish population and stock assessment models either ignored or made unrealistic assumptions about the physics and the availability of zooplankton as prey. This schism was because oceanography and fisheries used to be considered two separate disciplines, with advances in each seeming to leap-frog the other. In addition, computing power limited our ability to simply couple of all of the models into a single simulation. Recently, advances in physics and biology have created the needed pieces for physics-to-fish modeling. The demand is being fuelled by interest in forecasting climate effects on fish, and a perceived crisis in fisheries management attributed partly to its reliance on the population approach. We can overcome the computing issues; the serious challenges now relate to properly re(presenting) the biology and physics that permit their integration. We will describe an ongoing effort that involves imbedding an individual-based four-species fish model into a 3-D physics and NPZ model based on the Regional Ocean Modeling System (ROMS) and the lower trophic-level model NEMURO. One of the fish species is a predator on the other fish species, and another fish species is configured to mimic the fishing fleet and dynamic harvest. We will use the example to illustrate issues, such as how to couple the physics and fish models, the challenges of making multi-year simulations, and the melding of physics and behavior into fish movement. We conclude with an optimistic view of how close we seem to be to forging physics-to-fish-to-fishers models.

C5.1-6
Analysis of longline catch data from bycatch mitigation studies: a comparative study
Marti McCracken[1] (presenting). [1]Pacific Islands Fisheries Science Center, NMFS, Honolulu, HI, United States

A large number of research studies testing bycatch mitigation measures in the pelagic longline industry are being conducted worldwide. The aim of these studies is to find a mitigation measure that will reduce bycatch while maintaining or increasing the value of the commercial catch. As mitigation experiments typically have relatively small sample sizes and generate counts that are often hierarchal (trips being composed of multiple sets) and exhibit a large frequency of zeros with an occasional large outlier, it is not clear how to analyze them as the assumptions of parametric methods are in question. This presentation will present the results of a simulation study that compares methods of analyzing longline catch arising from mitigation studies. To capture the complexity of longline catch data, the simulation study is based on longline observer data. The performance of linear models, generalized linear models and extensions of these models (mixed models, zero-inflated models) will be presented in terms of their ability to achieve the nominal significance rate and estimate the efficiency of the mitigation measure.

C5.1-7
Can data collected during at-sea observer surveys be used to make general inferences about fishery discards?
Hugues Benoît[1] (presenting), Jacques Allard[2]. [1]Fisheries and Oceans Canada, Moncton, NB, Canada, [2]Université de Moncton, Moncton, NB, Canada

Proper estimation of the quantity and nature of organisms discarded at sea during commercial fishing operations requires direct observation. At-sea observer surveys are the most prominent method of direct observation currently employed world-wide. In many fisheries, observers cover only a small portion of all fishing trips. Total discards at the fishery level are therefore inferred from data collected on observed trips. Such inference is predicated on the assumption that observed activities are statistically exchangeable with unobserved activities. If the assumption of exchangeability is violated, any inference made will be biased to some degree. This may occur for two principal reasons: a 'deployment effect' resulting from non-random distribution of observers among sampling units (vessels or trips) and an 'observer effect' resulting from a change in fishing behaviour of fishers when observers are present. We tested and found evidence for both types of effects in the data collected by observers in a number of Gulf of St. Lawrence fisheries. We then undertook additional analyses to estimate the magnitude of biases resulting from these effects. For example, in the case of 'deployment effects' we used simulations of observer data from fisheries that had complete coverage. Finally we present recommendations for calculating estimates of discards (with estimation error) that best reflect known biases and sources of uncertainty.

C5.1-8
Estimating mortality rates from changes in mean lengths and catch rates in non equilibrium conditions
Todd Gedamke[1] (presenting), Clay E. Porch[1], John M Hoenig[2]. [1]NMFS, Miami, FL, United States, [2]Virginia Institute of Marine Scienc, Gloucester Point, VA, United States

In a recent study, a transitional form of the Beverton and Holt mean length mortality estimator was derived for application in non equilibrium conditions. We extend this approach one step farther by incorporating information from a time-series of catch indices into the mean length estimator to both better detect changes in mortality, and to estimate total mortality rates. Theoretically this proved interesting as only relative changes in mortality rates can be estimated from using catch rate data alone. We show how this information can be used in conjunction with the mean length approach to better detect and estimate changes in mortality rates. The motivation to pursue this research stemmed from the SEDAR 14 Caribbean mutton snapper assessment where the high variability of available mean length data resulted in considerable uncertainty in total mortality estimates. In this assessment, and utilizing only changes in mutton snapper mean lengths, a single significant increase in mortality was detected to have occurred in the early 1990's. When changes in catch rates were integrated into the analysis another change in mortality was detected and indicated a significant recent reduction in mortality had occurred by the early 2000's.

C5.1-9
Model selection uncertainty: a comparison among age-structured models in assessing walleye (*Sander vitreus*) fishery in Lake Erie
Yan Jiao[1] (presenting), Kevin Reid[2]. [1]Virginia Tech University, Blacksburg, VA, United States, [2]Ontario Commercial Fisheries Association, Ontario, Canada

Model uncertainty can be high if one specific model is selected without comparison to other possible models. That approach proceeds as if the model had generated the data, ignores the uncertainty in model selection, and leads to over-confident inferences and decisions with higher risk than expected. In this paper, we compared several statistical-catch-at-age models to assess the population dynamics of the Lake Erie walleye (*Sander vitreus*) fishery, and to estimate the vital parameters for population dynamics and fishery management. Models that we used included: a state-space statistical catch-at-age model (SCAG) with constant natural mortality, a SCAG with unknown natural mortality but a prior distribution from a tagging study, a SCAG with time-variated natural mortality following a random walk process, a SCAG with a time-variated catchability coefficient following a random walk process, and a SCAG with both natural mortality and catchability following random walk processes. A Bayesian approach was used to estimate parameters, and goodness-of-fit of the models was compared using the Deviance Information Criterion (DIC). Performance of the models was compared by goodness-of-fit and by the retrospective patterns of the models. A multi-model inference approach, using a Bayesian model-averaging algorithm, is suggested when more than one model is plausible for a fishery. We recommend that uncertainty in model selection be taken into consideration in fisheries stock assessment.

C5.1-10
Development of a user-friendly stock assessment model for the American lobster
Yuying Zhang[1] (presenting), Yong Chen[1], Carl Wilson[2], Minoru Kanaiwa[3]. [1]School of Marine Science, University of Maine, Orono, ME, United States, [2]Maine Department of Marine Resources, West Boothbay Harbor, ME, United States, [3]Tokyo University of Agriculture, Aquatic Resource Lab, Hokkaido, Japan

The American lobster (*Homarus americanus*) supports one of the most valuable commercial fisheries in the United States. A Bayesian size-structured stock assessment model has recently been developed. The model is sex-specific and uses season as time step. It can generate estimates of various key fisheries parameters such as legal biomass, fishing mortality, and recruitment and their associated uncertainty, and can also project the dynamics of the lobster population under different levels of catch or fishing mortality. The model has been tested extensively and adopted by the Atlantic States Marine Fisheries Commission for the assessment of American lobster in the north-eastern United States. As a model of high complexity, this new model requires a large amount of input data and generates a large quantity of outputs, which becomes an obstacle for the model being used by biologists and managers. In an attempt to overcome this problem, we design and develop a user-friendly version of the model and test its performance. We apply the user-friendly model to assess the lobster stock in the Gulf of Maine. This new software provides a new tool to lobster biologists and managers in their assessment of lobster population dynamic.

C5.2-1
Learning from losers: investigating the sources and severity of mortality in freshwater fish during their early life stages
Nicole McCasker[1] (presenting), Paul Humphries[1], Shaun Meredith[2], Nick Klomp[1]. [1]Charles Sturt University, Albury, NSW, Australia, [2]Murray Darling Freshwater Research Centre, Wodonga, VIC, Australia

Understanding the early recruitment dynamics of fish populations and the underlying causal mechanisms which determine year class strength is critical to successful conservation and management of wild fisheries. Although recruitment strength is thought to be determined during the first few weeks of life when mortality is greatest, few studies have documented the stage-specific mortality rates associated with development during the early larval and juvenile phases, or their effect on the longer-term ‘success’ of cohorts in wild fish populations. The main objective of this study was to investigate the sources and severity of mortality on individual cohorts of freshwater fish as they developed from yolksac larvae through to juveniles in a slow flowing temperate Australian lowland river. Fish larvae were sampled intensively (every second day for a period of 4 months) during the 2005/06 summer. Survivorship curves based on back-calculated aging techniques were produced for 18 cohorts of two species of small bodied facultative zooplanktivores (Hypseleotris spp. and Craterocephalus sp.) that occurred throughout the study period. These curves revealed that mortality was not constant across fish age or developmental stage, as many models assume. Indeed, there was strong evidence for the existence of a critical period for one species. Further, cohorts appearing at different times throughout the study period were exposed to varying conditions (e.g. temperature, food availability, conspecific densities, predator densities), and the differential effects of these conditions on cohort survivorship is discussed.

C5.2-2
Estimating bioenergetics parameters using capture-recapture data from an unfished population
Brett van Poorten[1] (presenting), Carl Walters[1]. [1]Fisheries Centre, University of British Columbia, Vancouver, British Columbia, Canada

Bioenergetics modelling is a proven technique for understanding environmental or anthropogenic impacts on individual metabolic processes. The modelling process involves collecting laboratory-based functions and parameters that link metabolic processes to environmental variations such as temperature. A criticism of this approach is that functions and parameters needed for these models are difficult and time-consuming to derive, and so estimates from other studies on the same or taxonomically similar species are often used. Furthermore, most bioenergetics models do not account for uncertainty in parameters leading to overly optimistic statements being made about anticipated impacts on fish physiology. We present a field-based alternative which requires no a priori

data requirements and provides estimates for all parameters, with probability distributions. We use a reparameterization of the Fabens growth model which can be fit to observed lengths of individuals at marking and recapture. The model performs well when fit to data from an unfished population and shows estimated growth similar to that predicted from a more traditional model using laboratory-based estimates. Our model results are derived entirely from the population in question, in field conditions and displays uncertainty in parameters that would not otherwise be known.

C5.2-3

Time-trend models and tag-based survival estimates: a cautionary tale

Stuart Welsh[1] (presenting), John Hoenig[2]. [1]U.S. Geological Survey, Morgantown, WV, United States, [2]Virginia Institute of Marine Science, Gloucester Point, VA, United States

Given a time series of tag-recapture data and an interest in annual survival rates (S), one can fit models that parameterize survival as constant, time-specific, or period-specific. Additionally, recent advances in methodology and software allow fitting of models with annual environmental covariates, and researchers have recently described a covariate approach with dummy variables that can fit linear monotonic time trends (time-trend models). Time-trend models are[1] reasonable given a hypothesized increase or decrease in S across a time series,[2] simple, i.e. involve a low number of estimable parameters and do not require complex datasets, and[3] potentially dangerous (as demonstrated from our analysis). Time-trend models are a part of the candidate set of models used in tag-based analyses of survival rates of Atlantic striped bass, and this paper will demonstrate examples of time-trend model underestimation of terminal year S from Atlantic striped bass stocks. Further, based on analyses of simulated data, we demonstrate that time-trend models underestimate S when the true model (i.e. generating model) represents a non-monotonic decrease in S. Clearly, underestimation of terminal-year S is critical, given management emphasis on terminal year estimates. If linear time-trend models are retained, then future analyses of striped bass tagging data should preferably include a non-monotonic trend model in the candidate set, or at least apply non-monotonic trend models as exploratory diagnostic measures. Also, simulation results indicated the importance of sample size to model selection, and further work is needed to address relationships among sample size, model selection, and model complexity.

C5.2-4

Identifying critical habitat across multiple scales for estuarine-dependent fishes with a landscape modelling approach

Richard Fulford[1] (presenting), Mark Peterson[1], Paul Grammer[1]. [1]Univeristy of Southern Mississippi, Ocean Springs, MS, United States

Identifying and protecting important habitat for estuarine-dependent fishes is crucial for minimizing negative effects of human development on fish production. Habitat quality can be defined at several spatial and temporal scales that must be accounted for in defining what habitat is critical to maintaining fish production targets. Landscape modelling approaches allow for the development of a habitat mosaic that includes habitat change over a broad range of scales and can be integrated with fish physiology and movement to understand how annual and multi-annual production may be influenced by habitat change. We developed a general landscape model in one coastal estuary which accounts for both spatial variation in static habitat based on landscape mapping and temporal variation in ephemeral habitat characteristics based on real-time, high resolution field data. This habitat mosaic was overlaid with a production model to generate an index of juvenile fish abundance that accounts for both physiological limits on growth, density-dependence and behaviour to predict where and how fish production is maximized. Results from this demonstration analysis suggest a landscape approach can be useful for understanding the linkage between static habitat loss, inter-annual variability in physical characteristics of the aquatic environment and longer term changes in fish population production.

C5.2-5

Stock assessment of chambo (*Oreochromis* sp.) in the southeast arm of Lake Malawi

Richard Bell[1] (presenting), Jeremy Collie[1]. [1]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, United States

We assessed the status of the chambo (*Oreochromis* sp.) stock in the southeast arm of Lake Malawi, the third largest lake in Africa. Chambo, one of the most economically important fish in the poor country of Malawi, has shown a sharp decline in catch over the last twenty-years. We used a delta-generalized linear model to standardize a time series of catch and effort data (1976 – 2004) from a wide array of vessel types, which contained a high proportion of zeros. The delta- model is the product of two separate generalized linear models. The first component, the binomial model, determines the probability of a given haul resulting in a non-zero catch-per-unit-effort (CPUE). The second component fits the non-zero CPUE with a gamma generalized linear model. The multiple factors affecting the CPUE (vessel size, gear type, fishing area) are removed resulting in a relative index of abundance. A non-equilibrium Graham Schaefer surplus production model was fit to the index of abundance to estimate the total biomass in the southeast arm of the lake. The "one way trip" exhibited by the data resulted in a range of parameter values which fit the model well. The stock reached its peak in the 1982 (13,000 tonnes) and dropped quickly thereafter due to high harvest rates through the mid 1980s. There was a slight reprieve in the late 1980s when the population stabilized at roughly 6000 tonnes. The harvest rate increased in the early 1990s and the stock declined to its current level around 2000 tonnes. The decline of chambo appears to be the

result of both increasing fishing effort due to the build up of the mechanized fleet and a change in the environment resulting in declining lake levels, decreasing the amount of nearshore spawning and nursery habitat. The stock assessment will form the baseline of chambo biomass from which to measure change and determine the effectiveness of different restoration activities.

C5.2-6
A simulation study to evaluate uncertainties of the simple yield analysis for the Taitung lobster fishery
Yi-Jay Chang[1] (presenting), Chi-Lu Sun[1], Yong Chen[2], Su-Zan Yeh[1]. [1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan,School of Marine Science, [2]University of Maine, Orono, Maine, United States

The life history and fishery process of the spiny lobster (*Panulirus penicillatus*) are complex and subject to large variations, resulting in large uncertainties in its stock assessment. Using a Monte Carlo simulation approach, uncertainty associated with yield per recruit analysis was evaluated for the Taitung lobster fishery in Taiwan. Two distributions (uniform and lognormal distributions) were considered in the simulation to examine the impacts of uncertainty associated with key life history and fishery parameters. The change of yield per recruit (PCY) value and percentage of positive PCY were evaluated under different combinations of exploitation ratio (E) and relative recruit levels (C). The management implications of such differences are discussed. Improving our knowledge on exploitation ratio (E) can result in more precise estimates and an increase in yield under a given regulation, but results may be sensitive to the level of certainty in the ration of natural mortality and growth parameters (i.e, M/K).

C5.2-7
Assessing impingement and entrainment impacts using population dynamic models with limited data
Matthew Bingham[1] (presenting), Jason Kinnell[1], Grant Crownfield[1]. [1]Veritas Economic Consulting, Cary, NC, United States

Age-structured population models are the best-recognized quantitative framework for the representation and evaluation of populations. Leslie (1945) developed the representation of a linear discrete population model as a matrix equation, now commonly referred to as the Leslie matrix population model. This model is frequently used in fisheries management and has long been an important component of professional-judgment, 316(b) assessments under 1977 draft guidance. Despite their appeal, the advantages of these models are somewhat offset by significant data requirements. For example, life history and population information for impinged and entrained species is often scarce. In situations where there is limited information about species life history, transfers using life history parameters, such as survival and fecundity, of similar species are sometimes employed. Because these approaches rely on dynamic simulation, specification errors can compound. This can lead to dramatic errors when minor differences between species are extrapolated through time. This paper presents an overview of a modeling approach designed to overcome these challenges and addresses potential problems with compounding errors using adjustments based on mathematical simulation techniques. A distinct advantage of this approach is that adjusted and transferred parameters can be combined with species specific information in a manner that has specific implications for observable population-level outcomes. This allows calibration based on bounds selected through empirical or even anecdotal information. This approach also supports the identification of cost-effective data sources to improve model accuracy. In addition to (presenting) a detailed description of the model, the paper also presents an empirical application for evaluating IM&E impacts at a Coastal California power plant.

C5.2-8
Methodology for Estimating Entrainment under Alternative Cooling Water Intake Screen Configurations
Alan W. Wells[1], John A.D. Burnett[1] (presenting), Thomas L. Englert[1]. [1]HDR, Pearl River, NY, United States

Section 316(b) of the Clean Water Act requires the evaluation of alternative cooling water intake designs to reduce losses of aquatic life, especially fishes, due to entrainment and impingement at power plants. This often includes estimation of entrainment and impingement under a number of alternative intake screen designs. We provide methodologies for estimating species- and life stage-specific reductions in egg and larval entrainment under variable intake screen mesh sizes. Reductions in entrainment of eggs are estimated from measured egg diameters and the standard normal cumulative distribution function, while reductions in larval and juvenile entrainment are estimated based on the reconfiguration of an existing equation incorporating morphometric attributes of each species and screen mesh opening. The methodology can be configured to estimate species- and life stage-specific entrainment under a given screen mesh size or determine the screen mesh size required to meet a particular regulatory performance standard.

C5.2-9
Considerations regarding production foregone as a tool for evaluating losses of organisms at power plants
Thomas Englert[1] (presenting), Alan Wells[1], John Burnett[1], Robert Norris[1]. [1]HDR, Pearl River, New York, United States

Production foregone has been applied nationwide in demonstrations developed as part of the requirements for compliance with Section 316(b) of the Clean Water Act. These studies have focused on estimation of the biomass that would have been produced by the eggs, larvae and young fish lost due to entrainment and impingement at power stations. In many cases, this lost production has then been converted via trophic-transfer rates and predator-prey relationships into an equivalent loss of biomass of fish that are important in commercial and recreational fisheries. The established methodology for calculating production foregone is to apply an equation developed by Rago (1984). However, in several prominent cases the equation has been incorrectly implemented, the result being substantial overestimation of production foregone. This error alone has caused large estimates of production foregone resulting from eggs, when in fact, post-spawn eggs do not increase in weight and thus production foregone during the egg stage should be zero. The misapplication of the equation has been compounded with overestimates of the weights of early life stages such as eggs and larvae. We show how the equations should be applied and provide methodologies for estimation of the weights and other parameters used in the calculation.

C5.2-10

Bias studies to test assumptions in NOAA's recreational fisheries surveys

Linda Barker[1] (presenting). [1]Md. Dept. of Natural Resources, Annapolis, Maryland, United States

The ability to characterize recreational catch is a key element of stock assessment and management efforts. Currently, the angler catch and effort information provided by NOAA through the National Marine Fisheries Service (Marine Recreational Fisheries Surveys) are the sole source of this information for many states. The National Research Council conducted an independent scientific review of this program, and identified more than 200 possible improvements. In January 2008, NOAA Fisheries provided $2.5 million in new funding to support 16 projects to improve various aspects of the program. Six of these projects are being conducted by the Design and Analysis Workgroup – a group of 17 biologists and statisticians from NOAA, the States, and recreational and industry groups as well as 3 consultants. This group of projects is intended to evaluate bias in results from the surveys as they are currently conducted and analyzed and make suggestions for re-design. One project is analyzing mis-match between current estimation procedures, sample design and implementation, and documenting the impact on catch and effort estimates. A second project is conducting an independent review of existing survey programs that use state license databases for telephone effort surveys, in order to evaluate bias due to unlicensed effort. A third project is examining the extent of bias due to unrecorded discarded fish, and will evaluate the use of other methodologies to collect more reliable information on released catch. Methodologies for these projects include pilot studies and data mining exercises, utilizing NMFS survey data and data from independent state surveys from North Carolina to Hawaii. The final 3 projects will test current assumptions about catch rates through pilot studies to determine if catch rates of anglers interviewed under the current survey design are different from catch rates of anglers that fish from private access sites, anglers who fish at night, and anglers who use professional guides. Results-to-date of the bias analyses will be presented.

C5.2-11

Commercial mark-recapture: new methodology for studying large valuable fish

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Fishery-dependent surveys are the main source of biological information for large valuable fish. However, even market sampling surveys can be made difficult by size grading practices, the need to minimize market-place interference and to preserve specimen's appearance, and by budget constraints in fish acquisition. These situations frequently lead to the adoption of suboptimal sampling designs penalizing accuracy and precision of the final life-history estimates. We developed a new sampling methodology – "commercial mark-recapture" (CMR) - that circumvents these difficulties and allows the collection of significant numbers of biological samples with minimal cost and sampling site disturbance, and quantifiable spatial, temporal, size and gear discrimination. CMR is based on tagging of landed individuals followed by recapture of their tags (and corresponding samples) within the commercial circuit. We present a first case-study of CMR application in the study of Argyrosomus regius, a large valuable sciaenid whose life-history studies were to present seriously constrained. CMR resulted in 75% recapture rate (279 fish, corresponding to over 4 tonnes and $60000 market-value) and negligible costs, rendering biological sampling of A. regius economically feasible. Finally, we present the CMR statistical model and discuss CMR utility in obtaining unbiased samples from fisheries landings of other worldwide fish resources.

C5.2-12

Designing marine reserve networks for species that move within a home range and the effects on persistence and yield

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Models of marine reserves are used to identify general principles regarding population persistence and fishery yield or to compare proposed designs for implementation. Many marine species move within a home range, and will not be well represented by previous models that describe adults as sedentary or diffusive movers. We incorporated home range into a spatially explicit marine reserve model to determine the effects on persistence and yield and to determine how results of home ranging species differ from sedentary species. Our results show that larval dispersal distance and adult home range size interact to determine the efficacy of marine reserves. Movement within a home range can lead to population collapse even when sedentary species with any length larval dispersal are persistent in a network of reserves. Spillover of adults into fished areas increased yield-per-recruit, but decreased total larval supply, reflecting a "trade-off" between persistence and yield. Movement within a home range can change persistence results significantly from those of sedentary adults and is important to consider in reserve design.

C5.2-13

Environmental modeling of a remote Arctic longline fishery

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Despite the high biomass and potential resource importance that cold-water fisheries exhibit, polar marine ecosystems and their associated fish stocks remain understudied–largely because of harsh environments and limited accessibility. Impacts of global climate change, such as sea ice melting and warm-water species invasions, have already been recorded in polar systems. Additionally, Arctic species are typically slow-growing and less productive than temperate or tropical species, making them sensitive to even modest exploitation rates. To effectively assess and manage fisheries in the face of global changes requires a basic understanding of fish-environment interactions. The Greenland halibut, *Reinhardtius hippoglossoides*, is distributed throughout the arctic and sub-arctic and harvested commercially by 16 countries. In this study, we focus on a small, ice-dependent Inuit fishery for Greenland halibut in Cumberland Sound, southern Baffin Island, and we evaluate how catch rates vary with multiple environmental factors. Catch data from 1987 to 2003 and 2006 is used to model population abundance within Cumberland Sound, and environmental correlates, such as depth and bottom substrate, are used as predictors of abundance. The study methods should be widely applicable in an ecosystem approach to fisheries management, both in the Cumberland Sound system and outside.

C5.2-14

When it rains, it pours: effects of freshwater influx on spatial dynamics of blue crabs and implications for fisheries management

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Freshwater influx to estuarine systems can vary sharply over temporal scales of weeks to years and routinely alters distribution and abundance patterns of mobile species. These alterations can change fish catchability and inflate fishing mortality rates despite effort control. Extreme freshwater inflow to Pamlico Sound, NC following three sequential hurricanes in September 1999 is hypothesized to have caused mass migration of blue crabs down-estuary, resulting in catch efficiency that increased 370% statewide. Subsequently, blue crab spawning stock has remained at historic lows since 2000. We used geostatistical spatial analyses to map the fishery-independent spatial distribution of blue crabs in Pamlico Sound and its tributaries over 20 years and found that (1) blue crab distribution patterning, (2) catchability in fisheries-independent surveys, and (3)catch efficiency by the commercial fishery vary with freshwater influx, with stronger relationships at regional than estuary-wide scales. We conclude that the spatial resolution of fishery-independent surveys should be increased to make strong inferences about blue crab spatial dynamics, and shifts in blue crab population distribution in response to freshwater should be accounted for by managers in calculations of abundance using fishery-independent surveys and in plans entertaining possible seasonal or spatial closures to conserve spawning stock.

C5.2-15

Metapopulation dynamics of oyster reserves in Pamlico Sound, NC

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Major declines in Eastern oyster populations have prompted the establishment of oyster reserves as a restoration tool. Here, we integrated demographics and connectivity of oyster reserves in Pamlico Sound (PS), NC within a theoretical metapopulation framework to determine[1] the relative contribution of each reserve to the network (λC),[2] the potential for reserves to persist as a network connected by dispersal (i.e. $\lambda \geq 1$) and[3] the network-level benefits of increasing reserve size. Mark-recapture studies, fecundity analyses, and larval dispersal simulations were conducted to parameterize a spatially-explicit stage-based matrix metapopulation model. The relative contribution of reserves to the network (λC) ranged from 0.23 to 1.9, indicating the presence of "source" and "sink" reserves. The intrinsic growth rate of the reserve network (λ) was 0.48. To ensure network persistence (i.e. $\lambda \geq 1$), reserves must be increased in size by 210%. The metapopulation framework applied in this study suggests that while oyster reserves in PS are currently inadequate to ensure network persistence, some reserves contribute disproportionately to the reserve network and should therefore receive priority for resource allocation.

C5.2-16

An analysis of current and alternate management strategies for summer flounder (*Paralychthys dentatus*) along the U.S. Atlantic coast

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Summer flounder (*Paralichthys dentatus*) are found along the Atlantic seaboard from Nova Scotia to Florida and support valuable commercial and recreational fisheries throughout southern New England and the Mid Atlantic Bight. The status and resulting management of this summer flounder stock has been the subject of considerable controversy over the past several years, warranting an assessment of the current management strategy and alternate scenarios. In theory, total yield and egg production from this population can be maximized through the proper combination of controls on size at first capture and exploitation rate. Yield-per-recruit (YPR) and egg-per-recruit (EPR) analyses are designed to evaluate the effects of various management strategies (e.g. levels of fishing mortality) on the overall yield and egg production of a stock, respectively. We therefore present both YPR and EPR analyses for summer flounder using data collected from the mainstem Chesapeake Bay (2002-2007) and coastal ocean of southern New England and the Mid Atlantic Bight (2006-2007). The results of these analyses were used to determine whether the current management regulations (e.g. size limits, catch quotas, etc.) are appropriate to manage the Atlantic coast summer flounder fishery. A variety of alternative management scenarios were also investigated.

C5-P-1

A simple model of Lake Ontario circulation and larval invertebrate transport

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Many sessile benthic invertebrates (e.g. Driessenid mussels) produce planktotrophic larvae that spend various lengths of time in the plankton before settling to the bottom and transforming. This is the primary means of dispersal for these creatures and is an effective mechanism for invading areas downcurrent. We constructed a simple physical simulation model to qualitatively examine circulation patterns in Lake Ontario in support of efforts to develop a spatially-explicit computer simulation model of carbon flow in the benthic subsystem. Model circulation patterns differed depending on which river inputs were initiated first. Observed circulation patterns were similar to those reported in the literature, with both a simple flow through pattern and the 2- or 3- gyre pattern associated with unstratified conditions being produced. This qualitative simulation suggests little offshore transport along the south shore, except near the mouths of the Niagara and Oswego Rivers. Three dimensional flow structure was evident and most likely occurs near the Niagara jet and in offshore waters of the eastern basin. Assuming an average residence time of eight years, larvae move downcurrent passively at a rate of approximately 100 m / day. Simulation results help identify invasion pathways and contribute to estimates of larval dispersal rates.

C5-P-2

Ten years after - a decade of atlantic salmon smolt trapping in Maine

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Interagency assessment work provides information on Gulf of Maine Atlantic salmon at several stages of their life history in an effort to develop a stage-based assessment. Smolt assessments are an integral part of this assessment providing data on population status during the transition between freshwater rearing and ocean migrations. In Maine, NOAA initiated modern smolt assessments in 1996 with a feasibility study of rotary screw traps (RST). Since then, RST have been used to estimate or index smolt production, collect biological data, determine hatchery-wild production ratios, and collect fish for estuary and marine telemetry or marking studies. A RST array in the lower Narraguagus River used to develop quantitative estimates of total smolt production from 1997-2007 indicate production was very low (0.5 smolts/unit) and below levels estimated to be necessary for recovery (2-3 smolts/unit). Smolt length, weight, and condition varied across populations and years but were within species norms. Smolt trapping studies in the Sheepscot River have documented production contribution of stocking products, providing quantitative data to assess if products are additive or substitutive of naturally-reared smolts (wild spawned or fry stocked). We summarize the use of RST technology in Maine and highlight important research results and implications for Atlantic salmon recovery.

C5-P-3

A bioenergetics approach to explaining variation in yellow perch (*Perca flavescens*) growth and size structure: the role of prey composition

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Yellow perch populations in Lake Ontario embayments differ in relative abundance, size structure, and the degree to which they rely on pelagic versus littoral energy sources. I hypothesized that differences in yellow perch size structure between embayments dominated by pelagic habitat versus littoral habitat are driven by differences in prey availability. To test this hypothesis, I developed an energy budget model to predict yellow perch growth in two pelagic-dominated and two littoral-dominated embayments, based on the biomass, composition, and energetic quality of prey consumed by yellow perch. Model predictions of size at age and annual growth rates were compared with otolith-based estimates for each population. Yellow perch in all embayments grew slowly, suggesting prey limitation across populations. Model predictions matched growth and size at age in the littoral embayments, supporting our hypothesis. In contrast, the model predictions underestimated growth and size at age in the pelagic embayments. More rapid growth and larger size at age than predicted in pelagic embayments compared to littoral embayments could be due to size selective mortality from higher predation pressure on yellow perch.

C5-P-4

A comparative study of inshore and offshore survey programs in quantifying groundfish population dynamics

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The Maine-New Hampshire Inshore Trawl Survey was initiated in 2000 to fill a significant information gap on nearly two-thirds of the inshore portion of the Gulf of Maine, which contains some of the Gulf's most important spawning and nursery grounds. Valuable information on population abundance, distribution, and reproductive status is collected each fall and spring for over 30 species of commercially and recreationally important fish and invertebrates, along with key environmental data. In this study we examine spatial and temporal variations in abundance and size distribution for six commercially important groundfish species and compare them with those derived from the NMFS groundfish surveys, which mainly focus on offshore areas and deeper waters. Differences identified in this study can improve our understanding of the spatial dynamics of fish populations between inshore and offshore areas in the Gulf of Maine. Since most stock assessments have been done based on the NMFS survey data alone, this study allows us to evaluate possible uncertainty associated with a stock assessment that is conducted without including the portion of fish population in the inshore area.

C5-P-5

Spatial analyses of Lake Erie walleye distributions, 1989 - 2003.

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The Lake Erie walleye population is characterized by large inter-annual fluctuations of abundance and year-class strength, which have continued to occur since the recovery of Lake Erie from eutrophication. Lake Erie walleye spawn primarily in the western basin, and fish move progressively eastward as they mature. Spatial dynamics of the walleye population are therefore important for understanding the factors that control year-class strength. The OCFA partnership gillnet survey has provided 15 years of data (1989 – 2003) that associate catches of walleye and other species with synchronous measurements of depth, temperature, dissolved oxygen and weather conditions. We are using this database to map the age-structured distribution of walleye by year and examine the relationships between spatial distributions and ecosystem factors. Initial analyses of age-aggregated catch data indicate that walleye numbers are significantly correlated with depth, dissolved oxygen and the biomass of fish prey species. For age-structured analyses we averaged walleye catch numbers by year-class within 0.2º latitude × 0.2º longitude grids over Lake Erie, and tracked the relative abundances from year to year. The inter-annual changes in year-class distribution from 1989 to 2003 are presented in relation to the changes in species composition and environmental variables.

C5-P-6

Impacts of seasonality in recruitment and growth on stock-recruitment analysis for American lobster

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The American lobster (*Homarus americanus*) support one of the most valuable fisheries in the United States. Although many studies have been done to study its biology, we only have a limited understanding of some key life history processes. American lobster have a protracted recruitment pattern (4-9 years) as a result of large variations in growth among individuals. Molting mainly occurs in summer and only a small portion of lobsters molt again in the following fall, resulting in strong seasonality in recruitment. The objective of this study is to examine how the seasonality in recruitment and growth may influence stock-recruitment analyses for the American lobster. Using fisheries-dependent and scientific survey data in the Gulf of Mane, we simulate a lobster fishery using an individual-based lobster simulator. The stock-recruitment analyses are conducted under different simulation scenarios based on the lobster simulator. The results are compared for evaluating impacts of seasonality in recruitment and growth on stock-recruitment modeling. This study suggests that strong seasonality in growth and recruitment increases the uncertainty in stock-recruitment modeling and that choice of seasons of measuring spawning stock biomass and recruitment may influence the quality of stock-recruitment modeling for American lobster. We suggest that season is used as time step in analyzing stock-recruitment data for the American lobster.

C5-P-7

Building predictive species models in the Delaware River basin

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To identify potential gaps in biodiversity conservation within the Delaware River basin, an aquatic gap analysis is being conducted that compares biodiversity to land stewardship. Central to this analysis is the development of predictive species models to estimate aquatic biodiversity. Both historical and current occurrences of freshwater fish and mussel species were obtained throughout the basin. A stream segment database was developed that includes habitat variables (e.g. land use, land cover, gradient, soils, geology, and ecoregion) for each segment within the stream network encompassing multiple scales (channel, local watershed, and total watershed). Initial analyses showed the stream segment database to be a useful foundation for predictive species modeling. Also, the hierarchical nature of the data enhanced modeling efforts as data from all scales were found in the resulting models, with the number and occurrence of individual scales differing by species. The results of these models will not only portray a more robust estimate of biodiversity within the basin, but will also provide resource managers needed information on species-habitat affinities and interactions that will enhance those management decisions critical to ensuring the health and diversity of the basin and its inhabitants.

C6. Marine Fish Spatial Ecology

C6-1

Is biological sound production important in the Deep Sea?

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Over 50 years ago N.B. Marshall of the British Museum of Natural History hypothesized that biological sound production by fishes is widespread in the deep sea based on anatomical studies. Since that time only a handful of studies have reported anecdotal observations of possible sound production by deep sea fishes. As the first step to begin to seriously address this hypothesis we developed a simple deep sea sound recording system for use in ships of opportunity operating along the continental slope in the Northwest Atlantic. We successfully obtained a 24 hour recording in October 2005 from the bottom in 680 m of water in Welkers Canyon located south of Georges Bank in collaboration with deep sea red crab fishermen. The recordings contained a wealth of biological sound production including sounds from fin whales, humpback whales, pilot whales and dolphins, as well as frequent examples of several unknown sounds that we attribute to fishes. We achieved the following objectives: 1) demonstrated a low-cost passive acoustic recording device for use on ships of opportunity; 2) demonstrated significant biological sound production in deep water (upper continental slope) in Welkers canyon, most likely attributable to fishes; 3) demonstrated the use of commercial fishing vessels as an important platform for deep-sea research.

C6-2

Fish Aggregating Device (FAD) effects of deepwater petroleum platforms in the northern Gulf of Mexico for yellowfin tuna, *Thunnus albacares*

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We studied yellowfin tuna (YFT), *Thunnus albacares*, presence around and movements between deepwater (depth > 300 m) petroleum platforms (DPPs) in the northern Gulf of Mexico to evaluate the fish aggregating device (FAD) effect of the DPPs . Six of 13 DPPs in the Mississippi Canyon area were instrumented with automatic receivers (Vemco VR2W). Three were nearer to shore (25-41 km) and neighboring DPPs (15-17 km); three were more distant from shore (58-94 km) and neighboring DPPs (24-25 km). We tagged 98 adult YFT with internally-implanted, ultrasonic transmitters (Vemco V16). Eighty-five, plus 5 of 12 tagged a year earlier, YFT were detected on at least one day after the tagging date. Continuous residence times (CRT = number of days detected without day-scale absences) ranged from 1 to 69 d. Mean CRT (10.7 d) at offshore DPPs was significantly ($\alpha = 0.01$) greater than at the inshore DPPs (3.8 d). Maximum and mean of times from first detection to last were 157 and 43.4 d, of number of continuous residence periods for individuals were 13 and 2.7 d, and of number of platforms visited by individuals were 5 and 1.6. The results indicate that YFT have a high degree of residency within the area, with both long and short periods of residence at DPPs. YFT move long distances between DPPs, including movement between offshore and inshore DPPs. Detection of 5/12 YFT tagged a year prior further indicates that inter-annual residency and general site fidelity may exist. These findings suggest that it is possible, if not likely, that the relatively recent deployment of deepwater petroleum structures in the northern Gulf of Mexico has placed a large number of very large structures in a relatively bathymetrically featureless environment, and has resulted in stronger FADs effects than in most others locations where YFT and FADs interactions have been studied.

C6-3

Quantifying the timing and location of spawning activity for bonefish in Eleuthera, The Bahamas

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Bonefish (*Albula* spp.) are circumtropical inhabitants of nearshore marine flats and support a lucrative recreational fishery. Despite their economic importance, there are considerable gaps in the knowledge of bonefish life history, including their reproductive ecology. To quantify the timing and location of spawning activity for bonefish in the Bahamian Archipelago, we used a remote acoustic telemetry array spanning 44 km2 of shallow tidal creeks, flats, and adjacent deeper coastal waters in Eleuthera, The Bahamas. In December 2007, we surgically implanted transmitters into 15 male and 15 female bonefish inhabiting tidal creeks within the array; an additional 47 transmitter-implanted bonefish were already at large for up to two years. Preliminary data show bonefish aggregating near deep water just prior to the new moon. Localized movements during this time include brief trips (< 2 hr) to deeper water primarily through a dredged flow-through marina at the end of Cape Eleuthera. Few individuals have been detected > 1 km offshore, suggesting that bonefish may spawn in transitional zones between shallow and deep water; areas often associated with high tidal flow. Frequent downloads from the receiver array and manual tracking will occur over the next two years to isolate and quantify bonefish spawning behaviour.

C6-4

The spatial ecology of bonefish and lemon sharks in nearshore coastal flats and tidal creeks of Eleuthera, The Bahamas

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Bonefish (*Albula* spp.) and lemon sharks (*Negaprion brevirostris*) commonly co-inhabit tropical nearshore flats and their spatial ecology could be driven in part by their interactions as prey and predator. To test this, we used acoustic telemetry to study the seasonal movement patterns of both species in tidal mangrove creeks and shallow flats of Eleuthera, The Bahamas between 2005 and 2008. A total of 77 adult bonefish and 11 juvenile lemon sharks were tracked for periods of up to 557 and 571 days, respectively. Inter-creek movements were frequently documented for bonefish and their movements were linked to semi-diurnal tides and ambient water temperatures. Conversely, lemon sharks showed greater site fidelity to specific tidal creeks but their within-creek movements were often in synchrony with the movements of bonefish, likely linked to tidal regime. These results represent the first attempt to understand the spatial ecology of multiple species inhabiting coastal flats. This approach is useful for understanding how movement patterns of bonefish and juvenile lemon sharks contribute to nutrient dynamics of nearshore coastal flats and the connectivity between these and other tropical marine habitats. Management strategies, including the development of marine protected areas, will benefit greatly from this approach.

C6-5

Obtaining fine-scale movement and habitat data for spatial fisheries modelling

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Fisheries models often treat demographic parameters as constant across large spatial scales. However, spatial variation in density- and habitat-dependent processes may be important to population dynamics, especially with spatially structured life histories. One reason for assuming process spatial homogeneity has been the logistic and technological challenges of gathering landscape and movement data at appropriate scales. We are testing new technology to record reef fish movements with exceptional spatial and temporal sampling characteristics, e.g. 3-D position estimates to sub-meter performance every 6 seconds over 39 days for grouper ranging >200 meters. Movements are analyzed relative to habitat features mapped using 600 kHz side-scan sonar. Positions of acoustically tagged fish are derived using an array of autonomous, fully submerged hydrophone data loggers. This autonomous logger position system (ALPS) employs a coded acoustic beacon at a known location to provide a clock synchronization signal to each logger, which allows compensation for clock drift between loggers. ALPS then uses hyperbolic positioning methods to derive two-dimensional locations of tagged fish, and derives position in the third, depth, dimension by pressure sensors in the tags. Understanding individual movements relative to landscape features at such fine resolutions will improve models that incorporate spatial variation in demographic parameters.

C6-6

Spawning activity and migratory characteristics of American shad and striped bass in the Cape Fear River, NC

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Anadromous fish populations within the Cape Fear River, NC have experienced declines since the late 1800s. Three low-head lock and dam structures contributed to this decline by limiting access to upstream habitat. We used egg and larval fish sampling and sonic telemetry to characterize patterns of migration and spawning activity for American shad and striped bass. Plankton samples were taken below each lock and dam, and at two locations further upstream. Distribution of American shad eggs and observed spawning activity suggest that most American shad spawning took place below the lowermost lock and dam. Collected eggs decreased by an estimated 80% for each successive dam. Twenty American shad and 20 striped bass were tagged and transported upstream of the three dams. Sixty percent of tagged American shad moved 1 to 33 rkm upstream of the release site, with an average migration rate of 0.52 rkm/hr. All striped bass moved downstream upon release. However, two striped bass made secondary upstream migrations of 52 to 134 rkm, passing 2 to 3 dams, and averaging 1.23 rkm/hr. Egg results indicate spawning activity of American shad is greatest in areas below the dams, while telemetry data shows usage of upstream habitat by both species.

C6-7
Habitat use of the Snohomish River Estuary, Washington, by juvenile Pacific salmon: affects of several landscape scale factors
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Since 2001, we have been studying use of intertidal habitats of the Snohomish River Estuary, Washington, by juvenile Pacific salmon. We found differences between hatchery-produced and naturally-produced salmon, with hatchery fish moving more rapidly through the estuary. Annual variability in the abundance of several species was synchronous but different factors appeared to explain annual fluctuations for each species. For example, the estuarine abundance of Chinook salmon fry, one of the main life history types of this species, appeared to be greatest in dry, warmer years in the watershed, while the abundance of fingerlings was greatest in wetter, cooler years in the watershed. The estuarine abundance of subyearling coho salmon was directly related to escapement. The seasonal occurrence of high estuarine temperatures was correlated with the disappearance of each species from the estuary with thermal tolerances varying between species. If the occurrence of thermal thresholds occurs increasingly earlier due to climate change, as suggested by studies within the Puget Sound region, then the opportunity for each species to use estuarine rearing habitats will decline. Abundance levels of each species were generally higher in mainstem channel habitats than in the main wetland rearing areas associated with the network of smaller distributary channels. We hypothesize that low connectivity of the main wetland areas under some flow/tidal conditions may limit their use by juvenile salmon.

C6-8
Patterns of movement in striped bass, *Morone saxatilis*, in the Penobscot River, Maine
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In the Penobscot River, the seasonal and daily movements of striped bass are poorly characterized. In this study, we used acoustic telemetry to describe patterns of movement through the lower Penobscot River and Bay. Thirty one fish were captured in fresh water between June and July of 2006. An array of 82 acoustic telemetry receivers provided detailed information on movement rates and patterns. These data were augmented by active tracks through November. Tagged stripers exhibited great variability in the scope of movement within the river, with some individuals remaining in fresh water for the majority of the period of tracking. Other fish displayed significant cyclical movements (greater than 20 km) presumably linked to tidal transport. Most tagged fish appear to have exited the lower river by the end of October (16 fish), with two tagged fish being reported from other Maine Rivers (one in the Piscataqua River, one in the Kennebec River). A subset of tagged fish[6] remained in fresh water until receivers were pulled in November. Such patterns may indicate some overwintering of striped bass in the Penobscot River.

C6-9
Tracking Atlantic croaker movement in the Gulf of Mexico: a shifting element mosaic in the "Dead Zone"?
Lance Sullivan[1] (presenting), Richard Strauss[1], Sandra Diamond[1]. Texas Tech University, Lubbock, Texas, United States[1]

The "Dead Zone" (<2 mg O2/L) in the Gulf of Mexico (GOM) covers an average area of 16,000 km2 during the summer, and can have adverse effects on the ecology and physiology of fishes. As a result, this can have implications on how long a juvenile, or even an adult, croaker is able to tolerate hypoxic conditions. To track the location of fish during the time preceding capture, we analyzed the elemental composition of juvenile Atlantic croaker (*Micropogonias undulatus*) otoliths using laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS). Principal component analyses, using 7-day stanzas, revealed that there were significant differences in the elemental assemblages for each stanza, in both groups of otoliths. A stanza-by-stanza discriminant analysis using the first four stanzas from the edge, across all otoliths used in the study, provided better resolution in determining which elements were correlated with hypoxic and normoxic conditions in the GOM. Rare earth elements (146Nd, 163Dy, 175Lu, and 147Sm) were mainly correlated with normoxic conditions. Several transition metals (63,65Cu, 55Mn, 51V, 68Zn) and, in some cases, 147Sm, 138Ba, 85Rb, 27Al, and 88Sr were correlated with hypoxic conditions. Interestingly, 31P was

present in all of the analyzed stanzas and correlated with hypoxic conditions.

C6-10

Physiological and environmental influences on emigration timing in juvenile anadromous alewife

Benjamin Gahagan[1] (presenting), Eric Schultz[1]. [1]University of Connecticut, Storrs, CT, United States

The alewife, *Alosa pseudoharengus*, an anadromous herring, is a major food source for many predators in the coastal ecosystems of the northwest Atlantic. In the last 15 years alewife abundance has drastically declined, stimulating studies of factors influencing the success of each life stage. One factor of interest is surface water flow, which is altered by land use and which may influence juvenile escapement and subsequent recruitment to the adult population. In this study we focused on the timing of juvenile emigration and seasonal changes in emigrant characteristics. We studied juveniles in Bride Lake, the site of a relatively large anadromous alewife run in Connecticut. Continuous video monitoring from mid-June to early August 2006 revealed multiple emigration peaks. Emigration rate was greatest a day or two after rainfall and was negatively correlated to temperature. During the peak migration period, most emigration occurred in the mid-morning hours. We sampled fish that were emigrating from the lake and fish that were staying behind, to test whether physiological factors affected the tendency to migrate. Analysis of daily age and size of collected fish revealed that emigrants were longer, older, and larger at age than fish remaining in the lake across the entire migration period. We conclude that individual factors interact with local conditions to trigger emigration behavior. The results vary from those of studies in other parts of New England, suggesting regional variations in alewife developmental processes.

C6-P-2

A summary of acoustic tagging programs for migratory and resident Chinook salmon in Puget Sound

Anna Kagley[1] (presenting), Fred Goetz[2], Correigh Greene[1], Tom Quinn[3], Joshua Chamberlin[3], Kurt Fresh[1].
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Like many other stocks throughout the Pacific Northwest, Puget Sound Chinook salmon have now declined to the point that they are listed as Threatened under the Endangered Species Act. An increased understanding of their residence time, origins, migration pathways, predator/prey interactions, and habitat use is needed to help reverse this trend. We are currently using acoustic telemetry to help fill this information void. Currently there are over 20 organizations deploying more than 900 tags and over 200 receivers in every Puget Sound basin and coincident with this is an international monitoring effort (POST project) using the same technology from California to Alaska. This presentation is a summary of the Chinook portion of this collaborative effort initiated over the last two years and an overview of the upcoming research plans. This united approach will give a clearer picture of the status of Puget Sound Chinook salmon including ocean-bound smolt and resident (blackmouth) behaviour and survival in both the estuarine and nearshore environments and contribute to a greater ecosystem level of understanding. This in turn will help direct future fisheries management decisions surrounding recovery and help focus future protection and restoration efforts.

C6-P-3

Interannual variability in mixing between Atlantic Ocean and Gulf of Mexico king mackerel stocks estimated with otolith chemistry

Will Patterson[1] (presenting), Kate Shepard[1], Todd Clardy[2]. [1]University of West Florida, Pensacola, Florida, United States, [2]Barry Vittor and Associates, Mobile, Alabama, United States

Genetics, tagging, and population dynamics data indicate two separate king mackerel stocks exist in US waters of the Atlantic Ocean (Atlantic) and Gulf of Mexico (Gulf). Management is complicated, however, due to the fact the stocks mix in waters off south Florida in winter. We developed natural tags based on otolith elemental and, subsequently, stable isotope chemistry to estimate winter king mackerel stock mixing. Stock-specific otolith chemical signatures were significantly different among sampling summers (2001, 2002, and 2006; MANOVA, $p < 0.001$). Jackknifed linear discriminant function classification accuracies ranged from 68-91% for elemental (Ba, Mg, Mn, Sr) signatures, which increased approximately 10% for models that included C and O stable isotope values. Results from maximum likelihood stock mixing models parameterized with stock-specific chemistry data and applied to samples from three south Florida winter sampling zones indicated an east to west gradient in the stock composition of landings, with the Atlantic stock estimated to have contributed a significant percentage (e.g. > 25%) of landings in all zones. Therefore, the current practice of assigning all winter landings to the Gulf stock is inaccurate. Otolith chemistry appears to be a robust natural tag with which stock composition of winter landings can be directly estimated.

<u>C7. Marine Fish Ecology</u>

C7.1-1

An RNA:DNA-based index for estimating growth rate in juvenile Atlantic menhaden

Jason Edwards[1] (presenting), Thomas Miller[1]. [1]University of Maryland Chesapeake Biological Laboratory, Solomons, MD, United States

Atlantic menhaden (*Brevoortia tyrannus*) is an ecologically and economically important species in the Chesapeake Bay ecosystem, linking primary and secondary production to higher trophic levels and supporting a valuable commercial fishery. Menhaden population dynamics are influenced by growth and survival during juvenile occupancy in Bay nursery habitats. Therefore, quantifying productivity of potential nursery areas is important to understand population processes and define essential fish habitat for this species. This study used fluorometric techniques to develop a nucleic acid-based index to estimate instantaneous growth rate in young-of-the-year Atlantic menhaden. A series of 8-day growth experiments consisting of varying temperatures and food rations was conducted. Instantaneous growth rate and RNA:DNA were measured in each fish and a model predicting growth rate from RNA:DNA, temperature and their interaction was developed. RNA:DNA is a reliable tool for estimating growth and condition over a short time scale in reference to specific habitat residency. Thus, the information obtained from this study can be used in conjunction with field based estimates of RNA:DNA and abundance to determine spatial and temporal patterns of the relative productivity of nursery habitats for Atlantic menhaden.

C7.1-2
Exploiting tissue-specific isotopic turnover rates to characterize dietary habits of summer flounder (*Paralichthys dentatus*) in Chesapeake Bay
Andre Buchheister[1] (presenting), Robert J. Latour[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

Stable isotopes have proven to be useful tools in ecological studies of trophic interactions and food webs in a variety of ecosystems. However, application of stable isotope techniques can be problematic when focusing on migratory fish in dynamic systems with temporal and spatial variability in prey sources. In these situations, fish muscle tissue has insufficient time to equilibrate to a new diet and does not reflect dietary patterns clearly. To address this problem, a laboratory study was conducted with captive summer flounder (*Paralichthys dentatus*) to assess the turnover rates of stable isotopes (δ13C and δ15N) in three different tissues: muscle, blood, and liver. Identification of the tissue with the fastest turnover rate then facilitated application of stable isotope techniques in the Chesapeake Bay environment. The goals of the field component of this study were then to quantify flounder diets and determine the prey groups most responsible for driving production. Dietary assessments made from stable isotopes were also compared to stomach content analyses, highlighting the differences and advantages of each method. This research emphasizes the utility of conducting laboratory studies to validate methodological assumptions and strengthen conclusions made in the field when using stable isotopes, particularly for migratory fishes.

C7.1-3
Among population differences in otolith chemistry has a genetic basis in *Menidia menidia*
Lora Clarke[1] (presenting), Simon Thorrold[2], David Conover[1]. [1]Stony Brook University, Stony Brook, NY, United States, [2]Woods Hole Oceanographic Institution, Woods Hole, MA, United States

The number of studies using otolith chemistry as a tool to reconstruct the environmental history of fishes and to detect population structure continues to rise, despite a lack of full understanding of factors influencing otolith deposition. Many studies have examined the influence of environmental parameters on otolith composition, but none to date have tested the possible influence of intrinsic factors. Using lab broodstock populations we examined the influence of genetic and genetic x environment (temperature) interactions on the influence of Mg/Ca, Mn/Ca, Sr/Ca, and Ba/Ca concentrations and partition coefficients in the otoliths of juvenile Atlantic silversides, *Menidia menidia*. Fish from two populations, South Carolina, USA, and Nova Scotia, Canada, were reared in 15, 21, and 27°C. Results show that population differences exist in otolith concentrations of Mg/Ca and Sr/Ca ratios as well as the partition coefficients for Mg, Mn, and Sr. Significant genetic x environment relationships were observed for Mn, Sr, and Ba partition coefficients. Furthermore, using linear discriminant analysis with cross-validation the two populations could be separated with over 90% accuracy. These results show the importance of genetic and genetic x environment interactions on otolith elemental concentrations and have important implications for understanding the physiological mechanisms behind otolith deposition.

C7.1-4
Spatial variations in otolith microchemistry for Tautoga onitis in Narragansett Bay
Ivan Mateo[1] (presenting), David Bengtson[1], Edward Durbin[1]. [1]University Rhode Island, Kingston, United States Minor Outlying Islands

Elemental composition of otoliths may provide valuable information in establishing connectivity between nursery grounds and adult marine fish populations. Juveniles of the economically important fish species Tautoga onitis were captured in five nursery areas along the RI coast. Concentrations of Rb, Mg, Ca, Mn, Sr, Na, K, Sr, Pb, and Ba were determined in otoliths of YOY using solution-based ICP-MS. Stable oxygen (18O) and carbon isotopic ratios (13C) in YOY otoliths were also analyzed using isotope ratio mass spectrometry to discriminate tautog nursery grounds. Results of MANOVA showed that elemental signatures differed significantly among the distinct nurseries within Narragansett Bay and the coastal ponds (Pillai's trace=4.465, $P<0.001$). Univariate contrasts indicated that concentrations of three elements (Sr, Ba, Rb) and two stable isotopes (18O and 13C) differed significantly among the five nurseries (ANOVA, $P<0.001$). Linear discriminant analysis distinguished the three tautog nurseries within Narragansett Bay (Mount Hope Bay, Gaspee Point, Rose Island) with 100% classification success. When data from Narragansett

Bay were included with the coastal ponds the results showed an overall accuracy of 92%. Since accurate classification of juvenile fish to their nursery sites was achieved, otolith chemistry analysis can be used as a natural habitat tag in this species.

C7.1-5
Use of a geochemical signature in otoliths to evaluate age determination methods for American shad
Sally A. Upton[1] (presenting), John E. Olney[1]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States

Natural variations in the chemical composition of otoliths are used to investigate a wide range of questions regarding the life history of fishes. We demonstrate the use of these natural variations as markers of an individual year class. Geochemical analyses of juvenile American shad (*Alosa sapidissima*) otoliths collected in the York River, Virginia revealed enriched δ18O values in otolith cores of members of the 2002 year class relative to other year classes (2000, 2001, 2003, and 2004). This unique isotopic signature is likely the result of varying inter-annual environmental conditions. Using this isotopic signature as a marker for the 2002 year class, we are able to identify known-age individuals in collections of adults from 2006 and 2007 and evaluate age determination methods for the species. Scale, whole otolith, and sectioned otolith-based age determination methods were evaluated in terms of precision, bias, and agreement with known-ages as determined by isotopic data. In addition, this marker will be used to track recruitment to the spawning stock of the 2002 year class over time. Natural markers such as the one used in this study, while rare, may provide a new source of known-age individuals for age validation and cohort recruitment studies.

C7.1-6
Can otolith microchemistry help elucidate the number of spawning grounds and population structure of South American Hoki?
Pia Schuchert[1] (presenting), Alexander Arkhipkin[1]. [1]Fisheries Department, Stanley, Falkland Islands (Malvinas)

Hoki (*Macruronus Magellanicus*) is a highly migratory pelagic species in the South Atlantic and South Pacific which is of great importance to the fishery in the Falkland Islands, Chile and Argentina. So far little is known about stock structure, migratory routes and spawning grounds which makes fisheries management particularly difficult. To date only one spawning ground in Chile is known, speculations exist whether there is an additional spawning ground in the South Atlantic. We employ otoliths trace element analysis (ICPMS) from the core and margin of fish collected in the Falkland Islands and northern Chile to gain further understanding of their stock identity. Stepwise quadratic discriminant analysis (QDA) using backward selection of Mahalanobis distances between groups is performed to determine whether fish can be spatially discriminated by their trace element composition in the margin of the otoliths and which of those elements are the most significant contributors towards the differentiation. As one cannot imply the spawning ground from the area fish were caught, we use cluster analysis of otolith core trace element concentrations to distinguish between different spawning grounds, and gain further understanding of the number of spawning grounds and population structure.

C7.1-7
Characterization of spatial variability in age-0 menhaden chemical signatures in Chesapeake Bay and its implications for recruitment
Jason Schaffler[1] (presenting), Cynthia Jones[1]. [1]Old Dominion University, Norfolk, Virginia, United States

Menhaden fill an important ecological niche as a filter feeder and prey species in Chesapeake Bay and support an important commercial fishery. Chesapeake Bay is a large and complex estuary fed by several major rivers that result in spatially isolated areas of high phytoplankton production and biomass where juvenile menhaden reside throughout the summer. It is highly likely that due to the dynamic nature of the rivers feeding Chesapeake Bay, that there is high inter-annual variability in the recruitment success of menhaden from each sub-estuary. However, before we begin measuring population parameters such as mortality or growth, we need to know if there is a relative difference in production of juvenile menhaden in their nursery areas that could be a result of differences in vital parameters. To accomplish this task, we need a marker that allows us to differentiate juvenile menhaden produced throughout Chesapeake Bay. Preliminary results indicate that there are strong differences in the nursery signatures of menhaden captured from major drainages throughout Chesapeake Bay. Based on out-migrating age-0 menhaden, we are able to assign juveniles to specific drainages. Thus, allowing us to asses the relative importance of each major nursery area to Chesapeake Bay.

C7.1-8
Factors influencing growth and pigmentation in settling glass stage American eels (*Anguilla rostrata*)
Daniel Luers[1] (presenting). [1]University of Maryland Eastern Shore, Princess Anne, MD, United States

As a decline in American eel (*Anguilla rostrata*) population has been noted at locations across the east coast, the study of factors influencing their growth and settlement may provide insight necessary to conserve this species. Analyses of growth (size and pigmentation) and settlement of the glass stage of American eels were performed on data collected from five tributaries of the Newport Bay sub-watershed (Maryland, USA). Traps were checked weekly from April to June (2007), with catches averaging

about 4.5 eels per trap. The objectives of my study were to elucidate the biotic and abiotic factors contributing to differences in eel size and pigmentation over time and at different sites. Eel size at settlement in upstream sites was found to increase significantly over the course of the study. Pigmentation of glass eels increased over time at a site. The level of pigmentation and the rate of pigmentation differed across the sites. Variation in pigmentation rate may be explained by distance traveled, abiotic (temperature, salinity, bottom substrate) and biotic (predator density) factors. My work will help determine why growth of glass eels differs across environments, and what consequences can be expected as human development continues to alter freshwater tributaries.

C7.1-9
Demographics and parasitism by *Anguillicola crassus* in Chesapeake Bay American eels
Kari Fenske[1] (presenting), Dave Secor[1], Mike Wilberg[1]. [1]University of Maryland Center for Environmental Science, Solomons, MD, United States

The Chesapeake Bay supports the largest US American eel *Anguilla rostrata* fishery; on average a half million pounds of American eel were harvested annually during 1997-2007. To facilitate management of this species on a regional scale we are conducting an assessment of their demographics in the Chesapeake Bay. The objective of our study is to compare population structure among several tributaries of the Chesapeake Bay, the Potomac, Patuxent, and Chester Rivers. We collected 800 American eels in 2007 and examined them for length, sex, age, quantity of parasites, anus color, and swimbladder condition. Size structure and sex ratios varied substantially among the three rivers. Large female eels (mean length 40 cm, 81% female) predominated in the Potomac River whereas smaller intersex eels (mean 29.3 cm, 44.6% intersex) dominated the Chester River sample. Parasitism rates were generally high, but varied between systems, ranging from 34% of eels infected in the Potomac to 67% in the Chester. Swimbladder condition is thought to reflect infection history, but did not correlate well with presence or absence of nematodes in the swimbladder. Anus color did not appear to be a useful sole indicator of infection status as has been reported in studies on European eels.

C7.1-10
Exploring the ecological significance of color variation in Atlantic cod
Graham Sherwood[1] (presenting), Jonathan Grabowski[1]. [1]Gulf of Maine Research Institute, Portland, ME, United States

Atlantic cod are known to exist as different color morphs (red versus normal). Perhaps the best studied case of red cod is from Gilbert Bay, Labrador where red cod exist in a semi-enclosed population. The basis for red coloration has been suggested to be genetic as well as a phenotypic response to local diets high in red pigments. Here, we present findings from Cashes Ledge, a shallow feature about 70 miles offshore in the Gulf of Maine where the two color morphs coexist. Roughly equal proportions of both color morphs were sampled by gillnet and hook-and-line from the center of the Cashes Ledge Closure Area (closed to fishing). We will present data on a new quantitative method to differentiate color morphs (image analysis) as well as data on diet, stable isotope signatures (□13C, □15N), morphometrics, parasite loads, growth and depth preference, all of which support the hypothesis that color morphs occupy distinct ecological niches. Red cod appear to be more resident to shallow water kelp beds on Cashes Ledge, whereas normal cod appear to be transient. Our data suggest that red color in cod is a consequence of a specific life-history strategy associated with certain habitats (e.g. resident within kelp beds), which is likely a fixed trait and may be considered as a basis for future conservation strategies.

C7.2-1
A genetic assessment of the potential for local depletion of Atlantic menhaden (*Brevoortia tyrannus*) within Chesapeake Bay
Abigail Lynch[1] (presenting), Jan McDowell[1], John Graves[1]. [1]Virginia Institute of Marine Science, Gloucester Point, Virginia, United States

Atlantic menhaden is an ecologically and economically important species along the U.S. east coast. As a filter-feeder, it provides a critical link between primary production, phytoplankton, and larger piscivorous predators, such as striped bass, bluefish, and weakfish. The species is also the target of one of the largest commercial fisheries in the country. Menhaden are assessed as a single, coastwide stock, and recent assessments indicate that it is not overfished. However, there is very limited population genetics data to support the assumption of a single stock and the recent consolidation of the fishery and intensified harvests within and around Chesapeake Bay have raised concerns over the possibility of 'localized depletion' of the species in this area. In this study, we used rapidly evolving molecular markers to examine Atlantic menhaden stock structure along the U.S. Atlantic coast, specifically to determine the potential for the loss of unique genetic variation resulting from concentrated fishing pressure in and around Chesapeake Bay. Samples were collected from three cohorts of Atlantic menhaden (2005, 2006, and 2007 year classes), at four geographic locations along the U.S. Atlantic coast (New England, mid-Atlantic, Chesapeake Bay, and U.S. south Atlantic) in 2006 and 2007. We surveyed two independent classes of molecular markers: the mitochondrial DNA and nuclear microsatellite loci. Hierarchical analyses of molecular variance (AMOVA) and examination of pairwise ϕST, FST, RST estimates indicate high genetic variability and homogeneous distribution of Atlantic menhaden. The genetic connectivity between New England, mid-Atlantic, and Chesapeake Bay suggests the potential for loss of unique genetic variation due to intensified fishing pressure in Chesapeake Bay, however, is not likely to occur in Atlantic menhaden.

C7.2-2

Saltwater intrusion impacts fish diversity and distribution in the Blackwater River drainage (Chesapeake Bay watershed): Effects on freshwater fish populations

Joseph Love[1] (presenting), John Gill[2], Joshua Newhard[1]. [1]University of Maryland Eastern Shore, Princess Anne, MD, United States, [2]Maryland Fishery Resources Office, Annapolis, MD, United States

We surveyed fish assemblages from Blackwater River drainage (Maryland, USA) in order to document spatiotemporal patterns of fish distribution from December 2005–2006. Three sites were sampled from each Little Blackwater River (a major tributary) and upper Blackwater River (a historically freshwater marsh). Fish assemblages strongly differed between upper Blackwater River and Little Blackwater River, likely due to higher salinity of upper Blackwater River (9–12 ppt) than Little Blackwater River (0–5 ppt). Little Blackwater River served as a nursery for freshwater-dependent fishes, such as white perch (*Morone americana*) and brown bullhead (*Amerius nebulosus*). We used Little Blackwater River as a model system to test the hypothesis that remnant freshwater-dependent fish populations of transitional assemblages in upper Blackwater River may have declined as saltwater has intruded from sea level rise. As salinity increased seasonally in Little Blackwater River, abundance of freshwater-dependent fishes declined for an upstream and downstream site. Declines of freshwater-dependent fish populations contributed to strong spatial differences in assemblage structure for Blackwater River drainage. Our research suggests that sea level rise and human modifications of coastal wetlands will have adverse effects on freshwater-dependent species and fish assemblages.

C7.2-3

The effects of winter temperature and flow on a summer-fall nursery fish assemblage in the Chesapeake Bay, Maryland.

Rebecca Wingate[1] (presenting), David Secor[1]. [1]University of Maryland Chesapeake Biological Lab, Solomons, MD, United States

In temperate estuaries, nearshore nursery fish assemblages are influenced by environmental conditions during and prior to the period of juvenile fish occurrence. An intensively sampled site (Chesapeake Biological Laboratory; Patuxent River) in mesohaline Chesapeake Bay provided nine years of data with which to relate previous and current environmental variables. Canonical correspondence analysis identified previous winter temperature and flow (January-March), and week and year of the assemblage sample as the most influential variables. In contrast, environmental variables at the time of sampling were not important. Cold winter temperatures and high winter flows were positively associated with high summer-fall abundances of Atlantic silversides, striped bass, white perch, and Atlantic needlefish. Species associated with the converse, low winter flows and high winter temperatures, included bluefish, spot, bay anchovy, and northern puffer. The mechanisms by which winter conditions affect the summer-fall nursery fish assemblage were not directly addressed in this study, but winter conditions can affect subsequent spring and summer estuarine production, spawning and recruitment phenologies, and distributions of juvenile fishes.

C7.2-4

Coral reef fish community shifts and declines in species richness and abundance in the upper FL Keys, USA

Todd Kellison[1] (presenting), Vanessa McDonough[2], Doug Harper[1], James Tilmant[3]. [1]NOAA Fisheries, Miami, FL, United States, [2]National Park Service, Homestead, FL, United States, [3]National Park Service, Fort Collins, CO, United States

Coral reef ecosystems worldwide are being impacted by anthropogenic and natural stressors, yet a lack of historical data often limits our ability to quantify change over time and thus to assess the necessity and exigency of management and conservation measures. We assessed reef fish community structure on patch reefs in Biscayne National Park, FL, USA, during 2006-2007 using the same sites and methods utilized in a historical study (1977-1981), and compared data between survey periods. Significant and substantial differences were observed in reef fish community structure between historical and recent surveys. Changes in community structure occurred across trophic guilds, with significant declines over time in multiple species of piscivores, macroinvertivores, planktivores, algivores, and corallivores. Mean species richness per survey declined over time by 17% (all sites combined); declines varied from 9 to 27% at specific sites. Frequency of occurrence values declined over time for 65% of the species observed in both recent and historical surveys. Significant declines were observed for multiple fishery-targeted species, suggesting that fishing impacts have contributed to the alteration of community structure. The changes observed in this study are consistent with those observed in other reef systems that are heavily utilized by humans, and may continue given predicted increases in human population and fishing pressure in south FL and the upper FL Keys.

C7.2-5

Using biological and habitat data to identify strategic habitat areas for juvenile fish in Albemarle Sound, North Carolina

Timothy Ellis[1] (presenting), Scott Chappell[2], Michael Loeffler[2], Anne Deaton[2], Jeffrey Buckel[1]. [1]Department of Zoology, Center for Marine Sciences and Technology, North Carolina State University, Morehead City, NC, United States, [2]North Carolina Division of Marine Fisheries, Morehead City, NC, United States

The designation of Strategic Habitat Areas (SHAs) is an integral part of North Carolina Coastal Habitat Protection Plan implementation. A site selection program, MARXAN, is being used to identify SHAs for the Albemarle Sound region. MARXAN

relies on a geospatial layer of natural resource targets (NRTs), which are defined as the habitats re(presenting) essential components of the system. Biological data were not used as an NRT because sampling stations are fixed and non-random; however, these data were used to corroborate the SHA selections made by MARXAN. Using long-term biological data collected by the North Carolina Division of Marine Fisheries, we examined various juvenile fish abundance metrics, including both single- and multi-species indices, and mapped the juvenile distribution and abundance of important fish species in Albemarle Sound. Nonparametric statistical procedures were used to examine the relationships between biological data (e.g. species diversity) and the habitat characteristics (i.e. NRTs) used as site selection criteria in MARXAN. Our results largely support the use of current NRTs selected for the Albemarle Sound region; however, there were areas not selected by MARXAN that are important habitats for juvenile fish. This latter information will be used by regional experts to modify the SHA designations from MARXAN.

C7.2-6
White perch bioenergetic responses to temperature, salinity and dissolved oxygen.
Deanna McQuarrie[1] (presenting), Dave Secor[1]. [1]UMCES-CBL, Solomons, MD, United States

Estuaries are highly variable in their physical and chemical structure, affecting habitat availability for those fish that use them as nurseries. White perch, whose entire life cycle is completed within estuaries, are among the most abundant and important fishes in the Chesapeake Bay. Here, we evaluated the effects of salinity, dissolved oxygen, and temperature on juvenile bioenergetic responses. Using an incomplete factorial design, young-of-the-year perch were reared in 10-d trials varying in temperature, salinity and dissolved oxygen conditions. Based upon ad libitum feeding, growth rates and feeding rates were estimated. Respirometry studies were performed to determine routine metabolism. Results showed a dominant temperature effect on growth and feeding rates with > 10 fold higher growth rates at 20 and 28 °C than at temperatures 4 and 12 °C. Feeding rate also increased with temperatures. Growth rates were strongly influenced by dissolved oxygen (20, 40, and 70% saturation), showing a strong positive linear relationship. Increasing salinity had no effect on growth rates; however feeding rates were significantly reduced at higher salinities. Our results indicate that white perch nursery habitat value can be substantially curtailed by hypoxia, which is a systemic summertime feature of the Chesapeake Bay and other estuaries.

C7.2-7
A history of the Pacific Biological Station
Richard Beamish[1] (presenting). [1]Fisheries and Oceans, Nanaimo, BC, Canada

The Pacific Biological Station was established by the Reverend George W. Taylor in 1908 because of his concern for the resource. For the past 100 years this concern resulted in a legacy of scientific literature that is known around the world. Despite the dedication of the investigators, fishing took its toll. Naturally changing trends in the environment also had impacts, although the impacts were only recently recognized. Today, perhaps surprisingly, a number of the species that were important in the early fisheries are in pretty good shape. However, the ecosystems that support the Pacific coast resources are changing as are the research issues. Climate now rules. The Strait of Georgia, for example, warmed an average of 1oC in forty years and the trend continues. We are returning to studying ecosystems. Net pens produce triple the number of salmon that are caught in salmon fisheries. Species and stocks have “rights” that are protected by an Act of Parliament. There is a policy that defines how wild salmon must be treated. These changes and others indicate that it is now a good time to use the lessons of the past 100 years to establish a strategy for the future.

C7.2-8
A history of the St. Andrews (Atlantic) Biological Station
Robert Stephenson[1] (presenting). [1]Fisheries and Oceans, St. Andrews, NB, Canada

The Atlantic (now St. Andrews) Biological Station, established in 1908, offers a 100-year case study in the development and delivery of marine science in Canada and the rapid evolution of marine science internationally. The St. Andrews Biological Station evolved from an institute of academic investigation through a series of arrangements and federal department affiliations that included the internationally renowned Fisheries Research Board of Canada. The legacy of the Biological Station includes major contributions to study of the oceans, to the development of marine activities of fishing and aquaculture, to the study of human impacts on the marine environment, to the rapid evolution of fisheries and oceans management, and to the evolution of international committees and marine initiatives. Throughout it’s history SABS has faced changing trends in a number of theme areas - private vs public good, the role and interaction of public science with universities, and the degree to which science can be proactive vs reactive. While the context and some of the driving forces have changed, there has been consistency in much of the underlying responsibility of ‘public science’ to undertake relevant science in support of legislation, to collect and maintain data, and to provide credible information and advice.

C7.3-1a
Comparing striped bass prey size-predator size relationships across the species range
Francis Juanes[1] (presenting). [1]University of Massachusetts, Amherst, MA, United States

Asymmetric predator size-prey size distributions are prevalent in aquatic systems and particularly in piscivorous fishes. Previous studies have shown that mean and maximum prey sizes are an increasing function of predator size whereas minimum prey sizes generally are not. The slopes of the maximum prey size vs. predator size vary among species and are often related to ontogenetic changes in mouth gape sizes. However, the variation in predator size prey-size distributions has not been assessed within a species. Here I report on variation in predator size-prey size distributions across the range of a widely distributed predator, the striped bass, *Morone saxatilis*. Datasets included modern and historical samples from Quebec to North Carolina and California. Although diets varied substantially across populations, minimum, median and maximum prey size slopes were consistent, asymmetric, and averaged 0, 13 and 30% of predator lengths. Similarly, ratio-based trophic niche breadths narrowed with predator ontogeny for all populations. The consistency of the results suggests that morphological and/or behavioral constraints may be more important in determining predator-prey relationships than site-specific prey type abundances and distributions.

C7.3-1
Predatory impact on YOY winter flounder, *Pseudopleuronectes americanus*: comparative dietary analysis of common fish species in Long island waters
Skyler Sagarese[1] (presenting), Michael Frisk[1]. [1]Stony Brook University, Stony Brook, NY, United States

Predation on juvenile flatfish is believed to be the primary cause of juvenile flatfish mortality. Upon settling into juvenile existence during late spring and early summer, young-of-the-year flounder become susceptible to decapod crustaceans, demersal fish, and avian piscivores. Predatory impacts on newly born young-of-the-year (YOY) winter flounder (*Pseudopleuronectes americanus*) were investigated by collecting and examining gut contents of common piscivorous fishes found in important feeding and nursery grounds: Great South Bay, Shinnecock Bay, and Port Jefferson Harbor. Samples were collected during otter trawl, beach seine and beam trawl surveys conducted from March to September 2007 in all three study locations. Upon capture specimens were measured and frozen in the laboratory. Analysis entailed identification, counting, and weighing of all food items. Preliminary results of data collected during year one of this two year study suggest varying dominance of prey items. Sand shrimp (*Crangon septemspinosa*) dominated striped sea robin (*Prionotus evolans*) stomachs (N=28) by both number and weight while Mysids dominated windowpane flounder (*Scopthalmus aquosus*) stomachs (N=33). Clearnose skate (*Raja eglanteria*) stomachs (N=9) are dominated by rock crabs (*Cancer irroratus*) by weight and sand shrimp by number. The contents of summer flounder (*Paralichthys dentatus*) stomachs (N=60) are more variable and include Mysids, rock and mud crabs (*Panopeus herbstii*), mantis shrimp (*Squilla empusa*), isopods, moonfish (*Selene setapinnis*), menhaden (*Brevoortia tyrannus*), silversides (*Menidia menidia*) and winter flounder. Abundance estimates of all fish were used to quantify the total predatory impacts of piscivores on winter flounder.

C7.3-2
Variability in the diet of Atlantic croaker and its consequences to the Chesapeake Bay fisheries ecosystem
Janet Nye[1] (presenting), Thomas Miller[2]. [1]NOAA/NMFS/NEFSC, Woods Hole, MA, United States, [2]University of Maryland Center for Environmental Science, Chesapeake Biological Lab, Solomons, MD, United States

Atlantic croaker *Micropogonias undulatus* is a commercially and ecologically important bottom-associated fish whose abundance and landings have increased in recent years. The diet of Atlantic croaker varies temporally and spatially in Chesapeake Bay. In particular, we found that at least 20% of the diet of croaker by weight consisted of fish, particularly bay anchovies *Anchoa mitchilli* in the summer. The use of a pelagic food source seems unusual for a bottom-associated fish such as croaker, but is likely a crepuscular feeding habit that has not been emphasized previously. To estimate the ecosystem consequences of diet variability in Atlantic croaker, I developed and validated a bioenergetic model for Atlantic croaker in the laboratory. The application of this model indicated that although anchovies made up a relatively small portion of croaker diet and only at certain times of the year, croaker could be an important competitor with weakfish and striped bass when their stock size is high. At the population-level, croaker consumed as much anchovy as weakfish in three of four simulated years and more anchovy than striped bass in all simulated years. These findings indicate that trophic interactions that are typically considered "weak" are dynamic and important in understanding ecosystem processes and in ecosystem-based management.

C7.3-3
Role of trophic processes in structuring nursery habitats
Cynthia Jones[1] (presenting), Jacques van Montfrans[2], Stacy Beharry[1], Renne Reilly[1]. Old Dominion University, Norfolk, Virginia, United States[1],Virginia Institute of Marine Science, Gloucester Pt, Virginia, United States[2]

The concept that certain habitats are pivotal to ecosystem function and serve as nursery habitats is taken on faith and has been enshrined in law. While significant regional and national efforts are aimed at the restoration and conservation of essential habitats, the actual value of these protected areas to healthy, sustainable fish populations is rarely tested or quantified. In this presentation, we identify and quantify fundamental trophic processes that render different value to seagrass nursery habitats in Chesapeake Bay by measuring their effect on juvenile spotted seatrout growth. In 2007, we collected samples for stable isotope analyses from water, the prey-field, fish-stomach contents, and fish muscle throughout the period of nursery residence. Further, we measured the physical properties of overlying waters. We used these data to develop spatial and temporal "maps" of trophic structure across the five major seagrass nursery habitats of the lower Bay. There were significant differences in habitats across the Bay that resulted in differences in growth. We show the results of stable isotope analyses in comparison with those of a bioenergetics model developed for this species.

C7.3-4
Current and historic states of the trophic structure of Great South Bay, New York
Matthew Nuttall[1] (presenting), Michael Frisk[1]. [1]State University of New York Stony Brook, Stony Brook, New York, United States

The community composition of the Great South Bay ecosystem has changed dramatically from its early counterpart. In order to sample the current composition of the finfish and crustacean community of Great South Bay, New York, we conducted a survey using a 9 meter otter trawl with 5.1 cm mesh netting and 0.6 cm mesh cod end. The survey was conducted during 2006 in the spring, summer and fall. Catch composition showed that the benthic community is dominated by blue crabs, *Callinectes sapidus*, spider crabs, *Libinia emarginata*, and mud crabs, *Panopeus herbstii* comprising 35% of total catches. Historically, the benthic community was dominated by groundfish species including winter flounder. Presently, winter flounder comprises 0.5 % of the total catch. Community composition in 2006 was compared to historical data on the Great South Bay ecosystem. The abundance of crabs within the current trawl data is drastically larger than a data set obtained twenty years prior. Further, the abundance of groundfish has shown a dramatic decrease over the same time period. Catch records of summer flounder, *Paralichthys dentatus*, have decreased ten fold from commercial landings in the 1930s. Total landings of shellfish have consistently decreased since the mid-1970s, most notably the Hard Clam, *Mercenaria mercenaria*. Similar trends have been shown for other commercially important shellfish: Soft Clams, Bay Scallops, Blue Mussels, Oysters, and Conchs. Finally, we explore historic changes in the trophic structure of the Great South Bay by creating mass-balanced food-web models of current and historic periods using the software Ecopath. We explore the influence of species competition, environmental changes and anthropogenic causes of ecosystem change.

C7.3-5
Essential nutrient contribution by heterotrophic protists in the marine pelagic food webs and its ecological implications
Fu-Lin Chu[1] (presenting), Eric Lund[1], Paul Littreal[1], Kate Ruck[1]. [1]Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA United States

The importance of essential lipids as membrane components and for proper physiological functions and neural development of marine organisms is well recognized. As intermediaries, heterotrophic protists enhance the content of the long chain n-3 essential fatty acids (LCn-3EFAs), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), of low food quality algae for subsequent use at higher trophic levels. The ecological benefits and implications of essential lipid contribution by heterotrophic protists at the phytoplankton-zooplankton interface are unclear. We examined the efficiency of essential fatty acid and sterol production of several heterotrophic protists, including those isolated from the Chesapeake Bay, fed an essential fatty acid-deficient alga or an alga containing brassicasterol as the predominant sterol >80%). Our findings suggest that certain heterotrophic protists have the potential to contribute significant amounts of LCn-3EFAs to food webs and alter the DHA:EPA ratio of the diet available to higher trophic levels. The DHA production efficiency in two of the tested protists was comparable to or higher than that for three DHA producing autotrophs. Two of the tested protists appeared to have the ability to modify dietary sterols for subsequent use by higher trophic levels (e.g. copepods and larval fish). This study is supported by NSF grant OCE-0525899.

C7.3-6
Impacts of fishing and striped bass predation on Atlantic menhaden
Jim Uphoff[1] (presenting). [1]Maryland Department of Natural Resources, Fisheries Service, Stevensville, MD, United States

Atlantic menhaden support both a large fishery and striped bass population along the Atlantic Coast of the US. I examined the roles of fishing and striped bass predation on Atlantic Coast menhaden dynamics during 1964-2005. Menhaden and striped bass share similar coastal migration patterns and all ages of menhaden serve as primary prey for an expanding striped bass population. Relative abundance of menhaden was negatively correlated with indices of fishing mortality and striped bass biomass. A logistic production model of menhaden biomass with a Type-III striped bass predation function fit the menhaden index time-series better (AIC = -311, $R2 = 0.66$) than a single species Schaefer model (AIC = -224, $R2 = 0.15$, F-test $P < 0.001$). Striped bass consumption of menhaden has varied from 10-120% of harvest. Intense conservation of striped bass since the mid-1980s produced a concurrent rise in menhaden predation from 10% of harvest to levels close to harvest after 1992. Total mortality ($Z = F + M$ from bass) has exceed levels for MSY (Zmsy) during 1964-1971 (mostly due to F) and since 1994 (≈ equal F and M). Losses in excess of Zmsy were associated with low menhaden biomass (≈ 2-3 • 105 mt) while an extended period of biomass in excess of 8 • 105 mt was associated with Z below 70% of Zmsy. Estimated consumption of menhaden generated from the Type-III function compared favourably with estimates of fish consumption from published striped bass bioenergetics models.

C7.3-7

Copepod nauplius production drives recruitment in a marine fish

Martin Castonguay[1] (presenting), Stéphane Plourde[1], Dominique Robert[2], Jeffrey Runge[3], Louis Fortier[2].
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Predicting fluctuations in the recruitment of commercial marine fish remains the Holy Grail of fisheries science. In previous studies, we identified statistical relationships linking Atlantic mackerel recruitment to regional climate, zooplankton biomass and the production of copepod nauplius over a decade (1982-1991) that included the exceptionally strong year class of 1982. Here the validity of these relationships is tested by adding a second decade (1992-2003) of observations that includes another exceptional year class in 1999. Recruitment is shown to strongly depend on the production of the copepod nauplii species that contribute to the diet of mackerel larvae. Both strong year classes were characterized by exceptionally high availability of these specific prey. We further demonstrate that, in the sea, the feeding and growth of first-feeding mackerel larvae are suboptimal under a threshold density of 1 μg C· L-1 of the preferred nauplius prey. The observed dependence of recruitment on prey availability was revealed thanks to the precise identification of the prey selected by mackerel during the early larval stage. We suggest that Atlantic mackerel recruitment can be anticipated three years in advance based on prey availability during the first weeks of planktonic life, and predict a strong year class for fish hatched in 2006.

C7.3-8

Identifying links between habitat and fisheries production of white shrimp *Litopenaeus setiferus*: life stage and habitat-related mortality

Ronald Baker[1] (presenting), Tom Minello[1], Phil Levin[2]. [1]NOAA Fisheries, SEFSC, Galveston TX, United States, [2]NOAA Fisheries, NWFSC, Seattle WA, United States

The generally weak spawner stock-fishery recruitment relationship for white shrimp in the northern Gulf of Mexico suggests that environmental and habitat interactions in early life history stages are important in determining annual recruitment of this species to the fishery. To explore the effect of habitat modifications on shrimp populations, we are developing a stage-based matrix population model to examine the sensitivity of adult stock size to expected variability in mortality rates at various life stages. Field studies were conducted in Galveston Island marshes to parameterize the model. Caging experiments provided growth rate estimates of 0.83 ± 0.05 mm d-1 for juvenile white shrimp on non-vegetated bottom adjacent to the marsh edge. Repeated sampling of a population in a large marsh pond through summer and fall provided estimates of daily instantaneous mortality of post larvae (0.25) and juvenile shrimp (0.07). Field experiments will provide information on the factors controlling variability in juvenile mortality rates (predation, access to protective marsh habitats), and model projections will provide a clearer understanding of the processes and mechanisms controlling white shrimp stocks. The findings will also help to refine the EFH designation of coastal habitats.

C7.3-9

Fisheries-independent measures of variation in American lobster abundance and distribution in Northumberland Strait

John Mark Hanson[1] (presenting). [1]Fisheries & Oceans Canada, Moncton, New Brunswick, Canada

The American lobster fishery, with annual landed values near $220 million, is the backbone of many coastal communities in the southern Gulf of St. Lawrence (sGSL), Atlantic Canada. The lobster fishery is typically dependent upon incoming recruitment (exploitation > 70% per year), and current management measures are based on information collected from the commercial fishery. Unlike most other marine resources (e.g. Atlantic cod, snow crab, shrimp), there are no fisheries-independent surveys to document distribution, and to estimate fishable and spawning stock biomass, distribution, or incoming recruitment. A large-scale trawl survey for American lobster was developed for the Northumberland Strait area (8,700 km2) of the sGSL. During July-August, lobsters were mainly restricted to coastal water < 30 m deep and > 6 °C – avoiding the cold (< 1 °C) intermediate layer. The distribution of subcommercial-sized lobster differed substantially from that of larger animals but there did not appear to be a distinct nursery area. Rather, immigration from adjacent fishing areas seemed to be the primary source of recruitment to the Strait fishery. The resident population of Northumberland Strait appears to have been reduced to a remnant. The size of the area of high lobster abundance (> 400 animals/km2) varied directly with abundance estimates derived from the survey. Very large lobsters (> 125 mm CL) are too large to enter most traps and likely serve as a pool of large animals with high fecundity that are maintaining the recruitment that occurs in the sGSL populations of American lobster.

C7.3-10

Impacts of fishing on the ecosystem of the East China Sea Shelf off the coast of China

Yunkai Li[1] (presenting), Yong Chen[2], Liqiao Chen[1]. [1]East China Normal University, Shanghai, China, [2]University of Maine, Orono, United States

The ecosystem of East China Sea Shelf (ECSS) has been subject to heavy fishing for the last several decades. Limited work has been done to evaluate changes in the ECSS ecosystem. In this study we use the Ecopath with Ecosim to develop a trophic mass-

balance model to evaluate impacts of fishing on the ecosystem during the period of 1997 to 2000. The ECSS ecosystem model includes 40 functional groups corresponding to pelagic, demersal and benthic organisms, detritus, and fishery discards. Different fishing fleets are also included. The impacts of fishing are evaluated using the MTI (Mixed trophic impact) method. Results show that the functional groups can be grouped in four trophic levels (TL) with the highest levels corresponding to marine mammals and seabirds. The fishery mainly targets organisms of intermediate to low trophic levels (TL=2.94), which is consistent with the long history of human exploitation in the area. The ECSS ecosystem is dominated by the demersal species with hairtail (Trichiurus japonicus) and small yellow croaker (P. polyactis) consisting of majority of biomass in the ecosystem and landings. According to the Odum's theory of ecosystem development, the ECSS ecosystem is in a relatively low developmental stage compared with other sea shelf ecosystems. This highlights the high intensity of fishing activity in the ecosystem, and is in accordance with the general assessment of ECSS marine resources. The trawling is found to have the greatest impacts on both target and non-target species, and purse seine and longline show medium to low impacts on the ECSS ecosystem.

C7.3-11
Marine ecosystem services in Clayoquot Sound, British Columbia
Genevieve Layton-Cartier[1] (presenting), Kai Chan[1], Tania Weller[1]. [1]University of British Columbia, Vancouver, Canada

A team of researchers is assessing near-shore ecosystems in British Columbia and the services they supply. The main goal of BC Coastal Ecosystem Services (BCCES) is to improve marine management practices by providing decision makers with more complete ecological and socioeconomic information. A small-scale pilot project will focus on Clayoquot Sound, on the West Coast of Vancouver Island, which provides marine resources for commercial, recreational and traditional fisheries. Nonetheless, there is concern that fisheries for certain species are becoming less profitable economically. For example, as the sea otter (*Enhydra lutris*) population increases, the abundance of their shellfish prey will likely diminish, but there are also likely indirect positive effects of otters on invertebrates mediated by kelp-forest regeneration. The net economic impacts on local communities will hinge upon the location and extent of various activities and ecosystem components (species and also habitat types). Accordingly, in this study we represent graphically the ecosystem components and economic activities that benefit from and affect those components and associated marine ecosystem services. We analyze the spatial layers to consider zones of overlap and the amount of various populations exposed to different factors (e.g. human harvesting, otter predation). Cartographic modeling tools are used including overlay analyses and capability modeling. We speculate regarding the socioeconomic implications by considering the interdependent variables which affect marine ecosystem services in Clayoquot Sound. Ideas of management actions are discussed providing direction for the development of a dynamic human-ecosystem model to assist coastal planning.

C7.3-12
Ontogenetic, seasonal, and annual variation in lipid content and composition of Atlantic herring (*Clupea harengus*) from the Bay of Fundy, Canada
Hillary Lane[1] (presenting), Heather Koopman[1]. [1]University of North Carolina Wilmington, Wilmington, NC, United States

Atlantic herring (*Clupea harengus*) are an abundant forage fish in the Bay of Fundy and represent an important prey item for several apex predators (whales, porpoises, seals, fishes, and seabirds) in the system. In light of the considerable decline in the stock size of this species, surprisingly little is known about the nutritional value of herring and how it may vary through space and time. Previous studies have been limited by small sample sizes, restricted study areas, and less advanced techniques for quantifying nutritional value. Using total lipid content and composition proxies for nutritional value, we evaluated seasonal, inter-annual, spatial, and ontogenetic variation in the fat content and composition of Atlantic herring We detected considerable variability between years in lipid content and composition of herring from the Bay of Fundy during 2005 and 2006. Fish from 2005 had significantly lower average total lipid content than fish from 2006 ($p < 0.001$). Within each year, ontogeny appeared to be the most important factor in determining lipid content, with larger fish yielding higher lipid concentrations. Fatty acid composition also varied with fish length, with higher levels of omega-3 fatty acids in small fish and more monounsaturated fatty acids in large fish. This change in fatty acid signature most likely reflects a change in diet as herring grow towards maturity. However, no spatial differences were detected in the data, indicating that population structure and variability within the Bay is not detectable with these methods. The data from this study provide evidence of variability in the nutritional value of Bay of Fundy Atlantic herring and can be used to determine harvesting strategies that will have the lowest impact on the population energetically.

C7.3-13
Evaluation of closed areas: Cashes Ledge as juvenile cod habitat
Jonathan Grabowski[1] (presenting), Julien Gaudette[1], Tom Weber[2], Christopher McGonigle[3], Robert Steneck[4]. [1]Gulf of Maine Research Instittue, Portland, Maine, United States, [2]University of New Hampshire, Durham, NH, United States, [3]University of Ulster, Northern Ireland, Ireland, [4]University of Maine, Orono, Maine, United States

The effectiveness of fisheries management is limited by the paucity of information on how management tools, such as marine protected areas, impact key fisheries species. In the Gulf of Maine, more information is needed to determine how marine protected areas including the Cashes Ledge Closure Area influence fish population dynamics and subsequently the status of fishery stocks.

We conducted seasonal surveys in 2006 and 2007 on the kelp, barren cobble, and mud habitats in the vicinity of Cashes Ledge using video, trap, and gill net sampling to quantify how habitat influences the abundance and distribution of Atlantic cod, *Gadus morhua*. Seasonal surveys identified that cod are still abundant on Cashes Ledge, and that their spatial and temporal distribution is influenced by habitat as well as by other species on Cashes Ledge such as spiny dogfish, Squalus acanthius. These results are being compared with historic cod datasets that were collected prior to the inception of the closure, and predate extensive harvesting on Cashes Ledge in the early 1990's, to determine if cod populations have recovered locally. Quantifying important ecosystem functions such as the provision of nursery habitat for commercially important fish species will assist managers in selecting the most appropriate areas for management action. This study will also provide baseline information that will be of value to ongoing efforts to monitor the impact of the Cashes Ledge Closure Area on rebuilding cod populations throughout the Gulf of Maine.

C7.3-14
Stable isotopes and gut content analysis reveal contributions of riverine invertebrates and organic matter in two Caribbean Island riverine estuaries
Katherine Smith[1] (presenting), Zoe Rodriguez del Rey[1], Merryl Alber[1], Cathy Pringle[1]. [1]National Marine Fisheries Service, Silver Spring, MD, United States

The contribution of riverine-derived organisms and organic matter to four fishes along the salinity gradient in two Puerto Rican estuaries, the Espiritu Santo and Mameyes, was examined via stable isotope and gut content analyses. Stable isotope analyses indicated that riverine organic matter potentially contributed as much as 69% of the diet of a benthic fish, caitipa mojarra (*Diapterus rhombeus*). In contrast, riverine organic matter was of little direct importance to two pelagic fishes, tarpon snook (*Centropomus pectinatus*) and ground croaker (*Bairdiella ronchus*), a benthic fish, white mullet (*Mugil curema*), and migratory diadromous freshwater shrimps (*Atya lanipes, xiphocaris elongata*, and *Macrobrachuim* spp.) contributing less than a third of their assimilated material even in the estuaries' upper reaches. Gut content analysis of estuarine fishes demonstrated that several species of pelagic or omnivorous fish consume riverine-derived organisms, specifically juvenile freshwater shrimps, during their residence in the estuary. Freshwater shrimps were frequently encountered (in 37 and 39% of guts examined) and composed an average of 18 and 22% of gut content material of omnivorous fishes sampled in the Espiritu Santo and Mameyes estuaries, respectively. To our knowledge, this is the first study to examine the contribution of riverine subsidies to a Caribbean island estuary. Given increasing demand for water resources on tropical islands and the importance of diadromy in these systems, there is a need for additional research on this topic to better inform water management decisions.

C7.3-15
The lionfish invasion: biological and ecological profiles of a successful marine invader in the Atlantic
James A. Morris, Jr.[1] (presenting). [1]NOAA National Ocean Service, Beaufort, NC, United States

The Indo-Pacific lionfishes, *Pterois volitans* and *Pterois miles*, are now established in the Atlantic from Cape Hatteras, North Carolina to the Caribbean. Since the first documented introduction of lionfish in 1992, the distribution and densities of lionfish in the Atlantic have rapidly increased. Prior to the introduction of lionfish, few studies have documented the biology and ecology of these species. The objectives of this study were to describe the reproductive biology, feeding habits, and venomology of lionfish using laboratory and field observations off North Carolina and the Bahamas. Observations of lionfish gonads reveal that lionfish are iteroparous, asynchronous, indeterminate batch spawners with each egg batch comprised of two buoyant gelatinous egg balls. Spawning periodicity measurements indicate that lionfish are spawning monthly with spawning events occurring during most months of the calendar year. Laboratory experiments designed to investigate predation on juvenile lionfish indicate that some native reef fishes avoid the lionfish as prey, likely due to their venom defence. Lionfish stomach content analyses reveal that lionfish are preying primarily on crustaceans and small reef fishes, but also some economically important snapper and grouper species. Tagging efforts indicate that lionfish exhibit site fidelity suggesting that local control at some locations, such as marine sanctuaries, may be a viable management strategy for controlling the impacts of this invader. These efforts are providing new insight regarding the integrated biology and ecology of the non-native lionfish and further demonstrate the need for aggressive early detection and rapid response efforts in the marine environment.

C7.3-16
Catch of red grouper (*Epinephelus mori*) from the bottom longline fishery in waters off the coast of Florida
Loraine Hale[1] (presenting), Lisa Hollensead[1], John Carlson[1]. [1]NOAA Fisheries Service, Panama City, FL, United States

The bottom longline fishery is active in the Atlantic Ocean from about the Mid-Atlantic Bight to south Florida and throughout the Gulf of Mexico. An observer program has monitored this fishery since 1994 to observe catch and bycatch on these vessels; however, observer coverage has historically focused on vessels targeting shark. With the recent closures of the shark fishery and growing concerns of shark bycatch in non-shark targeted sets, observer coverage has been extended to cover any vessel fishing with bottom longline gear, regardless of target. Since July 2005, observers covered 11 trips and 213 hauls targeting reef fish (primarily grouper and snapper). Data collected include size and disposition of catch. Biological and meristic data are also collected from a random subsample of the catch. Haul characteristics and catch frequencies for red grouper (*Epinephelus mori*) in Florida waters (both Gulf of Mexico and South Atlantic) are of particular interest, since red grouper is the main target for many of these vessels and is the major component of the shallow water reef fish fishery. Red grouper catch data will be compared to haul characteristics such as location, depth, and hook type and at-sea mortality will be examined. Future observations of reef fish targeting bottom longline vessels will continue to provide essential at-sea fishery dependent samples and data for stock assessment on many different species of reef fish.

C7-P-2
Spatial variations in elemental otolith elemental fingerprints for two reef fish species in nearshore nursery habitats in St. Croix (USVI) and Puerto Rico
Ivan Mateo[1] (presenting), Edward Durbin[1], Richard Appeldoorn[1], Aaron Adams[1]. [1]University Rhode Island, Kingston, United States Minor Outlying Islands

Many coastal fish species have juvenile and adult life stages that occupy spatially separated habitats. The juveniles often recruit to nearshore habitats where they reside for months to years before migrating to offshore adult habitats. Juveniles of many species recruit to more than one type of nearshore habitat (mangrove, seagrass, reefs, rubble). Determining which juvenile habitats are functioning as nurseries is important to understand the ecological roles of different habitats. This study investigates the utility of naturally occurring tags to determine habitat linkages in seagrass and mangrove habitats by juvenile French grunt and schoolmaster. This is an initial crucial step to quantify the relative contribution of mangrove and seagrass habitat for French grunt and schoolmaster adult populations. YOY fish were collected around mangrove and seagrass habitats in St. Croix and Puerto Rico during summer 2006. Trace elements concentrations were determined at discrete regions of YOY otoliths re(presenting) the post-settlement period (30-60 days) using laser ablation inductively coupled plasma mass spectrometry. Significant differences in concentrations of several trace metals were found for both species in mangrove and seagrass habitats using ANOVA and MANOVA. Discriminant analysis classified otoliths fingerprints between mangroves and seagrass habitats with 86% of accuracy for both species.

C7-P-3
A trophic analysis for hairtail, *Trichiurus japonicus*, during feeding migration in the East-China Sea
Yong Liu[1] (presenting), Jiahua Cheng[1], Yong Chen[2]. [1]Key and Open Laboratory of Marine and Estuarine Fisheries Certificated by the Ministry of Agriculture, East China Sea Fisheries Institute, Chinese Academy of Fishery Sciences, Shanghai, China, [2]School of Marine Sciences, University of Maine, Orono, Maine, United States

Hairtail (*Trichiurus japonicus*) supports one of the most valuable and largest fisheries in the East China Sea. As one of the top predators, it plays an important role in the ecosystem. Studying the prey composition of hairtail can allow us to have a better understanding of trophic dynamics of the ecosystem in the East China Sea. In this study, we analyze hairtail stomach samples collected on its feeding grounds from a fisheries-independent survey program in September 2005. Our analyses suggest that females in their 3rd maturity stage tended to feed more intensively. Fish were the most important preys for hairtail, accounting for 72.6% of the total stomach contents in weight. The most important 4 fish species were juvenile hairtail (25.2%), Japanese scad (11.4%), Japanese jack mackerel (7.73%), and small yellow croaker (5.91%), suggesting strong cannibalism. A cluster analysis suggests that hairtail can be divided into 3 groups based on their diets: one group with similar percentages of fish and crustacean preys mainly distributed in the south of East-China Sea far from the coast; one group mainly consuming fish and distributed over the north of East-China Sea near the coast; and the third group consuming mainly crustacean species mainly distributed in the open sea. Such differences in prey compositions should be considered in developing an ecosystem-based fisheries management in the East China Sea.

C7-P-4
Differential niche utilization and ontogenetic shifts in the feeding habits of the Barndoor skate on Georges Bank
Todd Gedamke[1] (presenting), William D. DuPaul[2], John A. Musick[2], Joseph D. Schmitt[1]. [1]NMFS, Miami, FL, United States, [2]Virginia Institute of Marine Science, Gloucester Point, VA, United States, [3]Christopher Newport University, Newport News, VA, United States

An examination of the stomach contents of the barndoor skate (*Dipturus laevis*) was conducted on 273 individuals caught as bycatch in the commercial scallop fishery on Georges Bank. To study ontogenetic shifts in prey selection, a length specific analysis was conducted by calculating the mean percent weight in each stomach and then averaging these values over 10 cm length bins. A total of 31 prey items were identified with the diet dominated by sand shrimp (*Crangon septemspinosa*), the rock crab (*Cancer irroratus*), the Acadian hermit crab (*Pagurus acadianus*) and teleost fish. The length specific analysis revealed that small juveniles were specialized feeders foraging solely on caridean shrimp. With increased size, the barndoor skate began feeding on the rock crab, and at slightly greater lengths the diet began to include the Acadian hermit crab. In the larger sized individuals the prevalence of teleost fish began to increase. Sex specific differences in food habits were observed in mature animals (>105cm) with males feeding primarily on teleost fish (~80%) whereas females maintained a diet of approximately equal amounts of fish and crustaceans. Sex specific feeding patterns and differential food niche utilization may be mitigated by sexually dimorphic dentition.

C7-P-5

Predation by sub-adult red drum (*Sciaenops ocellatus*) on juvenile blue crabs (*Callinectes sapidus*): estimation of daily ration and seasonal variation in the contribution of blue crab to the diet.

Joseph Facendola[1] (presenting), Frederick Scharf[1]. [1]University of North Carolina, Wilmington, North Carolina, United States

Physical processes have been identified as affecting the number of blue crab larvae settling into appropriate estuarine nursery habitats, and implicated in the regulation of initial year class strength. However, biotic interactions such as predation may significantly modify the initial patterns of larval supply and shape population structure. The red drum has been identified as a consistent and important predator of blue crabs throughout its range, yet the contribution of blue crabs to their diet has not been quantified. Using a combined field and laboratory approach, we are attempting to quantify seasonal and ontogenetic variation in diet composition, diel variation in gut fullness, and daily consumption rates of red drum in a large southeastern North Carolina estuary. To date, one year (May — Dec 2007) of sampling has been completed. Prey items were retrieved from 76% of all fish sampled, with Callinectes spp. occurring in 23%, and blue crab occurring in 17% of all guts containing food items. Other dominant prey items include, Penaeid shrimp (Penaeus spp.), white and striped mullet (Mugil spp.), and Atlantic menhaden (*Brevoortia tyrannus*). Diel sampling illustrated variable diurnal feeding patterns and identified several periods of declining gut fullness that will be used to calculate gastric evacuation rate in the field. Laboratory experiments to validate field observations are ongoing and include a series of trials to investigate the effects of body size, prey type, and water temperature on gastric evacuation rates. Size-based diet information will help to discern crab life stages that are most heavily impacted by red drum predation, and ultimately lead to estimates of red drum consumption rate that will enable the fraction of blue crab natural mortality due to predation to be determined.

C7-P-6

Development of coring methods to extract nursery signatures from red snapper otoliths

Beverly Barnett[1] (presenting), William Patterson, III[2]. [1]National Marine Fisheries Service, Panama City, FL, United States, [2] University of West Florida, Pensacola, FL, United States

We tested whether stable isotope (δ13C and δ18O) delta values or elemental ratios (Ba:Ca, Li:Ca, Mg:Ca, Mn:Ca, Pb:Ca, and Sr:Ca) of red snapper otoliths were significantly different between left and right otoliths, and whether coring affected chemical signatures. Pulverizing otoliths did not contaminate elemental signatures (MANOVA, $p = 0.958$; all ANOVAs of individual element:Ca ratios, $p > 0.464$). Coring did not produce a significant difference on elemental signatures (MANOVA, $p = 0.095$). Mn:Ca did show a significant difference between whole right and left otolith cores (ANOVA, $p = 0.033$), with the difference being driven by one outlying value. Coring significantly affected stable isotope signatures between pulverized whole right and pulverized left otolith cores (MANOVA, $p = 0.03$). That result was driven by slightly higher δ13C values in the otolith cores (ANOVA, $p = 0.024$). Significant differences in δ13C values between whole otoliths and otolith cores likely resulted from ontogenetic shifts in diet not fully captured with our initial coring technique. However, analysis of residuals resulted in no statistical difference in δ13C values between whole otoliths and otolith cores. Coring experiments support applying core chemical signatures as nursery tags since cores removed from thin sections reflected chemical signatures recorded in whole otoliths.

C7-P-7

Strong pulses production of catarina scallop (*Argopecten ventricosus*) fishery, under numerical modelling scenarios in a coastal lagoon system

Veronica Morales-Zarate[1] (presenting), Salvador Lluch-Cota[1], [1]Alfonso Maeda-Martinez[1], Francisco Werner[2]. Centro de Investigaciones Biologicas del Noroeste, La Paz, Mexico, [2]Department of Marine Sciences, University of North Carolina, North Carolina, United States

Natural beds of some sea scallop populations have shown strong abundance pulses in different regions of the world. In Bahia Magdalena, Mexico, catarina scallop *Argopecten ventricosus* (Sowerby II, 1842) pulses are thought to be related to abnormally high recruitment resulting from particular combination of successful spawning or importation of drifting larvae from another systems (open ocean shelf), availability of settlement substrata (mainly seagrass), low predation pressure, low temperature, and a larval drift pattern synchronizing all factors. Direct in field quantification is basically impossible due to the lack of observations of ocean currents and distribution of the spawners (particularly in the continental shelf). This work is aimed at exploring potential mechanisms and scenarios of successful recruitment through the simulation of larval drift during different wind conditions and temperatures. We describe circulation and passive particle transport in the Magdalena-Almejas Bay lagoon system through a linear circulation model in the frequency domain to obtain basic flux fields. The model is forced by tides, residual tides, mean wind speed, periodic winds (to simulate sea breeze), and an approximation of advection in the California Current. Our results show that particles seeded within the system tend to remain inside and concentrate in restricted areas that correspond to the real distribution of the catarina scallop banks. Also we found that only rare conditions of wind result in abnormal intrusion of particles from the shelf into the bay. In the 12-years period for which we have wind, temperature and catch records, abundance pulses have occurred two times (1989-1990 and 1995-1996), both corresponding to occurrence of the particular wind conditions and adequate temperatures, while a

third period of proper wind conditions (1992-1993) did not corresponded to abundance pulse, likely because strong positive temperature anomalies (ENSO conditions) far exceeded the estimated optimum temperature range. Pulse-like variations must be further investigated since they can drive strong social and economic problems at the regional level.

C7-P-8

Recruitment dynamics of gray snapper (*Lutjanus griseus*) among West Florida estuaries

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Many of Florida's economically important fish species depend on coastal estuaries for growth and survival as juveniles before moving offshore, connecting nearshore and offshore productivity. Gray snapper typify this pattern of estuarine-dependency, relying on mangroves and seagrass beds during early life. We examined gray snapper recruitment potential from coastal systems amoung four regions along the west Florida shelf in an effort to link habitat with recruitment. Juvenile snapper (n = 324) were sampled with a 6.1-m otter trawl and a 21.3-m center bag seine using a stratified random sampling protocol from August through December in 2006. Juvenile density was significantly different amoung sampling regions and habitat types (ANOVA, $p < 0.01$). Daily fish age was estimated from opaque zones in lapilli. Growth functions computed from size-at-age data were significant amoung regions (ANCOVA test for slopes, $p < 0.001$). Results suggest region-specific differences in recruitment potential exist among estuarine and coastal systems along the west Florida shelf. Ageing results from 2007 sampling and modeling of interannual differences in growth and mortality rates will be presented. We also will examine otolith element and stable isotope signatures amoung regions in an effort to link inshore recruitment with eventual recruitment to adult populations offshore.

C7-P-9

Improving the accuracy of maturity staging in black sea bass (*Centropristis striata*)

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Macroscopic assessment of gonads is rapid and relatively easy to conduct in the field but is only rarely validated with histology, introducing a large potential for error in maturity staging and sex determination. We present a species-specific key of maturity stages for the protogynous hermaphrodite species black sea bass (*Centropristis striata*; Serranidae) having defined sex and maturity stages with histological characteristics. We then identified macroscopic characteristics corresponding to these stages using digital photographs of whole gonads. Perhaps more importantly, we identified characteristics that corresponded to multiple stages and, thus, have limited value in assigning maturity. Using a set of test photographs spanning the entire range of maturity stages for both sexes we found that technicians using the species-specific key were able to correctly assign individuals to maturity stages in most instances. The rate of correct assignment to maturity stage was highest in active spawning stages and lowest in immature and resting stages. The rate of correct assignment to sex was also highest in active spawning stages and lowest in immature and transitional stages. While we emphasize that histological techniques are still superior for assigning sex and maturity, we have demonstrated how this key can be used to improve the accuracy of macroscopic staging and thus is very valuable for field studies of black sea bass.

C7-P-10

Preliminary analysis on feeding habits of lancelet at Naozhou Island Sea Area of Zhanjiang, China

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In this paper, the stomach contents of lancelet are observed and analyzed according to different seasons, genders and body length group. The samples were caught by the Executive Lancelets Gather with 0.075m2 cross-sectional area at Naozhou Island Sea Area of Zhanjiang City from April to July, 2006. Results show that mainly food residue in alimentary canal of Naozhou Island Sea Area lancelet are mud and sand debris, and about 34 species of creatures can be identified. Most of them are benthic diatom, at a percentage of 58.8%, including a few dinophyta, lamellibranch larva, copepods larva and protozoa, etc. The feeding habits of lancelet were not the same in different quarters, and the occurrence of its food organisms is also different in different seasons. The feeding habits of lancelets are similar between different genders. The lancelets begin to take animal food when they are mature.

C8. Human Dimensions

C8-1

Shad memories, unforgotten spring on the Susquehanna River

Amy Roe[1] (presenting). [1]University of Delaware, Newark, DE, United States

Anadromous fish species on the east coast of the United States, including the American Shad of the Susquehanna River, have experienced intensive extraction by community-based and commercial fishers in estuarine environments and inland rivers. As a result of over-fishing, dam construction which blockaded spawning rivers, and other physical changes to watersheds, many of these species are in such depleted numbers that they are no longer commercially viable. This paper presents an interdisciplinary approach to fishing, which emphasizes aesthetic media and narrative, to understand the important historical role of fishing and fishery conservation in the mid-Atlantic. Shad fishing on the Susquehanna River, represented through art, poetry and literature, when juxtaposed with historical analysis of fishing sustainability and species decline in the Susquehanna River Basin in Maryland and Pennsylvania, reveal social attitudes towards resource extraction and depletion.As collapse threatens many fisheries, the memories of the American Shad on the Susquehanna River beckon the integration of social science and humanities in the scientific effort to protect and restore global fisheries.

C8-2
Status of human dimensions information collection and utilization by fisheries management agencies
Jody Simoes[1] (presenting), Frank Lupi[1], Dan Hayes[1], Aaron McCright[1]. [1]Michigan State University, East Lansing, Michigan, United States

An assessment of the collection and application of human dimensions (HD) information by North American fisheries management agencies was conducted by Wilde et al (1996). We have updated and expanded Wilde's study to document the current status of HD information management within fisheries management agencies. We conducted a nationwide survey of fisheries management agencies via semi-structured telephone interviews with key agency personnel. Both closed and open-ended questions were used to capture data on respondent experience, survey frequency, staffing, partnerships and opinions of HD data quality, utilization and importance to decision making. Most respondents indicated that angler HD information was collected annually, either through local creel surveys or statewide angler surveys. They rated the quality and utilization of their angler HD data between fair and good. While most respondents ranked issues such as access, budgets and declining participation as very important or extremely important for their state's fishery, information on angler demographics, opinions and motivations, and general public opinions, were only ranked as moderately important to current fisheries management decision-making. Our findings provide a characterization of the collection and application of HD information to fisheries management, and highlight the diversity of opinions about the role and importance of HD information.

C8-3
What types of fishing opportunities are anglers looking for: Can New York provide those opportunities?
Nancy Connelly[1] (presenting), Shaun Keeler[2], Tommy Brown[1], Steve Hurst[2]. [1]Cornell University, Ithaca, NY, United States, [2]New York State Department of Environmental Conservation, Albany, NY, United States

For more than 35 years the New York State Bureau of Fisheries has been conducting statewide angler surveys about every ten years to learn more about angler participation, preferences, and satisfaction. The goal of these efforts has been to aid the Bureau's mission in a manner that is responsive to the needs and desires of anglers. The latest angler survey was conducted by Cornell University's Human Dimensions Research Unit with 51,000 anglers spanning three time periods in 2007. As an example of how the findings of this large survey might be used by the Bureau, we have analyzed angler preferences for different characteristics of the fishing location (e.g. place where there is a good chance to catch fish, place that is not crowded, place that is close to home) and compared that with preferences for different types of waters available in New York (e.g. inland trout streams, back country Adirondack Ponds, Lake Ontario). The results can serve as input for discussion on the allocation of management resources.

C8-4
A comparison of anglers in urban communities: do urban fishing program anglers differ?
Clifford Hutt[1] (presenting), Wes Neal[1]. [1]Aquaculture and Fisheries Center at UAPB, Little Rock, AR United States

Declines in recreational fishing participation, and increased urban immigration and sprawl have prompted the development of urban fishing programs. These programs are designed to provide fishing opportunities close to home for urban residents with limited time for recreational pursuits, and to provide urban youths with an opportunity to be exposed to fishing. The Arkansas Game and Fish Commission established the Family and Community Fishing Program (FCFP) to serve this purpose. Fisheries managers may be better equipped to meet angler needs if they understand why people fish and their preferences concerning the fishing experience. We conducted a mail survey of randomly selected licensed anglers (N = 5,000) that lived within five miles of ten FCFP ponds. Ponds were selected based on three criteria: [1] the pond had been in the FCFP for at least three years,[2] the pond was stocked at least six months a year, and[3] the pond was open to fishing for anglers of all ages. Questionnaires collected data on angling behavior, motivations, preferences, satisfaction, and demographics. Respondents were divided based on the percentage of their fishing trips in the previous year that were spent on FCFP ponds. Comparisons were made between anglers that primarily fished FCFP ponds and those that primarily fished more traditional fisheries. This information will allow fisheries managers to better address the needs of their urban constituents, and provide a more precise picture of FCFP participants.

C8-5

Going beyond fishing clinics and developing aquatic stewards

Steve Marshall[1] (presenting), Rae Waddell[1], Tony Fedler[2]. [1]Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, United States, [2] Human Dimensions Consulting, Gainesville, Florida, United States

Thousands of educational fishing programs have been conducted without evaluating their effectiveness. For fish managers and educators, the question still remains, "Are we creating more anglers?" More importantly, as resource managers, "Are we creating anglers that are better stewards of aquatic habitats?" Florida Fish and Wildlife Conservation Commission biologists evaluated the fishing activity and environmental attitudes of students following participation in the Joe Budd Summer Fish Camp to address these questions. The study's objectives were to determine if attending fish camp enhanced long-term fishing participation and awareness of and importance of protecting aquatic resources. Findings were based on a 19 question survey received from 260 (75.1%) campers that had participated in at least one week of Camp from 2000 through 2006. Participants in a school based fishing program (N=258) were used as a comparison group. Eighty-five percent of campers with no previous fishing experience continued to fish each year after attending Camp. Analyses showed Camp participation established fishing as a valued leisure activity. Campers rated all aquatic concern statements as more important to them than the Comparison Group did. Results showed that a week-long program moved users toward becoming life-long anglers who care about and support healthy aquatic systems.

C8-7

Human dimensions of managing muskellunge in Minnesota

David Fulton[1], Sue Schroeder[1], Robert Dodd[1] (presenting). [1]The University of Minnesota- Twin Cities, Minneapolis and St. Paul, MN, United States

A mail-out survey was distributed to three strata of Minnesota anglers to study muskie angling preferences and behaviour in Minnesota. Respondents were compared using chi-squared analysis, t-test, and cross-tabulations. Strength of association or dependency between two categorical variables was measured using Cramer's V statistic. Sociodemographics, motivations, preferred experiences, use histories, satisfaction levels, and management and regulatory preferences were characterized and compared between two groups of muskie anglers: those who did belong to a muskie club (Muskies Inc.) and those who did not. Attitudes and beliefs of muskie and non-muskie anglers were examined and compared. Results indicate significant differences between angling groups. Muskie Inc. members reported greater satisfaction with the overall fishing experience compared to other muskie anglers. Non-muskie anglers were 1) less satisfied with number of fish caught, 2) more satisfied with angler behaviour compared to muskie anglers 3) neutral about expanding muskie angling opportunities in MN 4) less supportive of restrictive regulations in muskie fishing. Respondents differed significantly in 13 of 15 beliefs relating to muskie and their effect on other fisheries. Between muskie angler strata there was no significant difference in what defined a successful day of muskie fishing. Muskie anglers defined a trophy-sized muskie to be smaller than Muskies Inc. members. Differences in motivations for muskie angling were reported. Overall, Minnesota muskie anglers and Muskies Inc. members fish more days than non-muskie anglers for muskie and for other types of game fish. They have substantial financial investments in angling, and they are generally satisfied with their angling experiences in the state. Muskie anglers largely practice catch-and-release fishing and they support more restrictive regulations for muskie.

C8-8

Partnering with stakeholders to ensure sustainable freshwater fisheries in Florida

Dennis Renfro[1] (presenting). [1]Florida Fish and Wildlife Conservation Commission, Eustis Research Lab, Eustis, Florida, United States

Florida Fish and Wildlife Conservation Commission staff developed a three-phase strategic process that incorporated stakeholder input to address the challenges confronting the future of freshwater fisheries in Florida. Phase one of the program incorporated the design and implementation of an online survey available statewide to stakeholders. This allowed stakeholders to provide staff with priority issues and information about participating in future summit meetings. Phase two consisted of conducting six Zone Summit meetings throughout the state, with locations identified by the online survey and taking into consideration the state's major resources. These interactive summits allowed stakeholders to present current and future issues to staff and to create a dialogue with the agency. The mission statement for the summits was: To develop a group of key stakeholders, document the most important fisheries issues by geographical and resource areas, inform stakeholders of those issues, and plan for long-term involvement with stakeholders. Phase three involved inviting key stakeholders re(presenting) major fishing organizations, resource organizations, fishing industries and media representatives to participate in a professionally facilitated freshwater fisheries Roundtable. By combining information derived from 1,500 online survey responses, 92 stakeholders attending the six Zone Summits, and 19 stakeholders convening at the Roundtable meeting, the Commission developed a list of the top five issues facing Florida's freshwater fisheries resources. The issues are, in order of importance: habitat issues, human dimensions, angler access, regulation management and non-native fishes. This strategy successfully accomplished the vision of expanding partnerships with stakeholders and identifying specific issues to assist the agency in implementing management plans to protect and preserve Florida's freshwater fisheries and status as the Fishing Capital of the World.

C8-9

Coastal CURA: supporting maritimes fishing communities engaging in coastal management

Anthony Charles[1] (presenting). [1]Saint Mary's University, Halifax, N.S. Canada

Fishing communities are facing many environmental, economic and social challenges. The Coastal CURA is a Community University Research Alliance working to help meet these challenges by providing support for the involvement of fishery organizations and First Nations in coastal management initiatives that are shaping their social and economic well-being. The Coastal CURA has eight partners spread across the Canadian Maritimes, including two universities – Saint Mary's University and the University of New Brunswick – and six community partners. The community partners include two fishing organizations (Fundy Fixed Gear Council, and Fundy North Inshore Fishermen's Association) and four First Nations partners (Acadia, Bear River, Lennox Island and Abegweit, the latter two forming the Mi'kmaq Confederacy of PEI) as well as a regional organization, the Bay of Fundy Marine Resource Centre. The Coastal CURA is designed to provide knowledge and understanding, improve analytical and evaluative tools, and strengthen organizational and institutional capacity for sustainable management of coastal resources in the Maritimes and beyond. The work begins with reflection and evaluation of past experiences, to provide valuable knowledge and insights that can be shared with communities, governments and others. This leads into a second stage of the work that focuses on studying and supporting place-based initiatives concerned with managing coastal areas across the Maritimes. The information obtained by the Coastal CURA is being disseminated through our website (www.coastalcura.ca), as well as a range of documents and videos.

C8-10

Mercury contamination in the Adirondacks: Science-based decision making about fish consumption

Hannah Shayler[1] (presenting), Clifford Kraft[1]. [1]Cornell University, Ithaca, NY, United States

Mercury contamination poses a known threat to human and ecosystem health, yet the degree of contamination and resulting human exposure remains unknown in many regions. Information about fish consumption behaviors and the mercury levels in fish consumed is essential for developing effective and targeted risk communication programs. This research builds upon ongoing assessments of mercury contamination in New York State waters by linking existing fish mercury data to humans. High mercury concentrations measured in fish from Adirondack waters – including sport fish harvested and prized by anglers – indicate an important water quality issue. We will gain a more comprehensive perspective of how mercury contamination affects Adirondack communities by quantifying historical angling catch records, surveying fish consumption by anglers and their families, testing hair samples from community volunteers, and estimating exposure using a mercury toxicity model. The findings from this study will inform our understanding of:[1] the influence of the availability and communication of mercury data on decision making about fish consumption, and[2] how data collection and communication efforts can better foster informed decision making about fish consumption.

C8-P-1

Fostering communication and relationships with key organizations yields positive results for fisheries projects

Brian Dresser[1] (presenting). [1]Shaw Environmental, Inc. Salem, NH, United States

Implementing fisheries research projects often involves coordination between the project team and other organizations re(presenting) diverse backgrounds, interests, and agendas. Success on fisheries projects may be measured differently, depending on the perspective of each organization. A pro-active approach to communicating the needs of all stakeholders to the project is critical to the successful implementation of any research or monitoring program. Examples are presented where this approach has resulted in positive benefits to the fisheries program, and how challenges were resolved. Some specific examples addressed include; the sharing of research data; the potential impact of an activity on threatened or endangered species; coordination with Homeland Security agencies for gaining access to sampling sites within restricted areas; utilizing the knowledge of academic researchers and their undergraduate field & lab assistants; and, access to data and grey literature that may not be readily available in the public domain.

C8-P-2

Behaviours and knowledge regarding aquatic invasive species: lessons from Lake Champlain boaters and tournament anglers

Mark Malchoff[1] (presenting), Meg Modley[2]. [1]SUNY Plattsburgh, Plattsburgh, NY, United States, [2]Lake Champlain Basin Program, Grand Isle, VT, United States

Numerous aquatic invasive species (AIS) vectors have been implicated in the spread of AIS in North America. While numerous outreach efforts and national campaigns have been directed at this spread prevention issue, little information exists which might document AIS knowledge status, behaviour and travel patterns of Lake Champlain boaters and anglers. Two preliminary data sets were analyzed to elucidate such behaviours and skills relative to AIS. During the period July-August 2007, part-time boat ramp

AIS stewards were deployed at four boat ramps in Vermont and New York. In September 2007, we also surveyed professional bass anglers at two Plattsburgh, NY-based tournaments. Boat ramp stewards documented numerous occurrences of plant material transport into/out of Lake Champlain, with no vegetation removal behaviours observed. This behaviour pattern suggests that large numbers of recreational boaters are still unaware of the threat posed by AIS transport. Similarly, 86 percent of the professional bass anglers indicated that their knowledge of AIS issues had increased following a slide lecture on current/future AIS threats to Lake Champlain. This knowledge increase was unexpected given the expertise of anglers competing for prizes in excess of $100K. In total, 28 different water bodies re(presenting) 11 states had been visited by these anglers (and their boats) immediately prior to the tournament. Vessel time out of water ranged from <24 hours to >5days. Mean time out of water equalled 5.4 days. The cumulative level of risk of AIS introduction via this cross-watershed transport activity would seem to warrant greater attention by both educators and regulators.

C8-P-3

Evaluation of consumer choices on spinner dolphin excursions and the implications on spinner dolphin conservation

Minling Pan[1] (presenting), Katya Boehle[1], Linda Cox[1], Wuyang Hu[1]. NOAA Fisheries, Honolulu, Hawaii, United States[1],University of Kentucky, Honolulu, Hawaii, United States[2],University of Hawai‘i at Manoa, Honolulu, Hawaii, United States[3],

Different types of wild dolphin excursions, particularly those that are in close proximity to dolphins may impact them in various degrees. This study investigated the supply and demand of different types of wild dolphin excursions in Hawaii. Using conjoint analysis, this study examined tourist/consumer's willingness to pay (WTP) for wild dolphin excursions in Hawaii based on the implied marginal values of various characteristics associated with excursions. The study found that ‘a guarantee to see a dolphin’ and proximity to dolphins, such as swimming with them or viewing them from a boat are important factors in the tourist/consumer's decision to take an excursion. Also, the study found the demand for interactive dolphin excursions was high because the marginal value of ‘swimming with the dolphins’ is substantial. However, the marginal value of other factors, such as ‘a guarantee to see a dolphin’, ‘a particular boat type’ like a catamaran, or ‘smaller boat size’, is even higher. As these excursions may adversely affect the dolphins, policy makers are considering regulations to protect the wild spinner dolphins in Hawaii's waters. The study's findings enhance the understanding of the effectiveness and the economic impacts of possible regulations of the industry.

C8-P-4

Predicting angler behaviours with an agent-based model: a case of the landscape fisheries model

Len Hunt[1] (presenting), Rob Kushneriuk[1], Nigel Lester[1]. Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada[1],Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada[2],Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada[3],

Understanding angler behaviours is an essential part of recreational fisheries management. Angler behaviours include a complex set of decisions that affect how often, when, and where fishing trips will occur. Understanding parts of these complicated decisions can help managers and others understand the implications of change (e.g. regulations, climate, fish populations) on angling effort at site and landscape scales. We present a virtual world model of recreational fishing that simulates the social and environmental conditions in northwestern Ontario, Canada. The virtual world consists of GIS-based data that describe the locations and characteristics of lakes and rivers, roads, access points, and hometowns along with information about regulations, weather, and calendar events like statutory holidays. This world is populated with artificial agents that represent resident recreational anglers from the different hometowns. The participation, trip type and site choice decisions of agents are determined from probabilistic models that are consistent with random utility theory. Information from angling diaries conducted with resident anglers allowed us to estimate these site choice and participation choice models. Site choice decisions are influenced by fish species presence and expected catch, road distance and quality, water body size, boat launch, accessibility, and development. Participation choice decisions are influenced by day of week, holidays, culturally significant times, and the quality of fishing opportunities at the sites. Users of the model can alter the virtual world in many ways to evaluate the potential effects of change on angler behaviours. We will demonstrate the model during the formal poster session.

C8-P-5

The challenges of developing a CARICOM fisheries agreement

John Duff[1] (presenting), Tricia Lovell[2]. [1]EEOS Dept. - UMass/Boston, Boston, MA, United States, [2] Fisheries Division, Antigua, Antigua and Barbuda

As coastal states claim extended Exclusive Economic Zones in accordance with principles codified in the United Nations Convention on the Law of the Sea, vast areas of the world's fishing areas that had previously been open to all are effectively closed to activities and individuals of other states. For the countries of the Caribbean region, the extension of maritime claims has displaced some fishing communities that had previously fished freely in the waters beyond the prior and narrower territorial sea limits.This paper examines the implications of coastal state EEZ claims in the context of state practices in the Caribbean region. In doing so it assesses the tension between two objectives being pursued simultaneously: individual state claims of greater EEZs; and, the regional CARICOM effort to fashion a regional fisheries agreement. As the discussion points out, the latter is a direct result of the former. The focal question is whether individual state EEZ claims will prove so attractive as to impede a regional agreement. A natural corollary to that question is whether and how coastal states will be willing to 'trade' EEZ access. The paper outlines the relevant history of the nations that constitute the Caribbean Community (CARICOM) and highlights the most recent (and ongoing) effort to construct a regional fisheries agreement. It sets forth the objectives sought to be achieved, the tactics employed in the endeavor and the respective concerns of the member states that have influenced the direction and content of a possible agreement. In doing so it analyze the most recent draft of the instrument designed to achieve this objective and assesses how member states' earlier concerns have been considered. It also compares and contrasts the CARICOM effort to regional fishery agreements that have been employed elsewhere. The paper concludes with observations on the CARICOM effort that analysts of regional marine resource agreements may find useful in assessing other agreements currently in effect as well as opportunities and impediments that may exist in other regions.

C8-P-6

Does herring fishing affect whale-watching in the Gulf of Maine?

Min-Yang Lee[1] (presenting). [1]University of Illinois, Urbana, IL, United States

In this paper, the effects of "localized depletion" of a pelagic fishery (herring) on a non-extractive marine activity (tourism) are investigated. Proponents of the localized depletion theory claim that intense fishing effort can lead to areas that are unsuitable for predators like tuna, groundfish, and whales. This leads to reduced catch rates in those fisheries and lower encounter rates for whale-watching. However, there has been little scientific research about this phenomenon. To test the hypothesis of localized depletion, a dynamic model of whale sightings (production) is developed that accounts for oceanographic conditions, unobserved heterogeneity, and fishing effort. Whale-watching vessels combine human capital, physical capital, and a measure of environmental quality to produce "whales seen." Fishing is not explicitly modeled; however, fishing effort occurs in regions of high abundances of herring which are also areas of high environmental quality. Under the hypothesis of localized depletion, fishing effort reduces the quality of a habitat for whales in future periods. Therefore, in periods following intense fishing effort, whales disperse to other areas, in search of higher abundances of prey. A unique dataset of daily whale-watching outcomes is combined with fishing effort and oceanographic data and used to test the hypothesis that intensive fishing effort reduces the number of whales seen by whale-watching companies. Our results suggest that while fishing may have an impact on sightings, this magnitude of this effect is fairly small. Sightings seem to be determined mostly by large scale oceanographic processes. These results should be of interest to policymakers in determining future fishing regulations.

C8-P-7

Learning inquiry-based teaching

Jim Winter[1], Janet Lanza[1] (presenting). [1]University of Arkansas at Little Rock, Little Rock, AR, United States

Commissions on educational reform recommend that students should be actively involved in doing science and that teachers should use more inquiry-based lessons rather than cookbook lessons or demonstrations (NCTM 1989, 2000; AAAS 1993; NRC 1996, 2003). We have developed and presented a workshop for ten years that can teach inquiry-based teaching approaches to secondary teachers, teaching assistants, and professors. Participants are given a theme of temperature and heat transfer, and then shown a table of materials. The materials are inexpensive and available at discount stores or from household waste. Then, participants are instructed to develop a hypothesis, develop an experimental design, conduct their experiment, and orally present the results. Participants experience through our immersion technique the feelings that their students have in an inquiry lesson, and they observe our approach in conducting an inquiry lesson. We conclude the workshop by discussing the inquiry approach and (presenting) our tips for developing inquiry lessons. We will present these tips with our presentation. Our approach is adaptable to a wide variety of themes, such as water as a medium for life.

C8-P-8

How to keep your favorite fishing hole from being Posted --- NO Trespassing!

Scott Wels[1] (presenting). [1]NYS Dept of Environmental Conservation, Region 4 Fisheries; Stamford, NY, United States

The art of angling has a long tradition of luring fisherman to the many diverse waters in New York State. While there is an array of opportunities for anglers to access larger waters by boat, many smaller lakes and streams are often privatized by neighboring landowners and closed to the public. The New York State Department of Environmental Conservation (NYSDEC) has long recognized the importance of acquiring angler access and has been active in working with private landowners to accomplish this statewide mission since 1935. Currently there are over 1,200 miles of Public Fishing Rights (PFR) easements along more than 350 streams in the state. NYSDEC's Region 4 is responsible for maintaining public fishing access points in nine counties including waters ranging from small urban ponds in the Capitol District, large boat launch sites along the Mohawk and Hudson Rivers, and PFR on some 50 streams in and around the Catskill Mountains. Fishing pressure is highest in the productive Delaware River Tailwaters and the famous Beaver Kill Fisheries. Unfortunately, many obstacles exist in the process of acquiring new PFR in Region 4 amongst increasing suburban sprawl and mass subdivisions spreading through our rural townships. With continued support from willing landowners and cooperative municipalities we have been able to succeed in keeping this mission alive. By providing the public with this service and effectively managing our aquatic resources, we are ensuring that all future generations will continue to say fishing is great in New York State.

C8-P-9

Testing adaptation strategies of Baja California (Mexico) coastal fishing communities to climate change

Salvador Lluch-Cota[1] (presenting), Veronica Morales-Zarate[1], Elisa Serviere-Zaragoza[1], Sergio Guzman-del-Proo[2].
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West coast of Baja California, Mexico, hosts an important complex of small coastal communities living from the fisheries of high valued abalone and lobster. They are very well organized (in cooperatives, and a cooperatives federation), hold exclusive concessions of areas (and resources within), and are frequently considered highly successful (as demonstrated by the Marine Stewardship Council certification of one of their two main fisheries). However, they are still highly vulnerable to several rapidly changing conditions, including climate. We built scenarios of future resources availability, based on retrospective analyses of climate driven abundance changes of abalone and lobster. Then, trough simple empirical relations and well known ecosystem models we explored potential adaptation strategies based on changing fishing practices, aimed at maximizing social benefits and minimizing ecosystem impacts.

C8-P-10

Estimating water, land, and other resources used to produce beef and trout for human consumption

Lubia Cajas Cano[1] (presenting), Christine Moffitt[2]. [1]University of Idaho, Moscow, ID, United States,USGS Coop Research Unit, [2]University of Idaho, Moscow, ID, United States

An estimated 70 % of the available global freshwater resources are used for agriculture, mainly for irrigation systems. Human population growth is increasing the demand for meat production and decreasing the options available to meet production needs and preserve the quality of water and land resources. In developing nations such as China, freshwater and marine aquaculture production provides a large portion of the animal protein consumed by their citizens. However, little is known about the total resource demands for aquaculture and few comparisons have been made between resource needs for aquaculture and terrestrially based animal protein production. We estimated the resource inputs and outputs for two systems of animal protein production that are important to the Idaho economy: beef cattle and trout. We estimated that production of one kg of boneless beef required an average of 1,100 m2 on land depending on the production system, and an average of 16,500 L of water. We estimated that to produce one kg of dressed and a kg of trout filet required less than 5 m2 of land and an average of 4,585 L of water. This volume of water included water for feed ingredients and water evaporated during the production system. Trout operations use water for raceway production that we estimated to range from 40,850 to 77,160 L per kg, depending on the availability and reuse of water. More than 99% of production water is released back into the rivers to support other ecosystem services or consumptive uses downstream. We provide comparisons for other measures that can be helpful in comparing beef and trout production systems, such as greenhouse gas emissions.

C8-P-11

Empowering recreational fishers to value each fish they release

Kane Moyle[1] (presenting), Frank Prokop[1], Bill Sawynok[2]. [1]Recfishwest, WA, Australia, [2]Infofish, QLD, Australia

Recreational fishers have a legislative requirement to release a number of fish caught due to size or bag limits. Many recreational fishers are increasingly choosing to release fish. Despite good intentions, many demersal species suffer significant mortalities from barotrauma, especially when taken from depths over 40 metres. Quantifying incidental mortality to obtain an accurate estimate of fishing mortality poses a significant challenge for management. Benefits from improving survival should accrue to the stocks and to management of recreational catch shares.There have been a number of research projects that have utilized recreational fishers as collectors of data for post-release survival studies providing a robust data set whilst providing a sense of empowerment and stewardship of the resource. One program particularly successful has been the ‘Released Fish Survival’ program. A significant component of the ‘Released Fish Survival’ program was a study undertaken in WA to estimate the effects of depth, venting and hook type on C&R mortality of dhufish (*Glaucosoma hebraicum*) and snapper (*Pagrus auratus*). The research was able to show that speed of return to depth was a critical factor in improving survival with the ‘Release Weight’ being the superior method of release. Recfishwest has been a strong advocate for the ‘Release Weight’ and has been the successful recipient of a federal government grant to produce a promotional DVD on the use of this release technique. A tagging study into the optimal release of Samson fish (Seriola hippos), in the world renowned jig fishery in Western Australia, enlisted the help of recreational fishers and tagged nearly 8,000 fish over two years. Recaptures showed fish migrated from spawning aggregations near Perth more than 3000 km in as little as 6 weeks.

C9. Bioengineering

C9-1

Behavioural responses of sea lamprey to hydrodynamic conditions

Greg Elliott[1] (presenting), Robert McLaughlin[1], Andrew Goodwin[2], John Nestler[2], George Constantinescu[3], Larry Weber[3], Jodi Benson[3]. [1]University of Guelph, Guelph, ON, Canada, [2]United States Army Engineer Research & Development Center, Vicksburg, MS, United States, [3]University of Iowa, Iowa City, IA, United States

This study examines how sea lamprey navigate hydrodynamic conditions of differing complexity. In the Laurentian Great Lakes, the sea lamprey (*Petromyzon marinus*) is a non-native parasitic invader that had and continues to have negative effects on large native fishes (its hosts). Understanding how sea lamprey navigate complex flows can assist fishery managers with efforts to control sea lamprey through the design and placement of traps for maturing individuals on route to their spawning habitat in streams. Behavioural experiments were conducted in flumes at Hammond Bay Biological Station, MI, USA. Hydrodynamic conditions in the flumes were modified in a two-way design: placing ribs or no ribs on the bottom of the flume to alter skin friction and placing a small or large log in the water column to alter form friction. Movement paths of individual sea lamprey were video recorded under low-light conditions. These movement paths will be integrated with 3D models of flow to (i) identify the behavioural rules used by sea lamprey, (ii) test whether the numerical fish surrogate approach developed for teleost fishes can be generalized successfully to sea lamprey, and (iii) evaluate whether improved understanding of swimming behaviour can be applied to enhance sea lamprey control in the Great Lakes.

C9-3

Response of blueback herring with a radio tag and without one to high-frequency sound

Dennis Dunning[1] (presenting), Quentin Ross[1], Chris Frese[2]. [1]New York Power Authority, White Plains, New York, United States, [2]Kleinschmidt, Strasburg, Pennsylvania, United States

Our objective was to compare the response of blueback herring with a gastrically-implanted radio tag and those without one to high-frequency sound. Four groups of blueback herring with a radio tag and three groups without a tag, each group comprised of four fish, were tested in an 8-foot diameter tank. The time it took each fish to swim one body length before and after exposure to high-frequency sound, expressed as a ratio, and the presence of a C-start were used as response variables. Almost all blueback herring swam faster when exposed to high-frequency sound and about half exhibited a C-start. There was no significant difference in the initial response of tagged and untagged fish. Repeated exposure to high frequency sound generally resulted in a diminished response from both tagged and untagged fish.

C9-4

An ultrasound barrier to prevent American shad (*Alosa sapidissima*) from entering the Des Prairies river powerhouse turbines – preliminary results

Jean Caumartin[1] (presenting), Denis Desrochers[1], Carl Schilt[1]. [1]Hydro-Québec, Montréal/Québec, Canada, [2]Milieu inc. Lapariries/Québec, Canada, [3]LGL Limited, Sidney, British Columbia, Canada

In an effort to minimize fish mortality, the Des Prairies power house, located on the island of Montréal (Québec, Canada), stops its activities for one hour every day during the post spawning migration of American Shad. The corresponding water is then passed via the spillway to produce a preferential flow for the fish. It is believed that during that period, up to 95% of the fish located in front of the powerhouse swims away from the station toward the spillway. However, when the power station is active (during the migration), a number of fish is passing through the turbines. To reduce this potential mortality, the power station has been experimenting with an ultrasound barrier to prevent the fish from approaching the power house during its activities. The results gathered so far are promising, but more tests are needed in extreme flow conditions before a final operational set up is installed.

C9-5

Site-specific assessment of cost-effectiveness of technologies for reducing impingement and entrainment of fish and shellfish on cooling water intake structures

Erik Heinen[1] (presenting), Mark Gerath[1]. [1]ENSR, Westford, MA, United States

A recent court decision on the Phase II 316(b) Rule found that considering costs relative to environmental benefits was not permissible when selecting the Best Technology Available (BTA) for reducing impingement and entrainment of fish on cooling water intake structures. This is problematic for the regulated industry given the extremely high costs and potentially low effectiveness of many technologies for reducing impingement mortality and entrainment. However, the court decision left open the potential to consider the relative cost-effectiveness of alternatives. EPA has historically used cost-effectiveness to select the best available technology (BAT) for reducing pollutants from facilities within an industry sector; the BAT is used as the basis for a national effluent guideline. Setting national standards for reducing impingement mortality and entrainment using this approach is problematic because the costs and performance of technologies are highly site-specific; what is cost-effective at one plant may not be at another. To address this issue, we propose applying the cost-effectiveness assessment on a site-specific basis to select BTA for a given plant. The results of applying this test to numerous steam electric power plants indicate that, in many cases, closed-cycle

cooling is not a cost-effective technology for reducing impingement mortality and entrainment.

C9-6
Evaluation of fine mesh panels as a means of reducing entrainment at cooling water intake structures
Mark Gerath[1] (presenting), Erik Heinen[1], Jonathan Black[2]. [1]ENSR, Westford, MA, United States, [2]Alden Research Lab, Holden, MA, United States

In its evaluation of potential CWIS technologies as part of the development of the 316(b) Phase II Rule, USEPA concluded that fine mesh panels (FMP) would be the most commonly installed technology to mitigate entrainment. While potentially promising, installation of FMP and their ability to successfully reduce entrainment is likely to be complex and should be carefully considered before making a commitment to install and operate them. FMP as a supplement to traveling water screen have been installed on very few CWIS. While there have been rigorous studies on their ability to exclude viable ichthyoplankton, the studies are few and assess limited numbers of taxa. Clogging and biofouling of fine mesh panels is an important concern, leading to intermittent installation coinciding with peak entrainment periods. This presentation will review several aspects of the evaluation of FMP as a means of controlling entrainment. Experiences with the employment of FMP will be reviewed. The distinction between exclusion and survival will be discussed including its implications for estimating the cost and effectiveness of the measure. The factors that affect post-impingement survival of ichythyoplankton will be discussed. Implications for this technology as a compliance measure under Section 316(b) will be considered.

C9-7
A tale of two fishways: contrasting performance of nature-like fishway designs in coastal New England streams
Abigail Franklin[1] (presenting), Alexander Haro[2], Theodore Castro-Santos[2]. [1]University of Massachusetts Amherst, Amherst, Massachusetts, United States, [2]United States Geological Survey, Biological Resources Division, Silvio O. Conte Anadromous Fish Research Center, Turners Falls, Massachusetts, United States

Nature-like fishways have been designed as a response to poor or unknown passage efficiency of technical fishways, and a desire to re-connect river corridors and provide passage for all species occurring in a system. Providing passage for adult anadromous clupeids to their spawning areas is especially important considering their recent dramatic population declines. Two nature-like fishways in New England were evaluated for passage of alewives (*Alosa pseudoharengus*) using passive integrated transponder (PIT) telemetry and showed differing results. At Town Brook in Plymouth, Massachusetts the 30-m long perturbation boulder-style fishway with a 1:20 slope passed 96% of the tagged fish with most ascending in under 22 minutes. At East River in Guilford, Connecticut the 48m long pool and weir style fishway with a 1:15 slope passed only 40% of the fish with a median time transit time of 75 minutes. Temperature, water level, and photoperiod were shown to have an effect on the entry rate and transit times of fish at both sites. The influence of drop per pool and specific local hydraulics of nature-like fishways appear to have significant effects on passage performance for this species.

C9-8
Sound attenuation of harmful noise produced in water construction activities
Hal Dreyer[1] (presenting), John Micketts[1]. [1]Gunderboom, Inc. Anchorage, AK, United States

Sound waves are composed of varying frequencies and intensities that can be harmful to mammals and fish. Reducing underwater sound to safe levels for aquatic life is challenging because sound waves propagate four times faster in water, with a logarithmic intensity 62 dB higher than in air. Additionally, aquatic environments vary in salinity, temperature, depth, currents and configurations, effecting the ability to apply any device necessary to reduce the sound intensity.Gunderboom has met these challenges with its successful SAS that utilizes conventional bubble curtain technology incorporated within its Aquatic Filter Barrier full-water-depth curtain and boom. The 2000 San Francisco-Oakland Bay Bridge pile driving project utilized a two-layer Gunderboom SAS permeable curtain with enclosed bubbler tubes. The system withstood tidally-induced current, protected aquatic life, reduced sound intensity by over 20dB, and produced a much smaller exclusion zone thereby reducing construction work stoppages. A proprietary SAS is currently under development for extreme environment applications including high water velocities, extreme tidal level changes and very long piles. Designed for field installation from the surface, it incorporates a reusable design, with a laboratory demonstrated noise reduction of over 40 dB at 10 mHz frequency. System design is adjustable to sound frequency where aquatic conditions dictate.

C9-9
Meeting screening criteria- issues and solutions
Edward Donahue[1] (presenting), Michael McGowan[1], Fiona Goodson[1]. [1]HDR Corporation, Richmond, BC, Canada, [2]HDR, Inc. Gig Harbour, WA, United States

Screening of water intakes is increasingly important relative to the sustainability of the fisheries resource, particularly given the continually increasing demand on Canadian water resources. Typical intakes requiring screens are associated with public water supply, supply for industrial applications, irrigation needs, and power production. Section 30 of the Fisheries Act requires that every water intake, ditch, channel or canal in Canada provide for a fish guard, screen, covering, or netting over the entrance or intake to prevent fish passage into a recipient water conveyance system, when the Minister deems it necessary. Other sections of Section 30, along with federal, provincial, or municipal legislation and policies may also impose other requirements to water extraction activities. In this paper we will describe issues that must be considered when designing screening facilities relative to lotic and lentic applications, species to be protected, and a process for selecting the most suitable screening technology. Drawing on experience gained from projects in both Canada and the United States, we will present examples of different approaches to the design of screening facilities and provide a brief overview of the different types of technology available to meet established criteria.

C9-10

A case study: improving the resilience of a watercourse to the stressors of increasing imperviousness of its drainage area and close proximity of municipal infrastructure using bioengineering and natural channel design techniques

Samantha Mason[1] (presenting). [1]Grand River Conservation Authority, City of Cambridge, Ontario, Canada

A portion of Laurel Creek, in the City of Waterloo was restructured in 1995 using elements of natural channel design including a number of bioengineering techniques. This work was undertaken by the municipality in response to increased bank erosion resulting from hardening of its drainage area due to urbanization. Increased flows during runoff events were exposing a sanitary sewage pipe that had been built parallel to the creek in 1960. The natural channel design and bioengineering was also undertaken to address garbage that was being exposed on the banks of the creek originating from an historic municipal landfill. This presentation will describe why the project was undertaken, how it was done and what aspects of the work were successful in improving fish habitat conditions on the site. The presentation will also discuss what parts of the project could have be en done differently to achieve better results for fish habitat and fish communities at the site today. Ongoing land development in the drainage area coupled with climate change is leading to higher peak flows through this creek during runoff events, which amounts to higher shear stress on the bottom and banks of the watercourse. The techniques that were used to reconstruct the watercourse 13 years ago are evaluated as to whether they were successful in making the watercourse more resilient in the face of a number of changes taking place in the catchment area of Laurel Creek.

C9-P-1

Simplifying barrier culvert determinations on large scale transportation projects

Bill Mavros[1] (presenting), Matthew Gray[1]. [1]HDR Engineering, Inc, Bellevue, WA, United States

Integrating fish passage restoration with road construction is a cost-effective way to accelerate barrier correction and to reduce equipment mobilization costs. The objective of this assessment procedure was to use field observations and available information to simplify and expedite fish passage determination on large scale road crossings. Barrier culvert determination is a step-wise process of data collection and analyses.Only culverts that conveyed fish-bearing waters were evaluated for fish passage. Fish passage was evaluated using a three-level approach. The first level was a screening analysis that identified potential passage barriers based on field observations, culvert measurements, and best professional judgment. The second level considered potential barriers and subjected them to more rigorous analysis in order to determine the existence of a barrier. The third level considered the feasibility of culvert replacement, in terms of the physical features of the stream crossing, logistics, and cost. In the few situations where field observations and available information were insufficient to make a fish passage determination, the culvert was identified as a potential barrier that required additional data and analysis.

C9-P-2

Reinitiating fluvial processes and improving salmon habitat at a flood control dam through use of gravel nourishment and large wood transport

Scott Pozarycki[1], Fred Goetz[1] (presenting), Eric Jeanes[2], Zachary Corum[1]. [1]US Army Corps of Engineers, Seatte, WA, United States, [2]R2 Resource Consultants, Redmond, WA, United States

While dams are widely known for impacts to flows and fish passage, impacts to other processes are not fully recognized. The Green River is a large river that flows into the Puget Sound and is regulated by a large flood control dam. The dam blocks transport of all larger sediment and woody debris, effectively starving 30 river miles of gravel and wood. Seven species of Pacific salmon utilize river habitats below the dam. To reinitiate sediment and wood transport, erodible gravel bars from 1000-2000 ft in length with 5000-8000 yd3 of materials, are annually built below the dam during late summer; while large woody debris is trucked below the dam and laid upon the gravel bar. High flows transport these materials downstream. Project effectiveness is physically monitored using cross-sections, sediment cores, pebble counts, mapping of downstream transport, and woody debris inventory. In a 4-mile reach below the material input point, annual steelhead redd counts have increased from 65.8/year (6 years pre-project) to 211.7/year (3 years post-project); and Chinook redd counts have increased from 55/year (1 year pre-project) to 245/year (3 years post-project).

C9-P-3
Entrainment exclusion by an aquatic filter barrier system - design, installation and exclusion and operational performance four seasons of operations
Andrew McCusker[1] (presenting), Melissa Hamlin[1], Christian Guelke[1], Jim Campbell[1]. [1]Gunderboom, Inc. Scarborough, ME, United States

The Aquatic Filter Barrier System (AFB) at the Lovett Generating Station (Lovett) has been the subject of numerous reports because Gunderboom technology, previously used solely for sediment control, evolved into a system for exclusion of fish eggs and larvae from water intakes. Its performance has been used for evaluation by industry, consulting engineers and regulators for possible application at other water intakes. March 2007 through October 2007 marked the fourth season at Lovett, another important milestone for the AFB. Consideration of this continued success is essential when evaluating solutions for sites that may benefit from exclusion of eggs and larvae rather than flow reduction or elimination. The presentation includes a system overview, description of the installation and challenges, and both operational and exclusion performance for each of the four years. Challenges included:[1] design/fabrication and first year deployment issues,[2] electrical component issues, especially as the components aged over the years and[3] management of "overtopping," designed to avoid exceeding curtain load design criteria. Entrainment exclusion rates were 72, 91, 89 and 95%, respectively. Operations were conducted on a fixed price basis after Year 1. The presentation will also include general cost information for annual O&M and life cycle information.

C9-P-4
Success of engineered fishway at Arborg Dam
Maureen Forster[1] (presenting), Jonathan Stephens[1]. [1]Golder Associates, Winnipeg, Manitoba, Canada

Golder Associates Ltd. conducted a field study in spring 2008 to assess fish passage through the weir-pool fishway installed at the Arborg Dam on the Icelandic River by Manitoba Infrastructure and Transportation (MIT). The installation of the weir pool fishway and reconstruction of the weir are part of works carried out in conjunction with the East Interlake Conservation District's (EICD's) Fish Passage Enhancement Project, funded under the former Manitoba Water Stewardship (MWS) Fisheries Enhancement Initiative. The reconstruction works at the Dam and assessment of fish passage through the fishway were done by MIT to meet conditions of a Fisheries Act Authorization issued by Fisheries and Oceans Canada (DFO). A mark-recapture study was used to assess fish passage through the fishway. Migrating fish were captured downstream of the Dam, injected with Passive Integrated Transponder (PIT) tags and released back to the river. A PIT tag reader was placed at the inlet and outlet of the fishway to determine if tagged fish could move from areas downstream of the Dam through the fishway to areas upstream of the Dam. The study included installation of underwater cameras at the fishway to visually record fish movements; collection of water velocity data below, within and above the fishway to provide information on the ability of different species to negotiate engineered fish passage structures under different flow conditions; and, observations of hydraulic characteristics at the fishway inlet to determine hydraulic features of the river that may influence successful use of the fishway by fish. Additional information on fish movements were collected by DFO staff with the use of a DIDSON camera. MWS and the EICD assisted with the mark-recapture and data collection.

C9-P-5
Diversion structure consolidation: more water for fish?
Michael C. Garello[2], Bill Mavros[1] (presenting). [1]HDR Engineering, Inc, Bellevue, WA, United States, [2]HDR/FISHPRO, Gig Harbor, WA, United States

We were tasked to provide an independent assessment of and implement the agreed upon configuration for a potential consolidation of several private irrigation diversion structures. The proposed consolidation was to result in a single point of diversion with an intake structure that met current federal and state agency fish screening and passage criteria while serving the needs of multiple irrigators with water rights from the local creek. Project results to date included the upgrade of two diversions, consolidation of two diversions to a single diversion structure, implementation of fish passage measures, and creek restoration. The successful consolidation of several private irrigation diversion structures has allowed for agricultural practices to continue while allowing the additional water to be made available for fisheries enhancement in the creek.

<u>C10. Centrarchids</u>

C10.1-2
Comparison of population dynamics of largemouth bass at three reservoirs from La Plata River, Puerto Rico
Marinelly Valentín[1] (presenting). [1]Natural Resources Department, Toa Alta, Puerto Rico, United States

Four reservoirs, Carite, Comerío I, Comerío II and La Plata; were constructed in La Plata River, one of the largest rivers of Puerto Rico. La Plata Reservoir is one of the most important fishing reservoirs of the island. Angler's interviews in Roving Creel Survey in La Plata reservoir indicate that the Largemouth bass and Peacock bass are the preferred species for fishing. The electrofishing data show the presence of the Largemouth bass around these three reservoirs. The CPUE and condition factor of the Largemouth bass in these three reservoirs is as follows: Carite Reservoir CPUE = 4 LMB/hour and condition Wr = 81.3, Comerío Reservoir CPUE = 20 LMB/hour and condition Wr = 83.7 and La Plata Reservoir CPUE = 10.6 LMB/hour and condition Wr = 105.3. Also, in Carite Reservoir the electrofishing data show the presence of Peacock bass CPUE = 2 PCB/hour and Bigmouth sleepers CPUE = 13.5 BMS/hour. In La Plata Reservoir we manage for two recreational fishes, the Largemouth Bass and the Peacock Bass CPUE = 11.1 PCB/hour. Only one Bigmouth Sleeper is reported on a Roving Creel Survey in La Plata Reservoir. Based on the data obtained on surveys and investigations we make recommendations for fisheries management in Comerío and La Plata Reservoirs. Also, we worked on the protection of the sport fish species and to increase anglers' satisfaction and improve benefits to those who use fishing as recreation.

C10.1-3
Effects of a summer high water event on young of the year largemouth bass in the Arkansas River
Jeffrey Horne[1] (presenting), Steve Lochmann[1]. [1]University of Arkansas at Pine Bluff, Pine Bluff, Arkansas, United States

Abundance of young of year largemouth bass in regulated river systems can be impacted by unusual high water events. The Arkansas River has an average flood cycle with peak flow from late March to mid April. In the summer of 2007, the river was over peak flow from June to August. Electrofishing was conducted to estimate the relative abundance of YOY largemouth bass in backwaters of Pool 4 of the river following this summer flow. CPUE estimates for September 2007 ranged from 1.6 to 22.7 fish/h with an average (SD) of 12.8 (7.5). November 2003 CPUE estimates during a normal year ranged from 18.5 to 53.8 fish/h with an average of 35.6 (13.3). The CPUE estimates were significantly different ($p<0.01$) between years. Largemouth bass had an average length of 139.0 (8.9) in 2007 and 162.9 (23.3) in 2003. The lengths from September 2007 were modified to compare to November 2003. Length was significantly different ($p<0.01$) between years. Relative weight was 100.3 (4.5) in 2007 and 103.8 (5.6) in 2003. Condition was not significantly different ($p=0.16$) between years. The unusual flow in 2007 appears to have decreased the fall CPUE estimates and might have caused slower growth in YOY largemouth bass.

C10.1-4
Trypsin activity as a measure of diet quality of age-0 largemouth bass in reservoirs with good and poor recruitment
Bradley Ray[1] (presenting), Brian Murphy[1]. [1]Virginia Tech, Blacksburg, VA, United States

Largemouth bass are typically self-sustaining through natural reproduction; however loss of age-0 fish to biotic and abiotic factors can negatively affect recruitment. Prolonged reduced recruitment can diminish future angler effort, satisfaction, and the economic benefits associated with sport fishing. In Virginia, Briery Creek Reservoir continually produces trophy largemouth bass (>3.6 kg), however, recent electrofishing assessments of age-0 largemouth bass exhibited low catch per unit effort. A potential recruitment bottleneck appears to be occurring shortly after the age-0 largemouth bass leave the nest. In order to examine this potential limiting factor on recruitment, the dietary enzyme important for digesting protein, trypsin, was examined. Trypsin activity is related to food intake and stomach fullness; therefore, starvation or reduced food intake decreases the activity. Results indicate that the age-0 largemouth bass from Briery Creek Reservoir have reduced trypsin activity compared to those from a nearby reservoir. This lower trypsin activity may indicate that poor diet quality is a possible cause of low age-0 abundance in Briery Creek Reservoir. The poor diet quality may be a result of smaller-sized zooplankton which were on average 30% smaller in Briery Creek Reservoir. This question of diet quality will be further investigated.

C10.1-5
Energetic consequences of habitat loss to an apex predator
Jakob Tetzlaff[1] (presenting), William Pine[1], Thomas Frazer[1]. [1]University of Florida, Gainesville, FL, United States

Increased nutrient loading and altered flow regimes in Florida's spring-fed, coastal rivers are possible drivers of documented changes in the structure of submersed aquatic vegetation communities (i.e. abundance, distribution and species composition). The broader ecological consequences of these changes in vegetative habitat, however, are not well understood. The objective of this study is to investigate the role of structural habitat (submersed aquatic vegetation) as it relates to the foraging behavior and energy acquisition rates of a freshwater apex predator, *Micropterus salmoides*. Specifically, we investigate the foraging costs and overall energy budgets of wild fish in rivers that vary markedly in their vegetative character, but are otherwise similar with respect to their chemistry, e.g. temperature, salinity and nutrient concentrations, and physical attributes, e.g. depth and flow. Our approach is to combine multiple independent methods of research including telemetry, diet analysis, muscle enzyme analysis, growth analysis, and bioenergetics modeling, to determine the potential energetic consequences on foraging behavior in rivers that afford different degrees of structural habitat complexity. This study attempts to link broad-scale changes in habitat to both individual and population growth rates using a bioenergetics framework.

C10.1-6
Temporal trends in largemouth bass mortality with fishery implications
Mike Allen[1] (presenting), Carl Walters[1], Randy Myers[1]. [1]University of Florida, Gainesville, Florida, United States

We reviewed estimates of annual exploitation (u) and total mortality (Z) for largemouth bass populations and used a simulation model to explore how temporal changes in u have likely influenced largemouth bass populations. The review revealed 32 estimates of u and 30 corresponding estimates of Z spanning 51 years. Fishing mortality was roughly parabolic through time, with a mean u of 0.35 for 1976-1989, and a mean of 0.18 for 1990-2003. Thus, results indicated that average fishing mortality rates have declined by about half since about 1990. Total mortality declined coincident with the decline in u, suggesting that changes in u caused lower overall total mortality rates. The evidence suggests that the decline in u was caused by voluntary release of fish by anglers rather than changes in overall fishing effort for largemouth bass. The simulation model showed that the decline in exploitation would increase adult largemouth bass abundance, but it also reduced the ability of size and bag regulations to improve population metrics due to low rates of directed harvest. Discard mortality (i.e. mortality of fish caught and released) would not negate the benefits of lower exploitation unless mortality of fish caught and released was 0.3 or higher. Changes in angler behavior have substantially reduced fishing mortality for largemouth bass fisheries, which should be considered when developing management plans for this species and others with high rates of voluntary release.

C10.1-7

The influence of selection for vulnerability to angling on foraging in largemouth bass

Michael Nannini[1] (presenting), David Wahl[1]. [1]Illinois Natural History Survey, Kinmundy, Illinois, United States

When fishing pressure is high, recreational angling can represent a strong selective force. Previous research has found that vulnerability to angling in largemouth bass had a high heritability component. Fish that had high vulnerability also had higher heart rates and showed greater parental care than low vulnerability fish. Selection on angling vulnerability could also directly or indirectly influence other traits, such as foraging ability To determine what other traits might be influenced by selection for angling vulnerability, we examined several traits related to foraging abilities in largemouth bass that had been through 4 generations of artificial selection. We examined differences in a number of foraging behaviors (time searching, number of strikes, capture efficiency, and handling time), reaction distance, functional response, and conversion efficiency for two populations of largemouth bass selected for high and low vulnerability to angling. Low vulnerability fish attempted more captures and had a shorter reaction distance than their high vulnerability counterparts. High vulnerability fish were also less efficient at converting prey consumed into growth. These results suggest that selection induced by recreational fishing impact other aspects of the predatory behavior of fish, which could have the potential to influence other interactions within the community.

C10.1-8

Effects of four deep hooked removal techniques on feeding, growth and survival of largemouth bass

Corey DeBoom[1] (presenting), Matthew VanLandeghem[1], David Wahl[2]. [1]Kaskaskia Biological Station, Division of Ecology and Conservation Science, Illinois Natural History Survey, Sullivan, Illinois, United States, [2]Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Champaign, Illinois, United States

Deeply hooked fish present a dilemma to anglers who wish to practice catch-and-release but are unsure about the probability of a fish surviving. Debate in fishing magazines concerning the best treatment of deeply hooked fish has prompted popularization of techniques for hook removal without adequate evaluation. The objective of this study was to evaluate the effects of four common removal methods on the short term feeding, survival, and growth of deeply hooked adult largemouth bass (259-388 mm TL). Angled fish were subjected to one of four removal treatments (n=10 each) including: hook left in and line cut, standard removal, standard removal with a barbless hook, and a recently popularized “through the gill” technique where the hook eye is pulled behind the last gill arch and rolled to pop the barb free. Fish hooked in the mouth (not deeply hooked) were used as controls. Consumption six days post treatment was significantly higher for controls and fish subjected to the “through the gill” technique. No differences were observed in growth or survival of largemouth bass after either two or eight months (n=94). Initial mortality was less than 13% within treatments (n=15 each) and was less than 30% overall (n=94). Our results suggest deeply hooked largemouth bass have a high probability of survival regardless of method of hook removal and can be safely caught and released. In addition, a recently popularized “through the gill” method of hook removal may reduce short term effects of an angling event on consumption by largemouth bass.

C10.1-9

Recovery profile and magnitude of physiological disturbance in two size classes of exercised largemouth bass

Andrew Gingerich[1] (presenting), David Philipp[2], David Wahl[2], Cory Suski[1]. [1]University of Illinois Department of Natural Resources and Environmental Sciences, Urbana Illinois, United States, [2]Illinois Natural History Survey, Urbana Illinois, United States

Fish that have been angled exhibit physiological disturbances, and these disturbances are corrected during recovery after fish have been released. Anglers and managers currently assume that recovery from exercise (angling) is uniform across fish sizes, but no research has either supported or refuted this assumption. The purpose of this study was to examine the magnitude of physiological disturbances following exercise, as well as the time required for recovery, for two size classes of largemouth bass: 200-250 mm and

400-450mm. These wild fish were exercised for 60 seconds and allowed to recover for 0, 1, 2, or 4 hours before being sampled for blood plasma and white muscle. Results showed that, in general, large fish experienced a greater physiological disturbance than small fish, and larger fish also required longer time to recover following exercise than did small fish. More specifically, large fish exhibited higher plasma glucose, potassium and sodium concentrations than small fish. In addition, large fish failed to restore potassium to basal levels, even after 4 hours of recovery. Muscle metabolites in large fish, including lactate and phosphocreatine, showed a greater disturbance trend; however appeared to recover at the same rate as small fish.

C10.1-10
Introgression and genetic structure among Florida's largemouth bass
Dijar Lutz-Carrillo[1] (presenting). Texas Parks and Wildlife Department, San Marcos, Texas, United States[1]

Introgression between subspecies of Florida's largemouth bass, *Micropterus salmoides*, was evaluated with allozymes in 1983. Here, samples (n = 1410) from 47 populations throughout Florida were genotyped using nine microsatellite loci to resolve the current extent of introgression and infer genetic population structure. Results indicate that the intergrade zone has expanded further south to near the middle of the Florida peninsula. At the most inclusive hierarchical level genetic structure comprised four geographic regions: 1) northwest, 2) north-central, 3) central-west, and 4) south, central-east and northeast Florida. Partitioning genetic variance among these regions accounted for 6% of the total genetic variation ($F_{CT} = 0.0643$, $P < 0.00001$), however there was also significant genetic variation within regions ($F_{SC} = 0.0551$, $P < 0.00001$) and extensive admixture among regions was detected by assignment tests. Overall and within regions 3 and 4, the slope of the regression of pairwise F_{ST} and distance matrices were significantly different from zero (overall: $r = 0.5534$, $P < 0.001$; region 3: $r = 0.5994$, $P = 0.023$; region 4: $r = 0.3520$, $P = 0.006$) indicating that isolation-by-distance is partially responsible for structuring genetic variation in Florida, particularly among central and southern populations.

C10.1-11
Genetic mark and recapture of stocked Florida largemouth bass
Michael Tringali[1] (presenting), Wes Porak[2], Rick Stout[3], Pamela Bellotti[1], Nick Trippel[2], Mike Matthews[3]. [1]Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, St. Petersburg, Florida, United States, [2]Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, Eustis, Florida, United States, [3]Florida Fish & Wildlife Conservation Commission, Florida Bass Conservation Center, Webster, Florida, United States

With the completion of the new Florida Bass Conservation Center (FBCC), a state-of-the-art aquaculture facility, the Florida Fish and Wildlife Commission has renewed its efforts to culture and release Florida largemouth bass, *Micropterus salmoides* floridanus. Stockings in selected lakes are being conducted as empirical treatments for which factors such as release habitat and stocking density are being studied. Most hatchlings will be too small to carry physical tags; thus, post-release assessments will utilize a program of genetic identification. Not only must hatchlings be distinguishable from wild bass, those belonging to different treatment groups also have to be distinguished from each other. We developed laboratory and statistical methods to identify FBCC bass in hatchery/wild admixtures and to determine the identities of their parents. These methods, collectively referred to as 'familyprinting', are based on individual genotype data from highly variable, co-dominant nuclear DNA (microsatellite) markers. In this presentation, the following will be described: 1) the resolving power of the de novo DNA markers for parentage ID in bass, 2) the genetic composition of wild largemouth bass based on assays of ~2,500 specimens from 60 Florida lakes, and 3) the results of a recapture survey following pilot releases in Newnan's Lake (Gainesville, Florida).

C10.1-12
Investigating interactions between largemouth and spotted bass, Lake Norman, North Carolina
Jason Godbout[1] (presenting), Jim Rice[1], Derek Aday[1]. [1]North Carolina State University, Raleigh, NC, United States

Largemouth bass *Micropterus salmoides* and spotted bass Micropterus punctulatus are ecologically similar congeners, and presumably competitors in systems in which they overlap. Largemouth bass recruitment in Lake Norman, a fairly unproductive reservoir in North Carolina, was perceived to be declining after spotted bass, most likely introduced by anglers, successfully established. Additionally, morphological observations suggested the two species were hybridizing. To better understand these issues, we investigated hybridization, diet overlap, and habitat use by black bass in Lake Norman. We used genetic analyses to understand the extent of hybridization in four zones of the reservoir. We then combined genetic information with morphological characteristics in three size classes in an attempt to identify reliable patterns for field identification of spotted bass, largemouth bass, and hybrids. To understand potential competition between the taxa, we compared diets of the groups through time. We also observed microhabitat variables to determine if the groups were segregating spatially. Our findings should guide future research and educate managers and anglers about the potential consequences of introducing spotted bass into lakes containing largemouth bass populations.

C10.1-13
Inter-specific relationship between largemouth bass and armored catfish at Lucchetti Reservoir, Puerto Rico

Darien López[1] (presenting). [1]Puerto Rico Department of Natural Resources, Puerto Rico, Puerto Rico

Armored catfish (*Pterygoplichthys multiradiatus*) are native to South America, and introduced in Puerto Rico mainly by pet shops. The presence of armored catfish has raised concerns not only from the government and scientific community but also to anglers. The goals of this study were to determine armored catfish population dynamics and how it relates to largemouth bass habitat utilization. The study was conducted from January through December, 2006 at Lucchetti Reservoir. Lucchetti's shoreline was divided into segments in which electrofishing was conducted every month. All armored catfish collected were measure and weighted. Those over 200 mm total length were kept and later euthanized. Gonads were extracted in order to determine sex and calculated gonadosomatic index (GSI) for the species. A total of 445 fish were collected, out of those 44% were males and 51% were females. GSI estimates suggested that the armored catfish spawning season was from May through August. When compared with previous studies, armored catfish population density was higher in the areas where bass spawn. Considering that these species not only utilize the same habitat but also the fact that bass forage on armored catfish, it is concluded that there is an inter-specific relationship between these species.

C10.2-1
Evaluating interactions between channel catfish and other sportfishes in Alabama's State public fishing lakes
Mike Leonard[1] (presenting), Dennis DeVries[1], Russell Wright[1]. [1]Auburn University, Auburn, AL, United States

Channel catfish Ictalurus puntatus is a popular sportfish maintained by yearling stocking in Alabama's State Public Fishing Lakes (ASPFLs). Catfish may negatively affect bluegill *Lepomis macrochirus* and largemouth bass *Micropterus salmoides* populations in these systems through direct and indirect effects of competition or predation. We sought to determine if catfish are becoming overly abundant in ASPFLs via stockpiling and if they are negatively affecting other sportfish populations. Using a variety of gears, we sampled catfish, largemouth bass, and bluegill in ten ASPFLs that contained variable catfish abundances and population size structures. Four of these lakes were sampled more intensively, including quarterly samples of diet of each fish species. Growth of catfish, bluegill, and largemouth bass were all negatively correlated with latitude and positively correlated with each other. Relative weight of catfish and bluegill were positively correlated. While catfish and bluegill both most frequently consumed chironomid larvae, there were many prey types not shared between the species. Largemouth bass most frequently consumed Lepomis species, which occurred in only 5% of catfish stomachs. We found no negative effects of catfish on populations of bluegill and largemouth bass, possibly due to reduced catfish stocking rates and dissimilarity in diet among these species.

C10.2-2
Movement and habitat use of smallmouth bass (*Micropterus dolomieu*) within the Beaver Archipelago, Northern Lake Michigan
Mark Kaemingk[1] (presenting), Tracy Galarowicz[1], David Clapp[2], John Clevenger[2]. [1]Central Michigan University, Mt. Pleasant, MI, United States, [2] Michigan Department of Natural Resources, Charlevoix, MI, United States

The Beaver Archipelago contains a very diverse habitat assemblage, which allows a relatively isolated smallmouth bass population to select a wide range of habitats. A total of 17 smallmouth bass were surgically implanted with ultrasonic transmitters within the Beaver Archipelago, northern Lake Michigan. A minimum of one location per individual was recorded daily to determine diurnal and crepuscular habitat use. Habitats were classified as either near-shore (i.e. shallow water <5m) or off-shore (i.e. deep water >5m) habitats. Movement and habitat use were evaluated based on locations recorded within three specific time periods, pre-spawn (prior to May 29), spawning (May 29 to June 25), and post-spawn (post June 25). Males exhibited less movement per day during spawning than females; however, there was no difference in daily movement rates between sex during pre-spawn and post-spawn time periods. There was a significant difference between smallmouth bass distance from shore between post-spawn and the remaining time periods indicating a shift in habitat use from spawning to post-spawn. A positive correlation was observed between mean location distance from shore and total length, suggesting larger bass are spending more time away from shore than other conspecifics. During the post spawn time period, smallmouth bass utilized off-shore habitats during diurnal hours and near-shore habitats during crepuscular hours. These results indicate the seasonal importance of both near shore and off shore habitats for smallmouth bass.

C10.2-3
Nutritional condition and physiology of paternal care in smallmouth bass (*Micropterus dolomieu*) relative to stage of offspring development
Kyle Hanson[1] (presenting), Steven Cooke[1]. [1]Carleton University, Ottawa, Ontario, Canada

Animal parental care requires a complex integration of physiology and behaviour, yet little is known about the physiological and energetic consequences or correlates of these behaviours. Using smallmouth bass (*Micropterus dolomieu*) as a model, the focus of this study was to determine the biochemical indicators of changes in nutritional status and potential for chronic stress during parental care. This was accomplished by randomly sampling individuals at 4 periods across parental care as well as sampling a subset of individuals repeatedly at three brood development stages to track changes in biochemical factors within the individual.

Though decreases in hematocrit and plasma magnesium were noted in randomly sampled fish, the magnitude of natural variation in most biochemical metrics had the potential to mask many physiological changes associated with parental care. Amongst repeatedly sampled fish, energetic indicators such as plasma triglyceride levels decreased indicating individual fasting across the majority parental care. Increases in plasma calcium and magnesium towards the end of care indicated that feeding may have resumed when the brood was close to independence after approximately three weeks of care. Last, indicators of chronic stress, such as plasma glucose and chloride levels, increased across the parental care period. These results are indicative of decreasing body condition (associated with prolonged activity and fasting) and chronic stress during parental care which may have marked impacts on the ability of an individual to successfully raise the current brood and impact subsequent individual fitness.

C10.2-4
The physiological impacts of decompression and fizzing on smallmouth bass during live-release tournaments
Matthew DeMille[1] (presenting), Bruce Tufts[1]. [1]Queen's University, Kingston, ON, Canada

Live-release fishing has become an integral feature of competitive angling events. Previous studies indicate that significant numbers of tournament-caught fish exhibit physiological disturbance. This disturbance influences the post-release survival of the fish and ultimately the effectiveness of live-release angling. Despite improvements in handling and release practices, a few physiological issues continue to concern tournament organizers. During an angling event, decompression occurs when a fish is rapidly brought to the surface from depth. The associated changes in their abiotic environment have the potential to cause a significant alteration to their internal physiology. Initial research has indicated significant elevations in tissue damage and anaerobic disturbance occur in decompressed fish. Swim bladder expansion, caused by the rapid change in pressure, generally causes a decompressed fish to lose control of their buoyancy. Once released, fish floating on the surface are exposed to a suite of biotic and abiotic stressors. Artificial swim bladder deflation, or fizzing, has been proposed as a technique to release built-up gas pressure within the swim bladder. This allows a fish to regain equilibrium and return to depth. To date, scientific studies on fizzing have been inconclusive; and this disparity is reflected in the fizzing policies put forth by North American fisheries agencies. Current experiments are underway to determine the factors that influence the incidence of decompression during live-release tournaments. This research will also examine whether fizzing will reduce the physiological disturbance in decompressed fish. Answering these questions will assist fisheries agencies in making sound policy decisions on the merit of using fizzing as a management tool.

C10.2-5
Life history variability of non-native centrarchids in the lower Guadiana drainage, Iberian Peninsula
Filipe Ribeiro[1] (presenting), Maria João Collares-Pereira[1]. [1]Faculdade de Ciências da Universidade de Lisboa, Departamento de Biologia Animal / Centro de Biologia Ambiental, Lisbon, Portugal

Life history variability of the pumpkinseed sunfish, *Lepomis gibbosus*, and of the largemouth bass, *Micropterus salmoides* was evaluated in three riverine populations of the lower Guadiana drainage (SW Iberian Peninsula). Fish abundance, condition and population structure were different between the studied populations for both species. Pumpkinseed was apparently well established in the analysed populations while largemouth bass presented lower fish abundance and strived in the Ardila river. Pumpkinseed sunfish juvenile growth was similar in all the populations (age 2, 56 mm SL) while the observed longevity was slightly bigger in the Guadiana river site (7+). Regarding reproductive attributes, pumpkinseed exhibited a long spawning period (April-May to August) but presented differences in duration of season, size at maturity and in reproductive effort. Largemouth bass populations had few reproductive adults which might have contributed to the lower success of the species in mediterranean-type rivers. The perceived differences on population and reproductive attributes in both centrarchids, provide insights that help to explain the distinct levels of invasion success found between pumpkinseed sunfish and largemouth bass in mediterranean-type streams.

C10.2-6
Site fidelity in *Lepomis macrochirus*: do males benefit from consistency?
Jennifer Bartlett[1] (presenting), John Epifanio[2]. [1]University of Illinois, Urbana, IL, United States, [2]Illinois Natural History Survey, Champaign, IL, United States

Fidelity to annual reproductive sites is common among many fish including bluegill. Better habitat quality, increased access to or attraction of mates, social structure, and previous reproductive success are hypotheses that have been proposed to explain this philopatric behaviour. The objective of this study was to examine patterns and causes of nest-site fidelity in bluegill. Preliminary observations indicate that male bluegills return repeatedly to the same sites to nest. From 2004 to 2007, the entire male breeding population (n=1841) of Long Lake in south eastern Ontario was captured and tagged during the breeding seasons. Of these nesting males, 34% (n=635) renested in subsequent spawning bouts in the same or subsequent years. On average, 78% of males recaptured within-years and 79% recaptured among-years displayed fidelity to spawning sites. To explain these high rates of fidelity, we hypothesized that fidelity and reproductive success are interrelated; i.e. nesting males garner a fitness benefit through fidelity to a breeding site. We removed fry from nests (treatment) and compared rates of renesting and distances between nest sites relative to undisturbed nests (control). We predicted treatment males would demonstrate a lower rate of fidelity to nest sites than control males. Contrary to our prediction, only one out of five colonies of treatment males renested at a greater distance from the previous nest site compared to its control colony. These results suggest that bluegill do not choose renesting sites based solely on assessed reproductive success and that habitat quality or social structure and interactions may be more important for choosing nest site locations.

C10.2-7
Ecological specialization in the introduced pumpkinseed in Iberian reservoirs
Yakuta Bhagat[1] (presenting), Michael G. Fox[2], Maria Teresa Ferreira[3]. [1]Watershed Ecosystems Graduate Program, Trent University, Peterborough, Ontario, Canada, [2]Environmental & Resource Studies Program and Department of Biology, Trent University, Peterborough, Ontario, Canada, [3]Instituto Superior de Agronomia, Tapada da Ajuda, Lisboa, Portugal

The introduced pumpkinseed (*Lepomis gibbosus*), native to eastern North America, is presently distributed across most of western and central Europe as a result of introductions dating back more than 100 years. On the Iberian Peninsula, pumpkinseeds occupy reservoirs that contain unique combinations of habitat and trophic environment, allowing for ecological specialization in pumpkinseeds occupying these environments. As part of an overall study to examine the effect of reservoir morphometry and food availability on morphology, we sampled pumpkinseeds from four habitats (fluvial-pelagic, fluvial-littoral, lacustrine-pelagic, lacustrine-littoral) testing the hypothesis that differences between habitats will lead to differences in functional morphology. Discriminant function analysis (DFA) and ANCOVA showed significant differences in external morphology between pumpkinseeds from all four habitats, with the most pronounced differences between littoral and pelagic individuals. Stomach content analysis showed high levels of zooplankton consumption, particularly in fluvial-pelagic pumpkinseeds, with corresponding differences in internal morphological characters; gill raker spacing was the narrowest in fluvial-pelagic individuals. DFA based on gill raker, pharyngeal muscle and jaw variables also showed separation between all four habitats. These results suggest that pumpkinseeds are able to adapt morphologically to both habitat and trophic environment, the likely result of high levels of phenotypic plasticity in this species.

C10.2-8
Changes in the Onondaga Lake macroinvertebrate community and shifts in pumpkinseed (*Lepomis gibbosus*) diet
Stephanie Johnson[1] (presenting), Lucas Kirby[1], Neil Ringler[1]. [1]SUNY College of Environmental Science and Forestry, Syracuse, NY, United States

Onondaga Lake near Syracuse, NY has been subject to more than a century of industrial and metropolitan pollution. The lake has shown recent signs of recovery, including record lows in phosphorus and ammonia levels and fewer days of anoxia. In addition to improving lake conditions, a remediation plan has been designed and is in the initial stages of implementation. Benthic invertebrates play a significant role in the structure and function of aquatic systems and are a critical component in predicting and monitoring changes in water quality and trophic structure. Temporal and spatial changes in littoral zone macroinvertebrate community and sunfish diets were described after sampling in the summer of 2007. Macroinvertebrate diversity remains low and has changed little since the first macroinvertebrate study conducted in 1989. Preliminary analysis shows a dominance of tolerant organisms in the littoral zone including, Amphipoda, Mollusca, Diptera (Chironomidae), Hirudinea and Oligochaeta. Despite minor changes in macroinvertebrate diversity, diet analysis indicates a shift from chrionomids and cladocera in 1991, to amphipods, dipterans (non-chironomid) and mollusks today. The invasion of zebra mussels in 1999 and subsequent increase in macrophytes is believed to have contributed to the shift in pumpkinseed diet.

C10-P-1
Effects of brood size, offspring age, and parent age on nest abandonment by smallmouth bass
Geoffrey Steinhart[1] (presenting), Brianne Lunn[1]. [1]Lake Superior State University, Sault Ste. Marie, MI, United States

Male smallmouth bass *Micropterus dolomieu* provide sole parental care for their offspring. Providing care is costly and can reduce future fitness; therefore, fitness gained by guarding small broods may be outweighed by lost future fitness. As a result, natural selection may lead males to abandon their broods under certain conditions. But when and why do males abandon? In previous research we created a dynamic programming model to predict brood abandonment, but the abandonment thresholds from the model had not been tested. Here, we present the results of a brood reduction experiment to determine how male age, brood age, and offspring number affect nest abandonment by smallmouth bass. We removed portions of the brood from nest guarding males in Lake Opeongo, Ontario, and observed nest abandonment rates. We compared observed nest abandonment with model predictions. Overall, the percent brood removed did not affect nest abandonment; however, abandonment was more likely for young males and nests with early developmental stages. The model correctly predicted all guarded and successful nests (i.e. specificity = 1), but only 33% of abandoned nests were correctly predicted (i.e, sensitivity = 0.33). Poor model sensitivity suggests that other factors might be affecting brood abandonment decisions.

C10-P-2
Longitudinal movement of smallmouth bass within tributaries of Lake Erie
Holly Kaas[1] (presenting), Timothy Strakosh[1]. [1]SUNY Fredonia, Fredonia, NY, United States

During the summer 2007, smallmouth bass (*Micropterus dolomieu*) were sampled in two tributaries of Lake Erie; Canadaway Creek and 18-Mile Creek. The NYSDEC has noted that there is a bimodal distribution of smallmouth bass in Lake Erie. This could be due to advantages that the tributary spawned smallmouth bass have over the lake spawned smallmouth bass. The tributary population spawn earlier due to warmer water temperature in the creeks. This study focused on the amount of time the bass remained in the creek after spawning and the length of time the bass spent moving out of the creeks into the lake. In Canadaway Creek, 201 smallmouth bass, and 215 smallmouth bass in 18-mile Creek were initially captured, tagged with elastomer tagging, then released back into their capture area. Approximately two weeks later in the same capture locations, a total of 74 smallmouth bass were recaptured in Canadaway Creek with 12 displaying tagging marks and 160 smallmouth bass were recaptured in 18-Mile Creek with 4 displaying tagging marks. The study indicates a strong likelihood that the smallmouth bass have a longitudinal movement out of the tributaries fairly rapidly and use the tributary as a nursery setting versus a resident population.

C10-P-3

Early life history characteristics of tributary vs. lake spawned age-0 smallmouth bass

Scott Sullivan[1] (presenting), Timothy Strakosh[1], Donald Einhouse[2]. [1]SUNY Fredonia, Fredonia, NY, United States, [2]Lake Erie Fisheries Unit, NYS DEC, Dunkirk, NY, United States

The Lake Erie smallmouth bass *Micropterus dolomieu* sportfishery is of considerable economic value to local areas. To properly manage this fishery a comprehensive understanding of their life history characteristics is needed. The purpose of this project was to compare relative abundance, growth, condition, and diet of tributary versus lake spawned age-0 smallmouth bass. Age-0 smallmouth bass in the tributaries were sampled using a backpack electrofishing unit between the months of July and August of 2007. Samples were collected from Lake Erie with gill nets and an electrofishing boat unit in August and early September of 2007. Saggital otoliths and stomach contents were removed to assess the age and diet of each fish captured. Condition was evaluated through residualized dry weight. Results indicated that age-0 smallmouth bass from Lake Erie had a larger mean length and greater overall condition than compared to samples from the tributaries. However, this is attributable to the greater proportion of fish in the diets of Lake Erie age-0 smallmouth bass. Zooplankton were absent from the majority of stomachs. Possible temporal variation in maturation of these age-0 smallmouth bass may explain some of the differences, but further investigation is needed.

<u>C11. Brook trout</u>

C11-1

Age and size structure of coaster brook trout in Pictured Rocks National Lakeshore, Michigan, USA

Jill Leonard[1] (presenting), Paul Kusnierz[1]. [1]Northern Michigan University, Marquette, MI, United States

The adfluvial migratory form of brook trout, locally called coasters, is endemic to the Lake Superior drainage. Severely depleted by the early 1900's, restoration efforts are now underway across the watershed. In Pictured Rocks National Lakeshore, we have been studying wild brook trout that exhibit the coasting behavior without apparently attaining the large sizes historically associated with coasters. Previously, we have demonstrated movement peaks between lake and stream in spring and, particularly, fall. The proportion of coasting individuals in the restoration streams ranges from 5-20%. Using scale analysis combined with RFID telemetry, we have now found that adfluvial brook trout are primarily age 1 (77%) with some age 2 (15%) and age 3 (7%) at the time of movement. Additionally, there was no difference in the length-at-age or condition-at-age of resident and coasting brook trout. This data suggests that initiation of coasting may not be linked to juvenile growth-at-age parameters in these systems and that other environmental issues may be important in determining the life history strategy adopted.

C11-2

Growth in coaster brook trout: seasonal and hormonal effects

Carla Serfas[1] (presenting), Rachel Holman[1], Lindsey Watch[1], Jesse Karner[1], Jill Leonard[1]. [1]Northern Michigan University, Marquette, MI, United States

We compared populations (3 coasters, 1 stream resident) of Lake Superior brook trout (age 1) over time to determine if they differed in growth parameters or levels of thyroid hormones. A coaster is a brook trout that spends all or part of its time in a large lake. In Lake Superior coasters were once abundant; however, angling and habitat destruction substantially depleted their numbers. A life history variant, coasters are thought to be larger in size than the resident fish that stay in the natal streams. Four strains of brook trout were held at constant temperature (~12°C ±1°C) and natural photoperiod. A subset of fish was sampled monthly. No significant difference was found between strain ($p=0.392$) or sampling period (month; $p=0.686$) in length based relative growth rate. However, there was a significant difference in condition factor across the sampling periods ($p<0.001$) and strains ($p<0.001$). The Nipigon strain had a higher condition factor than the Tobin Harbor, Iron River, or Siskiwit strains. We suggest that the differences in growth in field studies are most likely an environmental effect given the similarity in growth parameters seen under common rearing conditions.

C11-3

Alternative growth rates in populations of Lake Superior brook trout: a critical test for partial migration

Melissa Robillard[1] (presenting), Rob McLaughlin[1], John M Casselman[2], Rob Mackereth[3]. [1]University of Guelph, Department of Integrative Biology, Guelph, ON, Canada, [2]Queen's University, Department of Biology, Kingston, ON, Canada, [3]Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources, Lakehead University, Thunder Bay, ON Canada

Anecdotal evidence suggests that two ecotypes of brook trout (*Salvelinus fontinalis*) are found in Lake Superior and tributary streams: small fish (78 to 249 mm total length) assumed to be stream resident and larger fish (206 to 574 mm total length) assumed to originate in streams and reside in Lake Superior for significant parts of the year. Populations of these brook trout are a conservation concern due to perceived declines in the distribution and abundance of the lake ecotype. Evaluating the growth patterns of these fish is an important step toward understanding the nature of the life history variation observed in these populations in ways that will assist with conservation and rehabilitation efforts. We analyzed otoliths and vertebrae to demonstrate quantitatively that the variation in size is best characterized by two distinct growth trajectories where the lake ecotype grows faster and lives longer than the stream ecotype. There was no evidence of individuals switching from one trajectory to another, although our sample size was small due to restrictions on sampling. Uncertainties remain, but when considered in light of other recent research, our findings provide some of the first scientific support for the hypothesis that the variation between ecotypes represents a system of partial migration, and not just migration, or sympatric migrant and resident populations.

C11-4

Effects of summer temperature conditions on brook trout in a thermally marginal lake

Jason Robinson[1] (presenting), Daniel Josephson[1], Cliff Kraft[1]. [1]Cornell University, NY, United States

As thermal conditions in lake ecosystems potentially become more restrictive as a result of global climate change, a better understanding of how such conditions will impact susceptible fish species will increase the likelihood of preventing total population loss through management actions. Through a monitoring program this study establishes the effect of a range of summer thermal conditions on brook trout growth, reproduction and mortality in a natural setting. Cumulative degree-days exceeding 20°C in each year was used as a relative measure of annual thermal stress. This work seeks to establish degree day thresholds at which significant mortality will occur, and reproduction may be negatively impacted, for the purposes of developing management strategies for wild brook trout populations in thermally marginal lake systems. This work also highlights the importance of temperature monitoring in thermally stressful systems and considering degree-days in addition to temperature thresholds when making management decisions.

C11-5

Brook trout heaven and hell: life in a small shield lake impacted by beaver dam activity

John Parks[1] (presenting), Derek Parks[1], Wayne Groom[1]. [1]Damsa Integrated Resources Management Inc, Thunder Bay, Ontario, Canada

Brook trout are often stocked in small Shield lakes and ponds that are frequently modified by beaver activities. Construction of beaver dams play a major role in the creation (heaven) or destruction (hell) of trout habitat by altering temperature or dissolved oxygen values during critical periods, thus limiting brook trout growth and survival. In one dystrophic 4 ha shield lake water levels fluctuated 1.5 m over a ten year period (1992-2002), which included the life cycle of a beaver dam. High water inundation resulted in a 31% increase in lake surface area and a maximum depth of 4 m. Under higher water levels, flooded wetlands provided an increase in food supply, however end of winter dissolved oxygen demands in recently inundated wetlands were near anoxic (<0.2mg/l) conditions, creating toxic environments for trout. High water levels in summer permitted stratification, that provided relief from elevated surface water temperatures (> 25oC). Conversely low water levels resulted in lower dissolved oxygen concentrations at the end of winter (~ 3 mg/l) permitting trout to survive. Low water levels in summer however, resulted in minimal refuge habitat, as temperature regimes were considered lethal to survival. In these small lakes and ponds lake level management protocols that provide for high water levels during elevated summer temperatures and low levels during winter dissolved oxygen depressions, would improve survival of brook trout. Such protocols are frequently the natural outcome of resident beavers, a well maintained dam and normal precipitation patterns. Significant changes in any of these three factors would be detrimental to brook trout environs.

C11-6

Effects of stripping gametes on return visits to the spawning grounds of lake-spawning brook trout

Glenn Forward[1] (presenting), Viren Bharti[2]. [1]Ontario Ministry of Natural Resources, Whitney, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Kemptville, Ontario, Canada

Brook trout (*Salvelinus fontinalis*) are a highly esteemed sport fish. Unfortunately the presence of natural populations of brook trout has drastically declined. Superior performance of wild strains of brook trout following stocking and high genetic diversity of wild brook trout indicate wild populations may be important sources of gametes for brook trout restoration. However, the effects of stripping gametes on the mating behaviour of wild brook trout are unknown. To determine the effects of stripping gametes, we

stripped male and female fish from a lake-spawning population on two occasions in both 2003 and 2004. Gametes were not stripped from a control group for each sex and stripping date. All fish were measured and tagged. We used sex and body size as independent variables in a multivariate, logistic regression to compare the likelihood of visiting the spawning grounds before and after the date of stripping for stripped and control groups. Overall, brook trout that were stripped were thirty-five percent more likely to visit the spawning grounds after the date of stripping than brook trout that were not stripped. Stripping gametes may impose energetic costs to brook trout because stripping increases the likelihood to visit the highly competitive spawning grounds.

C11-7

Brook trout survival during summer: effects of fish size, water temperature and stream flow

Cailin Xu[1] (presenting), Ben Letcher[2], Keith Nislow[3]. [1]The Nature Conservancy, Amherst, MA, United States, [2]Conte Fish Research Centre, Turners Fall, MA, United States, [3]USDA Forest Service, UMass, Amherst, MA, United States

We examined the effects of water temperature and stream flow on survival of brook trout (*Salvelinus fontinalis*) during summer in a small stream network in western Massachusetts, USA. Using capture histories of > 5000 fish over five years (19 sampling occasions), we estimated effects of environmental variation on survival across fish body sizes and stream locations with multistate capture-mark-recapture models (M-Surge). Low summer flow had a strong negative effect on brook trout survival in small 2nd order tributaries but not in the larger 2nd and 3rd order tributaries. Low summer flow may increase vulnerability of larger trout to bird, mammal and fish predation in the small tributaries. In general, brook trout survival during summer decreased with mean temperature regardless of fish size or location. Our results suggest that the combination of low summer flow and high temperature will have the largest negative effect on summer brook trout survival, especially in small tributaries. The results will also be useful for evaluating effects of future climate change scenarios on population persistence.

C11-8

Biological relevance of summer stream temperatures on brook trout in Vermont

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Stream temperature plays a dominant role in the distribution of fish species within a river, especially in native coldwater fish such as brook trout (*Salvelinus fontinalis*). High summer temperatures can cause periods of sublethal stress that may affect individual growth rates, population density, and biomass of coldwater fish. In this study, we explored how sublethal temperature stress explains distributional patterns in brook trout populations of Vermont. For analysis, we used annual fish population and hourly temperature data that were collected at multiple sites for the past 10-20 years. To explore the spatial resolution of stream temperature data, we deployed many small, temperature loggers (iButtons) in a variety of stream types and sizes. The magnitude, duration, and frequency of stream temperature readings capable of inducing a heat-shock response (> 22°C) were used as predictor variables to explain variation in the brook trout populations. Combining the literature-based knowledge of sublethal stress on individual fish with seasonal patterns of fish population response to temperature allowed us to make predictions of suitable coldwater habitat. Our results provide a basis for assessing and predicting the availability of coldwater habitat that can inform management efforts to maintain or restore native trout in the future context of climate change.

C11-9

Riparian vegetation and stream temperature relationships; opportunities for trout management

Benjamin Cross[1] (presenting), Michael Bozek[1], Matthew Mitro[2]. [1]Wisconsin Cooperative Fisheries Research Unit, Stevens Point, WI, United States, [2]Wisconsin Department of Natural Resoruces, Madison, WI, United States

Elevated summer stream temperatures can become unsuitable for trout and thus limit the length of stream they can occupy. Riparian vegetation management offers opportunities for mitigating elevated temperatures through the reduction of solar radiation provided by shade. We modeled how the amount of riparian vegetation changes the length of stream thermally suitable for trout during the period of maximum stream temperatures. In twelve central Wisconsin streams, temperature data loggers were used to obtain a record of water temperatures at 1 km intervals. Incremental amounts of canopy cover that resulted in a range of shading were used in the model to predict the length of stream suitable to trout. Streams with minimal shading from riparian vegetation (~10%) show an increased length of stream suitable to trout by as much as 64% when riparian vegetation shading is increased to 50% and 349% when 75% shade is modelled. Statewide, opportunities exist to increase thousands of km of stream thermally suitable to trout with just 0.5°C decrease in current stream temperatures. With our models showing substantial increases in stream lengths thermally suitable to trout with the addition of shade, many of these km could be gained by managing for shade providing riparian vegetation.

C11-12
Factors influencing brook trout distribution in the Mill Creek Drainage, Utah
Benjamin Nadolski[1] (presenting), Phaedra Budy[1]. [1]Utah State University, Logan, Utah, United States

Brook trout (*Salvelinus fontinalis*) are implicated as a primary factor leading to the decline in distribution and abundance of native cutthroat trout (*Oncorhynchus clarkii*). To determine the factor(s) that influence the distribution and abundance of brook trout in Mill Creek and its tributaries, we collected a suite of biotic and abiotic data from ten index sites throughout the drainage. Additionally, at each index site, we conducted three-pass depletion electroshocking surveys to determine fish species composition and abundance. To determine drainage-wide population connectivity and invasion potential, fish movement was assessed using two-way weir traps. At the meta-population scale, based on GIS analysis, stream gradient appears to limit brook trout expansion into some portions of the drainage. At the local population scale, regression analyses indicate that water chemistry and minimum water temperature may influence abundance of brook trout. Using a mark/recapture model in Program MARK, we determined that large-scale fish movement was minimal, further suggesting that local conditions limit further expansion of this population. These findings will help prioritize cutthroat trout management actions in the Mill Creek drainage, and will be useful in determining why brook trout are successful invaders in some systems, yet, remain in low and patchy abundance in others.

C11-13
Accurate model prediction of potential stream brook trout abundance
James E. McKenna, Jr.[1] (presenting), James H. Johnson[1], Marc Chalupnicki[1], Christopher Nack[1], Timothy Wallbridge[1].
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Great Lakes Regional Aquatic Gap Analysis has constructed numerous species-specific models that predict potential abundance of stream fishes, based on enduring environmental conditions, including Brook Trout. These empirically-based models are highly accurate, but groundtruth is the best indicator of model performance. A predictive neural network model was constructed and trained for Brook Trout, based on observed Brook Trout abundances reported in the NY DEC Statewide Fisheries Database and ten associated landscape variables (including model-predicted water temperature). The fish model represents best potential conditions for streams under preset-day broad-scale human influences. Model predictions should match field conditions most closely where streams are least disturbed. Brook Trout model MSE was low and R2 was > 0.9; abundances were predicted in streams throughout the Great Lakes drainage of NY using this model. Brook Trout were collected from 19 sites re(presenting) a range of habitat disturbance conditions. Eighty-six percent of “least-disturbed” streams were correctly classified or slightly underestimated by model predictions. The one outlier (model over predicted) was at a site that contained Brown Trout, a known competitor with Brook Trout. Stream temperature predictions were also highly accurate, with 95% correctly classified or within one temperature class.

C11-P-1
Brook trout distribution in Lake Superior South shore tributary streams
Martin Jennings[1] (presenting), Gene Hatzenbeler[1], Jeffrey Kampa[1]. [1]Wisconsin Department of Natural Resources, Spooner, WI, United States

Factors limiting brook trout abundance in tributary streams along the Wisconsin shore of Lake Superior are poorly defined but relevant to coaster brook trout rehabilitation strategies. We measured salmonid abundance in 38 stream reaches within 22 streams in 12 watersheds to evaluate associations between salmonid abundance and stream habitat. We used electrofishing to conduct depletion estimates of salmonid abundance and measured habitat variables describing flow, channel morphology, substrate, cover, and riparian vegetation. Coldwater index of biotic integrity (IBI) was calculated with a single pass index of abundance for all fish species. Water temperatures were recorded at paired stations with continuously recording thermographs. Downstream reaches generally were warmer, had lower coldwater IBI scores and fewer brook trout than upstream reaches. Principal components analysis was used to reduce the number of habitat variables used to test fish-habitat relations. Modelling of brook trout abundance indicated that brook trout are more abundant in narrow, shallow, low-flow reaches. Although brook trout are less abundant downstream, population size structure is similar between upstream and downstream reaches. Brown trout, coho salmon and rainbow trout distributions differed among tributary watersheds but only rainbow trout distributions were associated with habitat differences within streams.

C11-P-2
Current status of the New York State Heritage Brook Trout Program
Chris VanMaaren[1] (presenting), Tim King[1]. [1]New York State Department of Environmental Conservation, Watertown, New York, United States, [2]United States Geological Survey, Leetown, WV, United States

Since the mid 1970s, the New York State Department of Environmental Conservation has been actively assessing and protecting brook trout populations that have not been genetically altered through introductions of stocked brook trout. These geographic populations have been termed “heritage strains” and given protection due to their intrinsic value and due to their value in conserving the genetic diversity of the species. In 1993, Cornell University completed a study using allozyme electrophoresis that supported the claim of 30 distinct populations having heritage status. Recently, in conjunction with the Eastern Brook Trout Joint Venture, NY samples were included in a range wide survey of microsatellite DNA variation. Results from that survey are consistent with the 1993 findings. Moreover, this survey has elucidated the phylogeographic relationships among NY strains and other northeastern populations. NYSDEC seeks to fully utilize the unique multilocus microsatellite DNA genotypes to advance and enhance the management of heritage strain brook trout. Modern tools are providing us with an avenue to identify new heritage strains where we have an unclear stocking history and allowing us to develop studies to test the adaptive significance of our various strains.

C11-P-3
Diel and seasonal variations in stream habitat use of brook trout
James Johnson[1] (presenting), Robert Ross[2], David Dropkin[2], Lori Redell[2]. [1]USGS, Cortland, NY, United States, [2]USGS, Wellsboro, PA, United States

Diel and seasonal variation in habitat use of subyearling and overyearling brook trout (*Salvelinus fontinalis*) were examined during summer and autumn in a small stream in northern Pennsylvania. Diurnal habitat was quantified from 1000 to 1400 hours, whereas nocturnal habitat was determined from 2300 to 0300 hours. Both fish and available habitat were quantified in a 1 km stream reach. Habitat variables measured included cover, depth, substrate and velocity. With the exception of depth in autumn, the habitat used by both groups of trout was significantly different from available habitat. Cover and substrate size governed the habitat use of subyearling trout more so than depth and velocity, whereas all habitat variables were important to overyearling trout. In summer, both age groups of trout used significantly different habitat during the day, but only depth was significantly different between the two groups at night. Subyearling trout used similar habitats during day and night periods during each season. Diel differences in the habitat use of overyearling brook trout were more pronounced, especially during autumn. Our findings suggest that studies to quantify the habitat use of overyearling brook trout in streams need to be carried out during both diurnal and nocturnal periods.

C11-P-4
Assessing interactions between walleye and smallmouth bass in South Dakota Waters
Melissa Wuellner[1] (presenting), Brian Graeb[1], David Willis[1], John Lott[2]. [1]South Dakota State University, Brookings, SD, United States, [2]South Dakota Department of Game, Fish and Parks, Pierre, SD, United States

Walleye *Sander vitreus* and smallmouth bass *Micropterus dolomieu* are popular recreational fishes in South Dakota. Both species are top-level predators, and some walleye anglers perceive that introduced populations of smallmouth bass compete with walleye, resulting in reduced walleye abundance and growth. Little information exists regarding walleye and smallmouth bass interactions. We explored population dynamics of both species in several South Dakota reservoirs and natural lakes to assess competition. Information on abundance, size structure, condition, and growth of both predators was obtained either from South Dakota Department of Game, Fish and Parks biologists or their state management reports. Dynamics of walleye in both reservoirs and natural lakes were apparently not affected (i.e. positively or negatively) by the introduction of smallmouth bass. In most waters, years of lower walleye abundance (as indexed by catch per unit effort in experimental gill nets) after smallmouth bass introduction were followed by several years of increased abundance. Further, size structure [(as indexed by proportional size distribution (PSD)] and condition [as indexed by relative weight (Wr)] of walleyes followed similar erratic patterns. Patterns in smallmouth bass dynamics varied little in some waters or followed patterns similar to walleye in others. Examination of abundance, size structure, and condition of both species over time suggests that other factors (e.g. climate, water levels, prey availability) more likely influenced population dynamics of both species rather than competitive interactions.

C11-P-5
Aberrant growth in brook charr in small Canadian Shield lakes.
William Gardner[1] (presenting), Tom Pratt[1], Karen Smokorowski[1]. [1]Fisheries and Oceans Canada, Sault Ste. Marie, ON, Canada

Brook charr (*Salvelinus fontinalis*) and white sucker (*Catostomus commersoni*) were tagged using Floy external spaghetti or PIT tags as part of a multi year mark-recapture study in the Turkey Lakes Watershed, Ontario, Canada. Spring and fall recapture periods allowed the seasonal and annual growth rates of individual fish to be determined. Inter-annual water temperature differences affected yearly growth patterns for both species, but the close proximity of the lakes meant that no among-lake growth differences were observed, allowing us to pool growth rates among lakes. Average growth of white sucker was typical of what would be expected from fish in north temperate lakes: rapid growth in the ice off period when water temperatures are warmer and little to no growth (in some cases negative growth) in winter. Brook charr, however, displayed the opposite pattern. Brook charr growth in the non-summer months (October to May) far exceeded the growth of brook charr over the summer months (May to October). Year-to-year individual growth was similar for both species.

C11-P-6
Behavioural and genetic assessment of mate choice in brook trout
Terin Robinson[1] (presenting), Joanna Freeland[1], Chris Wilson[2]. [1]Trent University, Peterborough, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada

A multifaceted approach is necessary in order to better understand the complex processes involved in mate choice. We investigated mate choice in a population of brook trout (*Salvelinus fontinalis*) with known ancestry. We are using a combination of genetic data (microsatellite and MHC loci) and behavioural observations in order to better understand how relatedness influences mate choice in this species. Video observations of female mate choice based on kinship versus MHC genotypes were paralleled with introductions of families of known ancestry (relatedness) and genotypes into a semi-wild environment, using offspring genotypes to infer parental mate choice. Our findings will be relevant to future management and conservation of brook trout, as they will improve our understanding of maintenance of genetic diversity, and evolutionary potential within populations.

C11-P-7
Population status and life history characteristics of coaster brook trout in Tobin Harbor, Michigan.
Henry Quinlan[1] (presenting). [1]USFWS, Ashland, WI, United States

Coaster brook trout are the subject of a lakewide rehabilitation effort in Lake Superior. Tobin Harbor, Isle Royale National Park, Michigan sustains one of the few viable remnant populations. Survey data is used to describe the status and life history characteristics of this population. Radio telemetry and visual implant tags have been used to identify the home range and describe movement of coasters. Relative abundance of coasters in spring has fluctuated from 0.3 to 16.7 fish per hour electrofishing. Low catch per effort during some years is a cause for concern of the long term population viability. The National Park Service and Michigan DNR implemented more restrictive angling regulations in response to abundance data. Life history parameters such as growth, age at maturity, fecundity, time of spawning, weight-length relation, mortality, and diet will be described. The growth rate and longevity of coasters will be compared to that of stream dwelling brook trout from Isle Royale and other brook trout populations at similar latitude. Diet of coasters in Tobin Harbor is indicative of the prey items present but is skewed toward piscivory. Habitat occupancy suggests a night-time preference for sand and silt substrate contrary to reports linking coasters to shoreline habitat composed primarily of rock.

C11-P-8
Effects of population density on feeding behavior by brook and cutthroat trout in an Idaho stream
David Owens[1] (presenting), Joe Benjamin[1], Colden Baxter[1], Kurt Fausch[1], Fabio Lepori[1]. [1]University of Nebraska, Lincoln, NE, United States, [2]Idaho State University, Pocatello, ID, [3]United States,Colorado State University, Ft. Collins, CO, United States

This research investigated the effects of nonnative brook trout (*Salvelinus fontinalis*) on a stream-riparian ecosystem in Idaho. Previous studies demonstrated that brook trout reach higher densities and out-compete native cutthroat (*Oncorhynchus clarkii*) for aquatic insect resources. Specifically, we examined whether brook trout alter their feeding with density, shifting from drift feeding to benthic foraging. After isolating 30 meter reaches with fencing, we removed fish by electro-shocking and restocked either with cutthroat at their natural density, brook trout at their natural density, or brook trout at a reduced density equivalent to natural cutthroat density. Fish were monitored visually, and each attempt to feed from the surface, drift, or substrate by different size classes was recorded. The results indicate that large brook trout rarely feed from the benthos in natural density treatments, whereas smaller size classes feed on benthic resources. In contrast, all sizes of native cutthroat fed on drifting invertebrates under natural density, as did all size classes in the low density brook trout treatment. These results indicate that as brook trout compete with and displace native cutthroat, size class differences in feeding habits will result in greater feeding pressure on benthic invertebrates, further altering food webs in these streams.

<u>C12. Habitat and Water Quality</u>
C12.1-1
Science and practice of aquatic ecosystem assessment, protection, and restoration
Gordon Wichert[1] (presenting). [1]Gartner Lee Limited, Markham, Ontario, Canada

Approaches that integrate reliable scientific information and practical experience provide effective means to promote ecological sustainability and protect key aquatic habitat and resources. General principles drawn from individual case-based studies form an approach that facilitates a standard level of information collection and interpretation. Ecosystem assessment provides a key component of such approaches and forms the basis of information for best management practices, ecosystem protection during development, and restoration. In Ontario, legislation and regulations related to fish habitat protection, water taking, and valley and floodplain development are implemented to protect and restore aquatic habitat features. Science practitioners must understand the intent of the regulations and guidelines, and develop analytical approaches that support these intents. Through case-study examples we examine the implementation of the regulations, and describe an investigative framework and strategies used to characterize and protect fish and fish habitat. Examples of assessment techniques include fish-as-indicator methods to characterize water temperature and water quality conditions, and aquatic habitat assessment based on physical properties. Case studies will be presented to demonstrate how these assessment techniques have been mobilized to support aquatic ecosystem sustainability. Finally some lessons learned and recommendations to enhance the effectiveness of a science and practice, knowledge generation cycle will be presented.

C12.1-2

Strategy for avoiding impacts to aquatic habitat while temporarily discharging pumped groundwater to watercourses

Robin McKillop[1] (presenting). [1]Gartner Lee Limited, Markham, ON, Canada

Aquatic ecosystems are susceptible to impacts from construction dewatering through aquifer depressurization and subsequent groundwater dispersion. A three-level hierarchical strategy, requiring a multi-disciplinary team, is proposed for avoiding impacts to aquatic habitat while temporarily discharging pumped groundwater into watercourses. At the regional and planning level, opportunities to reduce the need for dewatering through alternative construction methods and phasing are explored, in order to minimize the necessary rate of groundwater dispersal into streams. At the local level, groundwater receptor streams are selected based on their ability to convey the supplemental flow without potentially impacting aquatic habitat through overbank flooding, morphologic change, thermal barrier creation, or water quality degradation. At the site-specific level, the physical groundwater dispersal mechanisms are designed to improve water quality prior to stream entry and reduce the potential for localized erosion or plume generation. Assurance monitoring is required to verify that groundwater discharge is not impacting aquatic habitat, at the recommended locations and rates, and to provide the opportunity to detect early and remedy any potential problems.

C12.1-3

A stream sensitivity assessment tool developed for standardizing baseline condition reports

Daniel Gibson[1] (presenting), Gordon Wichert[1]. [1]Gartner Lee Ltd, Markham, Ontario, Canada

A Stream Sensitivity Assessment Tool was developed using i) primary fisheries data collected by Gartner Lee Limited (GLL) in 2005/2006, ii) secondary source data from regulatory agencies, and iii) existing fish habitat assessment protocols and sensitivity matrices. The goal of the Stream Sensitivity Assessment Tool is to create a consistent and defensible method of characterizing and reporting fish habitat sensitivities during the decision making process. A total of 106 sites were assessed within the Duffins Creek, Petticoat Creek and Rouge River watersheds in the GTA. Fish community composition and abundance surveys were conducted to assess water quality and water temperature characteristics. Data obtained from the Ministry of Natural Resources and the Toronto Region Conservation Authority was used to determine historic locations of Species at Risk and stream thermal designations. Groundwater/surface water interaction tools were also used to determine groundwater contributions to each watercourse. Fish community sampling results were subjected to a Species Associated Tolerance Index (SATI) for Water Quality (WQ) and Water Temperature (WT). The SATI-WQ score assigns individual fish a species tolerance score (STS) based on the degree of intolerance to specific water quality criteria. The SATI-WT score assigns a final temperature preferendum (FTP) for the fish communities within each stream reach sampled. Qualitative assessments of fish habitat were also conducted using the Rapid Assessment Method (RAM) of the Ontario Stream Assessment Protocol (OSAP). The results were displayed on one technical map to illustrate the fish and fish habitat characteristics at each sampling location. The results of the individual investigations were then subject to Fisheries and Oceans (DFO) Risk Management Framework criteria to estimate an overall stream sensitivity rating. Findings from this approach provide a consistent and defensible method of reporting baseline conditions and an overall assessment of stream sensitivity to environmental perturbation and degradation.

C12.1-4

Streamflow characteristics of California's Central Valley Rivers: implications for native and invasive fishes

Larry Brown[1] (presenting), Marissa Bauer[1]. [1]U.S. Geological Survey, Sacramento, CA, United States

The Central Valley of California encompasses the drainages of the Sacramento and San Joaquin Rivers. These rivers provide water for about 25 million Californians and support a multi-billion dollar agricultural economy. Previous studies suggest that differing water management practices in the two drainages are a major factor determining fish assemblage composition. Management for water delivery through natural channels in the Sacramento drainage appears to favor native species, while water diversions in the San Joaquin drainage seem to favor invasive species. However, alterations to natural flow regimes related to water development have not been well characterized. For 4 major rivers in each drainage, we compared estimates of full natural runoff before construction of major foothill storage reservoirs with measured discharge after construction. In the Sacramento drainage, pre-dam and post-dam mean annual discharges were within 10 percent and the hydrograph was flattened. In the San Joaquin River drainage, post-dam mean annual discharges were 42-62 percent less than pre-dam values and mean monthly discharges declined in most months, especially during spring. When considered with species' life history characteristics, these results support the hypothesis that water management has a major influence on the relative success of native and invasive fishes.

C12.1-5

Using biology to establish sediment criteria in mountain streams

Gregg Lomnicky[1] (presenting), Sandra Bryce[1], Philip Kaufmann[2]. [1]Dynamac Corp. Corvallis, OR, United States, [2]US Environmental Protection Agency, Corvallis, OR, United States

Sediment is a leading cause of impairment of biological condition in rivers and streams of the United States. Recently, federal and

state agencies have shown increased interest in developing sediment criteria to maintain or improve habitat quality for the protection of aquatic species. To develop biologically-based sediment criteria, sediment amounts must be linked with aquatic biota response. We relate an aquatic vertebrate index of biotic integrity (IBI) and an aquatic macroinvertebrate IBI with a measure of the areal percentage of streambed surficial fines. The associations suggested that fine sediment may limit the biological potential of mountain streams. We used quantile regression to model the upper limit of IBI response; the regression equation for each taxa group predicted a 4.5—5.0 percent decline in IBI for each 10% increase in areal percent surficial fines. However, the limiting relationship itself did not suggest a threshold sediment level above which impairment was evident. To develop more specific evidence regarding sediment impairment and possible impairment thresholds, we sought additional information from: 1) sediment levels at reference sites in our sample; 2) sediment tolerance values calculated for sediment-sensitive taxa in the mountain ecoregion; and 3) a literature review. We concluded that streambed areal surficial fine sediment levels of ≤ 5% fines retain habitat potential for sediment-sensitive aquatic biota in mountain streams.

C12.1-7

Selenium influence on fish assemblages in the Arkansas River and selected tributaries, Colorado

Lee Bergstedt[1] (presenting), Lareina Wall[2], Steven Canton[1], James Chadwick[1]. [1]GEI Consultants, Littleton, CO, United States, [2]U.S. Environmental Protection Agency, Denver, CO, United States

This study collected fish population data, determined background selenium concentrations, and defined physical habitat characteristics of the Arkansas River and nearby tributaries in the vicinity of the City of Pueblo, Colorado, USA, to evaluate relationships between selenium concentrations and fish populations. Total fish density was not significantly related to tissue selenium. Substrate conditions explained most of the variability in total fish density. A negative relationship was observed between whole body selenium and species-specific densities for the family Centrarchidae. Centrarchid tissue selenium was also correlated with habitat, confounding the relationship with density. Densities of cyprinid species were not significantly correlated to whole body selenium concentrations alone, but percent silt, percent sand, and whole body selenium explained 57% of the variability in the densities of cyprinid species. Catostomid densities were not significantly correlated with whole body selenium concentrations, but were significantly correlated with percent silt. Overall, the results of the study indicate no consistent relationships between selenium concentrations in water, sediment and fish tissues, to fish taxa richness or density for the range of concentrations observed. Analyses indicate that selenium plays a role in structuring fish populations at these sites, but habitat is potentially more important in structuring the fish community.

C12.1-8

Patterns of fish assemblages in a long-term, watershed-scale study to address the effects of pulp and paper mill discharges in four U. S. receiving streams

Camille Flinders[1] (presenting), Timothy Hall[1], William Arthurs[1], Joan Ikoma[1], Renee Ragsdale[1]. [1]NCASI, Anacortes, WA, United States

Changes in fish exposed to pulp and paper mill effluent (PPME) have been seen in laboratory, mesocosm, and short-term field studies. However, long-term patterns of fish community structure in PPME receiving streams have not been examined. We conducted a study of 4 PPME receiving streams (Codorus Creek (PA), the Leaf River (MS), and the McKenzie and Willamette Rivers (OR)) over 9 years to assess temporal patterns in small- and large-bodied fish community structure and metrics related to PPME discharge. Study streams represented different ecoregions, warm/coldwater systems, gradients of PPME concentration (<1 to 33%), and mill process types. Fish were sampled at multiple sites upstream and downstream of PPME discharges using boat and backpack electrofishing. Bray-Curtis similarity and MDS showed significant community differences across sites in Codorus Creek, but differences were related to a stream temperature gradient and not PPME. In the other study streams, spatial and temporal variation was high, with no clear patterns in community structure regardless of fish size. Community metrics (Abundance [standardized for effort], Richness, Simpson's Diversity, %Dominant Taxa, %DELT, %Omnivore, %Piscivore) showed no relationship with PPME discharge in any river, although some metrics were weakly related to temperature in Codorus Creek. The relationship between fish communities and measured water quality variables (pH, conductivity, colour, TN, TP) was relatively weak. The results of this study indicate that fish community structure is temporally variable, and reiterate the importance of long-term studies.

C12.1-9

A simulation model to evaluate common carp (*Cyprinus carpio*) removal as a tool to improve water quality

Michael Colvin[1] (presenting), Clay Pierce[1], Tim Stewart[1]. [1]Iowa State University, Ames, IA, United States

Benthivorous common carp adversely affect water quality and aquatic community integrity in North American lakes. Sporadic mechanical removals of carp have been used in lakes in the Midwestern USA over the past several decades to improve water and habitat quality for the aquatic community. High carp fecundity and growth rates limits the effect of removal on long-term ecosystem improvement which has stimulated the consideration of ongoing harvesting to maintain low carp abundance. We developed a simulation model to evaluate the ability of annual and biennial year carp removal to achieve water quality goals (e.g.

turbidity) for Clear Lake, Iowa, accounting for uncertainty in rate and type of juvenile recruitment. Annual removals rapidly achieved water quality goals, while biennial removal required additional effort to achieve water quality goals. Post-removal water quality returned to pre-removal levels within ten years for annual removals whereas water quality improvements were conferred beyond ten years for biennial removals. These results indicate that the combination of annual carp removals can quickly achieve water quality goals and biennial removals can maintain water quality over the long-term.

C12.1-10
Effects of omnivorous fish biomanipulation on water quality and macrozooplankton at a subtropical lake
Matthew Catalano[1] (presenting), David Buck[2], Micheal Allen[1], John Beaver[3]. [1]University of Florida, Department of Fisheries and Aquatic Sciences, Gainesville, Florida, United States, [2]University of Florida, School of Natural Resources and Environment, Gainesville, Florida, United States, [3]BSA Environmental Services, Inc., Beachwood, Ohio, United States

We used a Before-After-Control-Impacts Paired Series (BACIPS) study design to evaluate changes in water quality (chlorophyll a, Secchi depth, total phosphorus) and macrozooplankton biomass for two years before and two years after an experimental density reduction of omnivorous gizzard shad *Dorosoma cepedianum* at a hypereutrophic subtropical lake (Lake Dora, Florida, USA) and an unmanipulated control lake (Lake Harris). The biomanipulation was carried out by a government-subsidized gill net fishery that removed approximately 40% of the total gizzard shad biomass from 2005 to 2006. The fishery targeted large (>300-mm) gizzard shad owing to a 102-mm minimum mesh size restriction. We detected no significant changes in phytoplankton biomass (as estimated by chlorophyll a), Secchi depth, total phosphorus concentration, or macrozooplankton biomass following the biomanipulation. We conclude that phosphorus loads due to external sources, sediment fluxes, and wind resuspension substantially exceeded those attributable to nutrient translocation and recycling by the gizzard shad removed from the lake. Alternatively, the manipulation may not have been strong enough to elicit a phytoplankton response. The 40% biomass reduction fell short of the 75% reduction target that has resulted in phytoplankton reductions in temperate lakes.

C12.1-11
Grand River structural enhancement project: restoring quality habitat in a dam controlled environment
Al Murray[1] (presenting), Jennifer Wright[2]. [1]Ministry of Natural Resources, Guelph, Canada, [2] Grand River Conservation Authority, Cambridge, Canada

It has been identified through observations of fisheries managers and other river users that the Grand River below the Elora Gorge area has poor “river structure”. This is due in part to the operation of the Shand Dam which reduces flushing (flood) flows. In general, pools are to shallow and riffles are poorly defined. Improving this habitat was a recommendation of the watershed-based, Grand River Fisheries Management Plan (1998) and the Grand River Tailwater Fisheries Management Plan (2005). The restoration plan was developed by Parish Geomorphic with the help of watershed partners to engineer improved riffles and pools, channel structure and fish habitat through in-river work using heavy equipment and large materials (trees, boulders & gravel). In 2007 the first in-river improvements was undertaken. A Newbury Riffle requiring over 200 tonnes of stone was installed, six full sized trees were strategically secured into the bank and several large boulders or boulder clusters were strategically placed to improve about 200m of habitat. The expected result of this project is improved river structure that will provide benefits for a variety of fish species and aquatic environments. The steering committee representatives that carried out this initiative learned about completing “outside the box” fisheries habitat enhancement projects through the 10 years that spanned from project concept to in-river construction. Installing the structures was simple and cost effective. Planning and preparing for the installation was a more challenging and time-consuming part of the process. The project is now monitoring the first instalment and developing plans for future instalments associated with this project.

C12.1-12
Challenges of sustained blue crab fisheries in pollution-impacted Chesapeake Bay waters
Cynthia McOliver[1] (presenting), Thaddeus Graczyk[1]. [1]Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States

The Atlantic blue crab (*Callinectus sapidus*) is the most economically important seafood commodity in the Chesapeake Bay (The Bay). The Bay supports both commercial and recreational crab fisheries in six states along the East Coast of the United States (Delaware, New York, Pennsylvania, Maryland, Virginia and West Virginia, and the District of Columbia. The continued economic and cultural importance of blue crabs to this region, and to the United States as a whole is inherently dependent on the sustainability of crab fisheries in coming years. Unfortunately, the abundance and health of blue crab populations harvested commercially from the Bay have steadily declined over recent decades. Numerous ecological studies and assessments on Bay health and conditions reveal progressive deterioration of water quality and associated declining of blue crab populations which enforced limitations and restrictions on crab harvests.

C12.1-13
Ecological restoration of fish habitat at the watershed scale

Carole Godin[1] (presenting). [1]Fisheries and Oceans Canada, Moncton, New Brunswick, Canada

From a regulatory point of view, protecting the health and productivity of fish habitat requires the implementation of effective approaches to regulating impacts. But from a stewardship point of view, it will require the development of innovative and engaging environmental management approaches and strategies that can mobilize stakeholders' involvement and commitment. The ecological restoration approach developed in the Gulf region provides a model for such strategy for participatory action. It is based on a systematic methodology for addressing common fish habitat limiting factors such as:[1] fish passage,[2] physical aquatic habitat quality and[3] riparian zone quality. The success of this approach is based on partnership with key stakeholders to identify habitat issues at a watershed scale. At the moment, three main tools have been developed to provide general guidance. The manual on "Ecological Restoration of Degraded Aquatic Habitats: a Watershed Approach" outlines sound principles and provides helpful guidance in achieving ecosystem-based fish habitat restoration. The 'Protocol to assess fish passage at culverts' is a joint effort between DFO, the provincial departments of transportation and environmental groups. This protocol assists groups in assessing fragmentation of their watershed and to identify and document restoration opportunities. The 'Strategy for fish passage improvements in New Brunswick' has resulted in the removal of a number of dams in the Miramichi watershed, the installation of hundreds of new fishways in culverts. Overall, this strategy has resulted in the opening of hundreds of square kilometer of new fish habitat. This paper will present these tools and how their development was coordinated with other agencies and stakeholders. It will provide examples of how this integration of approaches with other institutions delivers improved short and long-term fish habitat protection outcomes.

C12.1-14
Assessing ecological risk in an increasingly complex world: proposed model for fish habitat managers
Sophie Bastien-Daigle[1] (presenting), Matthew Hardy[1], All authorsGuy Robichaud[1]. [1]Fisheries and Oceans Canada, Gulf Region, Moncton, New Brunswick, Canada

Canada's Habitat Management Program's (HMP) Risk Management approach implicitly recognises that all activities entail some risks which must be weighed in terms of the scale of negative effect and the sensitivity of fish and fish habitat. A risk-based approach allows habitat managers to prioritize and focus efforts on regulating the activities which are considered to have the greatest potential impact to fish and fish habitat. This entails the review of available relevant information in order to categorize the risks associated with development proposals and associated management options. There are a number of frameworks available to conduct comprehensive risk assessment of given activities, yet few have been formally validated. It is from this perspective that Fisheries and Ocean's Gulf region endeavoured to develop a risk assessment framework to apply for the review of water column oyster aquaculture. The format used for this framework is inspired in part by the USEPA Guidelines for Ecological Risk Assessment. These types of tools are used to identify and characterize potential risks of the activity and to make a determination as to their significance as they relate to the productive capacity of fish habitat. Additionally, because some projects can provide beneficial ecological services, a Net Environmental Benefits Analysis (NEBA) approach, as proposed by the US Department of Energy, was incorporated in the Framework. This paper will present the proposed approach and how it can be used to make determinations as to the effects and functions of projects, how it can present help risk to managers in a comprehensive and science-based manner and help dissociate true risks from the emotional discourse surrounding controversial projects.

C12.1-16
Impacts of human use of water drive need for improved and increasing use of incremental impact assessment tools
William Werner[1] (presenting). [1]Arizona Department of Water Resources, Phoenix, Arizona, United States

In the arid southwest United States human use of water resources has impacted aquatic and riparian biota. Impacts can result in changes to the hydrograph, conversion of gaining to losing reaches, and conversion of stream character from perennial to intermittent or ephemeral. Changes can affect aquatic biota and riparian habitats that provide allochthonous material and shade streams. Understanding and projecting incremental effects of changes from human use in the context of present and future physical conditions requires an understanding of the geohydrologic and hydrologic context. Modeling changes requires definition of species needs in terms that can be translated into relationships between flow and important habitat requirements. Such modeling can be an important part of impact assessment for environmental compliance documentation and can support instream flow claims. Instream Flow Incremental Methodology was developed to be used in impact assessment but is not commonly used in Arizona because it is data intensive and habitat relationships are not developed for many species. We need to improve our tools in incremental effect assessment, including development of relationships between flow and important habitat parameters. Understanding of relationships such as canopy cover on stream temperature are also needed. Arizona modeling examples will be reviewed.

C12.2-1
Hydro-climate and Atmosphere Indexed Runoff Prediction (HARP) Tool
Michael McMahon[1] (presenting), John Henz[1], William Badini[1], Steve Anderson[1]. [1]HDR - Engineering, Denver, CO, United States

The HDR-Atmospheric Sciences Group (ASG) has developed a hydro-climate and atmosphere indexed runoff prediction tool called

HARP. It has at its core a focus on the management of uncertainty and risk. Using the HARP tool, one is able to address the issue of predicting the potential runoff, and the timing of peak and runoff volume in a given basin for both water year forecasting as early as October, and for flow predictions required to formulate an Annual Operation Plan (AOP). Output from this tool yields not only forecast values, but, for each forecast value, confidence ranges are reported. This water supply prediction tool adds a realistic dynamic component to a classic stochastic (probabilistic) model. This method has been proven successful, and has held up under regulatory scrutiny by FEMA, the COE, and FERC. Furthermore, it has been accepted and used by NWS River Forecast Centers in Virginia, South Carolina, and Georgia The HARP tool was initially put into practice by the HDR-ASG at Flathead Lake, Montana during the formulation of a Drought Management Plan for the Bureau of Indian Affairs (BIA). It was used to identify definable relationships between naturalized stream flows into Flathead Lake (Result), basin precipitation (Diagnostic cause), and large scale climatic regimes (Prognostic cause). Although the tool was originally developed for input into the lake's AOP, it became an integral part of the EIS for the project. Fisheries in the lake (particularly native species like the Westslope Cutthroat and Bull trout) were found to be highly susceptible to changes in stream flows and lake levels regulated by the AOP. Issues such as the stranding of fish in the varial zone during flow reductions, reduced survival of fish eggs and young due to high winter flows, and low populations of invertebrates (a critical food source in the lake) due to habitat modifications associated with flow volumes and variability had to be addressed. The HARP tool provided the answer to managing water levels for the fisheries in the same way it managed water supply for other users of the lake.

C12.2-2

Actogram and Habitat Meter: tools for real time assessment of the fish habitat status in streams.

Piotr Parasiewicz[1] (presenting), Thomas Seager[2], Thomas Meyer[3], Ed Edelson[3]. [1]Rushing Rivers Institute, Amherst, MA, United States, [2]Rochester Institute of Technology, Rochester, NY, United States, [3]Pomperaug Watershed Coalition, Southbury, CT, United States

As documented by many scientists, running waters belong to the most endangered ecosystems on our planet. Many of these studies blame the decline of available habitat as a main cause of this impact. Yet, this message does not seem to resonate outside of a relatively small group of river and ecological scientists. One of the many reasons is a lack of practical tools that would continuously document the habitat status and convey this to the managers and the public. Two tiers of tools need to be provided, one for the managers that allows for quick assessment and determination of management action, and a second for delivering the message of the status of the watershed to the lay audience to create a willingness to support the actions of the managers. Two techniques have been developed so far to serve these purposes: Assessment of Cumulative Thresholds diagrams (ACTograms) and Habitat Meter. They define the status and need for management actions from the magnitude and duration of flows in the river. MesoHABSIM model and habitat time series analysis create the scientific foundation for this approach. Both tools and their development are presented in this paper supported by data from three case studies.

C12.2-3

Short-term effects of drain maintenance on fish assemblages inhabiting agricultural drains in southwestern Ontario

Belinda M.S. Ward-Campbell[1] (presenting), Robert L. McLaughlin[1], Nicholas E. Mandrak[2]. [1]University of Guelph, Guelph, Ontario, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Central & Arctic Region, Fisheries and Oceans Canada, Burlington, Ontario, Canada

The effects of maintaining agricultural drains on fish assemblages are of increasing interest as attempts are made to mitigate anthropogenic effects on natural populations. A recent survey of agricultural drains in southwestern Ontario revealed no constant long-term differences in the species composition of fishes inhabiting drains and reference water courses of comparable size, suggesting that fish populations recover quickly post maintenance. We present results on monitoring the recovery of fish assemblages for 1 year following maintenance in 10 agricultural drains in southwestern Ontario. We examined the short-term effects on and recovery of fish species composition using a Before-After-Control-Impact design applied to 10 pairs of reference (control) and drain (impact) water courses. Drains were sampled twice prior to maintenance, immediately following maintenance and monthly beginning the following spring. Overall, recovery times for species richness were short, but there was also considerable variability in recovery times among pairs. Greater understanding of recovery time will help drain superintendents and fish habitat managers develop better drain maintenance practices.

C12.2-4

The role of habitat patterns in controlling the impact of predatory trout on non-migratory galaxiid distributions across New Zealand riverscapes

Darragh Woodford[1] (presenting), Angus McIntosh[1]. [1]University of Canterbury, Christchurch, New Zealand

Introduced trout have been implicated in the decline of non-migratory galaxiid (NMG) fish populations within New Zealand river systems, though the mechanisms underlying these impacts are still poorly understood. Variation in habitat conditions across the landscape of a river network, or "riverscape" may mediate the interactions between trout and NMG, thereby controlling the distributions of the galaxiids. We investigated the seasonal distributions of Galaxias vulgaris and G. paucispondylus across three

trout-invaded riverscapes, which contained fragmented populations of both species. Analysis of NMG occurrence outside of trout-free "source" streams indicates that G. vulgaris forms source-sink metapopulations within invaded riverscapes. Galaxias paucispondylus does not display source-sink population structuring, and appears better able than G. vulgaris to use habitat cover in order to co-occur with trout. A reach-scale stream-manipulation experiment showed that the presence of large predatory trout is a critical factor controlling local distributions of both galaxiid species. While river disturbance appears to control the distribution of large trout, local channel size and habitat complexity of stream reaches interact to create refugia for recruiting young fish, allowing persistence of galaxiids in "sink" regions of the trout-invaded riverscape. By modeling riverscape habitat structure we aim to predict the presence of NMG in invaded reaches of other catchments based on the prevalence of trout-predation refugia.

C12.2-5

Response of fish assemblages to natural-channel-design restoration in streams of New York.

Barry Baldigo[1] (presenting). [1]U.S. Geological Survey, Troy, NY, United States

Fish assemblages and habitat at six pairs of treatment and control reaches in five Catskill Mountain streams were sampled 3 to 6 times from 1999 to 2007 to assess their response to natural-channel-design (NCD) restoration. A before-after-control-impact (BACI) study design and ANOVAs were used to quantify net changes in fish and habitat indices at the treatment reaches relative to those at nearby control reaches. With some exceptions, restorations produced significant increases in average community richness (2 species; +29%), Shannon-Weiner diversity (by 0.7; +39%), species and biomass equitability (0.05 to 0.17; +12-34%), and total biomass (3.2 g/m2; +28%), and a decrease in total density (1 fish/m2; -22%). Changes in community structure were attributed mainly to shifts in dominant species from dace (Rhinichthys spp.) and slimy sculpin (*Cottus cognatus*) before restoration toward one or more trout species following restoration. Net biomass of all trout increased on average by 3.4 g/m2 (+105%) at most reaches, whereas, dace and sculpin biomass decreased by 3.0 g/m2 (-38%) after restoration. These findings demonstrate that the health of fish communities in disturbed Catskill streams generally benefit from NCD restorations. Significant factor interactions, however, indicate that some streams respond uniquely; therefore, individual stream assessments are needed to fully understand the response of local fish populations and communities to NCD restoration.

C12.2-6

Road crossing designs and their impact on movement and diversity of Great Plains stream fishes

Wesley Bouska[1] (presenting), Craig Paukert[1]. [1]Kansas State University, Manhattan, KS, United States

Inappropriate road-stream crossings may prohibit the movement of stream fishes by creating physical or behavioral barriers. A mark-recapture study was conducted to evaluate fish passage through three types of vehicle crossings located on streams that contain federally endangered Topeka shiners (*Notropis topeka*) in the Flint Hills of Northeast Kansas. We tested passage through five concrete box culverts, five low-water crossings (concrete slabs vented by one or multiple culverts), and two single corrugated culverts. In addition, each site had a control reach where fish were marked below a natural barrier in the same stream allowing movement patterns to be compared between control and road crossing reaches for each site. A total of 6,539 fish including 192 Topeka shiners were marked in April and May 2007 and 723 (11.1%) were recaptured in June, July, and August 2007. Fish passage occurred at all crossing types. Topeka shiner passage was observed only through box culverts and corrugated culverts. Of the recaptured fish at each site, upstream movement was higher at the controls (41.1%) than at the crossing reaches (19.1%) for low-water crossings ($P<0.0001$). There was no difference in the proportion of fish that moved upstream, compared to control reaches, at box culverts ($P=0.665$) or corrugated culverts ($P=0.171$). Across all crossings and species, increased culvert bottom velocity decreased the probability of fish movement through culverts ($P=0.04$), but culvert water depth ($P=0.59$) or culvert length ($P=0.50$) did not. These results suggest that crossing type affects the degree of fish passage, with low-water crossings having the greatest impact. Use of properly designed and installed crossing structures has great promise in conserving critical stream habitat, preserving native fish communities and aiding the recovery of the Topeka shiner.

C12.2-8

Effects of a low-head dam on the fish community of a large Great Plains River

Joe Gerken[1] (presenting), Craig Paukert[1]. [1]Kansas State University, Manhattan, Kansas, United States

Large rivers have undergone many anthropogenic changes resulting in drastic changes in their hydrology and habitat availability. While many human-induced alterations have been studied in detail, few studies have examined the effects of low-head dams on fish communities. This study quantitatively analyzed spatial variation in the fish community above and below Bowersock Dam, a low-head dam on the Kansas River, over 24 seasonal electrofishing sampling trips from 2004-present. We used the Shannon-Weiner index to calculate species diversity at sites above and below the dam and at a site distant from the dam. Species diversity was similar above [$H = 1.18$] and below [$H = 1.06$] the dam, but both values were lower than the distant site [$H = 1.81$]. Additionally, lotic specialists comprised a larger proportion (68%) of species richness above the dam while native, fluvial specialists accounted for a larger proportion (59%) below the dam. Species diversity at sites near the dam was lower than that of the distant site, indicating that the low-head dam may be negatively impacting fish communities. This study shows that low-head dams can drastically change fish communities and may help conservation agencies better manage fishes impacted by similar dams.

C12.2-9

A multi-disciplinary dam removal feasibility study on the Mill River, Hatfield, Massachusetts

Piotr Parasiewicz[1], Jim MacBroom[2], David Ahlfeld[3], Bradley Compton[4], Scott Jackson[4], Diane Mas[3], Miira Wirth[5], Jeffrey Legros[4] (presenting). [1]Northeast Instream Habitat Program, GeoProcessing Laboratory, Mount Holyoke College, South Hadley, MA United States, [2]Milone and MacBroom, Inc. Cheshire, CT United States, [3]Department of Civil and Environmental Engineering, [4]Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA United States, [5]Massachusetts Water Resources Research Center, University of Massachusetts, Amherst, MA United States

A comprehensive dam removal feasibility study was conducted on the Mill River in Hatfield, Massachusetts. This multidisciplinary effort involved the complementary expertise of professionals in several fields to address: 1) the potential for passage of diadromous and migratory fish species, 2) the ecological risks and benefits of increasing free flowing habitat, 3) the reduction of wetlands and impacts on habitat, 4) removal costs and technology and 5) alternatives to removal. Using HEC-RAS modeling, habitat mapping, and habitat suitability regression models, we documented that dam removal would open substantial amounts of spawning habitat for migratory species and increase suitability of habitat for the Federally endangered dwarf wedgemussel and tessellated darter, a known host fish species of dwarf wedgemussel glochidia. Hydraulic control points (e.g. bedrock ledges and meanders) and modeled post-dam-removal beaver activities were predicted to mitigate the overall loss in wetland habitat of a dam removal scenario by creating a more natural, dynamic wetland system. This study demonstrates the importance of preliminary investigations when contemplating dam removals and illustrates the importance and potential of interdisciplinary collaboration in ecological assessments.

C12.2-10

What can clinical medicine teach fisheries science? A systematic review on the effectiveness of placing large wood in streams

Kelly Burnett[1] (presenting), Guillermo Giannico[2], Jeff Behan[3]. [1]USDA Forest Service Pacific Northwest Research Station, Corvallis, OR, United States, [2]Department of Fisheries and Wildlife Oregon State University, Corvallis, OR, United States, [3]Institute for Natural Resources Oregon State University, Corvallis, OR United States

Systematic review is a rigorous, transparent technique for synthesizing technical literature that is widely used in clinical medicine. In systematic reviews, all relevant evidence is assessed regarding the efficacy of an active intervention, for example a particular surgical procedure in clinical medicine. A systematic review differs from a traditional literature review in its narrow focus on a single question and a priori development of an explicit protocol for finding, screening, grading, and synthesizing primary research relevant to that question. Evaluation and documentation of evidence quality are defining traits of systematic review. Given that placing large wood in streams is an expensive restoration practice and is often used in lieu of other approaches, knowledge about its effectiveness in achieving restoration objectives would benefit regulators, land owners, and policy makers. Thus, a systematic review question was formulated around this topic: Does instream wood placement affect salmonid abundance, growth, survival or habitat complexity? To identify publications of interest, a reference librarian designed and implemented the systematic search strategy that specified a list of key terms, Boolean operators, electronic databases, search engines, and library collections. Two reviewers developed and applied criteria for summarizing each publication and evaluating its relevance to the review question, including assessing rigor of study design and statistical analyses. Ultimately, 33 peer-reviewed publications were identified for full review but only 10 of these meet the criteria of high relevance. Results from these high-relevance publications generally suggest at least short-term improvements in habitat consistent with objectives of placing wood in streams. However, surprisingly little evidence is available that supports the efficacy of large wood placement for increasing the abundance, survival, or growth of any salmonid species. Thus, much less than definitive science is available to inform decisions about whether to implement and how to design in-stream wood placement projects. Systematic reviews show promise for fisheries science in synthesizing technical information in a way that is accepted as objective and definitive, helping define "best available science," and identifying knowledge gaps to guide future research. This is especially true if partnerships can be established for funding and conducting systematic reviews of broad interest.

C12.2-11

Identification and assessment of lake trout spawning habitat through underwater surveys using volunteer scuba divers

Barry Corbett[1] (presenting), Laureen Parsons[1]. [1]Ontario Ministry of Natural Resources, Kenora, Ontario, Canada

For the past several years, Kenora District, Ontario Ministry of Natural Resources has trained and worked in partnership with volunteers to undertake and evaluate a new technique; underwater surveys using volunteer scuba divers. The technique has proven to be an effective and cost efficient tool, expanding the knowledge of lake trout spawning habitats and documenting the impacts of human activities on lake trout spawning habitat. The presentation is divided into three sections with the first part focussing on the benefits of diving; how to select high potential spawning sites for surveying; and the survey technique. Part two summarizes the results of eight lake surveys and over 60 spawning shoal assessments. Underwater photos are used to illustrate the variety of spawning habitats (e.g. shoals, ledges, and talus formations), substrates (e.g. cobble, angular rubble, vertical shale etc.) and profiles. Based on this data, recommendations on how to construct spawning habitat for rehabilitation or compensation were developed. Part

three, a case history, illustrates the impacts of human activities (shore land development) on lake trout spawning habitat and demonstrates how diving can be used to provide practical fisheries management information. NOTE: All symposium participants will receive a copy of "CFWIP (Community Fisheries and Wildlife Involvement Program) Beneath the Surface". This DVD contains all the underwater footage shown in the presentation; instructions on how to undertake an underwater survey; and the results of three projects involving lake trout and smallmouth bass habitat surveys.

C12.2-12

Prediction of young of the year muskellunge nursery habitat to guide protection and restoration efforts in the Upper St. Lawrence River

Katie Woodside[1] (presenting), John Farrell[1]. [1]SUNY-ESF, Syracuse, NY/Thousand Islands, United States

Muskellunge (*Esox masquinongy*) are an important native top predator in the Thousand Islands region of the St. Lawrence River and support a trophy sportfishery of economic benefit to the region. The muskellunge fishery may have declined in part due to loss and alteration of critical nursery habitat. Statistical models relating the presence of YOY muskellunge to habitat features were developed to identify potential nursery habitat for its protection and to help guide future restoration efforts. Habitat features included water depth, emergent, floating, and submergent aquatic vegetation coverage and density. The best early and late summer models were selected using Akaike's Information Criterion (AIC). Model sensitivity and specificity were evaluated for its regional predictive ability.

C12.2-13

Fish community and habitat assessment of a recovering urban lake in anticipation of habitat remediation

Lucas Kirby[1] (presenting), Anthony Siniscal[1], Neil Ringler[1]. [1]SUNY College of Environmental Science and Forestry, Syracuse, NY, United States

Following more than a century of industrial and metropolitan pollution, Onondaga Lake, in Syracuse, New York, is a system in flux. Water quality and clarity has improved following the closure of a chlor-alkali facility in 1987 and repeated improvements at a metropolitan sewage treatment plant. SUNY College of Environmental Science and Forestry began studying the lake in 1986 and found a littoral zone devoid of macrophytes, a warm water fish community dominated by planktivorous fish and low fish reproduction rates. More recently the macrophyte abundance, distribution, and diversity have improved, increasing habitat for fish and macroinvertebrates. Trapnet species richness has increased since 1926 and the average CPUE for 2005-2007 was higher than most NYS waters. The number of centrachid nests has also increased significantly and gill net surveys now capture populations of walleye, brown trout and lake sturgeon. Even with these improvements there remain areas of the lake in which there is sparse vegetation, no nesting and low juvenile recruitment. Many of these locations have high contamination levels and are scheduled for dredging and capping. In collaboration with Honeywell Inc. NYSDEC, USFWS, and USEPA we are working to collect baseline biological data as well as to provide habitat recommendations for remediation areas.

C12.2-14

Use of an artificial reef as habitat compensation in an arctic lake

John Fitzsimons[1] (presenting), Hilary Machtans[2], Sheena Majewski[3]. [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada, [2]Golder, Yellowknife, Northwest Territories, Canada, [3]Fisheries and Oceans Canada, Yellowknife, Northwest Territories, Canada

Integral to the DFO's Policy for the Management of Fish Habitat (1986) (the Policy) goal of maintaining the current productive capacity of fish habitats is the guiding principle of No Net Loss (NNL), by which the department strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis. To ensure NNL is achieved there is a need to monitor the effectiveness of the replacement habitats. We quantitatively evaluated the effectiveness of an artificial reef intended to compensate for the loss of a small lake and its outlet stream. The primary goal of the reef was to provide spawning habitat for lake trout as well as habitat for aquatic invertebrates and small fish. We compared use of the artificial reef with that of two putative natural reefs of similar substrate and depth and quantified egg and small fish density at each reef. Lake trout spawned on the artificial reef (egg density 38±±11.7 eggs.m-2), using approximately 30% of the reef area. No spawning was detected on the natural reefs. Small fish were virtually absent from all of the reefs. Artificial reefs can provide additional spawning habitat in arctic lakes but more work is required to understand their contribution to productive capacity.

C12.2-16

Wetland loss in coastal areas: bucking the national "net gain" trend

Susan-Marie Stedman[1] (presenting), Thomas Dahl[2]. [1]National Marine Fisheries Service, Silver Spring, MD United States, [2]U.S. Fish and Wildlife Service, Onalaska, WI United States

Coastal wetlands and other shallow-water habitats are extremely important as nursery, refuge, foraging, and spawning areas for estuarine, marine, and anadromous fish. Wetland trends in the continental U.S.A. have been measured and reported every 5-10 years by the U.S. Fish and Wildlife Service (FWS). Nationwide, net wetland loss has decreased from about 185,400 ha (458,000 acres) per year in the 1960s to 23,700 ha (58,500 acres) in the late 1990s. In the most recent period, 1998-2004, wetlands experienced a net increase. Coastal wetlands have not been tracked as a distinct category in the FWS reports, so in 2007 the National Oceanic and Atmospheric Administration (NOAA) partnered with the FWS to assess the status and trends of coastal wetlands in the continental U.S. Using the Coastal Assessment Framework developed by NOAA and the wetland data collected by FWS for 1998-2004, we determined that coastal wetland loss is occurring a rate of about 24,281 ha (60,000 acres) per year. Given the ever-increasing human population in coastal areas, it is not surprising that coastal wetlands continue to be lost. However, this study is the first to document the trend quantitatively nationwide.

C12.2-17
Evaluating the effects of nutrient enrichment due to land use activities in PEI estuaries using the estuarine fish, *Fundulus heteroclitus*
Megan Finley[1] (presenting), Michael van den Heuvel[1], Simon Courtenay[2], Kevin Teather[1]. [1]Canadian Rivers Institute, University of Prince Edward Island, Charlottetown, PE, Canada, [2]Fisheries and Oceans Canada, Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada

Prince Edward Island is intensively farmed and its estuaries are showing dramatic impacts as a result. The most obvious effect has been the proliferation of sea lettuce and subsequent decline of native seagrasses. In the most sever cases, summer anoxic events occur. The objective of this study is to examine the impact of nutrient loading on the health of the estuarine species, the mummichog (*Fundulus heteroclitus*). Twenty male and twenty female mature mummichogs were collected from seven estuaries across PEI with differing nutrient loadings once monthly from May through August. Measurements of fish performance (growth, reproduction, and survival), fecundity and in vitro steroid production were collected. Additionally, in the August sampling a population survey was conducted. Preliminary results indicate that mummichog populations appear to be most affected in environments which have both a non-point nitrogen source and a significant point source of phosphorus. This is manifested as an increase in recruitment and overall population number. However, many of the performance measures typically used in environmental effects monitoring programs, fish condition and reproduction, appear to be insensitive to the levels of pollution.

C12.2-18
Determining coastal restoration success: indicators of nekton functional support
Megan La Peyre[1] (presenting), Bryan Piazza[2], Bryan Gossman[2], Christopher Llewellyn[2], John Gordon[2]. [1]U.S.G.S. Baton Rouge, LA, United States, [2]School of Renewable Natural Resources, LSU, Baton Rouge, LA, United States

Coastal restoration often has as a primary goal to increase fishery habitat in terms of area and quality. Despite this goal, few techniques to assess the value of restored coastal areas for fisheries have been developed, and most assessments focus solely on extent of marsh created as indicated by sediment, water quality and vegetation characteristics. With over 500 coastal restoration projects constructed in Louisiana in the last 20 years, understanding their impacts on nekton communities is clearly important. Using data from several restoration projects in coastal Louisiana we examined the hypothesis that restoration success, as typically measured using structural measures (i.e. sediment and water quality, vegetation community and nekton abundance, presence/absence), is correlated with functional support of nekton communities (i.e. nekton condition, growth, food web support). In several cases, marsh structural measures indicated restored marsh equivalency with reference marshes, but functional measures failed to support this conclusion. To ensure that restoration of wetland systems fully supports nekton communities, indicators of nekton functional support need to be incorporated into restoration monitoring.

C12.2-19
Tidal and wave energy projects – assessment and monitoring of the biological and physical environment
Michael Burger[1] (presenting), James Dawson[1]. [1]BioSonics, Inc, Seattle, WA, United States

The push to identify and test alternative hydro-energy and ocean energy projects (wave, tidal, and open current) is driving a number of changes in traditional proposal, review, permitting, and monitoring of such projects. For example, FERC has implemented a "pilot project" process and other Local, State and Federal entities are scrambling to ensure that development is not hindered but that resources are also considered and the public is both encouraged by and apprehensive about the potential of this process. The importance of establishing both physical and biological parameter baseline data, before project installation, cannot be overstressed. The areas of interest for power generation generally have very little continuous temporal data available for planning purposes. Continuous information on long-term variation in abundance, distribution, and behaviour of mobile biological resources or on debris-loads, essential to planning for operations and biological impact is almost non-existent. The concept of continuous, long-term data collection and analysis is daunting, both in manpower and financial requirements. Advances in hydroacoustic assessment and monitoring tools enable the continuous collection of data from automated systems and rapid, automated data processing and reporting. Marine mammal, fish and zooplankton information provided by these systems can reveal (and measure) tidal, diurnal, and seasonal abundance, distribution and behaviour information essential to project planning, site selection, and operations. The pre-installation information can assist developers and resource managers in better understanding the site variables and post-installation monitoring enables real-time assessment of condition and impact. Examples of actual project implementation and

results will be presented.

C12.2-20

An analysis of habitat and benthic community effects of scallop dredging on Georges Bank using video photography data

Danielle Brzezinski[1] (presenting), Yong Chen[1], James Wilson[1]. [1]University of Maine, Orono, Maine, United States

The potential damage to marine ecosystems caused by bottom-tending fishing gear has generated concern since the 14th century. However, damage by gear and its longevity are still contested within the literature. Closed areas provide a system-level control for observing changes in the community structure, and underwater video technology allows a more accurate, visual analysis of the gear's effects than traditional studies. Using photos taken by the Woods Hole Oceanographic Institute's HABCAM, we evaluate differences in areas closed and areas opened to scallop dredging in the benthic community structure on Georges Bank. Visible changes immediately after dredging can often be clearly observed; however, long-term effects are less predictable, as local environmental variability, original community structure and state, and intensity of disturbance affect recovery rates.

C12-P-1

Effects of road salt on urban fish assemblages

Ray Morgan[1] (presenting). [1]UMCES-AL, Frostburg, MD, United States

In urban environments, road salt usage is significant to ensure safe winter driving conditions on high traffic volume highways and secondary roads. However, there are often excessive and repetitive applications of road salt, depending on storm severity and frequency. I used the Maryland Biological Stream Survey (MBSS) data base to examine water quality collected during the MBSS Spring Index period and fish assemblage data from the MBSS Summer Index period for the highly urbanized Eastern Piedmont of Maryland. Statistical analyses indicated that there are significant changes in fish assemblages in first, second and third order streams of the Eastern Piedmont, with simpler assemblages (2-3 tolerant fish species) present in streams with high chloride levels. The number of intolerant fish species declines significantly at chloride levels greater than 100 mg/L, along with decreases in fish assemblage diversity and the Maryland Fish Index of Biotic Integrity. Chloride levels during the spring often exceed 150 mg/l, and may underestimate winter levels. Although there is a complex of stressors present in urban systems, road salt is an important stressor to fish assemblages, and needs to be considered in conservation of intolerant Maryland fish species and stream biodiversity.

C12-P-3

Assessing habitat quality for silverside spawning via biochemical analysis of zooplankton

Barry Volson[1] (presenting), David Bengtson[1]. [1]Department of Fisheries, Animal and Veterinary Science,University of Rhode Island, Kingston, Rhode Island, United States

In two Rhode Island estuaries, Pettaquamscutt River (PR) and Point Judith Pond (PJP), the main forage fish are silversides *Menidia menidia* and Menidia beryllina. In spring, when these species ripen for spawning, the zooplankton community at PR is dominated by calanoid copepods, suggesting a rather clean environment, whereas that at PJP is dominated by polychaete larvae, suggesting a somewhat degraded environment. We studied the effect of zooplankton composition, i.e. food quality, on the provisioning of the two species for reproduction. We measured proximate composition and essential fatty acids in the zooplankton and Menidia eviscerated carcasses and eggs to trace the biochemical composition of prey to offspring. We monitored weights of gonadal and somatic tissues, egg volume, % hatch and length at hatch. For proximate composition, significant differences were observed in lipids a) for zooplankton between estuaries, b) between Menidia spp. and c) between estuaries for each species. Significant differences were observed in the $\Sigma n3$, $\Sigma n6$ and $\Sigma n9$ fatty acids for zooplankton and for M. menidia gonads between estuaries. No significant differences were found in egg volume or % hatch between estuaries for either species; however, length at hatch for M. menidia at PJP was significantly greater than at PR.

C12-P-4

Effects of recreational-flow releases on thermal refuges and their use by brown trout in two Adirondack rivers of northern New York, USA.

Beth Boisvert[1] (presenting), Barry Baldigo[2], Anne Ernst[2], Clifford Kraft[1]. [1]Cornell University, Ithaca, NY, United States, [2]U.S. Geological Survey, Troy, NY, United States

Fishing and rafting proponents disagree over appropriate use of water resources in the Indian and Hudson Rivers in the Adirondack Mountains of northern New York. Seasonal populations of stocked brown trout *Salmo trutta* may be adversely affected by regular (4-times weekly) flow releases from Lake Abanakee, that are used to augment low summer-time flows. River discharges, stages, and temperatures were logged, and the body temperatures and locations of 2-year old brown trout were monitored in a 30-km reach of the lower Indian and Hudson Rivers, and in the Cedar (control) River during the summers of 2005-06 to determine whether stocked trout use thermal refuges and if the releases affect their use of refuges and apparent survival. Qualitative and quantitative analyses indicate that as many as 21% of trout in the control river and 8% and 27% of trout in the Indian and Hudson Rivers, respectively, used potential thermal refuges and that discharge, release day, time of day, and proximity to tributaries affected refuge

use in most reaches. The use of thermal refuges in the three rivers was statistically significant, but the relatively small changes in body temperatures and occasional beneficial and similar responses during release periods and non-release periods, suggest that the effects of recreational-flow releases on trout populations may not be biologically meaningful.

C12-P-5
Does hypoxia directly or indirectly effect juvenile fish in the Neuse River estuary, NC?
Lindsay Glass[1] (presenting), James Rice[1]. [1]North Carolina State University, Raleigh, NC, United States

Hypoxia in estuaries is a recognized problem, but actual impacts on fish are not clear. Published studies show that fish can rapidly detect and move to avoid low dissolved oxygen (DO) levels. In laboratory experiments spot Leiostomus xanthurus avoid DO <2.0 mg/L and experience reduced growth at <1.5 mg/L. In pond and cage experiments spot growth decreased as density increased. Therefore, severe hypoxia may reduce spot growth via direct exposure, or indirectly by increasing density in oxygenated refuges. To evaluate this hypothesis we monitored water quality and fish density across the Neuse River estuary during varying water quality conditions, and quantified spot diets as an indicator reflecting both density-dependent effects on feeding success and cumulative impacts of hypoxia on prey availability. DO <2.0 mg/L was infrequent at near-shore sites (11-19% of total time) with only 3-4 events lasting >10hrs. Fish did avoid DO <2 mg/L, but hypoxic conditions did not compact refuges enough to produce changes in fish density that we could detect using bottom trawls. Given the fine spatial and temporal scale of hypoxia dynamics, evaluating the impacts of hypoxia on fish growth will require novel, short-term growth indicators that integrate the effects of rapidly changing environmental conditions.

C12-P-6
Effects of natural-channel-design restoration on habitat quality in streams of the Catskill Mountains, New York, USA
Anne Ernst[1] (presenting), Barry Baldigo[1], Christiane Mulvihill[1]. [1]US Geological Survey, Troy, NY, United States

Many streams and rivers throughout North America have been extensively modified, but the effects on aquatic ecosystems have not been extensively studied. Beginning in the early 1990's, stream restorations based on natural-channel-design (NCD) concepts have attempted to mimic stable reference-reach geomorphology and thereby allow recovery of the original stream processes and habitat. Six reaches on five disturbed Catskill Mountain streams were restored during 2000-03 through NCD techniques to decrease bed- and bank-erosion rates, decrease sediment loads, and increase the quality of streamwater. Habitat surveys were conducted during summer baseflow. A BACI (before-after-control-impact) study design and ANOVA tests were used to evaluate the effects of NCD restorations on net changes in stream-channel and bank variables in the study reaches relative to those in upstream control reaches. Three measures of bank stability indicate that stability increased significantly during the first 2 to 5 years after restoration. Mean channel depth, thalweg depth, and pool-to-riffle ratio generally increased, whereas mean channel width, percentage of streambank area covered by trees, and measures of shade generally decreased. Channel dimensions after restoration were generally characteristic of a more stable stream form. In general, these findings demonstrate that NCD restorations can improve habitat conditions in disturbed mountain streams.

C12-P-7
Dissolved oxygen dynamics in tussock-forming aquatic macrophytes
Aaron Bunch[1] (presenting), Mike Allen[1]. [1]University of Florida, Gainesville, Florida, United States

Stabilization of lake levels due to altered hydrology exacerbates the rate at which dense vegetation mats (i.e. tussocks) form. Tussocks affect water quality (e.g. dissolved oxygen and temperature) and substrate (i.e. accumulation of organic material), and thus, may affect fish community composition. We identified spatial and temporal trends in dissolved oxygen (DO) with respect to tussock-forming macrophyte species (i.e. cattail, pickerelweed, water primrose, smartweed, and torpe-dograss) and coverage levels (i.e. percent area coverage; 50-64%, 65-79%, and 80-95%) at Lakes Istokpoga and Kissimmee, Florida. In dense vegetated habitats, DO tended to be hypoxic during night and morning hours with an increase in DO during the afternoon, but the magnitude of the increase was influenced by macrophyte species and/or coverage levels. Some habitats exhibited anoxia throughout the diel DO profile. Poeciliids and cyprinodontids (88% of total catch) dominated the fish community in tussock habitats during fish collections. These fish are more adapted to environmental extremes (i.e. hypoxia/anoxia and hyperthermia) than centrarchids, which only contributed 7% to total catch. Management strategies to limit tussock formation will decrease the extent and longevity of hypoxia/anoxia and create habitats that can maximize the diversity of fish communities and increase abundance of species that support fisheries.

C12-P-9
The importance of scale and resolution of field data collection for fish habitat management in the land-use planning process
Jennifer Haslett[1] (presenting), Paul Villard[1]. [1]Geomorphic Solutions, Mississauga, Ontario, Canada

The land-use planning process in Ontario requires that consideration be given to the management of natural heritage features, including aquatic habitat, at several stages in the review of development applications. Focusing on fish habitat and geomorphology of aquatic systems, we have found that scale and resolution of field data collection can have significant effect on the management decision-making process. Typically, the scale of data collection required for development application review is relative to the design stage of the application; coarse-level field reconnaissance is conducted at the early stages of an application, and detailed field observations are gathered at the final design stages. We reviewed various data sets collected at the coarse and detailed levels to compare the conclusions drawn from each. We found that the coarse-level data typically provided in the early stages of the management decision process were often not reflective of actual habitat conditions found at the detailed level of investigation. Our observation suggest that more detailed field assessments at the early stages of the land-use planning process would ensure that management designations reflect the actual conditions and sensitivities of the aquatic features on the ground. This would improve the value and effectiveness of the large scale planning documents in protecting aquatic habitat and streamline the permitting process for proponents at later stages of the planning process.

C12-P-10
Fisheries ecosystem model in Chesapeake Bay and its coupling with a hydrographic model
Hongguang Ma[1] (presenting), Howard Townsend[2], Villy Christensen[3]. NCBO-Oxford Lab/Versar, Oxford, MD, United States[1],NCBO-Oxford Lab, Oxford, MD, United States[2],University of British Columbia, Vancouver, BC, Canada[3],

To assess the influence of water quality and fisheries management scenarios on multiple fisheries species, we coupled a fisheries ecosystem model for Chesapeake Bay (developed using Ecopath with Ecosim) with a hydrographic model and a water quality/eutrophication model. The hydrographic model takes wind, rainfall, river inflow, and relative loading as major inputs and it solves for equilibrium velocity fields and calculates mass-balanced chemical concentrations. The model simulates the long-term pattern (~ 50 years) in primary production and it can provide historical perspectives on changes in primary production if nutrient input was reduced according to management strategies. In addition, the eutrophication model projected significant increase in submerged aquatic vegetation (SAV) when nutrient loading was reduced. We used the outputs from these models as inputs or forcing functions for the fisheries ecosystem model. Modelled blue crab biomass was clearly enhanced through habitat mediation in the fisheries ecosystem model when SAV was adjusted by the projection from the eutrophication model. The impacts of reduced nutrient loading on primary production are currently being studied. Such model coupling can provide valuable tools for exploring ecosystem-based fisheries management options.

C12-P-11
Fish Passage and Fish Habitat Enhancement of the Blue Note Caribou Mines Diversion Channel near Bathurst, NB.
Ed Torenvliet[1] (presenting), Peter Pheeney[1], Eric Arseneau[2], John Middlemiss[2]. [1]Jacques Whitford Ltd. Fredericton, New Brunswick, Canada, [2]Blue Note Caribou Mines Inc. Bathurst, New Brunswick, Canada

Blue Note Caribou Mines Inc. located near Bathurst, NB, required alterations to the site Diversion Channel with respect to fish passage and fish habitat as part of the re-opening and return to production. The Diversion Channel was constructed in 1989 and was intended to function as a bypass for flow (not fish passage) from Caribou Lake around the Tailings Pond and Polishing Pond and returning flow into Forty Mile Brook. At the time of re-opening, portions of the channel were unstable and eroding, too steep for upstream fish passage, and of low quality fish habitat. Five projects were selected to enhance fish habitat within areas of the Diversion Channel that consisted of poor habitat and two projects were selected to by-passed existing portions of the channel that contained barriers to upstream fish passage or was unstable and eroding during high water events. Construction was conducted in the summer and fall of 2007. This presentation will outline the process involved in selecting areas to enhance fish passage and fish habitat and illustrate how field conditions required adjustment to the design in the field.

C12-P-13
Protection measures to minimize entrainment and impingement of fish at a desalination plant within the Taunton River Estuary, Massachusetts
Nathan Henderson[1] (presenting), Beysy Shreve-Gibb[1]. [1]Metcalf & Eddy, Wakefield, United States

In response to severe water supply shortages in Southeastern Massachusetts, Inima USA Corp. is currently building a desalination plant within the Taunton River estuary in Massachusetts. The overall goal of the water supply project is to relieve stresses on local ground and surface water supplies while striving to balance impacts in a sensitive coastal habitat. Provisions within state and federally issued permits required the integration of extensive measures to minimize the impacts to water quality and fisheries resources. Although the Plant is not regulated under Section 316b of the Clean Water Act, the protection measures mandated were equal to those of new facilities with Cooling Water Intake Structures. As a result, a filter barrier with redundant backup mechanisms will be installed during anadromous and resident fish spawning times to minimize impingement and entrainment of fish eggs and larvae. Prior to operation in 2008, an extensive baseline water quality and fisheries survey was conducted in 2007. The results of this effort indicated that the Taunton River Estuary has a diverse community including 34 species of marine, estuarine and freshwater species. These results coupled with water quality data will serve to provide a basis for comparison once the plant becomes operational.

C12-P-14
GIS applications for protecting aquatic values
Darren McCormick[1] (presenting), Rob Mackereth[1]. [1]Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada

Concern over land use impacts to riverine aquatic values tends to increase with increasing river size; however, focussing attention on local scale protection of larger rivers in the absence of a comparable level of concern for smaller sub-catchments may be misguided. For example, 80% of the area (295 of 369 sq km) of the Mackenzie River Watershed (MRW), located 20 km north of Thunder Bay, Ontario, is made up of small headwater sub-catchments that are between 0.1 and 3.0 sq km in size. Because of the dominance of small stream systems and their vulnerability to impacts from forest management, increasing efforts are being made to ensure their protection. However, small streams, which can be ephemeral and/or discontinuous, are difficult to map and are often missing from base maps used for the development of forest management plans. To address this problem we have developed GIS tools for predicting the location of small streams by delineating runoff pathways defined by the topography in DEMs. In this study we will investigate the reliability of using sub-catchment scale GIS attributes to both improve our understanding of boreal forest hydrologic processes and lower the risk of adverse effects from land management.

C12-P-15
An assessment of natural channel designs within the Greater Toronto Area, Ontario, Canada
Paul Villard[1] (presenting), Ryan Ness[2], Jennifer Haslett[1], Bradley Wright[3]. [1]Geomorphic Solutions, Mississauga, Ontario, Canada, [2]Toronto and Region Conservation Authority, Toronto, Ontario, Canada, [3]City of Ottawa, Ottawa, Ontario, Canada

As part of a Toronto and Region Conservation Authority initiative to develop a Natural Channel Design Monitoring Protocol a number of previously constructed channel designs were assessed. Rapid assessments were completed on 23 channel designs, which included assessment of channel form, stability, riparian vegetation and success of bioengineering elements. This assessment provided substantial insight into effectiveness of design and construction methods and identified the unanticipated results of certain early ‘natural channel design’ approaches. At 8 sites more detailed observations within the design and from adjacent unmodified ‘reference’ reaches were collected. This assessment included measures of the channel morphology, vegetation success, and the fish and benthic community. A range of standard and modified protocols were applied to measure conformance and success of the designs. Insight from these observations is presented. Improvements for design to avoid some of the identified issues and retrofit options for existing designed channels are presented.

C12-P-16
A comparison between field assessed and photo-interpreted macro habitat values of pallid sturgeon capture sites in the Lower Missouri River
Kimberly Chojnacki[1], Sandra Clark-Kolaks[1], Emily Tracy-Smith[1], Aaron DeLonay[1] (presenting). [1]U.S. Geological Survey, Columbia, MO, United States

The U.S. Geological Survey, Columbia Environmental Research Center is engaged in a multidisciplinary study supported by the US Army Corps of Engineers to investigate reproductive physiology, movement and spawning habitat use of Lower Missouri River sturgeon. Pallid sturgeon (*Scaphirhynchus albus*) were initially collected in two sections of the Missouri River from March 8, 2007 to April 19, 2007. The upper section was located between river mile 756 and 727. The lower section was located between river mile 685 and 648 (Blair, NE). A total of 86 pallid sturgeon were collected using multiple gear types. Data were recorded about each gear deployment, including habitat type, water quality, latitude and longitude. A geographic information system (GIS) was then used to map the pallid capture locations and aerial photography was used to visually assess the macro habitat of each location. The photo-interpreted data were then compared to the field assessment data. This comparison provides valuable insight on the potential for retrospective GIS evaluation of habitat types to augment field evaluations.

C12-P-17
Fishery conservation leaders within the Great Lakes Basin join forces to establish a new national fish habitat partnership
Mark Brouder[1] (presenting). [1]U.S. Fish and Wildlife Service, Ashland, WI, United States

The Great Lakes Basin Partnership is a candidate Partnership under the National Fish Habitat Action Plan. The U.S. Fish and Wildlife Service and U. S. Geological Survey, on behalf of the Council of Great Lakes Fishery Agencies, are currently organizing the Partnership, focusing efforts on bringing to the table Federal, Provincial, State, Tribal, and non-governmental organizations that support the protection, restoration, and enhancement of aquatic habitat within the Basin. The Vision of this Partnership is to protect and restore habitat within the Great Lakes Basin that supports fish species and their associated biological communities through improved watershed management by addressing the root causes of habitat degradation on a watershed scale, promoting sustainable land management practices that ensure long-term habitat protection, and improving future management by assessing the impact of our habitat restoration actions on aquatic communities. The Partnership envisions providing leadership to the Great Lakes Basin community by coordinating and strategically implementing aquatic habitat restoration and protection activities that build upon a foundation of existing Basin-wide conservation prioritization efforts. One such priority is the protection, restoration, and enhancement of tributaries and vegetated nearshore areas of the Great Lakes that provide spawning and nursery habitat for numerous fish species. The Great Lakes Basin Partnership is seeking interested individuals and conservation organizations that work throughout the Basin to become informed decision makers on the Partnership's Steering Committee, as well as those interested in participating on one of the Steering Committee's Work Groups (Strategic Planning, Assessment and Monitoring, and Outreach). If you or your organization is interested in becoming a part of the Great Lakes Basin Partnership's Steering Committee or one of the Work Groups, please contact Mark Brouder, USFWS at mark_brouder@fws.gov.

C12-P-18
Effect of an oil spill on northern pike incubation in a freshwater lake
Corey Stefura[1] (presenting), Barbara Wernick[2], Luanne Patterson[3]. [1]Golder Associates Ltd. Edmonton, Alberta, Canada, [2]Golder Associates Ltd. North Vancouver, British Columbia, Canada, [3]Canadian National Railway, Surrey, British Columbia, Canada

In August 2005, a train derailment along the north shore of Wabamun Lake (Alberta, Canada), exposed the lake to approximately 149,500 L of bunker 'C' oil. A northern pike (Esox lucius) in situ incubation study was initiated to assess the potential for impairment of developing larval as a result of the spill. Mature northern pike were collected for brood stock from a tributary to the lake. Following artificial propagation, the fertilized eggs were placed in incubation trays in reedbed areas in reference and exposed areas around the lake. Following the incubation period, the larvae were examined for deformities; we found few and relatively small differences in deformity of northern pike larvae among sites, and none that could be attributed to PAH exposure.

C12-P-19
How did the cable get to the other side? marine resource monitoring requirements and results at submarine cable crossings
Sarah Zappala[1] (presenting), John Duschang[1]. [1]HDR, Pearl River, New York, United States

Aging infrastructure and the need to access alternative energy resources has prompted significant planning and development of new electric transmission systems. Among these new systems are high-voltage submarine cables which introduce complex siting, environmental permitting and engineering requirements. Environmental resource agencies and utilities alike are navigating their way through the existing regulatory framework in order to meet new transmission development needs, while minimizing potential environmental impacts. Neptune Regional Transmission System, LLC was granted federal, state, and local permits and approvals for the construction and operation of a 660 megawatt high-voltage direct-current (HVDC) submarine transmission line. The submarine transmission line (approximately 51 miles) extends from Sayreville, New Jersey to Jones Beach State Park New York. The submarine cable was laid and buried simultaneously using water-jetting technology. As part of federal and state permit requirements pre- and post-installation marine resource surveys were developed. Pre-installation surveys were conducted to provide a baseline of existing conditions to be used to identify any major changes to the marine communities during cable installation. Results of these surveys can be used to assess future submarine transmission line projects on fish and aquatic resources.

C12-P-20
Assessing the Index of Biotic Integrity as a measure of Remedial Action Plan status in Areas of Concern.
Monica Granados[1] (presenting), Nicholas Mandrak[2], Donald Jackson[1]. [1]University of Toronto, Toronto, Ontario, Canada, [2]Department of Fisheries and Oceans Canada, Burlington, Ontario, Canada

The Index of Biological Integrity (IBI) is a multimetric index for biological assessment. The IBI has been applied to aquatic communities to quantify condition and detect recovery. The 1972 US-Canada Water Quality Agreement designated the degraded Detroit and St. Clair Rivers as Areas of Concern. The agreement requires the development of a Remedial Action Plan (RAP) to determine the causes and severity of environmental degradation, selection of remedial actions, implementation and assessment. The IBI was applied to fish assemblage data obtained in 1990 and 2004. The results indicated no significant increase in IBI scores following the implementation of RAP programs and projects. Sites were subsequently sampled in 2007 to detect concurrent changes in the fish assemblages and IBI scores. Further multivariate analyses were performed on the fish community data to provide a comparative classification method for sites.

C12-P-21
Pearl dace (*Margariscus margarita*): Bio indictor for mining effluent in small headwater systems within boreal ecosystems
Derek Parks[1] (presenting), Joe Tetrault[2], Dean Fitzgerald[2]. [1]Earth Tech Canada, Kitchener, Ontario, Canada, [2] Ecometrix, Mississauga, Ontario, Canada

Small-bodied fish can represent an integral component of an Environmental Effects Monitoring (EEM) program for mining effluents located in the headwaters of watersheds lacking large-bodied fish. In such a situation, Pearl dace (*Margariscus margarita*) were used to meet the biological monitoring requirements as directed by Environment Canada under the Metal Mining Effluent Regulations, for an ore extraction mine in northern Ontario. General biological information contributed to this species include: length-frequency distributions indicating strong sexual dimorphism within sexually mature adults; Age analysis of the pearl dace

involved different methods and contrasting age interpretations. Disparities in age estimates required the use of a proton-induced X-ray emission validation technique to resolve fish age from the otoliths. This resolution identified [Identification of older] pearl dace older than 7+ and indicates a longer generation time and lower productivity in these populations than inferred from previous studies. These results suggest that such forage fish populations may be vulnerable to over-exploitation and compromise long-term monitoring efforts and objectives. Implications of incorrect age determination on the biological interpretation for this EEM study and impacts on future EEM programs are discussed.

C12-P-22

Application of North American environmental best management practices for pipeline stream crossings in the Russian far east

David Hamilton[1] (presenting), Curtiss McLeod[2], Koen Broker[3], Malcolm Lowings[4]. [1]Golder Associates Ltd. Saskatoon, Saskatchewan, Canada, [2]Golder Associates Ltd. Edmonton, Alberta, Canada,Sakhalin Energy Investment Company, [3]Yuzhno-Sakhalinsk, Sakhalin Island, Russian Federation,[4]Golder Associates Ltd. Calgary, Alberta, Canada

Sakhalin Energy Investment Company (SEIC) is finalizing the development of the Sakhalin II oil and gas project on Sakhalin Island, which includes separate crude oil and natural gas pipelines that cross more than 1,000 watercourses, along their shared 800 km long RoW. Two hundred of the most sensitive rivers were crossed during the winters of 2005/06 and 2006/07 to reduce environmental impacts to salmon (Oncorhynchus spp.) and taimen (*Hucho taimen*) streams. The SEIC River Crossing Strategy outlines minimum construction standards expected to occur at each crossing to help reduce environmental impacts and comply with Russian Federation licenses. Staff from Golder Associates Ltd. provided independent environmental observers to monitor the winter construction at stream crossings to assess compliance with the SEIC River Crossing Strategy. During the initial stages of construction, some commonly used North American best management practices (BMPs) were not authorized by regulatory permit restrictions, which resulted in environmental impacts to fish habitat. SEIC worked with local authorities, to obtain permission to employ specific BMPs. During the second year of construction, environmental impacts associated with pipeline line crossings were significantly reduced by the utilization of BMPs and there was also an increase in sub-contractor compliance with the River Crossing Strategy. Based on the SEIC experience, when seeking to introduce new environmental protection methods project proponents should[1] begin discussions with regulatory agencies in advance of construction to educate regulators on how BMPs are implemented and their benefits,[2] conduct training programs with sub-contractors,[3] carryout several pilot crossings to evaluate sub-contractor performance prior to onset of construction,[4] monitor construction practices and provide immediate feedback to construction crews.

C12-P-23

Using carbon stable isotopes of the particulate organic matter as tracers of the anthropogenic impact in two contrasting riverine catchments of Eastern Cape Province-South Africa

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Anthropogenic activities affect greatly natural hydrological systems and nutrient cycles in the catchments, dramatically altering aquatic habitats. With increasing human pressures on coastal ecosystems, there is a need to develop better approaches to assess and monitor anthropogenic influences in riverine systems. Stable carbon (C) isotopic composition of the particulate organic matter (POM) in Tyume and Keiskamma rivers and at their Confluence of the Eastern Cape Province were analyzed to observe seasonal patterns in the ecosystem functioning. The stable isotopes of C (δ13C) were used to determine the contribution of natural and anthropogenic nutrients on POM. The mean summer and winter POM carbon stable isotopes in Tyume river were -20.2 ± 3.1 and -21.3 ± 2.1‰, in Keiskamma river were -20.9 ± 2.1 and -21.1 ± 2.9‰ and at the Confluence -20.4 ± 2.8 and-17.5 ± 2.3‰, respectively. There was positive correlation between chlorophyll-a with POM δ13C signatures, while both conductivity and pH were negatively correlated with POM δ13C signatures. Nitrate concentrations and fertilizer amounts applied were negatively correlated with δ13C signatures of POM. Spatio-temporal trends in POM δ13C signatures in both rivers showed an increase from source to downstream sites. It appears that POM carbon stable isotopes in both rivers reflected the anthropogenic loading in their catchments. Distinct isotope signals could be instrumental in tracking the organic carbon originating from the terrestrial macrophytes or from anthropogenic activities and as a consequence, could be an important tool to elucidate the importance in the export of anthropogenic carbon and energy for the secondary productivity in the riverine downstream ecosystems.

C12-P-24

Examination of metal contamination within the Rideau River waterway

Shannon LeBlond[1] (presenting), Kathleen Hamilton[1], Allison Rutter[1], Linda Campbell[1]. [1]Queen's University, Kingston, ON, Canada

The Rideau River Waterway is comprised of a series of lakes connecting the Ottawa River to the Cataraqui River in Kingston. In 2006, a preliminary study evaluated the sediment and water metal concentrations, grain size (GS) and organic content (OC) of nine lakes south of Smith Falls. Within Upper Rideau (UR) and Indian Lake (IL), Pb was found to exceed CCME Sediment Guidelines,

while Co and Zn were found to exceed CCME Freshwater Guidelines. Elevated concentrations of Cu, Co, Ni, Zn and Rb (0.003 to 0.073 ppm) were found in waters, but were not correlated with sediment concentrations. There were significant correlations between Hg and Cr and between Cd, Pb, and Zn sediment concentrations across locations ($p < 0.001$). While Hg was not detected in tested waters, it ranged between 0.067 and 0.253 ppm in sediments. The OME records for UR and IL indicate that average Hg concentrations in sport fish exceed recommended guidelines for at-risk groups (0.301 and 0.789 µg/g respectively). A total of 75 samples from nine species collected within UR and 47 samples from nine species collected within IL are being analyzed for total Hg. This study examines the relationships between sediment, surface and depth water, and sport fish dorsal tissue metal concentrations.

C13. Marine Fish Life History

C13-1a

Growth and survival of rainbow smelt larvae in relation to zooplankton species assemblages and freshwater discharge in the Saguenay fjord, Canada

Gabriel Diab[1]*, Pascal Sirois[1], Stéphane Plourde[2]. [1]Laboratoire d'écologie aquatique, Département des sciences fondamentales, Université du Québec à Chicoutimi, QC, [2]Pêches et Océans Canada, Direction des sciences océaniques et de l'environnement, Institut Maurice-Lamontagne, Mont-Joli QC, Canada

During fish early life, it is generally assumed that fast growing individuals have a higher probability to survive. Therefore, it is important to assess the influence of environmental conditions on the growth rate of fish larvae in order to understand recruitment dynamics in fishes. Rainbow smelt (*Osmerus mordax*) is an important forage fish in the Saguenay Fjord, the most important tributary of the St. Lawrence Estuary. This fjord is characterized by seasonal and spatial fluctuations in environmental conditions such as salinity, temperature and food density mainly driven by the seasonal freshwater discharge from the Saguenay River and the spring-summer warming. These variations are expected to influence larval growth through time and space. The objective of the study was to assess the influence of biotic and abiotic conditions on the growth of rainbow smelt larvae in the Saguenay Fjord. Ichthyoplankton and zooplankton were sampled once a month from May to September in 2004 and 2005 using a Bongo net and a Tucker trawl. Sagittal otoliths were extracted on 343 and 242 larvae in 2004 and 2005 respectively. Otolith microstructure analysis was used to determine ages and to estimate growth rates. Results showed that rainbow smelt larvae aged 0-20 d and its potential preferred prey, the copepod Eurytemora affinis, were both more abundant in the upstream region of the fjord than downstream. Rainbow smelt larvae aged 20+ d were more abundant in the downstream region in 2004, but greater densities were observed in the upstream region in 2005. Moreover, larval growth rates were lower in 2004 than in 2005. The slow-growing larvae found in the downstream region of the Saguenay fjord in 2004 coincided with a higher freshwater discharge in 2004 than in 2005. Hence, results of this study suggested that growth and survival of rainbow smelt larvae were enhanced in the Saguenay fjord when environmental conditions allow individuals to stay in the upstream region where the copepod Eurytemora affinis dominate the zooplankton community.

C13-1

Growth, mortality and abundance of young of the year winter flounder (*Pseudopleuronectes americanus*) in two Long Island environments

Melissa Yencho[1] (presenting), Mike Frisk[1]. [1]Stony Brook University-School of Marine and Atmospheric Sciences, Stony Brook, NY, United States

Historically, the waters of Long Island, New York have supported commercial and recreational fishing for winter flounder. However, landings hit record lows in 2004 and have not since recovered. This study aims to quantify growth, mortality and abundance of young of the year (YOY) winter flounder in two contrasting Long Island environments: Port Jefferson Harbor and Shinnecock Bay. Two-hundred foot beach seines were used to study both areas. In addition, a 1 m beam trawl was used in Shinnecock Bay. Each site was sampled by beach seine every other week from March to September, 2007. Beam trawl sampling occurred once a week from June until September and then once a month until November 2007. A total of 668 YOY winter flounder were caught during beach seining in Port Jefferson Harbor and 213 were caught in Shinnecock Bay. Beam trawling in Shinnecock Bay yielded 368 additional YOY flounder. Catch curve analyses indicates YOY winter flounder experience a daily instantaneous natural mortality rate ranging from 0.04 in Port Jefferson Harbor (seine net) to 0.03 (seine net) and 0.02 (beam trawl) for Shinnecock Bay. Differences in average length by date between Port Jefferson Harbor and Shinnecock Bay indicate differences in spawning dates or growth rates between regions. Additionally, two clear cohorts were observed in Port Jefferson Harbor indicating the possibility of multiple adult spawning groups. Preliminary results for hatching dates based on otolith analysis will also be presented.

C13-3

Age composition, growth and density-dependent mortality in juvenile red snapper estimated from observer data from the Gulf of Mexico penaeid shrimp fishery

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Bycatch reduction devices (BRDs) were required to be installed in penaeid shrimp trawl gear in the Gulf of Mexico beginning in May 1998. Changes in observer protocols were introduced and one change was that all red snapper (*Lutjanus campechanus*) collected would be enumerated and measured where possible. This change has yielded catch and length information from the Gulf of Mexico penaeid shrimp fishery. An integrated approach for dealing with age composition, growth and mortality of juvenile red snapper has not been previously attempted. We constructed a length-based, age-structured model to objectively estimate growth and mortality parameters, and age composition of the shrimp trawl bycatch of red snapper in the western Gulf of Mexico from 81 monthly length-frequency data sets (a total of 239,521 fish measured) over July 1999 to February 2007. Bayesian parameter estimation was accomplished through calculating the mode of the posterior distribution (maximum likelihood estimation). Important findings of this analysis include: (1) the shrimp trawl bycatch during the first trimester is dominated by age-0 fish (about 90%); (2) natural mortality of age-0 fish appears to be about double the value used in the last stock assessment; and (3) density dependent juvenile mortality appears highly likely. Inclusion of these findings in the red snapper stock assessment has the potential to substantially alter management advice.

C13-4

Intracohort variation in growth and mortality of age-0 red drum (*Sciaenops ocellatus*) with evidence for demographic restructuring during the overwinter period

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Processes occurring during juvenile life stages of estuarine dependent fishes can influence population structure. We used otolith microstructural analysis to estimate hatch timing, fall growth rates, and mortality rates for a cohort of age-0 juvenile red drum (*Sciaenops ocellatus*) and then tested for demographic restructuring of age and growth rate during the overwinter period. Demographic and life history traits were determined for fish shortly after estuarine arrival through weekly sampling during the fall recruitment period and again during the subsequent spring. Hatch timing extended over three months (mid-July to mid-Oct) and growth rates displayed three-fold variation (0.3 – 1.0 mm/d) among individuals. Mortality for the entire cohort was estimated at approximately 4 %/d and differed considerably between fish hatched early (~3.5 %/d) versus those hatched late (~7.2 %/d). Variation in hatch timing and estuarine growth rates generated a broad range of body sizes at the onset of winter. We hypothesized that mortality during the overwinter period may be size-selective and attempted to detect restructuring of age and growth rate distributions between fall and spring. We observed a relationship between initial growth (size at 10 d of age) and hatch timing indicating that individuals hatching earlier in the spawning season (July-August) experienced faster initial growth than individuals hatching later (Sept-Oct) ($r2=0.28$; $p<0.001$). We used this relationship to estimate hatch timing (a proxy for age) retrospectively for spring captured individuals that had survived the winter. We also estimated growth rates of surviving spring individuals through 40d of age. Both hatch timing and growth rate of spring captured individuals were compared to the distribution of these traits among pre-winter fish. Comparisons suggest some level of restructuring of demographic traits during the overwinter period. Our findings imply that first year processes can have important implications for population dynamics in estuarine fishes.

C13-7

Age, growth, and mortality of sheepshead in Chesapeake Bay, Virginia

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Sheepshead are an estuarine/marine member of the porgy family that have long supported large recreational fisheries along the southeastern coast of the United States, with a recently expanding recreational fishery in Virginia waters of the Chesapeake Bay. Due to this expansion into Bay waters, Virginia fisheries managers need to develop a management plan for this species. However, before any management plan can be developed, a comprehensive understanding of the age structure, growth and mortality rates of fish in the population is needed. To characterize the age, growth and mortality of sheepshead in the Chesapeake Bay, 394 fish were collected via recreational (n=205), commercial (n=129), and fishery independent (n=60) fisheries from April 16, 2006 through December 5, 2007 and their lengths, weights and ages determined. Sheepshead ranged in age from 0 to 34 years old, with the oldest fish being 8 years older than the oldest sheepshead reported in the literature to date. Marginal increment analysis validated the formation of one annulus per year, with annulus deposition beginning in mid-May and complete by early July. A Kimura's likelihood ratio test indicated that there is no sex specific growth differences with regards to length-at-age or the length-weight regression. Results of the von Bertalanffy length-at-age analysis, weight-at-age analysis, and length-weight regressions suggest that Chesapeake Bay sheepshead are attaining larger sizes than sheepshead found elsewhere along the coast of the United States, with sheepshead obtaining a mean maximum fork length of 554 mm and mean maximum weight of 5002 g. This is strongly suggestive that the Chesapeake Bay sheepshead population constitutes a separate population, as large differences in vital rates are often indicative of this. These differences in growth could arise due to a variety of factors, including differences in mortality rates, environmental conditions, food sources, or genetic variation. Further, catch-curve analysis and natural mortality estimators indicate that currently the fishing mortality of sheepshead in Chesapeake Bay is either compensatory or negligible, as there is no difference in the total mortality rate from the catch-curve and the natural mortality rate from the natural mortality estimators.

C13-8

Aspects of the biology of large monkfish in the northwest Atlantic Ocean

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Monkfish (*Lophius americanus*) support important commercial fisheries in the northwest Atlantic. Although life history information is available for smaller monkfish, the biology of large monkfish is poorly understood. During 2006 and 2007, 631 monkfish 69 cm and larger (maximum size 118 cm) were collected from commercial gillnet fishermen operating in the mid-Atlantic Bight and in the Gulf of Maine to investigate: [1] growth rates of large monkfish;[2] reproductive biology; and[3] rates of cannibalism. All of the large monkfish collected were females ranging in age from 8 to 13 years. Growth rates were highest during the 2nd and 3rd quarters of the year. Hepato-somatic indices peaked in February. Gonado-somatic indices peaked between February and May but females with hydrated oocytes were caught between January and August. This may be taken as evidence that monkfish spawn over a protracted period and several times during the year. Evidence of cannibalism was seen in 4% of the samples and frequency of feeding and cannibalism were highest in females during the final stage of oocyte maturation. Cannibalism rates are higher than those observed during Northeast Fisheries Science Center resource surveys (0.13%; n = 10,236), which capture relatively few large monkfish.

C13-9

Relative contribution of spring- and summer-spawned bluefish to North Carolina

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YOY bluefish recruit to the U.S. Atlantic coast during much of the year. At the end of the growing season, YOY length distributions can be separated into fish spawned during the spring or summer, based on a consistent antimode (180mm). Based on studies that back-calculated lengths from adults, summer-spawned fish show variable contribution to the population; this variability is not associated with the magnitude of summer-spawned age-0 production. We test the hypothesis that apparent variable contribution of summer-spawned fish is an artifact of sampling bias of adults in earlier studies. Scales and otoliths from adult bluefish were obtained from NC commercial fisheries 1997-2000; additional samples from age-1 fish were obtained from a NC trawl survey 2001-2008. Back-calculated age-1 length distributions from scale analysis revealed that NC commercial fisheries are dominated by bluefish that were spawned during spring, supporting recent evidence that summer-spawned fish don't contribute as much to the adult population as YOY surveys in the Middle Atlantic Bight suggest. However, the relative contribution of each cohort to the adult population was gear specific; gear that was selective for smaller age-1 bluefish had the largest contribution of summer-spawned fish. Therefore, sampling gear and location biased initial examination of cohort contribution.

C13-10

Estimating true growth and body condition in coastal bluefish

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Detailed growth measures of bluefish are essential to understand factors governing their populations and interactions with other species. Information on protein, water, and fat levels of bluefish and interacting species across their distributions is important in evaluating spatial population level demographics, migratory and overwintering energetics, and as a barometer for fish health/condition and competitive interactions. Drawing upon earlier work with brook trout where masses of body compartments were estimated using non-lethal bioelectrical impedance analysis (BIA), we developed models to estimate percent body composition. We collected bluefish from near Sandy Hook, NJ and held them in the laboratory. To achieve different fish body condition, N=38 age-0 and N=24 older bluefish were divided equally among tanks receiving ad libetim feeding and those receiving a restricted ration (fed ad libetum one every 10-14 days). After 45-60 d on this regiment, resistance and reactance was measured on each fish at two temperatures (15 and 27 C). Fish were sacrificed and dried, and body composition estimated to relate to BIA measures in a predictive model. The resulting models accurately predicted percent water and other components in the fish (R2>0.70, $p < 0.01$). Press Cp statistics and independent validation suggest BIA models for bluefish can accurately estimate body condition and dry mass. Once this research and technology is made available to fishery scientists and managers we expect to see these tools used to foster coast-wide collaborative studies of the spatial and temporal demographics of growth and condition of bluefish, and ultimately striped bass and other species.

C14. Contaminants and Toxicology

C14-2

Analysis of an alternative method for measuring methyl mercury in fish

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Methyl mercury is a pollutant of tremendous concern because it can be introduced into many trophic levels within an ecosystem through methylation of inorganic mercury by aquatic bacteria. Biomagnifications of methyl mercury poses a serious health threat to piscivorous wildlife and to anglers who consume freshwater fish. A recent technique (Mohammadi et al. 2005 Microchim Acta 149: 251- 257) measured the levels of methyl mercury in saltwater fish tissue using an Invertase enzyme assay. Methyl mercury inhibits Invertase enzyme activity, and thereby, reduces the amount of sucrose hydrolysis per time period. Using a modified protocol of this method, the levels of methyl mercury contamination were investigated in two species of sunfish; *Lepomis gibbosus* (Pumpkinseed) and L. macrochirus (Bluegill) from two southeastern Massachusetts ponds. Fish age was determined by counting the growth annuli of scale samples taken from the fish. Muscle tissue samples were processed to extract methyl mercury in toluene before incubation with Invertase enzyme. A standard curve was constructed using methyl mercury chloride in standard concentrations in toluene. Preliminary results suggest that this technique might be another method for determining methyl mercury concentrations in freshwater fish. More testing and work is needed to perfect the protocol to produce consistent results.

C14-3

Bacteriological, light, and scanning electron microscopical studies on vibrio spp. in Penaeus indicus

Salah Afifi[1] (presenting). [1]Assiut University, Assiut, Egypt

The present study describes the histopathological changes by light microscopy in the hepato-pancreas (HP) of the white shrimps, Penaeus indicus and to study the effects of both carbenicillin and Bacillus sublitis (ATCC 6633) filtrate on the isolated vibrio spp. We also investigated by scanning electron microscopy (SEM). Fifteen white shrimps of an average body weight of 3-6 g were sampled and the HP and intestine were fixed in Davidson's fixative, processed for light microscopy, and stained by H&E and Gram Stain. Bacteriological isolation, counts, and identification were also made. In Vitro studies the effects of the B. sublitis filtrate and the antibiotic carbenicillin on the isolated vibrios by means of SEM were also investigated. Light microscopy showed corrugation and separation of the myoepithelial cells from the tubules, and slight ,moderate and diffuse necrosis of the hepatopancreatic tubules. Melanocytic nodules were not observed in this study. Gram negative bacteria were identified inside the lumen of the HP tubules. The increased number of Gram-negative bacteria in the tubules was associated with lower number of bacteria in the intestinal lumen. The necrotic changes were attributed to the effects of isolated vibrios (V. parahemolyticus,V. anguillarium,V. splendidusII;V .alginolyticus).SEM showed that B. sublitis filtrate on isolated bacteria exerted diffuse damage of the outer cell wall treated with the antibiotic. Moreover, B. sublitis filtrate resulted in marked decrease in the number of bacteria and a wide zone of inhibition on TCBS media. This study concluded that the histopathological changes were attributed to septicaemia of the isolated pathogenic vireo spp. and also suggested that the overwhelming of pathogenic vibrio may decrease the flora of the intestines. Bacillus sublitis filtrate had more alterations on isolated vibrios compared to the antiobiotic.

C14-4

Species-specific differences in mercury concentration and trophic position of planktivorous fish from Caddo Lake, Texas

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We conducted a survey of mercury contamination in three species of planktivorous fish, brook silverside (*Labidesthes sicculus*), threadfin shad (*Dorosoma petenense*) and gizzard shad (*Dorosoma cepedianum*), from Caddo Lake, Texas. Brook silversides had the highest concentration of mercury followed by threadfin and gizzard shad. We also examined trophic position (determined using δ15N), growth rate, and horizontal food web position (determined using δ13C) of planktivorous fish as factors responsible for species-specific differences in mercury contamination. We found a strong relationship between trophic position and mercury concentration. Species-specific differences in growth rate and horizontal food web position did not explain differences in mercury concentration. Although these three fish species are assumed to be in the planktivore guild, they feed at different trophic positions and have different mercury concentrations.

C14-5

Mercury, cadmium, lead and arsenic in muscle tissue of striped marlin and Indo-Pacific sailfish from the southwestern Gulf of California

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Billfishes are important game fish species in the Gulf of California, and are also used for human consumption. Previous studies have shown that oceanic billfish have elevated concentrations of metals in the edible muscle. In our study we estimated the concentration of Hg, Cd, Pb and As in two billfish species caught by the sport fishing fleet of Mazatlan (southwestern Gulf of California). Muscle samples of 12 striped marlin and 17 sailfish were frozen and subsequently digested using HNO3 with a microwave digestion system, analysis of Hg and As were made by VGA-AAS and for Cd and Pb by HG-AAS. The Hg and As concentrations varied from 0.43 to 3.62 ·g g-1, and 1.5 to 9.9 ·g g-1 respectively. Cd and Pb levels oscillated from 0.16-1.5 and 0.18-0.49 ·g g-1, respectively. About 90% of samples exceed the USFDA limits of 0.5 ·g g-1 and 2 ·g g-1for Hg and As respectively, 17% of 1.0 ·g g-1 for Cd and 5% of 1.0 ·g g-1 for Pb. The high levels of Hg and As in this study indicate there is a need for a moratorium on the use of this species for human consumption in the studied area.

C14-P-1

Value chains and health standards in shrimp export from Bangladesh to the world's market

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Shrimp, the second largest export earner, is potentially the next to garment sector of Bangladesh. The EU (45%), USA (35%) and Japan (4%) are the world's major importers of shrimp from Bangladesh. It is already among the top 10 exporters in the world. On the international level, buyers and consumers are increasingly demanding that shrimp is produced and exported in compliance with the recognized codes of conduct. This study aims to sketch out various activities in the value chain from the production level to export market inconformity with the food safety standards. Field surveys, interviews, discussions, communications, consultations and interactions with different stakeholders were conducted which are analyzed and used as the basis of the paper. The results reveal that Bangladesh implements HACCP principles about 85% in all stages of production, distribution, processing and export of shrimp. Processing plants are practicing traceability and improving labour practices. International organizations named SGS, Lloyd's, and Baltic Control are working as third party certification agency. However, it is recommended to ensure traceability from the farm level to shipment as well. It is also needed to improve the conformity of local producers with global labour and environmental standards for achieving competitiveness in shrimp industry.

C14-P-2

Fatty acid profile of freshwater sardine *Mirogrex terraesanctae* from the Sea of Galilee

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Mediterranean sardine is an important commercial freshwater fish species. The fatty acids of different sardine tissues, fished in Lake Kinneret (the Sea of Galilee), were examined. The benefits of including omega-3 fatty acids in the diets of humans are well documented. Fatty acids play a major role in the functioning of the immune system and the maintenance of all hormonal systems in the body. Mediterranean sardine (*Mirogrex terraesanctae*) is an excellent source of both DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid). Sardines are one of the most popular treats at Israeli houses. *M. terraesanctae* (=*Acanthobrama terraesanctae*) known as the lavnun or Galilee sardine-like cyprinid fish is popular diet of many of the people in Bible Land since ancient ages. The receding lake was expected to reduce the sardine population. Fatty acids of M. terraesanctae have not yet been studied. Fatty acid from different tissues of Galilee sardine important in the diet of East Mediterranean inhabitants were examined. More than 50 fatty acids were detected in freshwater fish Sardine (*M. terraesanctae*). Muscles of this fish contained a high level of omega-3 fatty acids (over 50% of total fatty acids). The difference between marine and freshwater fish may be due simply to differences in the fatty acid content in the diet or it may be related to a specific requirement of fish related to physiological adaptations to the environments. The phospholipids are generally considered to be structural or functional lipids, being incorporated to a larger extent in the membrane structure of cell and subcellular particles. The triacylglycerols are more often storage lipids and reflect the fatty acid composition of the diet to a greater extent than do the phospholipids. The fatty acid compositions of the neutral (triacylglycerols mainly) and polar (phospholipids and glycolipids) fractions of fish lipids are presented. It can be seen that the effect of changing environment on the fatty acid composition of the phospholipid is as great in the case of salmon, and considerably greater in the case of sweet smelt, than it is on the triacylglycerol composition.

C14-P-3

Physiological disturbances in largemouth bass: consequences of temperature and oxygen shock

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During angling tournaments, largemouth bass can experience rapid temperature and dissolved oxygen changes as they are removed from their environment and placed into livewells. Currently, the physiological consequences of these shocks are unknown. The objective of this study was to quantify the physiological disturbances in largemouth bass at two levels of heat- and cold-shocks and at two levels of hypoxia and hyperoxia shock. For the temperature shock treatment, resting bass acclimated to 20°C were instantly exposed to water at either 15°C, 8°C, 25°C or 32°C. For the oxygen shock experiment, bass acclimated to 8mgO2/L were instantly exposed to water containing 4mgO2/L, 2mgO2/L, 12mgO2/L, and 18mgO2/L. Fish were held at these temperatures/oxygen concentrations for either 1- or 6-h and then sampled for blood and muscle. Results showed the physiological disturbances were most pronounced at the extreme treatments for both temperature and dissolved oxygen shocks. Plasma glucose concentrations increased at 8°C and 32°C for 1h but returned to near control concentrations at 6h. Some temperature shock treatments resulted in ionic disturbances. Muscle phosphocreatine was consumed and tissue lactate was produced following 6h exposure to 2mgO2/L. Our results provide recommendations to anglers and tournament organizers to minimize the physiological impacts on fish.

C14-P-4

Ecophysiology of the gray snapper (*Lutjanus griseus*): salinity challenges and choices in the laboratory

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Depending on their location, nearshore, shallow-water habitats are often characterized by substantial fluctuation in salinity levels, which can represent a source of osmotic stress for associated organisms. In South Florida, one of the most important fish species that utilizes these habitats is the gray snapper (*Lutjanus griseus*). Although this species constitutes a significant portion of the region's total recreational fishery harvest, the effects of salinity on its distribution, physiology and behavior remain poorly understood. The main goal of this research is to investigate the ecophysiological basis of habitat selection by the gray snapper. Two objectives include:[1] measuring physiological responses to salinity changes; and[2] conducting behavioral trials to examine for salinity preferenda (if any). Fish were challenged with five different salinity treatments (with controls): 0, 5, 30, 50 and 60ppt for 192 consecutive hours. Blood samples were taken at times ranging between 6 - 192h and plasma osmolality was measured. Overall, fish exposed to 5 or 50ppt did not exhibit a significant change in osmolality at any time point, whereas fish exposed to 0 and 60ppt did show significant changes at 96 and 48h, respectively. Results after 192 hours of exposure suggest that this species may possess an extraordinary capacity to osmoregulate in such salinity extremes. Field measurements of osmolality across the salinity gradient show a similar pattern to that observed in the laboratory. Behavioral results suggest that gray snapper has a salinity preference that may be in the range of 12-22ppt. Overall, results of this work are expected to provide valuable insight into the effects of the Everglades Restoration on a species of significant economic value within the South Florida aquatic ecosystem.

C14-P-5
Housatonic river remediation and aquatic community response
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The Housatonic River Project is one of the largest Superfund restoration sites in the United States. Historic releases of polychlorinated biphenyls (PCB) contaminated approximately 12 miles (19.31 km) of the River. In 2000 during the Site Specific Environmental Restoration Contract (SSERC) phase, remediation work was initiated to restore the first 1.5 Mile Reach of the Housatonic River located in Pittsfield, MA. Baseline aquatic community data were collected in 2000. A post-remediation aquatic community assessment of the 1.5 Mile Reach was conducted in 2007. The objectives of this post-remediation study were to: 1) measure [PCB] in benthic macroinvertebrate tissue; 2) determine benthic macroinvertebrate taxa and Ephemeroptera, Plecoptera, Tricoptera (EPT) richness and abundance; and 3) characterize the fish assemblage and community structure. Comparisons were conducted between 2000 and 2007 data. There was a 99% reduction in [PCB] reported in macroinvertebrate tissue. Based on taxa and EPT richness at several locations, 2007 water quality conditions were reported as increase quality compared to conditions in 2000. The abundance and diversity of fish species identified is suggestive of improving water conditions and habitat quality.

C14-P-6
Incidence of barotraumas in fish in the St. Lawrence River
Jason Gokey[1] (presenting), Jason Schreer[1]. [1]SUNY Potsdam, Potsdam, New York, United States

Barotraumas have been documented in many freshwater and marine game fish and are increasingly being recognized as a serious conservation and management issue in catch-and-release fisheries. Barotraumas result from a process called decompression where fish are brought from depth to the surface quickly leading to rapid changes in ambient pressure. The decline in ambient pressure can have profound physiological and physical consequences, especially in physoclistous fishes (including black bass) where the swim bladder does not directly connect to the digestive tract. Beyond problems with swim bladder distention, fish that are exposed to decompression can experience internal and external hemorrhaging, ocular pressure, formation of gas bubbles within the circulatory system, gills, heart, and brain and general tissue damage. In the summer of 2007 we angled for deepwater fish (>20 ft.) in the St. Lawrence River to determine the rates of incidence of barotraumas in commonly angled fish. A total of 66 fish were caught including perch (n=42), smallmouth bass (n=11), rock bass (n=7), blue gill[4], walleye[1], and bullhead[1] in depths ranging from 0-42 ft (42% > 20 ft.). The only fish that showed signs of barotraumas (bloated and unable to maintain equilibrium) were 3 of the 4 fish caught at >35 ft (2 smallmouth bass and 1 rock bass). This study suggests that there are some species differences in the incidence of barotraumas, but clearly sample sizes were small and more work is needed. In the summer of 2008 we will increase sample sizes through additional angling effort and by conducting creel surveys in the area.

C14-P-7
Aquatic risk assessments for regulation of pesticides in Canada
Brigitte Lavallée[1] (presenting), Scott R. Kirby[1], Lizanne Avon[1], Ian Kennedy[1]. [1]Pest Management Regulatory Agency, Health Canada, Ottawa, Ontario, Canada

Health Canada's Pest Management Regulatory Agency (PMRA) is the federal agency responsible for the regulation of pest control products in Canada. The Environmental Assessment Directorate of the PMRA has implemented a new framework for pesticide aquatic risk assessments.The new framework uses a science-based tiered approach that considers both the inherent toxicity of the pesticide as well as the potential for exposure to that pesticide. Initial tiers (screening levels) use a deterministic approach with conservative exposure scenarios for various taxonomic groups including aquatic macrophytes, algae, pelagic and benthic invertebrates, amphibians, and fish. This approach allows those pesticide uses that do not pose any significant risk to the environment to be rapidly identified. The screening level also allows for the identification of taxonomic groups not at risk from the proposed pesticide use. Subsequent tiers of the risk assessment focus on refining exposure estimates using more sophisticated fate models with specific regional scenarios. This new framework makes better use of Agency resources while providing a more scientifically sound approach to characterizing the potential risks of pesticides to aquatic systems, including fish.

C14-P-8
Sex-based divergence in mercury bioaccumulation by northern fishes
Kyla Standeven[1] (presenting), Tom Johnston[2]. [1]Laurentian University, Sudbury, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Sudbury, Ontario, Canada

It is well known that concentrations of bioaccumulative contaminants, such as mercury (Hg), are positively related to the age and/or size of fish. But, how might this relationship be influenced by the sex of the fish? Sex-based differences in feeding ecology, habitat use, growth, energetics, and reproductive allocation could lead to divergent rates of Hg bioaccumulation. We examined muscle total Hg concentrations in mature males and females of 20 boreal fish populations, comprising 7 species. We predicted that the net effect of all ecological and physiological differences between the sexes would result in higher Hg bioaccumulation in females than males at a given body size. We found significant differences in Hg concentrations between the sexes in some populations but not in others. Furthermore, females had significantly lower mercury concentrations than males in some walleye populations, contrary to our predictions. Reanalyses of these data following adjustment for both body size and growth rate indicated that some of the sex-based differences in Hg concentrations were attributable to differences in growth rates. Our results have implications both for setting fish consumption guidelines and for understanding contaminant dynamics in aquatic systems.

C14-P-10
Impacts of disturbance on mercury levels and bioaccumulation in small stream environments of Northwestern, Ontario
Eric Misener[1] (presenting), Rob Mackereth[1]. [1]Lakehead University, Thunder Bay, Ontario, Canada

In the Boreal forest, disturbance from forest fire and forest management are associated with increases in both the flux of mercury to aquatic systems and the concentrations of mercury in fish. However, the mechanisms by which mercury enters and bioaccumulates in the food chain with increased flux are poorly understood. Our study area has two 2 adjacent drainage systems which are ecologically and geographically similar but differ in disturbance history: one is an area of active forest management while the other has had no disturbance over the past 100 years. We will focus on small streams (10 in each area) which are numerous and are predicted to respond relatively quickly to disturbance impacts. This study will examine mercury concentrations in periphyton, stream macro-invertebrates and fish (brook trout and dace species) to test the hypothesis that increased forest disturbance will result in increased mercury concentration at all levels of the food chain. We will also evaluate other watershed characteristics, including beaver impoundment and wetland area, to help explain relative mercury differences due to natural variation. The results of this and several other studies are intended to improve our ability to predict manage mercury inputs into aquatic systems during land-use planning.

C14-P-11
Habitat relationships with fish assemblages in minimally disturbed Great Plains regions
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Effects of local environmental influences on the structure of fish assemblages were evaluated from 159 sites in two regions of the Great Plains with limited anthropogenic disturbance. These regions offered an opportunity to evaluate the structure and variation of streams and fish assemblages within the Great Plains. Principle component analysis (PCA) was used to identify patterns of site structuring within regions separately. Comparisons of correlations matrices from each region's PCA indicated similar structuring (Mantel test $r = 0.496$, $P = 0.0001$) despite differences in environmental variables between regions with a multiple analysis of variance (Wilk's lambda = 0.079; DF = 22,136; $P < 0.0001$). We used canonical correspondence analyses (CCA) to determine the influence of environmental conditions on species abundances and assemblage characteristics (e.g. trophic guilds, native family richness, etc.). Analysis of regions separately indicated that similar environmental factors structured streams and fish assemblages, despite differences in environmental conditions and species composition between regions. The ordination of the sample scores for the CCA of combined fish abundance data indicated a distinct separation between regions, because of differences in fish assemblage composition and environmental conditions. However, combined analysis of assemblage characteristics data resulted in a greater overlap of sample scores. Variance in fish abundance and assemblage characteristics from both regions was best explained by metrics of stream size and associated metrics (width, depth, conductivity, instream cover). Our results provide a framework and reference for conditions and assemblage structure in North American prairie streams.

C14-P-12

Patterns of dam building over time in new york state: implications for migratory fish

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One of the most critical challenges to threatened migratory fish species is habitat fragmentation due to anthropogenic barriers. A common perception among fisheries biologists regarding dam development within the Northeastern US is that early industrial revolution era construction drove dam proliferation. This perception may be misleading. Within the major freshwater basins of New York State, dam development has continued at a steady pace from the early settlement period through to present day, with more than 6,850 known dams constructed. Total dam numbers in New York State are estimated to have more than doubled after 1950. While some impacts of these dams have been documented, they mainly focused on large dams or hydroelectric projects. The pervasive impacts of small dams as migratory barriers may play a significant role in the distribution of fishes throughout New York State freshwaters. These impacts may resonate throughout the entire aquatic ecosystem. Using the American eel as an example for migratory fishes, we document the historic pattern of impacts of man-made migratory barriers in affecting potential fish distribution in the major New York State watersheds.

C14-P-13

Fish assemblages in an urbanizing basin

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Aquatic biologists are faced with the challenge of quantifying how human activities in urbanizing areas influence aquatic ecosystems at the watershed and/or riparian scale. Scientific literature reports degradation occurs in aquatic systems as developed land cover increases within a watershed and fish assemblages are adversely affected. Fish assemblages were sampled at twenty-one sites in a rapidly urbanizing basin in the upstate of South Carolina in 2005 and 2006. Land cover within catchments ranged from 16 to 88%. Principal components analysis was used to create two composite variables: land cover and substrate. Other parameters measured were dissolved oxygen, pH, temperature, turbidity discharge and mean canopy cover. Canonical correspondence analysis was used to explore the potential of these variables on community structure. Monte Carlo tests were performed to test the null hypothesis of no relationship between the two matrices, fish assemblage and environmental parameters, and to evaluate significance of the eigenvalues of the axes. Monte Carlo tests failed to reject the null hypothesis of no correlation between the community and the environmental variables measured for catchments ($p = 0.43$). This suggest fish communities may have already been impacted by historical development.

C14-P-14

Monitoring changes in resident and anadromous fish communities in Sedgeunkedunk Stream (Penobscot Co. Maine) after low-head dam removal

Cory T. Gardner[1] (presenting), Stephen M. Coghlan[1], Joseph D. Zydlewski[1]. [1]University of Maine, Orono, Maine, United States

Sedgeunkedunk Stream is a 3rd-order tributary to the Penobscot River in Orrington, Penobscot Co. Maine. The stream once supported anadromous fish runs of alewife, Atlantic salmon and sea lamprey that have either disappeared or have been reduced as a result of three dams. A restoration project has been planned to remove the lower dam and bypass the middle dam in 2008, thereby opening up kilometers of stream and pond habitat to these fish populations. This restoration may have dramatic effects on the physical characters of stream system (hydrology, and temperature) as well as facilitating an influx of marine derived nutrients. Responses of resident fish communities and anadromous fish populations to the dam removal will be monitored. The Sedgeunkedunk and four control streams will be electrofished four times a year; abundance, length, weight and age of all encountered fish will be determined. Sea lamprey, the only prominent anadromous species currently in the system, will be assessed at both the migratory adult and juvenile stages. The abundance of adults arriving to the stream will be estimated along with the abundance and distribution of sea lamprey ammocoetes in the stream. Because this restoration effort may serve as a dam removal model for other small streams in the Penobscot River watershed (and elsewhere) our results will help managers understand the dynamics of re-establishing connectivity on fish ecosystem structure and function.

C15. Marine Fisheries Management

C15.1-2

An analysis of individual transferable quotas for both the commercial and recreational fishing sector

Ming Ng[1] (presenting), Jesse Patterson[1], Steve Choy[1]. [1]UCSB- Bren School, Santa Barbara,CA, United States

Individual transferable quotas (ITQs) have been implemented in some commercial fisheries. These ITQ management programs have led to increased profits, decreased costs of gear and labor, and a safer and more stable industry. Despite these successes, ITQs have been limited to just a few commercial fisheries, and are virtually nonexistent for recreational fisheries. While the operations and value-creating mechanisms of the recreational fishing industry are completely different than those of the commercial industry, in reality, the two compete for the same resources. In fisheries where there is both a commercial and recreational sector, the benefits accrued by ITQ management in the commercial fishery may be dissipated by the fishing levels in the recreational sector. This study focused on the Santa Barbara Channel Nearshore fishery, with both commercial and recreational sectors. We analyzed the potential economic, environmental, political and social benefits and impacts of implementing an integrated "fish tag" system for both commercial and recreational sectors. The framework for this analysis can be applied to many other fisheries with both commercial and recreational sectors.

C15.1-3
Development of a monitoring tool for fish populations of the St. Lawrence estuary using the bycatch from the commercial eel fishery
Pierre Pettigrew[1] (presenting), Andrée-Anne Vézina[1], Serge Perron[1], René Richard[1]. [1]Ministère des Ressources naturelles et de la Faune, Rivière-du-Loup, Canada

A fish monitoring program, including standard sampling methods, is being developed for the brackish and tidal waters of the St. Lawrence Estuary. This new tool uses the bycatch from the commercial eel fishery to collect data on fish populations and communities. In order to evaluate fish catchability, catch efficiency and gear selectivity, eel weirs were compared to gillnets and seines standardized for the freshwater segment of the St. Lawrence River. Nearly 60 000 fish and crustaceans were caught of which more than 15 000 were sampled. Atlantic tomcod (*Microgadus tomcod*) and rainbow smelt (*Osmerus mordax*) represent respectively 79% and 15% of the total sample. Regarding fish catchability and catch efficiency, the eel weirs caught 25 species out of a total of 28 species and 95% of the total sample. Also the eel weirs are less selective, as for each species, samples cover a larger size range. This new monitoring tool will be reliable, easy to support, practical and cost effective. Samples, taken annually from the commercial eel fishery bycatch and adjusted for gear selectivity, will give valuable information on the status of the fish communities and key species of the St. Lawrence Estuary.

C15.2-1
Improvements in data collection spark new ideas in reporting compliance and overall data quality
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The Atlantic Coastal Cooperative Statistics Program (ACCSP) is a cooperative state-federal program to design, implement and conduct marine fisheries statistics data collection programs and to integrate those data into a single data management system. The primary ACCSP systems are the Standard Atlantic Fisheries Information System (SAFIS) for data collection and the data warehouse for historical queries. With SAFIS, the ACCSP has improved the timeliness and availability of data, allowing partners to monitor quotas, reporting compliance and reporting accuracy more effectively and efficiently. The real-time nature of SAFIS has eliminated the delay between reporting and data entry/processing providing partners with the opportunity to proactively manage and prevent surpassing quotas. Customized queries have allowed several states to review reporting problems or to validate fishermen and dealer reporting against paper records and in some cases reduce or eliminate paper records. More complete reporting results in the availability of better data for stock assessment purposes. The data warehouse consolidates over a dozen datasets to provide the most complete picture of Atlantic coastal catch-effort data possible. Public users can query non-confidential data while confidential data access is available upon request. The ACCSP standardized reporting systems improve the quality, quantity and resolution of available data, while the data warehouse provides a more efficient mechanism to compile raw information for analysis.

C15.2-2
Developing standardized survey abundance indices for groundfish species in the inshore Gulf of Mane
Keri Stepanek[1] (presenting), Yong Chen[2], Sally Sherman[1]. [1]Maine Dept. of Marine Resources, West Boothbay Harbor, Maine, United States, [2]University of Maine, Orono, Maine, United States

The accurate assessment of stock abundance and distribution is essential to sound and sustainable fisheries management. Prior to 2000, a significant information gap had existed for nearly two-thirds of the inshore waters of the Gulf of Maine, which contain some of the Gulf's most important spawning and nursery grounds. The Maine-New Hampshire Inshore Trawl Survey was initiated eight years ago to fill this gap and provides valuable information on the structure of fish community and its spatial and temporal variations. In this study using generalized additive model we analyze the spatial and temporal variation of the survey data to identify environmental variables that may influence the abundance of six commercially important groundfish species (Atlantic cod, haddock, white hake, witch flounder, American plaice and monkfish) and derive a time series of standardized indices of abundance for these species. This study improves our understanding of the dynamics of fish community and provides critical information needed for stock assessments.

C15.2-3
Determining recreational summer flounder management options in Maryland using a volunteer based angler survey
Allison Luettel[1] (presenting), Angel Bolinger[1], Michael Luisi[1], Steven Doctor[1], Gary Tyler[1]. [1]Maryland Department of Natural Resources, Annapolis, MD, United States

The Maryland Volunteer Angler Summer Flounder Survey (MVASFS) was initiated in 2002 after anglers expressed dissatisfaction with the Marine Recreational Fisheries Statistical Survey's (MRFSS) harvest estimates, which resulted in an increase in minimum size and a creel reduction in Maryland. The survey design was derived from the successful Maryland Striped Bass Cooperative Angler Survey, and data collected during the first few years played a vital role in establishing current regulations in Maryland waters. Recreational anglers, charterboat captains, and partyboats were asked to count the total number of fish caught, measure only the first 20 summer flounder to the nearest ¼ of an inch, and indicate the fate of the fish (kept or released). Length-frequency data, which include sub-legal or undersized fish, are used to predict future harvest of summer flounder based on potential minimum size and creel limits in Maryland. The resulting analysis of these data have also been vital to the acceptance of Maryland's conservationally equivalent split area management option (coastal - four fish @ 15.5 inches and Chesapeake Bay - two fish @ 15 inches) by Atlantic States Marine Fisheries Commission (ASMFC), which has been in effect since 2005. In addition to Maryland's direct use of this survey, these data also influence management decisions along the Atlantic coast. Fisheries managers in Virginia and Delaware develop creel and size limits, and the National Marine Fisheries Service (NMFS) annually estimates size structure of released (undersized) fish, based on these data. Until the state of Connecticut started a similar program, the MVASFS was one of the only sources of discard data for the recreational summer flounder fishery along the Atlantic coast.

C15.2-4

Estimating virgin catch rate for thorny skate on Georges Bank: a possible method for setting restoration targets

Lynn Waterhouse[1] (presenting), Mathew Smith[1], John Hoenig[1], Todd Gedamke[2]. [1]Virginia Institute of Marine Science, Gloucester Point, VA, United States, [2]National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL, United States

The thorny skate (*Amblyraja radiata*) population on Georges Bank collapsed in the 1960s and remained at extremely low levels. Currently, the abundance, based on catch rate in a trawl survey, is the lowest level observed in the survey. There is a need for biological reference points in order to set targets for stock rebuilding and to assess current stock abundance relative to the target. We develop a method to estimate catch rate in a virgin population. The method makes use of the fact that the spawner:recruit ratio in a virgin population is a function of the natural mortality rate. Given an estimate of natural mortality one can calculate the ratio of spawners:recruits in a virgin population. And, given a stock-recruitment curve derived from catch rates of recruits and spawners in a trawl survey, one can calculate the abundance of spawners necessary for the virgin spawner:recruit ratio. Sensitivity analyses, using various values of natural mortality and age at maturity, suggest that the stock abundance was never near the virgin level at any point in the time series.

C15.2-5

Mississippi rigs to reef program: retaining valuable hard bottom habitat in the northern Gulf of Mexico

Kerwin Cuevas[1] (presenting), Eric Broussard[1], William Perret[1]. [1]Mississippi Dept. of Marine Resources, Biloxi, MS, United States

Mississippi Department of Marine Resources (MDMR), Mineral Management Service (MMS) and petroleum companies are working together to utilize decommissioned oil and gas platforms in the northern Gulf of Mexico for offshore artificial reef development in a program commonly known as "Rigs to Reef". Expanding on Title II of the National Fishing Enhancement Act of 1984, the National Marine Fisheries Service published a National Artificial Reef Plan. This plan opened the door to federal support for offshore artificial reef projects, which the MMS and coastal states expanded on further to develop the Rigs to Reef program to stimulate conservation minded reuse of oil and gas production platforms for offshore hard bottom habitat. The average platform jacket can provide up to 1.2 hectares of hard bottom habitat for marine invertebrates and fishes. Submerged platform jackets currently provide habitat for thousands of marine species in the northern Gulf of Mexico. MDMR artificial reef personnel are using the Rigs to Reef program to work cooperatively with oil and gas companies to utilize these decommissioned structures for enhancing fish and invertebrate habitat which could aid in the conservation and rehabilitation of important reef fish such as red snapper (*Lutjanus campechanus*) and benefit commercial and recreational fisheries.

C15.2-6

To stock or not to stock? How have stock enhancement programs affected the striped bass population in the southeastern United States

Jennifer Woodroffe[1] (presenting), Roger Rulifson[1]. [1]East Carolina University, Greenville, NC, United States

Striped bass (*Morone saxatilis*) have been a species of interest in North America since before the Massachusetts Bay Colony enacted the first law providing a fish protection in 1639. A bountiful resource, it was among the first fish populations to be studied by the newly formed US Commission of Fish and Fisheries. Along with American shad (*Alosa sapidissima*), striped bass was not only among the very first fish species to be successfully cultured, it was also one of the original "introduced" species; 435 yearling fish from the Navesink and Shrewsbury Rivers in New Jersey were released into the San Francisco Bay in 1879 and 1881. Striped bass culture continued to improve and when overfishing and poor water quality caused the stock crashes of the 1970s it was presented as a panacea. Stock enhancement programs were immediately instituted in conjunction with moratoriums on fishing. Slowly the populations rebuilt to "stable" levels by 1995. Yet, stocking has continued. Initially, striped bass were caught, spawned, and stocked in their home rivers thus maintaining the genetic integrity of the population; the stock enhancement programs changed all that. Fish were not being taken from the Chesapeake Bay and stocked into the Roanoke River or Roanoke River fish were being stocked into the Savannah River. Brood stock was also being retained on site at the fish hatcheries from year to year, further diluting the gene pool. Simultaneously, a significant increase in the numbers of Mycobacterium spp. infections in striped bass populations that were heavily stocked has been noticed. By studying the striped bass stocking record it is anticipated that the number of number of strains stocked into the key watersheds of the study area will be determined. This information will provide the necessary ground work to later determine the genetic composition of the current stocks and supply an essential tool in the effective future management of this most important species.

C15.2-7
Coupling, signals, and responses in commercial fisheries
Bonnie McCay[1] (presenting). [1]Rutgers University, New Brunswick, NJ, United States

The idea that ecosystems involve "coupled" interactions between human and non-human attributes of the systems raises questions about the nature of the "couplings" or linkages and what the interactive relationships are. It is also important to reconsider the general roles of humans in the systems. From the perspective of ecology, the focus on the human dimension has typically been on anthropogenic sources of change to the state of non-human variables in the system. From the perspective of the social sciences, the focus is usually on the "social impacts" of changes in natural, social, and regulatory dimensions of the systems. From the perspective of complex adaptive systems theory, the human dimensions aspect should also explore how people and their institutions respond to signals of change, and in turn how their responses "feed back" to the system. In addition, people need to be respected as witnesses, as creators and repositories of information and understanding, and as ecosystem crafts folk or designers. I consider these aspects of human dimensions through case studies of commercial fisheries in Newfoundland, Canada, Baja California, Mexico, and New Jersey, USA and of the evolving "science" of ecosystem-based management.

C15.2-8
Implications of quota allocation from a dynamic economic-biological model
John Ward[1] (presenting), Christopher Hayes[1]. [1]National Marine Fisheries Service, Silver Spring, MD, United States

The allocation of fish harvests between recreational and commercial fishermen is a problem in nearly all U.S. fisheries. Typically, the allocation issue is resolved based on the political power of the different groups, the historical allocation that has occurred in the fishery, or is based on what is considered fair by the fishery management group. This allocation decision is often made as a part of the larger fish stock conservation issue. Rarely, however, is allocation based on a rigorous scientific assessment of the fishery. Even in these cases, economic impacts have sometimes been incorrectly used as a basis for the allocation instead of the proper economic value contributed by each group of users. For the first time, a generic computer simulation model has been developed that allows the assessment of the change in economic value caused by different allocations between user groups. In addition to standard commercial-recreational fishery tradeoff, a model of heterogeneous recreational fisherman behavior has been combined with a multi-species, stock, resource area, cohort, and fishing fleet simulation model to determine how different groups will behave over time for different market values and satisfaction levels for harvested fish and different suballocations of total allowable catch. Different management objectives are evaluated for each management scenario using stock abundance, fishing mortality, or net benefit indices.

C15.2-9
Comparative dynamics of commercial and recreational sectors of marine fisheries
Thomas Ihde[1] (presenting), Thomas Miller[1], Michael Wilberg[1]. [1]University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD, United States

Recent work has called attention to the need to improve our understanding of recreational fishing in the marine environment. Here, we present an analysis of more than two decades of commercial and recreational landings data for more than thirty species of the Atlantic, Gulf of Mexico, and Pacific coasts of the United States. For a wide variety of coastal marine species the importance of the harvest by the recreational sector has increased relative to that of the commercial sector. We found very few exceptions to this trend. Moreover, species demonstrating this trend are not limited to those with historically-important recreational fishing sectors and include commercially-dominant species and some species that are not targeted by either sector. Available data also suggest that anglers in most of the fisheries examined have become increasingly conservation-minded during this time series, as evidenced by a generally increasing trend to release captured animals alive. Observed trends indicate that a conservation goal of 70-80% catch and release is reasonable for many recreational fisheries.

C15.2-10
Changes in species catch composition from artisanal fisheries in San José Island, Baja California Sur, Mexico.
Mauricio Ramirez-Rodriguez[1] (presenting), Mauricio Montoya-Campos[1]. [1]CICIMAR - IPN, La Paz, Baja California Sur, Mexico

In order to detect potential changes in the composition of fish catches from artisanal fisheries, samples were collected from catches landed by five fishing vessels in southern San José Island, southwestern Gulf of California, from 2004 and 2006. The data included catches in term of number of specimens and weight for each species landed, and were grouped by season (cold or warm) into six fishing areas, according to the fishing gear (lines with hooks, longlines and small-, medium- or large-mesh nets). Sixty five species were identified, belonging to 53 genera and 34 families. Forty four, 37 and 21 species were found for small-, medium- and large-mesh nets, respectively. Twenty one and 5 species were caught with hooks and longlines, respectively. When considering the contribution of each species in the catch in terms of number of specimens, total weight and frequency of occurrence, the fact that just a few are target species was confirmed. In general, no substantial changes were detected upon considering the location of the catch, but the opposite was found in relation to the fishing season.

C15-P-1

Management recommendation for Paragyrops edita in Beibu Gulf based on per-recruit analysis

Huosheng Lu[1] (presenting), Bo Feng[1], Gang Hou[1], Yunrong Yan[1]. Fisheries college, Guangdong Ocean University, Zhanjiang, China

The status of the crimson tai resource in Beibu Gulf has been assessing using a per-recruit model noting that there are no significant difference in growth and mortality between sexes. It is estimated that at the current fishing mortality rate the spawning biomass per recruit is 6% indicating that the fishery is overfished with a recruitment failure at present. A number of management scenarios, based on minimum size limits, closed season and closed areas were evaluated for this fishery in order to determine which of the scenario would increasd spawning biomass per recruit without comproming yield harvest rates to levels which may lead to socio-economic hardship among fishers. It has been shown that the closed areas and minimum size limits may be the most effective current means of achieving these objectives and it is proprosed the marine protected areas be implemented in spawning ground and larva nusery. This would keep spawning biomass per recruit above 30% and prevent this fishery from collapsing.

C15-P-2

Gulf of Maine mapping initiative: advancing regional fisheries research and management

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The distribution, types, and quality of subtidal marine habitats are largely unknown in the Gulf of Maine. This lack of information hinders the management of marine fisheries. Effective management requires knowing where distinct habitats occur so that productive and sensitive habitats can be protected or restored. Maps of the seafloor are important tools for scientists, managers, and fishermen, alike. Scientists can use benthic habitat maps to study linkages between species abundance, depth, and habitat; recovery of closed areas; distribution of invasive species; and effects of fishing gear on bottom habitat. Managers can use seafloor maps to guide decisions that affect fisheries and coastal zone activities, e.g. the siting of closed fishing areas, aquaculture leases, oil and gas pipelines, fiber-optic cables, alternative energy projects, dredged materials disposal, and sand and gravel mining. The fishing industry uses maps of seafloor topography and habitat to improve fishing efficiency, minimize gear impact on seafloor, and reduce by-catch and gear loss. Despite the proven value of seafloor maps for fisheries research and management, only about 20% of the Gulf of Maine has been mapped using modern acoustic survey technologies. The Gulf of Maine Mapping Initiative (GOMMI) is a partnership of governmental and non-governmental organizations in the US and Canada whose mission is to map the entire Gulf of Maine basin. GOMMI's goals are to facilitate communication and collaboration within the mapping community, to coordinate ongoing mapping efforts, spearhead new projects in priority areas, and make maps and data widely available to users and stakeholders.

C15-P-3

The importance and consequences of striped bass maternal condition on reproductive potential

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Ensuring the sustainability of fish populations continues to challenge scientists and managers. Understanding the relationship between the abundance of spawners and the number of new recruits they produce is central to this problem. Traditional approaches have principally related recruitment to stock biomass only. However, factors such as the size and age of spawners are known to influence survival of their eggs and offspring through a variety of mechanisms. Less understood is the role of female nutritional condition on reproductive potential. For Atlantic coast striped bass, the role of condition has become particularly important due in large to near record population abundance and a decline in lipid rich piscine prey. To investigate the role of striped bass maternal condition on reproductive potential, females were collected from the Chesapeake Bay and Roanoke River to assess fecundity; and in the lab, females were spawned to assess egg and larval quality, egg viability and larval growth and survival. Our results show that total liver energy is positively related to fecundity, as well as oil globule diameter and larval growth to 5 days post hatch. These results are the first to demonstrate that striped bass female condition can have significant impacts on individual and population reproductive potential.

C15-P-4

The influence of temperature on monkfish (*Lophius americanus* V.): Historical distribution based on bottom trawl survey data

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The monkfish, *Lophius americanus* V. is an important commercial species in the Northwest Atlantic. Some aspects of monkfish life history are not well-known including the influence of sea water temperatures on the distribution of monkfish within their geographic range. Here an assessment of historic data from annual bottom trawl surveys conducted by the NOAA Northeast Fisheries Science Center (NEFSC) was presented to examine the influence of temperature on monkfish distribution in the Mid-Atlantic Bight, Georges Bank, and Gulf of Maine. Monkfish catch rates (number per tow) and bottom temperature data from spring (1968-2007), summer (1963-2007), fall (1963-2007), and winter (1992-2007) were used to examine changes in temperature and monkfish distributions over time, define a range of monkfish temperature preferences, identify the amount available thermal habitat for monkfish, and determine whether monkfish distribution shifts can be correlated with changes in temperature.

C15-P-5

A comparison of the starfish (*Pisaster ochraceus*) population dynamics in two fishing grounds exposed to different fishing intensities in Baja California

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The starfish is an important predator in the rocky intertidal and subtidal that can have an important impact in prey populations such as mollusks and equinoderms. Pisaster has been considered a keystone species in the community because its presence promotes higher biodiversity and determines community structure. Although *Pisaster ochraceus* has been harvested in Baja California since the 70's, there is no information about the population dynamics of this species in the area. The lack of biological information has prevented the establishment of adequate management practices and conservation strategies for the region. These work aims to estimate some population parameters of the species and to determine the effect of fishing in the studied populations. Two localities in Baja California were selected that have been exposed to high (Punta Piedra) and low (Bajamar) fishing pressure. From February 2005 to January 2006, monthly samples were collected to estimate abundance, size structure, biomass, reproductive cycle, fecundity, sex ratios and size at maturity. The effect of fishing was evident in parameters such as size structures, abundance and biomass, that were higher in the less harvested area (Bajamar). *Pisaster ochraceus* has an annual reproductive cycle with a peak spawning period in February and March in both localities. Size at maturity was 5.6 cm and no significant differences were found between areas. Although the individual fecundity was similar in both populations, the reproductive output was significantly grater in the population that has been exposed to low fishing pressure. This study will help to propose an adequate management plan for the species in Baja California.

C15-P-6

Testing the effects of sea turtle bycatch reduction techniques on catch rates in existing gillnet fisheries in Baja California

Adrian Alvarez[1], Khahn Chi Dam[1], Shara Fisler[1], Cody Hooven[1] (presenting), Yaffet Mehari[1], Marlem Rivera[1], Ahiram Rodriguez[1], Yonat Swimmer[2], Edgar Trujillo[1], John Wang[3]. [1]Aquatic Adventures, San Diego, CA, United States, [2]NOAA NMFS, Honolulu, HI, United States, [3]NOAA/JIMAR/University of Hawaii, Honolulu, HI, United States

Incidental capture, or bycatch, in fisheries has been implicated in the rapid decline of sea turtle populations worldwide. There is a need to identify strategies that will reduce sea turtle bycatch while maintaining catch rates of target species. The purpose of our study was to test sea turtle bycatch reduction methods in a commercial, gillnet fishery in Bahía de Los Angeles, Baja California, Mexico. We examined the effect of two gear modification techniques that have been demonstrated to act as visual deterrents for sea turtles on target species catch rates, market value of catch, and sea turtle catch rates. During the daytime, we compared gillnets with shark shaped banners hung from the float line to gillnets without banners. During the nighttime, we compared gillnets with activated light emitting diodes (LEDs) hung from the float line to gillnets with non-activated LEDs. These methods may provide a useful strategy to reduce sea turtle bycatch in gillnet fisheries that could additionally be exported into pelagic longline fisheries, aiding in the recovery of sea turtle populations.

C15-P-7

Coastal mangrove ecosystems: co-management with social communities

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Coastal marine environment constitutes a major source of biodiversity on earth. Mangroves sheltering numerous species of microbes, fishes, plants, birds and animals, serve as buffer for marine food web. Mangroves - a source of medicines, ground for breeding of flora and fauna, curb strong tidal currents gushing into the main land. These ecosystems though very productive, are highly sensitive and fragile. Mangrove forests once covered 200,000 km2 of global coast line, now are disappearing by 1-2% per year. Comparatively, mangroves loss is continuing rapidly in developing countries, where 90% of the world's mangroves are located. Since 1980, world has lost about 20% of total mangrove area and in India alone, total mangrove forest area has been reduced from 6740 km2 in1987 to 4870 km2. Coastal reclamation, urbanization by population pressure and environmental degradation have been found to make the mangroves as most threatened habitats. In past decade, Mumbai has lost about 40% of mangroves forest. Therefore, coastal zones, mangroves and other green marine natural habitats must be protected, restored and managed in a sustainable way by both public-private partnerships. There is need for effective socio-economic policies, international cooperation/governance, education and awareness among the communities, to reverse the trend of mangrove destruction, so that future generation may also enjoy the coastal habitats, the gift of Nature to human-kind.

C15-P-8
Project FishSmart: harnessing the knowledge and insights of fishery stakeholders
Thomas Ihde[1] (presenting), Thomas Miller[1], Michael Wilberg[1], Michael Nussman[2]. [1]University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD, United States, [2]American Sportfishing Association, Alexandria, VA, United States

There is increasing recognition that both stakeholder satisfaction and the sustainability of some fisheries could be enhanced with a management approach that incorporates a wider perspective than the traditional yield-based management approach. Management bodies have striven to include a wide variety of stakeholder perspectives through public meetings, but there continues to be frustration within the recreational fishing sector that their knowledge and opinions are not effectively incorporated into the management options and strategies used by management. Here we describe a breakthrough collaborative project called "FishSmart" that seeks to fully incorporate angler knowledge, improve the relationships between stakeholder groups, and identify and rank the most effective alternative management strategies. We set out to accomplish these goals by comparing and ranking the efficacy of a range of stakeholder-identified management options through professionally-facilitated workshops that include all the key stakeholders of a fishery. We report the challenges, benefits, and preliminary results of the application of our methods to the Atlantic migratory group of the king mackerel fishery. This first case study of Project FishSmart identifies the stakeholder-preferred options for Atlantic king mackerel management to the Southeast Atlantic Fishery Management Council and complements the SouthEast Data, Assessment, and Review (SEDAR) process.

C15-P-9
Cost-time efficiency of aging menhaden (*Brevortia tyrannus*): scales versus otoliths
Billy Culver[1] (presenting), Jason Shaffler[1], Cynthia Jones[1]. [1]Old Dominion University, Norfolk, VA, United States

Menhaden (*Brevortia tyrannus*) have historically been an important commercial fishery of Chesapeake Bay, leading to intense management of the fishery. However, before fisheries management regulations can be formulated, information regarding menhaden population dynamics in the bay is needed. One important piece of information is the age-length relationship of juvenile menhaden. Two methods have generally been used to age menhaden. In the past the aging of scales has been the preferred method; however, aging using otoliths is generally accepted to be more accurate. This is not only the case in menhaden but is generally true of other fish species. In our evaluation we compared each method of aging juvenile menhaden from Chesapeake Bay. To evaluate these two methods we compared the predicted lengths of age one juveniles using back calculated lengths-at-age from otoliths and scales. Using a two sample t-test we were able to determine that the two methods were not significantly different. Since the time to prepare and age menhaden with scales is considerably less than with otoliths, and the cost of equipment is also reduced, the cost-time benefits suggest that aging menhaden with scales is more efficient and to be preferred.

C15-P-10
Efficacy of venting protocol on juvenile red snapper exposed to rapid decompression
Karon Radzik[1] (presenting), Wayne Bennett[1]. [1]University of West Florida, Pensacola, FL, United States

Gulf of Mexico red snapper catch has undergone steady decline. An important source of mortality is capture and release of regulatory discard fish. Previous studies have shown organ damage resulting from catastrophic decompression, swimbladder (SB) gas overexpansion, on captured snapper. Current recommended protocol of SB venting via lateral puncture could ameliorate decompression effects, but the efficacy of venting on survival is debated. This study evaluates effects of SB venting on survival in decompressed red snapper under controlled laboratory conditions. Pairs of fish are acclimated to simulated depths (control, 3atm, 6atm, and 11atm) in a flow-through pressure chamber and then decompressed at a rate of 1 m/s. One fish of each pair is vented, and survival of both is assessed over 30 days. To date, 90% of all deep fish die by 48h. Venting appears to positively influence survival of low and mid fish though mortality is still high in both groups (low vented 36%, low unvented 57%, mid vented 64%, mid unvented 87%). A 23% mortality in control vented fish suggests venting stress. Data suggest venting may provide some survival benefit in shallow depths, but total mortality of regulatory discards due to decompression should be addressed for effective fishery management.

C15-P-11

Providing quantitative metrics for Marginal Increment Analysis (MIA) to validate annulus formation

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Spot, Leiostomus xanthurus, is an important marine fish along the U.S. Atlantic coast. While there have been validation studies for otoliths and scales of spot in Louisiana and of younger spot in the Chesapeake Bay, Virginia, there have been no studies validating annulus deposition across the full range of ages (0-6) present in the Chesapeake Bay. Moreover, validation has traditionally used marginal increment analysis (MIA) to evaluate the periodicity of annulus deposition across age classes in a largely qualitative fashion. In this study, we use time-domain and frequency-domain time-series methods to provide a reliable statistical foundation to measure trends and periodicities in MIA results. We found that annulus formation for spot in the Chesapeake Bay occurs May through July, later than Louisiana (January-March). This period of annulus formation differs from scales in Louisiana (February-March) and Virginia (January-February). We conclude that there are both geographical and hard-part specific influences on the timing of annulus formation in spot. Finally, we demonstrate the value of time-series approaches in providing quantitative metrics to the studies of periodicity in annulus deposition in calcified structures.

C15-P-12

Mind the Gap: the state of knowledge of ecosystem impacts of fisheries in Canada

Candace Picco[2], Jennifer Ford[1] (presenting), Susanna Fuller[1], Dorthea Haangard[2], Fan Tsao[4], Lance Morgan[4], Ratana Chuenpagdee[3]. [1]Ecology Action Centre, Halifax, NS, Canada, [2]Living Oceans Society, Sointula, BC, Canada, [3]Memorial University, St. John's, NF, Canada, [4]Marine Conservation Biology Institute, Bellevue, CA, United States

To assess our current state of knowledge about the impact of fishing on marine species we compiled most publicly-available literature about bycatch and habitat impacts of Canadian fisheries. In addition, we analyzed observer data from many Pacific Canadian fisheries and the Gulf of Maine groundfish fisheries. Most Canadian commercial and recreational fisheries have very limited reporting of discard rates and species. In the Pacific region, groundfish management and industry have taken steps towards 100% transparency and accountability but other sectors still remain data deficient. In the Atlantic, many of the largest fisheries, such as those for herring, scallops, and lobster, have extremely low levels of observer coverage (under 1%) and very little is known about their bycatch and discard rates, even when effort is substantial. The longline fishery for swordfish and tunas in Atlantic Canada in particular has very high bycatch rates but observer coverage is very low. With improved reporting and observer coverage we can maximize inferences from the data collected thereby increasing the availability of the information critical to the shift to ecosystem based fisheries management.

C15-P-13

Steelhead pre-screen loss in Clifton Court Forebay, CA, USA

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The State of California and the US Bureau of Reclamation each divert water from the Sacramento-San Joaquin Bay-Delta (Delta) for agricultural and urban use. The State's diversion at the head of the California Aqueduct draws water from Clifton Court Forebay(CCF). The CCF, in turn, receives its water from the Delta via 5 radial gates operated on a tidal cycle. When these gates are opened fish are entrained, including threatened steelhead (*Oncorhynchus mykiss*) smolts. We evaluated, using PIT and acoustic tags, the proportion of steelhead entering the CCF but not being salvaged at the Skinner Fish Protective Facility. In addition, we acoustically tagged striped bass and studied the behavior of these predators and steelhead. In 2005, 13.5% of acoustically tagged steelhead released at the radial gates were salvaged at the fish protection facility. In 2007, 12.8% of 922 PIT tagged juvenile steelhead released at the radial gates were salvaged. In January (18.6 d) and February (18.0 d) fish exhibited longer mean time to salvage than March (6.2 d) and April (5.9 d). We also investigated potential avian predation on steelhead smolts; we found a significantly higher percentage of double crested cormorants were actively foraging when the radial gates were open.

C15-P-14

Reproductive potential of Pacific cod in Alaska

Olav A. Ormseth[1] (presenting), Brenda L. Norcross[2]. [1]NOAA Fisheries/ Alaska Fisheries Science Center, Seattle, WA, United States, [2]Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK, United States

In some species of marine fish (e.g. Atlantic cod *Gadus morhua*), older and larger females produce eggs and/or larvae with greater viability. Because the reproductive potential of these females is higher, the age structure of the population may be an important determinant of reproductive and recruitment success. To determine whether similar phenomena occur in Pacific cod (*Gadus macrocephalus*), I analyzed fecundity and egg size over a four-year period in three regions of Alaska. Contrary to expectations, no maternal effects on egg size were observed. Females defend length-specific fecundity levels at the expense of egg size, implying that the number of eggs produced is the primary determinant of reproductive potential in Pacific cod. It is possible that the maternal effects observed in species such as Atlantic cod result from fishery-induced early maturation of young fish. Therefore, the lack of such effects in Pacific cod may reflect the fact that similar changes in age structure and maturation have not occurred in Alaskan cod populations. Alternatively, there may be environmental factors that favour a reproductive strategy that relies on maximizing the number of eggs produced rather than the size of individual eggs.

C15-P-15
Temporal characterization of the surf zone macrofauna at Folly Beach, South Carolina
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The fish assemblage within the surf zone is widely variable consisting of a large number of individuals which represent a small number of species. Although a few species in the surf zone in the South Atlantic Bight have been well studied, data are lacking for most species, especially fishes. A study is being conducted in conjunction with a study of the surf zone in Horry County, South Carolina, which has a history of hypoxic events. The study conducted on Folly Beach is being used to evaluate long term changes to the macrofauna in the surf zone by comparing findings to studies conducted from 1969 to 1971, and 1980. A 19.8 m by 1.8 m, 9 mm bag seine is pulled through the surf zone parallel to the shore for 100 m at two sites 0.5 km apart. Samples are taken biweekly within one hour of low tide in the morning from June 2007 to August 2008. After the seine is beached, each specimen is preserved, then measured and weighed. Before each seine haul, the following physical measurements are taken: turbidity, temperature, salinity, percent dissolved oxygen, and concentration of dissolved oxygen. Data collected has been analyzed to compare species richness and abundance between studies as well as between seasons. Abundant species will be used in additional analysis to examine any correlations between abundance or biomass and any of the physical measurements.

C15-P-16
Location choice and expected catch: determining causal structures in fisherman travel behaviour
Michael Robinson[1] (presenting), Kostas Goulias[1]. [1]University of California, Santa Barbara, Santa Barbara, CA, United States

We use California Department of Fish and Game (DFG) fishing logbook data and National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) environmental data to identify variables responsible for determining when and where someone goes fishing and produce models that predict fishing location choice based on these governing variables. Linear regression models determine the expected catch (a continuous variable) for red sea urchin and spiny lobster fishermen. Multinomial logit (MNL) models determine expected fishing location (a discrete variable). This research explores two causal structures for modelling fisherman travel behaviour:
* Expected catch affects location choice
* Location choice affects expected catch

C15-P-17
Reproductive biology and fishery of the blue lobster *Panulirus inflatus* in the Central Mexican Pacific
Eduardo Juarez-Carrillo[1], Eduardo Rios-Jara[1] (presenting), Ernesto Lopez-Uriarte[1], Jose Luis Gomez-Marquez[1], Elaine Espino-Barr[1]. [1]Universidad de Guadalajara, Zapopan, Jalisco, Mexico, [2]Universidad Nacional Autonoma de Mexico, Mexico, DF, Mexico, [3]Centro Regional de Investigaciones Pesqueras, Manzanillo, Colima, Mexico

This study examined aspects of the reproductive biology and fishery of the spiny lobster *Panulirus inflatus* in the central coast of Jalisco, México. The lobsters were obtained from the commercial catches from June 1999 to November 2000. Estimates of the total length, cephalotorax length, abdominal length, total weight and egg mass weight of 1,410 lobsters were taken during the period of study. Individuals were sexed and classified in reproductive stages. The sex ratio between females and males was 1.04:1. The size of the ovigerous females ranged between 8.0 and 19.2 mm of cephalotorax length. Fecundity went from 32,798 to 67,344 eggs per gram. The mortality parameters (Z = 0.99, M = 0.35 and F = 0.65) indicate that the lobster population is heavily fished and a regulation should be applied immediately. The spiny lobsters, together with the octopus, are the most important resources in the artisan diving fishery of Jalisco. A description of these activities and estimations of the fishery effort for the region is presented. These results present a solid background to regulate the fishery.

<u>C16. Sampling Techniques</u>
C16-1
An empirical study of angling assessment methods: catch and harvest rate comparisons from complete and incomplete trip

data

Scott D. Krueger[1], James R. Jackson[1] (presenting), Anthony J. VanDeValk[1]. [1]Cornell Biological Field Station, Bridgeport, NY, United States

Creel surveys have been used to quantify angler success, the impact of angling regulations and the effects of angling on fish populations since the early 1950s. A variety of techniques have been developed to accommodate the variable nature of fisheries being surveyed, however, all biological creel surveys require two phases: an effort estimate and estimates of catch and/or harvest rates. This study focused on the catch and harvest rate estimation phase of the Oneida Lake Creel Survey. Anglers were interviewed during a roving survey and asked to provide information on duration of trip, catch and harvest (incomplete trip data). They were then given a postage paid postcard coded to the individual angler to be filled out and returned at the completion of the trip providing information for the remainder of their trip (complete trip data). Study design included a variable reward system for returned cards to provide information on incentives necessary to achieve desired levels of angler participation. Return rates did increase as potential reward increased, but comparisons of catch rates at time of interview among anglers who did and did not return cards revealed that returned cards were a representative subsample of all anglers interviewed, regardless of prize category. Comparisons of catch rates (all fish landed) derived from the incomplete trip interview and complete trip data from postcard returns indicated that there were highly significant differences in rate estimates from complete and incomplete trips for walleye (*Sander vitreus*, $P < 0.001$), and yellow perch (*Perca flavescens*, $P < 0.001$), but not for black bass (Micropterus spp. $P = 0.1$). Harvest rate (all fish landed and kept) comparisons indicated there was a significant difference for anglers specifically targeting yellow perch ($P < 0.001$) only, but all-trip comparisons were significant for walleye ($P = 0.025$). These results indicate that roving creel surveys may not accurately reflect total catch or harvest in all fisheries.

C16-2

Evaluation of finrays as a non-lethal aging method for protected goliath grouper in Florida

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Currently, there is a conflict between the need to conserve protected fish species and the need to use lethal methods to collect essential biological data, such as age, to assess their population status and recovery trends. Our goal was to develop an accurate, non-lethal method of estimating the age of goliath grouper (Epinephelus itajara), a protected species in U.S. waters. Paired finray and otolith samples were collected from fish that had been killed by red tide events in southwest Florida, from mark-recapture research activities, and from confiscated fish. Preliminary aging of these matched samples indicated that finrays may be useful for aging goliath grouper up to at least 14-17 years of age. Further aging comparisons to assess the limitation of the finray aging method will depend on obtaining samples from larger, and presumably older, goliath grouper. If the non-lethal aging method can be used as an alternative
to lethal aging using otoliths then it will significantly reduce the need to sacrifice protected goliath grouper.

C16-3

Comparison of aging methods and structures for bighead and silver carp

Duane Chapman[1] (presenting), Joseph Deters[1]. [1]USGS Columbia Environmental Research Center, Columbia, MO, United States

Bighead carp *Hypophthalmichthys nobilis* and silver carp *H. molitrix* are notoriously difficult to age. To date, researchers in North America have used sections from the ossified rays of the pectoral fin as aging structures. However, aging from these pectoral rays is fraught with multiple problems. The structures are complex, annuli are not symmetrical, and minor differences in distal distance of sectioning results in radical differences in annulus shape. Pectoral rays have a central lumen, which increases in size as the fish ages. This makes it difficult to locate the focus, and central annuli may be lost in older fish. Annuli in pectoral rays are often diffuse and poorly legible. Lastly, we show that choice of ray radius results in extreme and inconsistent differences in the back-calculated length estimations of early ages. We evaluated the following alternative aging structures for bighead and silver carps: two otoliths (sagitta and asteriscus), vertebrae centra, scales, and postcleithra (an easily extractible bone posterior to the pectoral fin). Accuracy was evaluated with 36 known-age bighead carp (up to 4+ in age). Precision was evaluated by comparing the age estimates from three readers. Known-age fish combined with more than 100 wild fish of both species were used to evaluate precision. Differences in age estimates and in back-calculated growth estimates between methods are described.

C16-4

Advances in coded wire tag technology: meeting changing fish management objectives

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Coded Wire Tags are lengths of magnetized stainless steel wire 0.25 mm in diameter and 1.1 mm long. The tag is marked with numbers denoting specific batch or individual codes. The tags are implanted hypodermically, and can be detected, but not read, externally. Because they are so tiny, Coded Wire Tags can be implanted into very small animals with little effect on the host and nearly universal high retention rates. In the Pacific Northwest of the United States and Canada, more than 1 billion salmonids have been tagged and released with coded wire tags and more than 5 million tags have been recovered since the early 1970s. This represents the largest tagging program in history. The coded wire tag system has changed dramatically to accommodate new fisheries management requirements related to marking all hatchery salmonids and emerging selective fisheries. Most significantly, these include the introduction of electronic detection for tag recovery and a completely automated system for tag injection. This system, known as AutoFish, can be used to tag and/or adipose clip up to 60,000 fish per day with just one operator and requires no human handling or anaesthetic. Around the world, the use of coded wire tags has expanded to hundreds of species.

C16-5

Comparative survival and behavior of acoustic and PIT-tagged yearling Chinook salmon in the Snake and Columbia Rivers

M. Brad Eppard[1] (presenting), A. Michelle Wargo Rub[2], Rich Brown[3], Katherine Deters[3], Lyle Gilbreath[2], Lynn McComas[2], Benjamin Sandford[2], Jessica Vucelick[3], Eric Hockersmith[2], Geoff McMichael[3], Ryan Harnish[3].
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In 2007, we conducted a comprehensive study to determine whether yearling Chinook salmon implanted with the recently developed JSATS 'micro' acoustic transmitter (17 x 3.5 x 5.7 mm, and 0.625 g) could provide unbiased estimates of survival and travel time as they migrated seaward through the Federal Columbia River Power System. We released 3,380 acoustic-tagged (95-168 mm FL) and 46,782 PIT-tagged (71-284 mm FL) river-run, hatchery yearling Chinook salmon into the tailrace of Lower Granite Dam(Rkm 695) on 10 occasions from April 24-May 15. Survival and travel times were estimated from PIT and acoustic tag detections of individual fish at multiple detection locations over a total distance of 461 Rkm. There were no significant differences in survival or travel times between acoustic and PIT-tagged fish within the Snake River (a distance of 157 Rkm from point of release). Time elapsed from release to this location was under 9 days for 90% of study fish belonging to both treatment groups. Relative survival AT/PIT –tagged fish was lower for study fish overall beyond a distance of ~225 Rkm traveled (inriver travel time > 11 days). The results of this study indicate that yearling Chinook salmon tagged with JSATS tags may provide unbiased estimates of survival and travel time as they migrate within the lower Snake River.

C16-6

Comparative performance of acoustic and PIT-Tagged juvenile subyearling Chinook salmon in the Snake and Columbia Rivers

M. Brad Eppard[1], A. Michelle Wargo Rub[2] (presenting), Rich Brown[3], Katherine Deters[3], Lyle Gilbreath[2], Lynn McComas[2], Benjamin Sandford[2], Jessica Vucelick[3], Eric Hockersmith[2], Geoff McMichael[3], Ryan Harnish[3]. [1]U.S. Army Corps of Engineers Portland District, Portland, OR, United States, [2]NOAA Fisheries NWFSC, Seattle, WA, United States, [3]Battelle Pacific Northwest Division, Richland, WA, United States

The Juvenile Salmonid Acoustic Telemetry System (JSATS) acoustic transmitter is the smallest acoustic transmitter currently available (17 x 3.5 x 5.7 mm, and 0.625 g). In 2007, we conducted a field study to determine whether salmon implanted with a JSATS transmitter could provide unbiased estimates of travel time and survival as they migrated seaward through the Columbia River hydropower system. We released 9,831 acoustic-tagged and 26,112 PIT-tagged river-run subyearling Chinook salmon into the tailrace of Lower Granite Dam(Rkm 695) on 27 occasions from June 4-July 13. Study fish ranged from 85-146mm FL. Survival and travel times were estimated from PIT and acoustic tag detections of individual fish at multiple detection locations over a total distance of 461 Rkm. Survival estimates declined over time and space for both acoustic and PIT-tagged fish. Relative survival of AT/PIT-tagged fish was consistently lower over time and space. Evidence of a 'tag effect' appeared at the first downstream detection location following release (Rkm 635). Time elapsed from release to first downstream detection was under 10.5 days for 90 % of study fish belonging to both treatment groups. Results of this study offer caution to researchers utilizing acoustic technology to study survival and behavior in juvenile salmonids (85-146 mm FL), and dictate avenues for further research and development.

C16-7

Effects of incision location on wound healing and suture retention on juvenile Chinook salmon

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When acoustic transmitters are surgically implanted into fish, the incision is commonly made anterior of the pelvic girdle and lateral to the linea alba (mid-ventral line). However, some researchers place incisions directly on the linea alba. This study was conducted to determine if incision location influences inflammation, wound healing, tag expulsion, and suture retention in juvenile Chinook salmon. An experienced surgeon implanted each fish with a micro-acoustic transmitter and a PIT tag, making the incision either on the linea alba (n=30) or slightly lateral to it (n=30) such that sutures did not pass through or around the linea alba. All incisions were closed with two interrupted sutures made of a 5-0 absorbable monofilament. Fish were held for 60 days in 17°C water and

were examined at weekly intervals following implantation. Evaluations of digital images taken at day 0 and subsequent intervals showed there were differences in inflammation, suture loss and wound apposition between the two incision locations. Results from this work will be used to guide the methods for surgically implanting acoustic transmitters into migrating juvenile salmon in the Columbia River Basin.

C16-8

Survival and behaviour of river-run juvenile Chinook salmon after surgical implantation of acoustic transmitters: what role does the physical condition of fish play?

Jennifer L. Panther[1] (presenting), Richard S. Brown[1], M. Brad Eppard[2], Michelle Rub[3], Lyle Gilbreath[3]. [1]Pacific Northwest National Laboratory, Richland, Washington, United States, [2]U.S. Army Corps of Engineers, Portland District, Portland, Oregon, United States, [3]NOAA Fisheries NWFSC, Seattle, Washington, United States

To better understand the behaviour and survival of river-run salmon smolts, we implanted 3,380 yearling Chinook salmon smolts (95-168 mm FL) with Juvenile Salmonids Acoustic Tagging System (JSATS) acoustic transmitters (17 x 3.5 x 5.7 mm, and 0.625 g) and monitored their migration from below Lower Granite Dam on the Snake River to McNary Dam on the Columbia River with underwater receivers. Survival and behaviour were related to the presence of pre-existing external maladies, their length-weight ratio (condition factor), and fish size. Fish with higher condition factors had higher survival. Survival of fish also varied with the hatchery origin of fish comprising the run. Although there are many other factors (predation, river discharge, temperature, and seasonality) that impact survival, the external condition of fish, the condition factor, and the hatchery of origin are important factors related to survival and behaviour.

C16-9

Use of a flat-bed antenna grid for continuous monitoring of wild juvenile Atlantic salmon (*Salmo salar*) movements in a natural stream

Patricia Johnston[1] (presenting), Francis Bérubé[1], Normand Bergeron[1]. [1]INRS-Eau, Terre et Environnement, Québec, Québec, Canada

Traditional telemetry methods (radio or acoustic) are widely used to monitor fish movements in freshwater and saltwater habitats but they do not allow continuous long-term tracking of small fish. In our project, we developed a flat-bed antenna grid, which allowed the tracking of PIT-tagged fish. The flat-bed antenna grid is composed of 256 antennas controlled by a computer and powered with a solar panel and batteries. The system was installed in 2006 on the Xavier brook, a tributary of the Sainte-Marguerite River (Saguenay, Canada). The antennas were buried in the substrate and georeferenced, thereby allowing real-time monitoring of tagged juvenile Atlantic salmon. The antenna grid covers a stream section of approximately 100 m long by 10 m wide. In 2007, 60 Atlantic salmon parr were PIT-tagged using 23 mm tags (half-duplex, Texas Instrument) and released in the study section. The flat-bed antenna
grid monitored continuously the position of parr from July to December and provided 122 500 detections over that period. Day and night trackings using a portable antenna were also carried out in order to locate parrs that were not on the antennas of the grid or that were slightly outside the study section. Results reveal that several parrs had a small home range while many others had no specific territory or home stone. Daily movements were clearly synchronized with sunrise and sunset. Day/night activity pattern varied amongst individuals with most parrs being nocturnal at all times, a few being active only during the day and some others being active both at day and at night. To our knowledge, this study is the first to present such detailed information on wild salmon parr movements and activity patterns over such a long period in a natural stream.

C16-10

Using hydroacoustics to enumerate and identify Atlantic salmon smolts in the Sheepscot River: Is it feasible?

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The Sheepscot River supports Atlantic salmon (*Salmo salar*) that are federally listed as endangered. Key management actions include ongoing efforts to better document and understand population dynamics. Presently, smolt production is indexed through data collected from rotary screw traps. Because sampling efficiency is potentially variable, the accuracy of annual estimates derived from these data is uncertain. Hydroacoustics was investigated as an alternative technology for measuring the timing, duration and magnitude of smolt emigration. In this pilot study we tested two types of sonar technology: split-beam and DIDSON. The acoustic systems were deployed side-by-side on the river bank, with a fish diversion fence installed to guide fish toward the ensonified portion of the river. Both naturally-migrating smolts and test-released smolts were detected, and acoustically-detected temporal patterns and length frequencies were compared to data obtained from rotary screw traps that were concurrently fished immediately upstream. The results showed similar patterns in temporal smolt abundance and length frequency between independently recorded trap data and post-processed DIDSON data. The similarity in the temporal patterns suggests that both sampling methods provided relative measures of smolt abundance. However, further development is required to obtain an estimate of absolute abundance.

C16-P-1

The differentiation of Chinook salmon, natal streams in Lake Huron, Laurentian Great Lakes: the use of otolith microchemistry as a natural tag

Stephen Marklevitz[1] (presenting), Yolanda Morbey[1], Brian Fryer[2]. [1]University of Western Ontario, London, Ontario, Canada, [2]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada

Chinook salmon were originally introduced to the Laurentian Great lakes to increase the diversity of fish species in 1873, and have been extensively stocked since the 1967. Since 1968 the Great Lakes Fishery Commission has supported large scale Chinook salmon stocking programs in Lake Huron and the population now consists of wild stream- reared and hatchery- reared fish. Traditionally the tracking of hatchery salmon has utilized the labour intensive method of fin clipping and/or tagging. The use of fin clips and tag release studies are not an effective or practical method of tracking wild populations. This study will examine the ability to differentiate the stream of origin in Lake Huron Chinook salmon by examining the otolith microchemistry. Recent studies have shown relationships between the elemental compositions of the otoliths in teleost fish and the environment. The biologically inert and archival properties of the otolith allow for the analysis of the environmental conditions throughout the life history of an individual fish. We will examine fry collected from various streams of different geological and geographical regions and relate the otolith microchemistry to elemental composition of the local water. The information gathered will later be used to determine origin of adult Chinook.

C16-P-2

Standardized removal and sectioning locations for shovelnose sturgeon fin rays

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Fin rays are a common structure used in age and growth analyses, but many inconsistencies exist regarding their removal and processing. The purpose of this study was to evaluate fin ray section location on precision of age estimates of shovelnose sturgeon *Scaphirhynchus platorynchus*. We examined fin rays from 203 shovelnose sturgeon sampled from Pools 9, 13, and 14 of the Mississippi River. Three readers provided age estimates for sections acquired from five locations along fin rays to determine the optimum location for removing and sectioning fin rays. Precision was generally highest for sections taken from the two most proximal areas on the fin ray. Readability and precision decreased as sections approached the distal tip. Age structure of shovelnose sturgeon populations was affected by section location. Based on these results, we recommend that scientists remove shovelnose sturgeon fin rays at the articulating process and section immediately distal to the curve of the ray.

C16-P-3

Otolith chemistry as an indicator of fish environmental history in the Upper Illinois River System and Lake Michigan

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Naturally occurring chemical markers in otoliths offer a potential means to identify source environment for fish within the upper Illinois River system and in Lake Michigan, including individuals that may breach electrical barriers in the Chicago Sanitary and Ship Canal or be transferred via bait buckets between these formerly isolated drainages. The objectives of this study were to determine whether water and fish otolith stable isotopic and elemental compositions differ among Lake Michigan, the upper Illinois River, and three tributaries of the upper Illinois River and to determine whether otolith isotopic and elemental signatures could be used to identify the water body from which individual fish were collected. Water and fish otolith samples were obtained from each site during summer 2007 and analyzed for δ18O, δ13C, and a suite of trace element concentrations. Otolith δ13C values for Lake Michigan fish were distinct from individuals collected in the Illinois River and tributaries. Fish collected in the Fox and Des Plaines Rivers could be distinguished from one another and from fish captured in the Illinois and DuPage Rivers using otolith Sr:Ca and Ba:Ca ratios; otoliths reflected differences in water chemistry among environments. Otolith isotopic and elemental compositions may enable determination of source environment for any Asian carp discovered in Lake Michigan and could also be used as indicator of environmental history for fishes in the upper Illinois River and its tributaries.

C16-P-4

Using visible implant elastomer to tag rare species

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Visible Implant Elastomer (VIE) tags provide the solution for many researchers when an externally visible, but benign tag is needed. The tags are injected beneath transparent or translucent tissue and remain externally visible. These tags have been successfully applied to many species of fish, cephalopods, crustaceans, reptiles, and amphibians and are often suitable for animals that are too small for other tagging methods. Because it has little effect on the host and can be used in small specimens, VIE is gaining widespread acceptance as a method for identifying rare species. We survey some of the ways VIE tags are used with rare species around the world to gather basic biological information about their life cycle habitat use, growth rates, and population sizes. In restocking programs, VIE has been used to distinguish stocked animals from their naturally occurring counterparts and to evaluate the success of supplementation hatchery programs. Observations of tagged animals have given new insights into their

behaviour.

C16-P-5

Preservz-It is a suitable alternative to formalin

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Preservz-It (PI) is a non-carcinogenic and easily-disposed-of alternative to formalin-based fixatives. We investigated the quality of PI preservation in contrast to formalin preservation in several species of freshwater fishes. Specimens were collected from western Lake Erie using a 26 foot headrope bottom trawl. Fish were fixed in 50% PI or 10% formalin solution for seven days, rinsed in water for two days, then transferred to a 70% ethanol solution for preservation. Body length (fork length, mm) and weight (g) were measured prior to or shortly after death, immediately after their 7-day fixation period, after the 2-day rinse and after 1, 2, 4, 7, 9, 20, 40 and 90 days in alcohol. PI fixed specimens differed markedly in appearance and pliability from formalin-fixed specimens; specimens took on a reddish-brown hue and did not become entirely rigid in 50% PI. Additionally, better results are achieved when a small amount of the PI solution is injected into the body cavity to ensure complete fixation. Overall however, the level of preservation achieved with PI is comparable to that of formalin. We conclude 50% PI solution is a suitable alternative to formalin as a fixative for small freshwater fishes.

C16-P-6

Analysis of age with different methods for five species of minnows from streams across Ontario: implications for assessment and management

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Analyses were completed on five species of minnow sampled from different streams in Ontario to resolve the age structure evident in the populations and to identify the most economical and efficient method for age determination. The minnow species considered were blacknose shiner (*Notropis heterolepis*), creek chub (*Semotilus atromaculatus*), lake chub (*Couesius plumbeus*), finescale dace (*Phoxinus neogaeus*), and northern redbelly dace (Phoxinus eos). Age determinations were completed for the minnow species with different bones that included the cleithra, lapillus otoliths, opercula, and scales. Analyses of the cleithra were not considered reliable for these small fish. The age estimates among the otoliths and operculum of sexually immature fish, usually less than about age III+ years, were generally consistent. By contrast, differences in age estimates among these bones became large when sexually mature fish were assessed. Estimates of maximum age were primarily derived from the interpretation of lapillus otoliths. These analyses collectively identified that a diverse age distribution is evident in the minnow species considered from these streams. These analyses also indicated scale interpretations produced the most variable estimates of age while the opercula and otolith were most consistent. This pattern identifies that small-bodied minnows achieve older ages that previously reported in the scientific literature, and such longevity complicates the management of these species.

C16-P-7

A comparison of nearshore fish sampling gears in Oneida Lake, New York

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Sampling and assessment of nearshore fish communities is difficult due to the wide variety of habitats, substrates, and often complex structures. During the summers of 2005 and 2006, we conducted a comparison of ten different gear types, with the intent to develop a long-term sampling protocol of nearshore communities in Oneida Lake, NY. Gear types consisted of nine configurations of fyke nets and one seine. Fyke nets varied by frame size (large vs. small), mesh size (large vs. small), orientation (parallel vs. perpendicular), and the inclusion/exclusion of wings. Summers were broken into two sampling periods, during which 2 different sites were chosen for each of three major substrate types (sandy, rocky, and muddy) for a total of six sites. Student's t-test indicated significantly higher species richness and total catch during sampling period two. However, few significant differences were observed in any net-to-net comparisons using Tukey's Honestly Significant Difference (HSD). Catches of key sport fishes, such as smallmouth bass and largemouth bass were significantly higher in smaller meshed nets. In order to maximize ease, efficiency and accuracy, we recommend assessments of nearshore communities take place in sampling period two, using a combination of perpendicularly set medium frame fyke nets, with both large and small mesh sizes. Additional species, not caught by fyke nets, can be supplemented by seining at all sites.

C16-P-8

Assessing length-related bias and the potential for standardization in the development of standard weight (Ws) equations

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Standard weight (Ws) equations have been developed for many species in an effort to evaluate fish condition. The currently accepted method for developing Ws equations is the regression-line-percentile (RLP) method. However, equations developed with this method are often unreliable for small- and large-sized fish of a given species. In response to this issue, a new method to compute Ws equations—referred to as the Empirical Quartiles (EmP) method—was recently published. A subsequent study claimed that Ws equations generated from the EmP method reduced the length bias of the RLP method, but these claims were not evaluated with independent data. To determine if the EmP method does perform better than the RLP method, we developed two new Ws equations from the EmP method and one new equation from the RLP method for two morphologically distinct species, walleye *Sander vitreus* and black crappie *Pomoxis nigromaculatus*. We evaluated these new Ws equations with an independent data set and determined which equation reduced the greatest amount of length bias. For walleyes, the RLP method did not exhibit any length-related biases when evaluated with randomly chosen populations, while Ws equations generated with the EmP method were length biased when applied to those same populations. In black crappies, both methods generated Ws equations that were length biased. As a result, we suggest that when developing new Ws equations, both the EmP and RLP methods be used and the resulting equations validated with an independent data set covering the geographic range of the species under investigation. This will allow researchers to determine which method best reduces length-related bias and hence, which equation should be used. Finally, we suggest standards for developing Ws equations that include performing quality control on developmental data.

C16-P-9

Development and efficacy of an electrified trawl for sampling benthic fishes

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Sampling small benthic and lithophilic fish species in large rivers and lakes can be difficult and, as such, they remain a relatively unknown component of many aquatic ecosystems. The recent (2003) development of the Missouri benthic trawl has proven effective in sampling these species in rivers throughout North America, dramatically altering known distribution and abundance estimates for many of these taxa. However, our observation by SCUBA of the Missouri trawl in action has revealed significant avoidance of the trawls by some species and life-stages, especially in cobble-gravel substrates where fish can easily avoid the trawl by seeking refuge between rocks or, in the case of larger species and individuals, by swimming away from the trawl. To remedy this, we equipped a Missouri trawl with cathodes and anodes similar to standard boat-electrofishing gear, and tested it in using a paired comparison with the standard Missouri trawl. Our results have shown that we are able to not only catch significantly more individuals using this electrified trawl, but also a greater diversity of species. With the electrified trawl, we caught a wider size range of fishes, especially larger individuals, and also species that were poorly represented or even absent from the non-electrified trawls.

C16-P-10

Comparison of channel catfish age estimates and resulting population demographics using two common structures

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Sagittal otoliths and the articulating process of the pectoral spine of channel catfish have both been validated as sound structures for estimating age of channel catfish (catfish < age four). However, limited information exists about relative precision of these two structures. Thus, we analyzed precision of age estimates between sagittal otoliths and the articulating process of the pectoral spine. Additionally, we compared population processes (i.e. recruitment, growth, and mortality) generated from age estimates derived using these structures. Aging structures were removed from 110 channel catfish captured from the Wabash River (River km 550 through River km 9.6). Agreement between the two structures was high. Average percent error was 8.4%, coefficient of variation was 11.4 and the slope of the age bias plots did not differ from one indicating similar age assignments between structures. Correspondingly, recruitment patterns, von Bertalanffy growth models, and mortality rates did not differ between the two structures (all comparisons; $P > 0.05$). The two structures provided similar age assignments, resulting in the similar population parameters. The articulating process of the pectoral spine provides a suitable alternative to otoliths and channel catfish can be released alive.

C16-P-11

Documenting taxonomic data quality for field fish identifications: a proposal for national surveys

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The U.S. Environmental Protection Agency is in the midst of a multiyear series of national surveys of water resource conditions. Because communicating ecological condition is the primary objective of the surveys, quantitative biological indicators are key. To assure the defensibility of the raw date (identifications and counts), it is important that the taxonomic data are of known quality. For the National Rivers and Streams Assessment (NRSA), fish assemblage samples will be collected from approximately 2,000 river and stream sites over a 2-year period, beginning in 2008. As part of the NRS, the vouchering system for fish assemblage samples will include the full complement of species in each sample. Digital images will be taken for each species that is rare, threatened, or endangered; ubiquitous, common, and distinct; or very large-bodied. For all others, at least one specimen will be preserved to represent the species. Sample vouchers will therefore be a combination of preserved specimens and digital images that regional experts can use to reconstruct a complete taxa list for each site. Our proposal is to have whole-sample species lists reproduced from a sample voucher by regional experts. Direct comparison of the taxa list from the voucher (Taxonomist 2) with that produced from the field (Taxonomist 1) will allow quantification of rates of differences by sample, as well as highlighting those species that are consistently difficult to correctly identify. This will be performed on a randomly-selected subset of the samples for each field taxonomist. Discrepancies between the two lists will be examined, and reasons for the differences determined. Corrective actions will be developed based on the comparison results and lead to updating of the database, and potentially lead to initiatives focused on taxonomic training for the identification of selected taxa. This paper will focus on our concept of this quality control initiative and its use as a component of national surveys.

C17. Percids

C17.1-1

Blue walleye of Canada - an overview

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We describe the biology of a blue morphotype of walleye, *Sander vitreus* vitreus, from Ontario, Canada. The fish lacked yellow pigment and produced a novel blue protein, which we named Sandercyanin, in their skin mucous. Sandercyanin is a homotetramer with a molecular mass of 87,850 and a subunit molecular mass of 21,836. Solutions of the protein were deep blue in color and showed absorbance maxima at 383nm and 633nm respectively. Amino acid sequence analysis suggested that Sandercyanin is a new biliprotein and is a lipocalin. Acetone treatment of the protein released a blue ligand which we identified as biliverdin. Biliverdin is produced in animals from the chemical breakdown of heme. Observations using a dissecting microscope showed that Sandercyanin was produced in membrane-bounded structures which we believe to be mucous cells and which are primarily concentrated along the posterior margins of the rays of both dorsal and caudal fins. Cyclic variation was noted in the seasonal production of Sandercyanin, with highest quantities produced in late summer. The function of Sandercyanin is still unknown but the protein did absorb UVA radiation and may aid in photoprotection against increased UV from depletion of ozone over the north pole. Sightings by fishermen, registered to our web site bluewalleye.com, indicate that blue walleye are broadly distributed from northwestern Ontario to west central Quebec between latitudes 45 and 60. Occurrence of blue walleye appears to have increased in recent years and appears to be spreading south into northern United States.

C17.1-2

Genetic variation in walleye populations

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Walleye are large predaceous percid fish species that are common in Canada, and the Great Plains region and the mid-western United Statesthat are popular with anglers. Cellulose acetate gel electrophoresis was used to screen genetic variation in more than 1362 walleye from 22 populations at two polymorphic loci in walleye, malate dehydrogenase (mMDH-3*) and general muscle protein (PROT-3*), were surveyed. Highly significant among population heterogeneity was found at both mMDH-3* and PROT-3*. A number of populations showed significant deviations from Hardy-Weinberg expectations, all due to heterozygote deficits, likely caused by the Wahlund effect because some samples were collected during the summer and fall, a period when walleye are highly mobile, rather than during the spring when they are presumed to segregate into discrete spawning aggregates. Managers are encouraged to manage populations of walleye that are genetically distinct separately because these populations may exhibit local adaptations.

C17.1-3

Population genetic structure of naturally recruiting walleye populations in Wisconsin

Jeremy Hammen[1] (presenting), Brian Sloss[1], Michael Bozek[1]. [1]UW - Stevens Point, Stevens Point, WI, United States

Maintaining genetic integrity in naturally recruiting walleye populations is a primary goal of the Wisconsin Walleye Management Plan. To understand the dynamics and realized threats to walleye genetic integrity, it is necessary to understand the spatial distribution of walleye genetic diversity across the state. Our objectives are to: 1) determine the extent of intra- and interpopulational genetic diversity in >25 naturally recruiting walleye populations in Wisconsin and, 2) determine whether the interpopulational diversity is consistent with multiple stocks of walleye in Wisconsin using genetic stock identification methods. A suite of microsatellite loci (≥12) have been used to measure the genetic diversity of sampled populations. Preliminary data show genetic diversity within these populations is consistent with similar studies of naturally recruiting walleye populations in Minnesota and Ontario. These data also show an apparent split between a Northwest cluster of populations and Northeast walleye populations in the state. These two major groups are consistent with major watersheds (Chippewa River/Mississippi River and Upper Wisconsin River) but differ with current management units. This study will help provide a more quantitative and usable framework to gauge walleye genetic integrity in Wisconsin and further efforts to effectively manage the resource while maintaining and conserving genetic diversity.

C17.1-4
Exploring adaptive and plastic variation in egg size of Great Lakes walleye (*Sander vitreus*)
Hui-Yu Wang[1] (presenting), Tomas Höök[1], Donald Einhouse[2], David Fielder[3], Lars Rudstam[4], Christopher Vandergoot[5], Anthony VanDeValk[4], Troy Zorn[6]. [1]CILER, University of Michigan's School of Natural Resources & Environment, NOAA/GLERL, Ann Arbor, MI, United States, [2]New York State Department of Environmental Conservation, Lake Erie Fisheries Research Unit, North Dunkirk, NY, United States, [3]Michigan Department of Natural Resources, Alpena Great Lakes Fisheries Research Station, Alpena, MI, United States, [4]Department of Natural Resources, Cornell University Biological Field Station, Bridgeport, NY, United States, [5]Ohio Division of Wildlife, Sandusky Fish Research Unit, Sandusky, OH, United States, [6]Michigan Department of Natural Resources, Marquette Fisheries Research Station, Marquette, MI, United States

Egg size is a partially heritable trait that may affect offspring survival rates. Given that there are tradeoffs between egg size and number of eggs produced by an individual, selection should favor evolution of particular egg sizes given system-specific environmental and genetic backgrounds. While several studies demonstrate plasticity of egg size (e.g. egg size is correlated with growth rates and maternal age and size), adaptive variation in egg size is under-studied. In this study, we aim to explore potentially adaptive and plastic variation in egg size of walleye in the Great Lakes region. We collected walleye eggs and maternal information from five stocks located in lakes Huron, Erie, Michigan, and Oneida Lake. These stocks display a wide range of life history traits, and some of the stocks have been supplemented by stocking. To explore potentially adaptive variation, we controlled for maternal age and size to assess inter-stock variation in egg size. Moreover, we compared egg size variation (after controlling for maternal age and size) among naturally reproducing and supplemented stocks. Results from our analyses should inform system-specific adaptive variation of an important fisheries resource and have implications for stocking practices within and across systems.

C17.1-5
Habitat selection and spawning success of walleye in a tributary to Owasco Lake
Marc Chalupnicki[1] (presenting), Jim Johnson[1], Jim McKenna, Jr.[1], Dawn Dittman[1]. [1]Tunison Lab of Aquatic Science, Cortland, New York, United States

Dutch Hollow Creek, a tributary to Owasco Lake is the main spawning stream for walleye. Approximately 68.9 million fry and fingerlings have been stocked in two time periods (1915-1948 and 1996-2006) to help reestablish the population. Assessment of walleye spawning is essential to determine if those efforts to create a fishery were effective. During the spring spawning runs in 2006 and 2007, surber samples were taken from the lower 725 meters of the stream to estimate egg densities. Drift nets were set downstream of the spawning section to assess hatch survival. Environmental variables were also recorded to characterize spawning habitats within the stream. Based on the surber samples and drift net catches in 2006 and 2007, 1.51 and 1.17 million eggs were deposited, with 162,596 and 126,437 hatching. Further analysis of habitat variables indicated a significant correlation with %Cover, Substrate, and Depth: Velocity ($p<0.05$). Analysis of egg deposition showed that the lower 125m and the 300m-500m upstream sections had significantly higher egg deposition ($p<0.05$) than the other sections with hatching success of 10.8% annually. In the lower 725m of Dutch Hollow Creek spawning Walleye selected gravel substrate in deeper water with slow velocity and low cover.

C17.1-6
Consistent walleye recruitment failure: where is the bottleneck?
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Numerous long-term studies of walleye population dynamics point to the importance of early life history processes regulating year class success with both biotic and abiotic factors being important. In Pymatuning Reservoir (6800 ha), stocking of post-yolk sac larvae generated a renowned walleye fishery. However, since 2001, CPUE data from fall YOY surveys indicate almost complete recruitment failure from these stockings. To identify the timing of the failure, we quantified stocking survivorship and then tracked the YOY walleye population (i.e. ichthyoplankton and zooplankton sampling, summer beach seining and fall electroshocking census). The PA F&BC along with the OH DNR stocked 16 million post-yolk sac walleye (7-9 mm TL) and about 90,000 early juveniles (15-20 mm TL) with distinctive OTC markings. Stocking survivorship was >90%. Although zooplankton densities were apparently sufficient (i.e, >100.L-1), no YOY walleye were collected in ichthyoplankton sampling; no juveniles were collected in 1.5 km of diel beach seining in June, and in the fall electroshocking survey, CPUE was 10-50 times lower than the long-term average. These results pointed to the timing of the bottleneck and historical data suggest that a potentially stable fish community shift has occurred that may limit the lake as a walleye fishery.

C17.1-7

Survival and stock-recruitment of walleye in Lake Ontario in response to dreissenid invasion

James Bowlby[1] (presenting), James Hoyle[1], Bruce Morrison[1]. [1]Ontario Ministry of Natural Resources, Picton, ON, Canada

Walleye populations in Lake Ontario declined during the late 1990s, after the invasion of dreissenids and associated increases in water clarity. We examined survival of four life stages of walleye from egg to adult and stock-recruitment relationships to test the prediction of the thermal-optical habitat area model that this decline was related to lower foraging efficiency in clearer water. We drew on data from walleye tagging and marking, index gill netting and trawling, and angler surveys in the Bay of Quinte and Lake Ontario over the last 2 decades to produce estimates of population and survival of different life stages of walleye. We found no significant differences in the survival of adults (age 4+), sub-adults (age 2-4), and juveniles (age 0-2), comparing before and after increases in water clarity. These results were not consistent with the hypothesis that reduced foraging efficiency in clearer water contributed to the decline in walleye in Lake Ontario. However, the Ricker stock-recruitment relationship was significantly different before and after increases in water clarity, indicating that survival during the egg, larval or early juvenile stage had declined. These early life stages of walleye are prior to the onset of increased light sensitivity. We propose that sunfishes, yellow perch, or zooplankton responded to habitat changes in the Bay of Quinte, and that competition or predation involving these species may be involved in declines of larval walleye.

C17.1-8

High mortality on walleye and yellow perch larvae in clupeid lakes: evidence from comparisons among ten New York lakes

Thomas Brooking[1] (presenting), John Forney[1], Anthony VanDeValk[1], Lars Rudstam[1]. [1]Cornell University Biological Field Station, Bridgeport, NY, United States

We followed the decline in stocked walleye larval abundance in 10 New York lakes with different open water fish communities. Lakes were sampled from 3 to 20 days after stocking of newly hatched walleye larvae. A total of 18 post-stocking surveys in lakes with abundant clupeid populations (alewife and gizzard shad) failed to catch any walleye larvae 3-11 days after stocking, whereas larvae survived up to 20 days after stocking in 50 surveys in non-clupeid lakes. Mean walleye density in non-clupeid lakes was 0.069 larvae/m3. The density of yellow perch larvae was an order of magnitude lower in the clupeid lakes (0.16/m3) than in the non-clupeid lakes (3.48/m3). Larval walleye survival was positively related to zooplankton mean size, an index of predation pressure by planktivorous fish, but not to mean zooplankton density. Daily instantaneous mortality rates for larval walleye from 3-20 days post stocking were highly variable, and averaged 0.15 in lakes where walleye survived. Larval walleye survival in predator exclusion enclosures was high (65-85%) for 5 days in these lakes indicating that the high immediate mortality observed in clupeid lakes was not due to starvation due to low zooplankton abundance, or stocking stress. Other explanations for the high mortality in clupeid lakes, such as thiaminase related declines in the viability of percid larvae, are not consistent with the survival of the same batches of walleye larvae in non-clupeid lakes. We conclude that high mortality of larval percids in the clupeid lakes was caused by predation. Limnetic percid larvae are some of the first ichthyoplankton to appear in the spring in our lakes, and thus may be subject to high predation risk as no other larvae are present to buffer predation from limnetic planktivores. Yellow perch larvae reached higher densities than walleye larvae, which may facilitate some successful recruitment even in lakes with abundant alewife populations.

C17.2-1

Predicting walleye and yellow perch recruitment with the addition of a top predator

Robin DeBruyne[1] (presenting), Lars Rudstam[1], Travis DeVault[2], James R. Jackson[1], Anthony VanDeValk[1].
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Management benefits greatly from the ability to predict adult abundances of harvested fish. Walleye and yellow perch are heavily fished recreationally in many inland lakes and the Great Lakes. Predicting recruitment to harvestable size in advance allows for timely management actions aimed at balancing exploitation to prevent overharvest and possible population crash. Perturbations to systems often change recruitment dynamics and compromise predictive capabilities. The addition of an avian piscivore, the double-crested cormorant, coincides with the distortion of a once predictable relationship between age-1 trawl CPUE and recruitment to age-3 (yellow perch) or age-4 (walleye) in Oneida Lake. Previous work has shown cormorants are a likely reason for the prediction change, however new recruitment relationships have not been developed. Here we present results to predict adult population numbers based on age-1 and age-2 abundance indices, prey abundance, and predator abundance. We used AIC to select the most probable models to explain adult population numbers. Including cormorant feeding days in the predictive models with trawl catches of subadults improved predictions of the number of age-3 yellow perch and age-4 walleye compared with previous predictions from trawl or gill net catches alone. Including potential prey abundance (YOY yellow perch and gizzard shad) was also important. Our results demonstrate the need to include food web interactions into recruitment analyses and predictions for inland fisheries. Prediction of the future harvestable population allows management agencies to be proactive rather than reactive to a decline in a fishery.

C17.2-2
Alberta's small walleyes: diagnosis and correction of a stunting or an overfishing problem?
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To recover Alberta's collapsed walleye (*Sander vitreus*) populations, a minimum size limit was implemented thereby dramatically increasing densities. Few large fish, however, were captured invoking angler complaints of stunting followed by demands for increased harvest. Complaints of stunting (small fish), however, may be due to other reasons than density-dependant growth reductions, including angler recall bias, increased recruitment of young fish, or size-selective harvest -all of which may result from overharvest, not under-harvest. To resolve this management paradox we use data from walleye fisheries in Alberta and a model of logically nested hypotheses to test whether walleye populations with reportedly small fish were stunted. At lakes with old, but small fish, we tested for size-selective mortality using reconstructed growth histories. We backcalculated size-at-age from pelvic fin rays to compare pre-recruitment walleyes to those that survived several years of fishing. This analysis indicated that the surviving walleyes initially grew quickly but then matured early at a small size supporting the hypothesis of size-selective mortality (favouring early maturity). In all observed cases of reported small fish in Alberta walleye fisheries, we determined that none were entirely caused by density-dependent growth (stunting), but rather all lakes showed evidence of alternate causes, suggesting harvests should decrease, not increase.

C17.2-3
Mark-recapture analysis on walleye (*Sander vitreus*) spawning populations in eastern Lake Erie
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A mark-recapture experiment was continuously carried out at two selected spawning sites (Lackawanna Shoreline and Van Buren Bay) during spawning season in eastern basin of Lake Erie for 18 years. We applied Cormack-Jolly-Seber (CJS) model to estimate survival, abundance and recruitment of spawning stock for each site. Spawning fidelity and migration pattern were also explored using the tagging data. The results showed that majority (about 90%) of marked fish were male walleye spawners and they showed strong fidelity to the spawning sites. The survival rates for eastern basin walleye were higher than those for western basin walleye--the most productive and extensively exploited populations in the lake. On average, total abundance of walleye spawners from both sites was only 0.1% of lakewide spawning stock size. We also discussed the potential contributions of walleye from western populations to harvests in eastern Lake Erie. In the study, we used the adjusted AIC to make model selection and adjusted our estimates to account for tag loss during the early period of the experiment.

C17.2-4
Bioeconomic risk assessment of the Lake Erie walleye commercial fishery
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This study is an empirical analysis of the effect of alternative management strategies on Ontario's commercial Lake Erie walleye (*Sander vitreus*) harvesters and processors in the presence of risk. A dynamic, stochastic bioeconomic model of the fishery is developed to examine the implications of significant fluctuations in the abundance of walleye, and decision makers' different risk preferences for economic returns. The biological model consists of a discrete time and age structured simulation of population dynamics. The biological model has an error term, which reflects variation in recruitment. Ricker parameters are generated using a Bayesian method and a Markov Chain Monte Carlo algorithm. Simulations are used to account for recruitment variability. The output of the biological model, future time series of stochastic catch at age, is used as input into the economic model. We evaluated the effect of alternative management strategies on the harvesting sector and the processing sector separately. A profit function is estimated for each sector using collected cost and revenue data. Risk aversion is incorporated into the model by using expected utility of profit as a performance measure. Management strategies are ranked in terms of probability of zero profits, certainty equivalence of profit and value-at-risk.

C17.2-5
Evaluation of a 14 to 18 inch protected slot for walleye in 12 northern Wisconsin waters
John Kubisiak[1] (presenting), Steve Gilbert[2]. [1]Wisconsin Department of Natural Resources, Rhinelander, WI, United States, [2]Wisconsin Department of Natural Resources, Woodruff, WI, United States

A protected-slot walleye regulation has been in effect on selected northern Wisconsin waters since 1996 or 1997, depending on the lake. On these lakes there is no minimum length limit for walleye but fish from 14 through 18 inches may not be kept. The daily

bag limit is three walleye with only one fish over 18 inches allowed. Twelve lakes or lake chains were surveyed before and at least four years after implementation of the regulation and adult walleye populations were estimated using mark-recapture methods. Angler creel surveys were also conducted both before and after implementation on six lakes or chains. Adult walleye abundance remained stable or increased and abundance of fish within the protected slot increased dramatically in the lakes with strong recruitment. Abundance of 18 inch and larger fish increased in lakes where strong recruitment was combined with average or better growth rates. In contrast, stocked and low-recruitment lakes had variable adult populations and little change in the number of fish 14 inches and larger. In lakes where walleye population metrics improved, creel surveys estimate similar angler catch rates after implementation, but harvest rates and harvest of 18 inch and larger fish increased. These results suggest that a 14-18 inch protected-slot regulation can be effective in improving walleye size structure and harvest rates in lakes with strong recruitment.

C17.2-6
A patch occupancy model to assess importance of habitats for walleye
Dustin Martin[1] (presenting), Kevin Pope[1]. [1]Nebraska Cooperative Fish and Wildlife Research Unit, University of Nebraska-Lincoln, Lincoln, NE, United States

Recruitment of walleye (*Sander vitreus*) varies spatially and temporally, particularly in Midwestern water bodies. This may be especially pronounced in irrigation reservoirs, like those of the Republican River basin of southwest Nebraska, because of extreme intra-annual fluctuations in water level. Within this basin there exists a gradient of intra-annual water-level fluctuation with greater fluctuations in spring-fed reservoirs and lesser fluctuations in rainwater-fed reservoirs. One possible effect of this variability is limited habitat suitable for spawning and the subsequent hatching of eggs. We sampled adult and larval walleye, on multiple independent sampling periods within a short timeframe, using a boat electrofisher and larval light traps to examine the consequences of habitat limitation on walleye recruitment. A patch occupancy model, which utilizes a detection probability to minimize the number of false absences, was developed to obtain a more accurate estimate of the proportion of sampled sites used by both adult and larval walleye. Habitat characteristics at occupied sites were assessed to determine the most critical habitats for successful spawning and recruitment to the larval stage. This methodological approach provided greater understanding of habitat selection by walleye.

C17.2-7
Walleye spawning habitat use: development of statistical models to guide restoration
Brian F Kelder[1] (presenting), John M Farrell[1]. [1]SUNY College of Environmental Science and Forestry, Syracuse, NY, United States

Streams throughout North America have been altered and degraded by a host of anthropogenic factors. The perturbation of stream characteristics such as flow regime, substrate composition and sediment load has been shown to have deleterious effects on habitat quality for many aquatic organisms. Habitat restoration is frequently offered as a solution when degraded habitat appears to be limiting a particular population or ecosystem of interest, however identifying the most critical habitat characteristics to restore can be very difficult. While walleye (*Sander vitreus*) habitat requirements have been well studied there is a need for predictive models that deal with site-specific habitat usage. Tributary streams often contain crucial spawning and nursery habitat for the vulnerable early life stages of walleye. We documented and quantified egg deposition with respect to microhabitat characteristics including depth, substrate, velocity, dissolved oxygen and turbidity in a number of tributaries to Lake Ontario and the St. Lawrence River. Using data from our spring 2006-2007 sampling efforts we will develop statistical models to predict spawning likelihood and density within a tributary based on habitat characteristics. These models will ultimately be used to inform management decisions and focus restoration efforts by identifying bottlenecks to walleye production.

C17.2-8
Distribution of egg strands of European perch (*Perca fluviatilis*, L.) with respect to depth and spawning substrate
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The distribution of egg strands of European perch was studied during late April and early May 2007 in Chabařovice Lake, Czech Republic. Three SCUBA divers spent 50 hours underwater during which they found 896 individual egg strands. Depth distribution of egg strands differed significantly between the two sampling dates, being much deeper in early May compared to late April, which was most likely due to the warming of upper layers of water column. Surprisingly, only four egg strands were found shallower than 2 m. Egg strands were found up to the depth of 16.6 m. Perch regularly used at least 7 different spawning substrates. While alive submergent vegetation (curly pondweed Potamogeton crispus, Eurasian water milfoil Myriophyllum spicatum and common stonewort Chara vulgaris), although more abundant, was generally avoided, dead submergent vegetation (common reed Phragmites communis, worm weed Artemisia sp., trees and branches including black elder Sambucus nigra) was highly preferred. It appears that this large grown dead vegetation is an ideal spawning substrate for perch since placement of the egg strands over those structures practically into the open water column ensures that eggs remain well oxygenated for whole 24 hours a day.

C17.2-9

Predictions of year class strength of yellow perch in central basin Lake Erie based on projected spawning dates and winter severity indices

Carey Knight[1] (presenting), Ann Marie Gorman[1]. [1]Ohio Division of Wildife - Fairport Fish Station, Fairport Harbor, Ohio, United States

The goal of this project was to characterize the distribution, movement, and spawning of yellow perch and predict cohort strength. Weekly sampling with bottom trawls (March 31 – June 26, 2007) throughout yellow perch spawning allowed us to resolve when and where female yellow perch spawn in the central basin of Lake Erie. Almost all yellow perch spawned from 5.4-9.1o Celsius (C) and 96% of females were spent by 9.1o C. Thus, based on water temperature, the peak spawn occurred on April 30 while the majority of the spawn ranged from April 18 to May 7. We ranked young-of-the-year (YOY) yellow perch trawl indices (1990 to 2007) from August and October as poor (lower 33%), fair (middle 33%), or good (upper 33%) year classes (YC). Poor YC were associated with an early spawn (5o C on March 23) and increased spawn duration (28 days to get from 5-9o C) while good YC were associated with a later spawn (March 29) and shorter spawn duration (22 days). We had highly significant p-values ($p < 0.0006$) and high r-squares ($R2 > 0.71$) from start date of the spawn/ winter severity indices (heating degree days) model.

C17.2-10

Variation in early growth, condition and size of age-0 yellow perch in Lake Erie

Alex Johnson[1] (presenting), Paris Collingsworth[1], Elizabeth Marschall[1]. [1]The Ohio State University, Columbus, Ohio, United States

Understanding factors that lead to variation in growth and size of early life history stages is a key to understanding the complex processes of recruitment. In the present study, we measured variation in the early growth, condition, and total length of age-0 yellow perch sampled during summer 2005-2007 in the Ohio waters of Lake Erie. Early growth, estimated from otolith microstructure analyses, was greater in the central basin than the western basin and differed across years. However, the early growth advantages of central basin fish did not result in greater size or condition of age-0 yellow perch by the end of the summer. In general, age-0 yellow perch were larger and in better condition, as estimated by residual mass, in the western basin than in the central basin. We then regressed August catch-per-unit-effort (CPUE) of age-0 yellow perch, a proxy for year class strength, against our measures of early growth, condition, and total length to determine how these measurements correlate with recruitment in Lake Erie. Although none of the regressions was significant, there was a positive correlation between the August condition of age-0 fish and CPUE. Our results suggest that environmental differences between the western and central basins of Lake Erie may lead to different growth rates of larval yellow perch, but these differences are not indicative of the size or condition of fish by August and that the condition of fish at the end of their first summer may be a good indicator of recruitment.

C17.2-11

Impact of forest harvesting on growth of yellow perch larvae: an example of a bottom-up effect

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Forest harvesting in drainage basins of boreal lakes is known to increase turbidity and nutrients concentration. These changes are susceptible to influence the food web in lake ecosystems, from primary producers to fishes. Our objectives were to determine the impact of forest harvesting on growth of yellow perch (*Perca flavescens*) larvae, an important forage fish in Canadian Boreal Shield lakes, and to link larval perch growth to limnological variables. To achieve these objectives, we sampled water quality, limnoplankton and young-of-the-year yellow perch before forest harvesting in 2003 and after the perturbation in 2004 and 2005 in three control lakes and three cut lakes. Otolith microstructure analysis indicated that yellow perch larvae caught in cut lakes two years after forest harvesting grew significantly faster between 15 to 40 days of age than fish captured in control lakes. Higher growth in cut lakes was linked to higher pelagic limnoplankton biomass, suggesting that yellow perch growth was controlled by a bottom-up effect due to the perturbation. Results of the present study improve our knowledge on early life history of fishes in small freshwater systems under the influence of forest harvesting, an important anthropogenic perturbation of drainage basin of lakes in Canada.

S3-19

Response of yellow perch to hypoxia in Lake Erie's central basin: spatial patterns

James J Roberts[1] (presenting), Tomas O Höök[1], Stuart A Ludsin[2], Steven A Pothoven[3], Henry A Vanderploeg[3].
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Large areas of hypolimnetic hypoxia (< 2 mg O2L-1) recur seasonally in Lake Erie's central basin. However, the ecological consequences of such hypoxic areas remain largely unknown. Yellow perch (*Perca flavescens*), a demersal species, may be negatively impacted by seasonal hypoxia as such phenomena may limit access to benthic prey or preferred temperatures. To assess the ecological consequences of hypoxia for yellow perch in central Lake Erie, we collected a suite of biological (i.e. fish with bottom and mid-water trawls; benthic macroinvertebrates using Ponar grabs; and zooplankton using pumping and net tows) and physical (via vertical CTD casts) data during August and September 2007. We assessed yellow perch vertical migration, feeding behavior, and short-term growth (RNA:DNA) in response to hypoxia in Lake Erie. Spatial comparisons were made by sampling inside and outside of hypoxic conditions. Results of 2007 spatial surveys will be compared to results from similar surveys during 2005, which focused on temporal differences in yellow perch ecology in response to hypolimnetic hypoxia. Collectively, results from 2005 and 2007 should elucidate behavioral and ecological responses of yellow perch in both space and time.

C17-P-1

Hydroacoustic monitoring of the bathypelagic layer of European perch (*Perca fluviatilis* L.) fry in reservoirs: from raw ecological characteristics to particular features of fish behaviour

Martin Cech[1] (presenting), Jan Kubecka[1], Vladislav Drastik[1], Jaroslava Frouzova[1], Michal Kratochvil[1], Josef Matena[1], Jiri Jarosik[1], Josef Hejzlar[1]. [1]Biology Centre, Academy of Sciences of the Czech Republic, Institute of Hydrobiology, Ceske Budejovice, Czech Republic

In the pelagic zone of reservoirs and most probably lakes, European perch fry create simultaneously two different communities – epipelagic and bathypelagic. The epipelagic perch fry (EPF) spent the whole 24 hours in epilimnion whereas the bathypelagic perch fry (BPF) performed diel vertical migrations, being in the epilimnion during the night and migrating into the deep cold hypolimnetic layers during the day. At this time the BPF community was present as a several meters thick scattering layer, which could be followed by the echosounder. The EPF remain pelagic until fin development, the timing of which varies with temperature from June to July, and then move inshore to the littoral area. The BPF remain in the open water up to autumn. Using scientific echosounder and complementary net catches the BPF layer was recently recorded along most of the longitudinal profile of many canyon-shaped reservoirs. The size, abundance and shoaling activity of BPF increased significantly in direction from the dam towards the tributary following the reservoir's trophic gradient. The presence of the BPF layer in the riverine part of those reservoirs is restricted by local floods or cold hypolimnetic water released from the reservoir situated upstream in the cascade.

C17-P-2

Diet overlap between native yellow perch and invasive white perch in Lake Champlain, Vermont, U.S.A.

Jeffrey White[1] (presenting), Douglas Facey[1]. [1]Saint Michael's College, Colchester, Vermont, United States

White perch invaded Lake Champlain in the 1980s and are now abundant. Elsewhere, they have been reported to overlap in diet with yellow perch. We measured diet overlap between adult white and yellow perch in three areas of the Lake Champlain ecosystem. Stomach contents were identified and enumerated, and diet overlap was evaluated using the Schoener Index. Overlap was not significant in five of seven samples from Missisquoi Bay, where white perch ate up to 92% zooplankton while yellow perch fed mainly on benthic invertebrates. Overlap was significant when both species consumed juvenile fishes and chironomids. In the Missisquoi and Winooski Rivers, where yellow perch were in shallow vegetated areas and white perch were deeper in the channel, overlap was significant in one of four samples each, due to comparable consumption of chironomids, juvenile fishes, and unidentified fish eggs. We conclude that there is little diet overlap between adult white perch and adult yellow perch in Lake Champlain, and that significant diet overlap likely occurs with occasionally similar shifts in opportunistic feeding. Future studies might investigate diet overlap between white perch, which fed heavily on zooplankton at times, and juvenile yellow perch, or other species, in Lake Champlain.

C17-P-3

Evaluation of shifts in yellow perch sub-population dynamics in response to habitat changes associated with the introduction of zebra mussels

William Fetzer[1] (presenting), Katie White[1], John Forney[1], Randy Jackson[1], Lars Rudstam[1], Tom Brooking[1], Tony VanDeValk[1]. [1]Cornell Biological Field Station, Bridgeport, NY, United States

Changes in the abundance and quality of habitat types can alter population dynamics of species with habitat-specific demographic rates. Zebra mussel (*Dreissena polymorpha*) introductions are a non-native species that has altered the ecology and habitat heterogeneity of aquatic ecosystems. Despite the many effects of zebra mussels to lower trophic levels, impacts to fish have been difficult to assess and often inconsistent. Irwin et al. (2007) assessed the effect of mussel introduction and other perturbations on age-0 yellow perch (*Perca flavescens*) dynamics in Oneida Lake, NY, observing reduced abundance across all early life stages, increased mortality from the pelagic to demersal stage, and decreased mortality throughout the demersal stage. Despite decreased age-0 abundance, age-1 abundance remained stable. Quality and quantity of littoral habitats increased, and we suggest that the observed changes in age-0 dynamics are not the result of mortality and increased migration to littoral habitats. Increased recruitment from littoral habitats may also explain the relatively stable age-1 abundance. Observed time trends in site-specific age-0 catch patterns support this hypothesis, however assessing habitat segregation and contribution to age-1 recruitment remains difficult. Here we use δ13C and δ15N isotope ratios from age-0 and age-1 yellow perch and their major diet items, to evaluate age-0 segregation/movement patterns and habitat-specific contributions to age-1 recruitment.

C17-P-4
Do freshwater habitats enhance growth of juvenile white perch (*Morone americana*)?
Joshua Newhard[1] (presenting). [1]University of Maryland, Princess Anne, MD, United States

White perch is a commercially and recreationally important fish found within the Blackwater River drainage (Maryland, U.S.A.). The objectives of my study were to determine if size and growth of juvenile white perch differed between freshwater (<1.5 ppt) and brackish habitats (1.5–13.0 ppt). For 10 monthly sampling events (March-December 2007), two freshwater and three brackish habitats were sampled for 379 juvenile fish. Two distinct size classes were collected: 2006 young-of-year (YOY) (March–June) (101-120mm, N=158) and 2007 YOY (July–December) (49-100mm, N=221). The slope of the length-weight relationship and the proportion of variance in mass explained by total length (TL) was greater for 2007 YOY (Log10 mass=2.67(Log10 TL)-4.35, r2=0.85) than 2006 YOY (Log10 mass=1.32(Log10TL)-1.46, r2=0.06). Body condition was higher in freshwater than brackish habitats for both size classes. Growth rate did not differ between freshwater and brackish habitats for either size class. The 2007 YOY collected in freshwater habitats were larger (in TL), and showed higher body condition than those from brackish habitats. Spatial heterogeneity may be necessary for nursery habitats, which can promote growth. My future work will determine how growth differs across other environmental gradients, such as salinity, dissolved oxygen, and productivity.

C17-P-5
Inter-reservoir variation in walleye isotope signatures: implications for food web analysis
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Stable isotope analysis (SIA) is an alternative approach to traditional assessments of fish diets that can be used to quantify average, long-term feeding patterns of fishes. We used SIA to monitor food web linkages between four Missouri River impoundments in South Dakota from 2001 to 2007. Over the last six years, walleyes *Sander vitreus* in Lake Oahe had more negative carbon signatures, suggesting a reliance on pelagic food webs, while walleye signatures in the lower impoundments had less negative carbon signatures, suggesting more riverine conditions and a reliance on littoral food webs. We also found common trends in nitrogen signatures between impoundments, with a positive correlation between body size and nitrogen signatures. We found SIA to be a quick, inexpensive approach when evaluating long term trends in food web structure.

C17-P-6
Timing of walleye spawning runs as an indicator of climate change
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Determining the best indicators of climate change is one of the basic challenges of predicting its effects. We are studying walleye (*Sander vitreus*) spawning records and ice out records (1960s-present) collected by the Minnesota Department of Natural Resources from lakes and rivers in Minnesota to determine if spawning is related to climate signals. Records from Lake Sallie, Big Lake Creek, Pine River, and Bucks Mill have been analyzed. The beginning of walleye spawning at these sites was measured by the date of first egg-take, which was highly correlated with the first sighting date of ripe walleye females. The timing of the beginning of spawning was also highly correlated across all locations. Four lakes at about the same latitude showed significant positive correlations between the beginning of walleye spawning dates and ice out dates (r between 0.66 to 0.82), and slopes and intercepts were similar. Further analyses should help to answer if other walleye spawning runs respond similarly or if the relationships differ across latitudes.

C18. Salmonids in Streams
C18.1-1
Development of an integrated salmonid population and habitat study model on Sakhalin Island, Russia, for the detection of population status and trends
Vladimir Samarskiy[1] (presenting), Alexander Kaev[2], Anatoly Semenchenko[3], Nicole Portley[5], Gordon Reeves[4]. [1]Russian Federation Federal Fisheries Agency, Sakhalin Branch, Yuzhno-Sakhalinsk, Sakhalin Oblast, Russia, Russian Federation, [2]Sakhalin Fisheries and Oceanography Institute, Yuzhno-Sakhalinsk, Sakhalin Oblast, Russian Federation, [3]Sakhalin Salmon Initiative Center, Yuzhno-Sakhalinsk, Sakhalin Oblast, Russia, Russian Federation, [4]USDA Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, United States, [5]Wild Salmon Center, Portland, Oregon, United States

Sharp declines in salmonid populations have occurred in several geographic areas over the past 150 years. These declines have serious environmental, economic and social ramifications. Efforts to restore these populations to their prior abundance levels have demonstrated that prevention of such declines through focused habitat and fish population conservation and monitoring programs is more successful and cost-effective than population restoration. This project aims to improve the ability to measure salmonid population and habitat condition and detect trends on Sakhalin Island through the creation of a comprehensive, long-term fish and habitat monitoring program. The program will employ a rotating panel study design, focusing on individual ecoregions of the island year by year. We will thereby encompass the entire island of Sakhalin with our program, allowing for enhanced ability to measure regional habitat and population condition and trends. Digital Elevation Models of monitored basins will be analyzed in the remote sensing software program NetMap. Using basin physical parameters derived from satellite imagery, key sites for within-basin monitoring can be identified, including quality habitat locations for the various salmonid species and places where erosion could affect salmonid survival. A suite of physical habitat and salmonid population parameters, gathered from methodologies employed by the Russian Federal Fisheries Agency, the Sakhalin Fisheries and Oceanography Institute and the USDA Forest Service, will be measured within the study basins. The fish population studies included in this program build on existing monitoring plans for pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) on Sakhalin. The program will also include a suite of other salmonid species commonly found on the island: coho (*O. kisutch*), cherry salmon (*O. masu*), Sakhalin taimen (*Hucho taimen*), arctic char (*Salvelinus leucomaenis*), arctic grayling (*Thymallus arcticus*) and Dolly Varden (*Salvelinus malma*). The results generated will provide a more comprehensive understanding of the status and trends of salmonids and their freshwater habitat on Sakhalin Island. This project also has the potential to aid similar efforts throughout the range of Pacific salmon.

C18.1-3

Pacific salmon in hot water: using aerobic scope and physiological characteristics to predict the success of spawning migrations during climate warming

Scott Hinch[1] (presenting), Tony Farrell[1], Steve Cooke[2], Dave Patterson[3], Glenn Crossin[1], Todd Mathes[1], Stefan Larsson[4], Lapointe Mike[5]. [1]University of British Columbia, Vancouver, British Columbia, Canada, [2]Carleton University, Ottawa, Ontario, Canada, [3]Fisheries and Oceans Canada, Burnaby, British Columbia, Canada, [4]Umea University, Umea, Sweden, [5]Pacific Salmon Commission, Vancouver, British Columbia, Canada

River warming in recent years has been associated with large levels of adult Pacific salmon mortality for some populations in the Fraser River. The specific causes of mortality and its predictability are not well established though disease, energy depletion, stress, and metabolic limitations have been implicated. We found a direct association between the temperature optimum for aerobic metabolic scope and the temperatures historically experienced by three Fraser River salmon populations, thus thermal optimum for aerobic scope may be adaptive for river migration at the population level. This association predicts that a period of anomalously high river temperatures in 2004 led to a complete collapse of aerobic scope for a portion of one of the salmon populations. This prediction was corroborated with empirical data from biotelemetry studies that year which tracked migration of individuals in the Fraser River and revealed that success of migration for that population was temperature-dependent. We argue that collapse of aerobic scope is an important mechanism to explain high salmon migration mortality during high temperature years. Management models which incorporate aerobic scope and other physiological characteristics are needed to help improve predictions of population fitness under future climate scenarios.

C18.1-4

Effects of summer flow variability on juvenile salmonid survival in coastal California streams

Ted Grantham[1] (presenting), Adina Merenlender[1], David Newburn[2]. [1]U.C. Berkeley, Berkeley, CA, United States, [2]Texas A&M, College Station, TX, United States

Upland tributary streams to the Russian River provide important spawning and rearing habitat for central California coast steelhead trout (*Oncorhynchus mykiss*). During the summer months, flows in these small streams decrease substantially, limiting suitable habitat available for juvenile steelhead. Tributary flows may be further reduced by agricultural and residential developments that meet their water needs by pumping directly from streams or from shallow wells adjacent to stream channels. To evaluate if summer flows are an important limiting factor to juvenile steelhead survival, we analyzed a 9-year record (1994-2002) of fish surveys conducted at multiple tributary streams sites in the Russian River watershed in Sonoma County, California. Bayesian logistic regression models indicate that over-summer survival declines with decreasing summer stream flows, controlling for the effects other significant habitat variables. Substantial inter-annual variation in abundance and survival highlights the need for long-term population data. In recognition of the growing regional demand on water resources, these findings suggest that protections of tributary flows during the dry season are critical to salmonid recovery efforts in the Russian River watershed.

C18.1-5

Spatial analysis of beach susceptibility for stranding juvenile salmonids by ship wakes in the lower Columbia River

Walter Pearson[2], William Fleece[1] (presenting), Kevin Gabel[3], Sarah Jenniges[3], John Skalski[4]. [1]Stantec Consulting Services, Cincinnati, OH, United States, [2]Peapod Research, Port Angeles, WA, United States, [3]ENTRIX, Inc. Vancouver, WA, United States, [4]University of Washington, Seattle, WA, United States

Nearly 1,200 deep draft vessels traverse a 100-mile long section of river of the Lower Columbia River annually. Recent studies have shown that wakes from a proportion of these passages strand juvenile salmonids, many of which are federally protected under the Endangered Species Act. Pearson et al. (2006) studied three low slope beaches between the summer of 2004 and the spring of

2005 and observed 46 stranding events from 126 vessel passages, accounting for 520 stranded fish of which 442 were juvenile salmon. Prior investigations of wake-related stranding suggest that not all beaches pose a stranding threat. Stranding is a function of the complex interaction of a number of factors including vessel characteristics, tidal height, fish density in shallow nearshore areas, and channel morphology. The objective of this study was to estimate the frequency of occurrence of beaches in several categories that represent degrees of susceptibility to stranding of federally-listed salmon stocks by the wakes of deep-draft ships. This analysis was spatially explicit and was based on physical factors that influence wave generation and energy including 1) the degree of channel confinement, 2) the decay of wave height with distance from the sailing line, 3) the presence of steep berms on the stream bed between the navigation channel and low-gradient beaches of interest, 4) the presence of shielding features (e.g. islands), 5) beach slope, and 6) the presence of reflecting or refracting surfaces (e.g. rip rap) that may redirect or amplify nearshore wave energy. Data sources for this analysis included the U.S. Army Corps of Engineers channel bathymetry, NOAA Fisheries hydrographic surveys, geo-referenced videography, and orthorectified aerial imagery. The results of this analysis suggest that susceptibility to stranding is limited to about 33 miles (53 kilometres) of both shorelines (208 miles total length) and the highest susceptibility to about eight miles of shoreline (13 kilometres).

C18.1-6

Modelling stranding of juvenile salmonids by wakes from increased deep-draft vessel traffic in the lower Columbia River

Walter Pearson[1] (presenting), John Skalski[2], Kathryn Sobocinski[3], William Fleece[4]. [1]Peapod Research, Port Angeles, WA, United States, [2]University of Washington, Seattle, WA, United States, [3]Pacific Northwest National Laboratory, Sequim, WA, United States, [4]Stantec Consulting Services, Cincinnati, OH, United States

The effects of deep-draft vessel traffic in confined riverine channels on shorelines and fish are of widespread concern. In the Pacific Northwest of the United States, wakes and subsequent beach run-up from ships transiting the Lower Columbia River have been observed to strand juvenile salmon and other fish. As part of a before-and-after study to assess stranding effects that may be associated with channel deepening, we measured 19 co-variables from observations of 126 vessel passages at three low-slope beaches and used multiple logistic regression to discern the significant factors influencing the frequency of stranding. Subyearling Chinook salmon were 82% of the fish stranded over all sites and seasons. Given a low-slope beach, stranding frequencies for juvenile salmon were significantly related to river location, salmon density in the shallows, a proxy for ship kinetic energy, tidal height, and two interactions. The data collected in the before-phase study enabled us to develop a series of statistical models and a conceptual framework relating seven factors to wake characteristics and stranding occurrence. These statistical relationships were then used in a deterministic model to examine the implications of adding 300 additional auto carriers to the 1,200 vessels that already traverse the river on an annual basis. Under the base scenario, loss of all salmon species at the three known stranding sites ranged from an estimated 0 fish in the fall, to 4,148 fish in the summer and to 22,915 fish in the winter. Winter and spring losses were estimated to be about 54% and 36%, respectively, of the total annual losses. Chinook constitute 95% of the juvenile salmon expected to be stranded. The projected addition of 300 car carriers annually increases the estimated overall loss of juvenile salmon to stranding at the three locations from 42,605 fish to 52,185 fish. With the additional car carriers, the patterns of loss by species, season, and location remain similar to those in the base scenario. Slightly more than a doubling of car carrier traffic in the alternative case is estimated to produce about a 22% increase in the overall loss to stranding at the three locations. Because under the before-phase study design required selection of sites known to be stranding sites, these results can not be extrapolated to the whole river without additional studies.

C18.1-7

Timing, abundance, and population characteristics of hatchery and natural origin Chinook salmon on the spawning grounds in the Cedar-Sammamish Watershed, Washington

Hans Berge[1] (presenting), Steve Foley[2], Mistie Hammer[1]. [1]King County Dept. of Natural Resources and Parks, Seattle, WA, United States, [2]Washington Dept. of Fish and Wildlife, Region 4, Mill Creek, WA, United States

In the Pacific Northwest, Pacific salmon are an important economic, biological, and cultural resource that embodies the values of the region. Habitat degradation and fragmentation coupled with harvest and hatchery practices has led to an acute decline in the abundance of Pacific salmon, particularly in the Puget Sound ESU. In the Cedar-Sammamish Watershed there are three naturally spawning groups of fall Chinook salmon in the Cedar River, Bear Creek, and Issaquah Creek Basins. Beginning in 1998, we began to study the spawn timing, variability in abundance, and biological characteristics within these three basins in an attempt to understand productivity, identify protection and restoration efforts, and contribution rates of hatchery origin adults to the escapement estimates on the natural spawning grounds within the watershed. Chinook begin to enter the watershed in June, peak in August, and continue until early October. Spawning begins in September, peaks in October, and concludes in December. In most years, the majority of Chinook on the spawning grounds are age-3, although fish of age-2 through age-6 are common, and both 1 year and 2 years of freshwater residences have been observed. The variability in age at return is important in determining strength and productivity of brood years. Pre-spawn mortality was observed in all three basins, but it was more common in hatchery origin females ($p<.003$). The proportion of hatchery adults on the spawning ground in Issaquah Creek is very high (>85%) due to the occurrence of a hatchery in that system. However, marked fish contribute a highly significant (~60%) proportion of fish on the spawning grounds in Bear Creek, and the Cedar River (~30%), neither of which has a hatchery located within the respective basins.

In addition, through the sampling of coded-wire-tagged fish, we have found Chinook from hatcheries as far away as the Cowlitz River on the natural spawning grounds in the watershed.

C18.2-1
Movement and fate of non-migratory subyearling Chinook salmon detected on autonomous acoustic receivers in a hydropower reservoir
Geoff McMichael[1], Jessica Vucelick[1], Eric Hockersmith[2], Ben Sandford[2], John Skalski[3], Rebecca Buchanan[3], Ian Welch[1] (presenting), Ann Setter[4]. [1]Battelle, Richland, Washington, United States, [2]NOAA Fisheries, Seattle, Washington, United States, [3]University of Washington, Seattle, Washington, United States, [4]U.S. Army Corps of Engineers, Walla Walla, Washington, United States

Autonomous acoustic telemetry receivers were used to investigate the joint probability of subyearling Chinook salmon migrating and surviving through Lower Monumental Reservoir on the Snake River, WA. In 2006 and 2007, interactions between subyearling Chinook salmon migratory behavior, biological factors, and hydraulic conditions were investigated. Fish were collected and tagged at the dam upstream of the study reservoir (n= 1,949 in 2006 and n=1,780 in 2007). Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitters (0.63 g in air, 0.35 g in water, 60 day operating life) and PIT tags were surgically implanted in each fish prior to release in the upper end of the reservoir. Estimated joint probability of survival and migration of fish passing through the reservoir was high (0.84 to 0.96) between June 16 and July 1, 2006, and decreased between July 4 and 11 (0.46 to 0.78), and was very low for fish released between July 14 and 18 (0.09 to 0.19). Thermal stratification and underflow hydraulic conditions developed at the mid-point of the reservoir in early July and persisted through September. The majority (76%) of the fish that ceased downstream migration did so in the stratified portion (downstream half) of the reservoir. To increase understanding of the fate of the fish that ceased migration in the reservoir, we released fish later in the season in the 2007 study and used a novel integrated approach of a dense array of autonomous receivers and innovative statistical analyses.

C18.2-2
A cross-continental, bioenergetic comparison of factors limiting the endemic and exotic distribution of brown trout under current and future environmental conditions
Phaedra Budy[1] (presenting), Javier Lobon-Cervia[2], Gustavo Ganzalez[3], Leif Asbjorn Vollestad[4], Eloy Becares[5].
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Brown trout (*Salmo trutta*), native to Eurasia and widely introduced, represent both a popular sport fish and threat to the native fishes world-wide. Our goal was to determine the factors limiting the distribution of brown trout within a their native and current exotic habitat, and to predict changes in this distribution under scenarios of climate and habitat alteration. We compared energetic potential of brown trout both within and among exotic and endemic populations as part of a cross-continental, meta-analysis, using bioenergetic P-values and their distributional characteristics as response variables. Populations within Spain demonstrated relatively high but variable energetic potential, a pattern explained by the length of the growing season and density. In contrast, Norway and Denmark, native brown trout energetic potential and fish density were low, and temperature and flow regime appeared influential. In comparison, exotic populations of brown trout in the USA demonstrated intermediate energetic potential, suggesting brown trout are well adapted to a wide range of environmental conditions; however, their upper elevational distribution may be limited by winter temperature and the timing and magnitude of flow. Anthropogenic changes to stream temperature and flow regime are predicted to expand their exotic range, (presenting) an intensified threat to native fishes.

C18.2-3
Bioenergetic evaluation of food supply and consumption demand by brown and rainbow trout in catch-and-release areas of Arkansas tailwaters
Jon Flinders[1] (presenting), Dan Magoulick[1]. [1]University of Arkansas, Fayetteville, AR, United States

Catch-and-release regulations are commonly used in sport fisheries in an attempt to provide increased residence times and survival rates and provide more and/or larger fish. Most catch-and-release studies address factors that affect immediate mortality rates in fish, but rarely evaluate fish growth rates and food resources. We used a bioenergetics modeling approach to examine whether food resources limited brown and rainbow trout production in three catch-and-release areas in Bull Shoals and Norfork tailwaters. We incorporated field data on brown and rainbow trout thermal experience, growth, diet analysis, and abundance from catch-and-release areas into species-specific bioenergetics models to quantify seasonal consumption of benthic fish and drifting invertebrates and compared prey consumption rates to prey availability. Results from the bioenergetics simulations will be discussed. Ultimately, this information will assist managers in determining the effectiveness of the catch-and-release areas.

C18.2-4
Evaluating the variability of spawning patterns expressed by finespotted cutthroat trout in the Snake River below Jackson Lake Dam, WY

Kris Homel[1] (presenting), Robert E. Gresswell[2]. [1]Montana State University, Bozeman, MT, United States, [2]USGS- Northern Rocky Mountain Science Center, Bozeman, MT, United States

Undisturbed river networks are characterized by numerous channel processes and structures that function as behavioral cues or habitat for organisms. In response to this temporal and spatial variability in the environment, organisms evolve adaptations that allow them to persist. When river systems are altered (e.g. dammed), novel environmental conditions may restrict the expression of behavioral adaptations (e.g. life-history types). Finespotted cutthroat trout *Oncorhynchus clarkii* sp. have persisted in the Snake River through a century of flow regulation. However, it is unknown to what degree flow regulation has reduced the range of cutthroat trout life-history expression. As a first step in exploring this question, we evaluated the effects of flow regulation on spawning patterns. We hypothesized that flow regulation has decreased available spawning habitat, and that spawning would predominantly occur in unregulated stream areas (e.g. tributaries), because these areas provide cues and conditions for spawning to which cutthroat trout are adapted. We evaluated time and location spawning in both unregulated and regulated streams in the 50 km of the Snake River below Jackson Lake Dam using a combination of tagging, remote detection (fixed antennae), and spawning ground surveys (using mobile PIT tag trackers to detect tagged fish, and redd counts to detect untagged fish). Ultimately, through describing the range of spawning patterns expressed in a regulated river network, we hope to develop new insights into the potential for restoring elements of ecosystem function that have been constrained by flow regulation.

C18.2-5
Spawning ecology and early life history of Bonneville cutthroat trout in northern Utah
Sara Seidel[1] (presenting), Phaedra Budy[1], Stephen Bennett[2], Brett Roper[3]. [1]Utah Cooperative Fish and Wildlife Research Unit, Logan,UT, United States, [2]Utah State University, Logan,UT, United States, [3]US Forest Service, Logan,UT, United States

The Logan River, Utah, is home to one of the largest metapopulations of Bonneville cutthroat trout (BCT). As the reproductive stage is important to overall persistence, there is a need to better understand the spawning ecology of BCT. Spawn Creek, a Logan River tributary, is an important spawning area for BCT. Spawning surveys (2007) documented 113 redds, and peak spawning occurring on the descending limb of the hydrograph, between May 5 - 25. In addition, based on pilot surveys conducted throughout the Logan River; the spatial distribution of BCT spawning is far more widespread than originally thought. Spawning encompassed over 25 km (including the mainstem), for a total of 870 redds. In two sites, we counted a high density of redds at 98 and 130 redds per km, respectively, whereas in two others of apparent similar suitability, we counted only 24 and 54 redds per km, respectively. Using this data, we will select index sites for intensive future studies of spawning ecology and egg survival across sites re(presenting) variation in both physical habitat and redd density. Future conservation efforts for BCT must address potential limiting factors operating at the sensitive and influential reproductive and early-life stages.

C18.2-6
Effects of a long-term elevation of perceived predation risk on individual behaviour and population density in wild juvenile Atlantic salmon
Jae-woo Kim[1] (presenting), James Grant[1], Grant Brown[1]. [1]Biology Department, Concordia University, Montreal, Quebec, Canada

Local predation risk has striking effects on the short term behaviour of prey, including juvenile salmonids, in both laboratory and field conditions. However, the long term consequences of increased predation risk have rarely been examined. To examine the potential effects of prolonged exposure to an elevated perceived predation risk on the[1] long-term individual behaviour and the[2] population density of juvenile Atlantic salmon, we established three contiguous sections differing in predation risk in each of seven reaches of relatively uniform habitat in Catamaran Brook, New Brunswick, Canada. Each reach consisted of a low predation site (stream water control) and a high predation site (conspecific alarm cue) separated by an undisturbed buffer zone. We manipulated the perceived predation risk over a two week period, when young salmon emerge from gravel nests and begin defending territories. As predicted, individuals in high predation risk sites had smaller territories compared to low predation risk sites. Furthermore, juvenile density in high predation risk sites decreased, whereas the density in control sites increased. Our results indicated that juvenile salmon either detect and avoid habitats with a high risk of predation or modify their behaviour when using such sites.

C18.2-7
Impact of environmental variation on Atlantic Salmon freshwater growth rates
R. Scott Davidson[1] (presenting), Ben Letcher[1], Keith H. Nislow[2]. [1]USGS, Ma, United States,US [2]Department of Agriculture, Forest Service, Ma, United States

Environmental variation within and among years as well as individual variation in growth can affect size distributions of Atlantic salmon (*Salmo salar*). It is important to understand mechanisms governing the development of size distributions because many processes during freshwater residence are size-dependent. Analysis of a long term data set from the West Brook, MA, USA using generalised linear models allowed us to estimate the effect of environmental variation (stream flow and water temperature) on Atlantic salmon growth rates. Growth rates corresponding to each season were calculated for fish that were recaptured during consecutive electrofishing sampling occasions. Growth in both length and weight were highly seasonal with fastest growth occurring during spring. Variation in discharge and temperature were important (partial R2 0.5), variation from year to year (partial R2 0.05). Fish that had better body condition at the start of a season also had higher growth rates during that season although body condition at the end of a season was not correlated with body condition at the start. Variation in temperature and discharge are important variables affecting Atlantic growth rates.

C18.2-8

Long-term seawater performance of Atlantic salmon smolts

Gayle Zydlewski[1] (presenting), Joseph Zydlewski[2]. [1]University of Maine, Orono, ME, United States, [2]USGS - Maine Coop Unit, Orono, ME, United States

Penobscot strain Atlantic salmon were held in saltwater for up to four months to examine the relationship between growth and survival. In May 2006, 940 salmon smolts from Green Lake National Fish Hatchery were analyzed for their freshwater gill Na+,K+-ATPase activity levels. Individuals were classified as having "low", "medium", or "high" levels based on the normal distribution of activities observed on the day of gill collection (May 10 2006). All individuals were transferred isothermally to full strength seawater and maintained on photoperiod and temperature regimes similar to what they would normally experience during their migration from the Penobscot River to the Labrador Sea. Fish scales were taken and size (fork length and weight) was recorded on days 1, 3, 14, 44 and monthly for four months. Fish grew throughout the experiment, but differences (fish size, growth rate, and gill Na+,K+-ATPase activity in saltwater) among freshwater ATPase groups were not evident. Based on this laboratory experiment, it is unlikely that small scale variation in gill Na+,K+-ATPase activity is predictive of long-term performance (measured as survival and growth) in seawater.

C18.2-9

Density-dependent growth in juvenile Atlantic salmon: mechanisms of competition

Istvan Imre[1], James W.A. Grant[2], Richard A. Cunjak[3]. [1]Algoma University College, Sault Ste. Marie, Ontario, Canada, [2]Concordia University, Montreal, Quebec, Canada, [3]University of New Brunswick, Fredericton, New Brunswick, Canada

Density-dependent growth commonly occurs in stream-dwelling salmonids and it is strongest at population densities <1 fish/m2, resulting in concave density-average body size curves. The occurrence of density-dependent growth at densities <1 fish/m2 is surprising, because space limitation is thought to occur at higher densities. Our findings suggested that individuals are competing for food and decrease each other's foraging rate in an exploitative manner (shadow competition). A recent study, based on a spatial competition model, suggested that competition for space can also yield similar density-growth curves. This model assumes that juvenile salmonids occupy dominance hierarchies and their growth is related to the quality of their foraging territory. These assumptions suggest that in a purely space competition scenario, the growth rate of the largest fish occupying the best foraging territories would not be influenced by population density. Our study examined how the body size of individual juvenile Atlantic salmon interacts with population density to modify growth patterns at low densities. Consistent with shadow competition, the body size of the largest fish at each site declined with increasing population density. As expected, the growth rate of the largest individuals was less influenced by population density than the growth rate of the smallest individuals.

C18.2-10

Habitat-dependent growth and survival of brook trout and Atlantic salmon in a small stream - everybody in the pool?

Ben Letcher[1] (presenting), Keith Nislow[2], Jason Coombs[3], Matthew O'Donnell[1], Todd Durbeuil[1]. [1]Conte Anadromous Fish Research Center, Turners Falls, MA, United States, [2]US Forest Service, Amherst, MA, United States, [3]The University of Massachusetts, Amherst, MA, United States

We estimated relative growth rates and survival of brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*) living in pools vs. riffles. We estimated survival using capture-mark-recapture analysis of > 4000 fish over 18 sampling occasions. Growth rates were estimated for individual fish recaptured on successive sampling occasions. Overall, pools had a positive and important effect on brook trout survival, but little effect on salmon survival or on growth of either species. Average yearly survival was 8% higher for trout in pools compared to riffles. A large portion of the survival differences between pools and riffles occurred in the fall where survival was size-independent for trout in riffles, but in pools, large fish (> 135 mm) had 67% higher survival than small fish (60-95 mm FL). Thus, variation in microhabitat structure (pool vs. riffle) appears to have little effect on Atlantic salmon and will impact brook trout population dynamics by influencing survival, but not body growth.

C18.2-11

Competition between Atlantic salmon and smallmouth bass; experiments in an artificial stream

Gus Wathen[1] (presenting), Stephen Coghlan[1], Joseph Zydlewski[2]. [1]University of Maine, Orone, ME, United States, [2]Maine Cooperative Fish and Wildlife Research Unit, Orone, ME, United States

Competition and predation from smallmouth bass is hypothesized to threaten the persistence of wild Atlantic salmon, yet there is no empirical evidence on the existence of competition. We have constructed and annular artificial stream tank (7m diameter) consisting of conditions structured to mimic natural pool and riffle habitats. An array of PIT tag antennae are imbedded in the substrate and have been used to detect fish location. We conducted initial density experiments to quantify the number of fish needed for habitat saturation, and used that data for the design of our displacement experiment. Over the summer of 2008, we will observe Atlantic salmon parr and juvenile smallmouth bass in sympatry and evaluate if active displacement from habitats occurs between the two species.

C18.2-12
Planting Atlantic salmon eggs with a new hydraulic planter
Paul Christman[1] (presenting), Daniel McCaw[1], Jason Overlock[1]. [1]Maine Department of Marine Resources, Augusta, Me. United States

In the past several years the Maine Department of Marine Resources has made several advances in utilizing green and eyed eggs for population enhancement of Atlantic salmon (*Salmo salar*). Green eggs have been found to be difficult to move due to handling shock however both green and eyed eggs have been successfully transported and buried in artificial redds in the Sandy and Sheepscot rivers. In the most recent studies, efforts have been made to overcome the logistics of burying eggs in the gravel while minimizing mortality. In the 2006 and 2007 projects eggs were buried using a newly developed hydraulic egg planter that utilizes a water stream to drill into the substrate and deposit eggs. Green and eyed eggs were buried using the new planter on the Sandy River and eyed eggs on the Sheepscot River in 2006 and 2007. Fry trapping results indicate that the new planter successfully deposited eggs and produced juveniles. The difficulties of burring eggs were also greatly reduced with the new egg planter. In ten hours a three person crew planted 200,000 eggs. The Maine Department of Marine Resources is currently developing Atlantic salmon management plans utilizing this technology.

C18.2-13
Effects of fish size, habitat, flow, and density on capture probabilities of age-0 rainbow trout estimated from electrofishing at discrete sites in a large river
Josh Korman[1] (presenting), Mike Yard[1], Carl Walters[1], Lewis Coggins[1]. [1]Department of Zoology, University of British Columbia, Vancouver, BC, Canada, [2]Grand Canyon Monitoring and Research Center, Flagstaff, AZ, United States, [3]Department of Zoology, University of British Columbia, Vancouver, BC, Canada, [4]Grand Canyon Monitoring and Research Center, Flagstaff, AZ, United States

Capture probability, the proportion of a population that is captured per sampling event, usually needs to be accounted for in studies of juvenile salmonid populations, but has received little investigation in large rivers where fish and habitat management issues are important. We estimated capture probability of age-0 rainbow trout in the Lee's Ferry Reach of the Colorado River, AZ, by backpack and boat electrofishing at discrete shoreline sites using both depletion and mark-recapture experiments. Our objectives were to evaluate the feasibility of estimating capture probability for juvenile salmonids in larger rivers, to determine how it is influenced by fish size, habitat, flow, and density, and to test population closure assumptions. There was no mortality of 351 fish that were captured by electrofishing, marked, and held for 24 hours. Of a total of 2966 fish that were marked and released, only 0.61% were captured outside of mark-recapture sites. Total emigration from mark-recapture sites was estimated at 2.2-2.6%. These data strongly suggest that populations within discrete sites can be treated as effectively closed. Eighty percent of capture probability estimates from 66 depletion experiments and 42 mark-recapture experiments ranged from 0.28-0.75 and 0.17-0.45, and the average CV of estimates was 0.26 and 0.25, respectively. There was strong support for a fish size -capture probability relationship that accounted for differences in vulnerability across habitat types. There was little support for capture probability models that accounted for within-day and across-month variation in flow. The effects of fish density on capture probability were challenging to discern, variable among habitat types and estimation methodologies, and confounded with the effect of fish size. Our results support the use of mark-recapture experiments to estimate capture probabilities for juvenile salmonids in large rivers. Size-vulnerability relationships determined from mark-recapture were used in a stock synthesis model along with data on spawn timing, otolith microstructure, catch-per-effort, and length-frequencies to estimate hatching success, age-0 growth, habitat use, and survival rate.

C18.2-14
Effects of urban development in the Muskegon River Watershed on growth, survival and potential recruitment of a Lake Michigan steelhead population: results of a multi-modeling approach
Jeffrey Tyler[1] (presenting), Edward Rutherford[2], Mike Wiley[2], Catherine Riseng[2], David Hyndman[3], Bryan Pijanowski[4]. [1]Fisheries Projections, Farmington, CT, United States, [2]University of Michigan School of Natural Resources and Environment, Ann Arbor, MI, United States, [3]Department of Geology, Michigan State University, East Lansing, MI, United States, [4]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, United States

We examine how rates of urban development and reforestation in the Muskegon River watershed affect age-0 steelhead populations with a multi-modeling system. Basin-wide land use change and hydrologic models forecast alterations in the ecosystem's water budget. Local-reach hydraulic models provide a high-resolution, spatially-explicit depiction of the physical environment that we combine with site-specific data to model the biological environment. Our individual-based model (IBM) operates in this model environment and follows steelhead from spawning until the end of the first growing season in early October. The IBM includes mechanistic submodels which simulate steelhead foraging, growth, movement, and mortality resulting from predation, starvation, and substrate alteration. We run the IBM for landscapes re(presenting) years 1998, 2010, 2020, 2040, 2070 and 2100 under land use scenarios reflecting: 1) expected urban development (baseline), 2) urban development under a 'slow growth' regime, and 3) baseline with reforestation. IBM simulations show changes in survival, density, size and potential recruitment of age-0 steelhead under the three different urban development scenarios.

C18.2-15
Changes in suitable habitat for salmonids in the Muskegon River resulting from different paths of urban development
Edward Rutherford[1] (presenting), Jeffrey Tyler[2], Mike Wiley[1], Catherine Riseng[1], David Hyndman[3], Bryan Pijanowski[4]. [1]University of Michigan School of Natural Resources and Environment, Ann Arbor, MI, United States, [2]Fisheries Projections, Farmington, CT, United States, [3]Department of Geology, Michigan State University, East Lansing, MI, United States, [4]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, United States

Urban development and reforestation in the Muskegon River watershed affect water discharge, river substrate and water temperature. Here we explore how these changes affect the availability of suitable habitat for steelhead, brown trout and Chinook salmon. Our approach uses a dynamic weighted usable area (DWUA) as the measure of habitat suitability and measures DWUA on a daily basis with a high resolution model of the river. We use a multi-modeling system to simulate basin-wide land use change and hydrologic models to forecast alterations in the ecosystem's water budget. We run the DWUA analysis for landscapes re(presenting) years 1998, 2010, 2020, 2040, 2070 and 2100 under three land use scenarios. The first scenario reflects expected urban development. The second scenario reflects urban development after 'slow growth' rule have been implemented to reduce the rate of development. The third scenario reflects expected development with reforestation. DWUA analysis suggests that the changes to the Muskegon River habitat for the three salmonid species we examine show differences based on the different land use scenarios and that the effect of land use change on suitable salmonid habitat is not the same for each of the three species.

C18-P-1
Intraspecific variation in habitat use of juvenile Atlantic salmon in a Lake Ontario tributary
James Johnson[1] (presenting). [1]USGS, Cortland, NY, United States

The summer and autumn habitat use of subyearling and yearling Atlantic salmon (*Salmo salar*) were examined over a three year period in a New York tributary of eastern Lake Ontario. For each of the three years of the study subyearling salmon were stocked in the stream in mid-May and habitat observations were carried out in July and October. Salmon habitat (n=1,665 observations) and available habitat (n=1,300 observations) were quantified in a representative 0.6 km stream reach. The habitat variables examined were cover, depth, substrate and velocity. Differences in the habitat occupied by subyearling salmon compared overyearling salmon were greater in summer than in autumn. Differences in the habitat used by subyearling salmon between the summer and fall were more pronounced than for overyearling salmon between seasons. The habitat occupied both age groups of salmon was significantly different than available habitat within the stream reach, a strong indication of habitat selection. Both age groups of salmon occupied areas that had higher velocities, greater depth, more cover, and larger sized substrate materials than were generally available within the stream reach. Mean velocities where juvenile salmon occurred were about twice that of mean velocities within the stream section.

C18-P-2
Habitat dependent superimposition of Pacific salmon redds by brown trout in the Salmon River (New York) drainage and implications to Atlantic salmon restoration
John Fitzsimons[1] (presenting), Karala Passow[1], Fran Verdoliva[2], Chris Wilson[3], Dustin Everitt[4]. [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada, [2]New York State Department of Environmental Conservation, Altmar, New York, United States, [3]Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada, [4]Nebraska Game and Park Commission, Nebraska, United States

Spawning activity by Pacific salmon has been considered to have negative consequences to reproduction by other salmonines like Atlantic salmon. The Salmon River drainage has been targeted for Atlantic salmon restoration but has abundant Pacific salmon (Chinook and coho salmon) runs during the fall. We conducted redd surveys in the Salmon River and tributaries and used restriction-length polymorphisms of PCR-amplified 5S rDNA and mtDNA to confirm species identity. Although no Atlantic salmon redds were detected, redds of brown trout, a close ecological analogue to Atlantic salmon in terms of spawning characteristics (e.g. substrate, flow, depth, timing), were found in some side channels off of the main stem and three tributaries but were rare in the main stem. In several instances dependent on habitat characteristics, most notably flow and substrate, we found evidence of superimposition of Pacific salmon redds by brown trout. Since resuse of redds constructed by large Pacific salmon can reduce the energy expenditure of smaller spawners and improve embryonic survival by reducing fines, spawning by Pacific salmon may facilitate reproduction and hence restoration of Atlantic salmon.

C19-1

Rapid response: the tunicate's tale…and then there were four

Andrea Locke[1], J. Mark Hanson[1] (presenting), Renee Bernier[1]. [1]Fisheries and Oceans Canada, Moncton, NB, Canada

Following the discovery of the clubbed tunicate, Styela clava, on a bivalve aquaculture site in an estuary of eastern Prince Edward Island in December 1997, management measures to reduce dispersal to other sites were considered. For the first three years, no management was deemed necessary, but by 2000 they had developed into a pest, and management of bivalve transfers and harvests was initiated. There were few models for methods to manage tunicates at that time, but by trial and error a quarantine system was adopted which has proven largely successful. When the vase tunicate, Ciona intestinalis, subsequently colonized, minor adaptations of the method also worked to limit its dispersal. The arrival of two colonial tunicates, the golden star tunicate, Botryllus schlosseri, and the violet tunicate, Botrylloides violaceus, has proven problematic. Because these colonial species can reproduce by fragmentation, and disperse by natural means such as rafting, containment has been ineffective. An unexpected observation has been their ability to hitchhike on species such as American lobster, *Homarus americanus*, which is transported live worldwide.

C19-2

New names, evolutionary resolution, and founding sources for exotic Great Lakes gobies

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Two Ponto Caspian neogobiin gobies were identified in the Lake St. Clair region of the Great Lakes in 1990: the round goby (formerly *Neogobius melanostomus*) and the tubenose goby (formerly *Proterorhinus marmoratus*). We examine their evolutionary relationships in comparison with Ponto-Caspian relatives, using nuclear and mitochondrial DNA sequences. We further test population genetic patterns for 1000 round goby individuals across its Eurasian and North American ranges using 8 nuclear microsatellite loci. DNA evidence refutes monophyly of Neogobius, and we thus elevate the subgenus Apollonia to genus level, encompassing *A. melanostoma* (the round goby), *A. fluviatilis* (the monkey goby), and A. caspia. The former *P. marmoratus* comprises at least three species and we retain that name for the marine tubenose goby. The species in the Great Lakes is the newly resurrected freshwater tubenose goby *P. semilunaris.* We also identify the southern Dnieper River as the founding source population for the round goby in the Great Lakes. There is considerable population genetic variation throughout the Great Lakes and substantial genetic diversity, supporting large numbers of propagules, several introduction events, as well as localized selection.

C19-3

Fish assemblages and environmental factors associated with gobiids in the lower Great Lakes

Lynda Corkum[1] (presenting), Silvia Dopazo[1], Nicholas Mandrak[2]. [1]University of Windsor, Windsor, ON, Canada, [2]Fisheries and Oceans Canada, Burlington, ON, Canada

We investigated which fish species and environmental variables were associated with two invasive species, round goby and tubenose goby, in nearshore Canadian waters of the Huron-Erie corridor of the lower Great Lakes. Using triplicate beach seine samples, we caught fishes in the day (n=30 sites) and at night (n=14 sites). Of 1955 individuals caught in daytime samples, the most abundant fishes were round goby (21.0 %), spottail shiner (17.3 %) and emerald shiner (14.2 %); tubenose goby represented 0.9 % of all fishes. Of 1521 individuals collected at night, the most abundant species were round goby (42.3 %), emerald shiner (24.1 %), brook silverside (9.0 %) and spottail shiner (8.5 %); tubenose goby represented 1.6 % of all fishes. Characteristic fish assemblages associated with the three daytime clustered sites were the benthivore (round goby) and two groups of schoo1ing, pelagic fishes (1. emerald shiner and spottail shiner; and, 2. white perch, alewife, gizzard shad and brook silverside). Tubenose goby, rock bass and yellow perch were associated with round goby, but did not characterize the group. Discriminant function analysis showed that turbidity, water temperature and distance from shoreline best delineated groups. Round goby were abundant in deeper, cooler, clear water.

C19-4

Monitoring the expansion of round goby (*Neogobius melanostomus*) into Great Lake tributaries; closing the knowledge gap for fisheries managers

Jason Barnucz[1] (presenting), Jeff McNeice[2]. [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada, [2]Central Lake Ontario Conservation Authority, Oshawa, Ontario, Canada

Within the province of Ontario agencies have prepared Fisheries Management Plans which have been developed to manage fisheries and fish habitat in Great Lakes tributaries. One common fisheries recommendation in all of these plans is controlling the spread invasive species into tributaries of the Great Lakes. Implementation of such a recommendation has proven challenging. To date there are no tested methods for evaluating round goby invasions into Great Lakes tributaries. Since its introduction the round goby (*Neogobius melanostomus*) has rapidly spread throughout the Great Lakes basin. Recent fisheries surveys in Ontario have documented the spread of this species into many tributaries of the Great Lakes. During the summer of 2007 the Central Lake Ontario Conservation Authority (CLOCA), in partnership with the Ontario Ministry of Natural Resources and the Ontario

Federation of Anglers and Hunters, began a project to evaluate the current spread of round goby in four Lake Ontario tributaries. The first objective of this project was to develop a standardized method to detect round goby in wadebale tributaries of the Great Lakes. The second objective was to evaluate the current invasion of round goby within four wadeable Lake Ontario tributaries. All sampling sites were surveyed using backpack electrofishing units. Sites were sampled using a combination of single pass and triple-pass sampling methods. All sampling sites were selected from historical watershed monitoring reports which provided a historical perspective regarding changes to the fish assemblages in the tributaries sampled. This project demonstrated the round goby has successfully invaded several Lake Ontario tributaries. This study demonstrated that backpack electrofishing single-pass methods are a very effective at detecting round goby in wadeable streams. Two of the four sampled tributaries possess lamprey barriers which have been successful in impeding the spread of round goby. Based on our monitoring streams without barriers may be at additional risk to round goby invasions. This project will be expanded in 2008 to investigate the rate of this invasion after one year of sampling.

C19-5

Population dynamics of an invasive fish in its expansion phase: the roundgoby in an Ontario river

Lee Gutowsky[1] (presenting), Michael Fox[1]. [1]Trent University, Peterborough, ON. Canada

The round goby (*Neogobius melanostomus*) is an invasive fish that is expanding its range throughout the Great Lakes watershed. The mode of expansion and life history is poorly understood and requires investigation in newly invaded environments. Round gobies were mistakenly introduced into the Trent River (central Ontario) in 2003, and have expanded their range both up- and downstream. Individuals were collected near the centre and upstream edge of their distribution in the 2006 and 2007 breeding seasons. These fish were used to examine any differences in somatic growth and life history traits in order to test the hypothesis that invasive populations will grow faster and allocate more energy to reproduction where they are expanding. Preliminary data support this hypothesis, as gobies near the edge of expansion have higher gonadosomatic indices than those collected from the site of original introduction. These data suggest that a high level of phenotypic plasticity in life history traits may be an important precondition to invasion success in fishes. With a seasonal growth assessment, we will determine whether increased reproductive allocation at the edge of expansion is the result of greater energy availability or a change in the relative energy allocation to growth and reproduction.

C19-6

Invasion dynamics of round goby (*Neogobius melanostomus*) in Hamilton Harbour, Lake Ontario

Luis A. Velez-Espino[1] (presenting), Marten A. Koops[1]. [1]Fisheries and Oceans Canada, Burlington, Canada

Most introductions of non-native species fail to establish soon after introduction either through mortality or reproductive failure. The presence of an established population increases the probability of survival and reproductive success of new propagules by avoiding both Allee effects and demographic stochasticity. Previously, attention has been paid to the establishment phase of the invasion process and the probability of establishment has been modelled as a stochastic process, while the spread phase and habitat saturation has received little attention. We model this aspect of the invasion process as a stochastic progression using the invasion dynamics of round goby, *Neogobius melanostomus*, in Hamilton Harbour, Lake Ontario, as a case study. Our modelling predicts that[1] propagule pressure in the form of adults can be very low and still represent a significant probability of establishment,[2] much higher concentrations of juveniles would be needed to pose a significant risk of invasion,[3] the round goby exhibited a short time lag between arrival and establishment, probably establishing before it was detected, and[4] very aggressive management actions would be needed to halt population growth after the population has established. Our study demonstrates that important prospective and retrospective insight into the invasion dynamics can be gained during the spread phase of an ongoing local invasion. This information can be of paramount importance to control and prevent further increases in invasion range. From our case study case it is clear that preventive measures are the most effective management options available to reduce the risk of future range expansion of round goby within the Great Lakes basin.

C19-7

Urine pulses as a male-female signal during mating period in round goby *Apollonia melanostoma*

Benjamin Meunier[1] (presenting), Lynda Corkum[1]. [1]University of Windsor, Windsor, ON, Canada

It is thought that round goby *Apollonia melanostoma* as many other freshwater fish species uses urine pulses to release pheromonal signals into the water. This study investigates whether or not reproductive male round gobies increase their urination rate in the presence of gravid (pre-spawning) females. In order to reveal the release of urine in the water, male round gobies were injected with a non-toxic fluorescent dye and placed in a tank under UV light. This resulted in the fish releasing glowing urine. During the trials a pre-ovulatory female and a post-ovulatory female were successively introduced to the tank with the injected male. For each period, the number of urination events was tallied up and their duration timed. Preliminary results showed that males increase dramatically their urination rate when confronted to a female. Also this increase appears to be more pronounced when the female is in a pre-spawning state. Secondary observations seem to reveal two very distinctive patterns in the way males discharge their urine. If confirmed, these observations would suggest that male round gobies are able of an active control of their release of urine and therefore of their release of pheromone.

C19-8
Longitudinal variation of fish assemblages in Canadaway Creek: focus on invasive species
Alicia Fahrner[1] (presenting), Timothy Strakosh[1]. [1]SUNY Fredonia, Fredonia, NY, United States

Dispersion aspects of lentic versus lotic and native versus non-native species were investigated in Canadaway Creek, a tributary of Lake Erie. Longitudinal variation in the fish assemblage was assessed using backpack electrofishing at twenty sampling locations from the mouth to the headwaters during the months of July and August in 2007. Physiochemical measurements at each site included substrate, shoreline vegetation, pH, dissolved oxygen, depth, water temperature, and flow. Over 4,000 fish specimens were collected and brought back to the laboratory for identification and length measurements. The collection serves as baseline data for future research and voucher specimens will be sent to the NYS Museum. The number of fish caught at each site varied widely, as did the distribution of species, with a definite predominance of native species. Many potadromous species were found at the mouth sites due to proximity of the lake. One exotic species, the round goby *Neogobius melanostomus*, was found at a site upstream. This incidence implies that the fish was able to transverse multiple waterfalls. Round gobies are known to be opportunistically predacious, as they eat the eggs of other fish, so their presence could have serious implications.

C19-9
Seasonally extended effects of the invasive round goby (*Apollonia melanostoma*) on young-of-the-year smallmouth bass (*Micropterus dolomieu*): eviction from winter refuges
Christopher Winslow[1] (presenting), Jeffrey Miner[1], Daniel Wiegmann[1]. [1]Bowling Green State University, Bowling Green, Ohio, United States

Effects of invasive round goby (RG) on smallmouth bass (SMB) depend on their combined influences over SMB life stages. Earlier research quantified RG impacts on unguarded SMB nests, the consequences of their competitive interactions with pre-piscivorous young-of-the-year (YOY) SMB and their impact on the growth rate of adult SMB. The ability of RG to exclude YOY SMB from refuges observed in our earlier studies may extend into the winter and, hence, affect overwinter YOY SMB survival. In this study, we quantified RG effects on refuge use and activity of YOY SMB under conditions that simulated the onset of winter. YOY SMB were forced out of preferred shelter and were more active in the presence of RG compared with YOY SMB housed alone or with bluegill. Results also indicate that negative impacts of RG are higher for relatively small YOY SMB. In northern systems where YOY SMB grow relatively slowly YOY SMB may consequently experience a pronounced competitive disadvantage late in the first year if the invasive RG are introduced.

C19-10
What the way for sustainable fisheries development in Ulungur Lake of China?
Jianzhong Shen[1] (presenting). [1]College of Fisheries, Huazhong Agricultural University, Wuhan,Hubei Province, China

Ulungur Lake, the second largest in Xinjiang Autonomous Region and the ninth largest freshwater lake in China, historically was a very important fisheries base which is still a mainstay in local poor county economy. However, the native fish fauna which is unique in China and its natural catch have been threatening by increasing human activities such as overfishing and intentional introduction of exotic species. How to make good use of the vast area of waterbody to increase the fisheries benefits while conserving the unique fish fauna is a big challenge. Wise selection of fishes and rational stocking density for enhancement according to the ecological conditions and the carrying capacity are necessary for the sustainable development of fisheries in it. Status quo of fisheries in Ulungur Lake is analyzed based on our field survey and proposal for development in the future is put forth in view of principle of priority for conservation of native fish species and prospect of long-term economic benefits.

C19-11
Food web effects of a nonnative fish: initial results of a large-scale field experiment
Joseph Benjamin[1] (presenting), Fabio Lepori[2], Colden Baxter[1], Kurt Fausch[2]. [1]Idaho State University, Pocatello, ID, United States, [2]Colorado State University, Fort Collins, CO, United States

Nonnative species may have unforeseen effects on communities they invade, and impacts may propagate across habitat boundaries. In streams, invading fish may deplete benthic insect consumers, causing not only increased periphyton, but reduce adult insect emergence and riparian spiders (Tetragnathidae). We tested these hypotheses by manipulating the presence and density of nonnative brook trout and native cutthroat trout in a large-scale field experiment. Treatments included enclosed reaches with either no fish (NF), brook trout at natural densities (0.4 fish/m2; BKNat), cutthroat trout at natural densities (0.15 fish/m2; CT), or brook trout at densities similar to CT (BKRed). We expected BKNat to reduce the flux of emerging insects and tetragnathid abundance and increase periphyton biomass, NF to exhibit the opposite response, and CT and BKRed to have intermediate values. Initial results suggest that, contrary to our hypotheses, the abundance of riparian spiders and periphyton was similar across treatments. However, samples from the end of the experiment indicate that trout affected insect emergence, with brook trout showing the strongest effects. Although further analysis will be necessary to identify the mechanisms involved, our results suggest that the replacement of native by non-native species can alter potentially important fluxes of organisms across ecosystems.

C19-12

Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River

Kevin Irons[1] (presenting), Greg Sass[1], Michael McClelland[1], Joshua Stafford[2]. [1]Illinois River Biological Station, Illinois Natural History Survey, Havana, Illinois, United States, [2]Forbes Biological Station, Illinois Natural History Survey, Havana, Illinois, United States

Non-native, Asian bighead *Hypophthalmichthys nobilis* and silver carp H. molitrix have been present in the Illinois River since the early 1990's. Catches of both species have increased since 2000. Analyses of monitoring data revealed significant declines in body condition of gizzard shad *Dorosoma cepedianum* (-7%) and bigmouth buffalo Ictiobus cyprinellus (-5%) following the Asian carps invasion from 2000 to 2006. Segmented regression analyses showed no significant change in the rate of decline in gizzard shad condition after 2000, whereas the rate of decline in bigmouth buffalo condition increased significantly after 2000. Statistically significant declines in mean gizzard shad condition were observed after Asian carps establishment (2000–2006), whereas condition of bigmouth buffalo was significantly lower in all years following Asian carps establishment as compared to 2000. Declines in gizzard shad and bigmouth buffalo condition were significantly correlated with increased commercial harvest of Asian carps and poorly correlated with other abiotic and biotic factors (e.g. temperature, chlorophyll a, discharge) that may influence fish body condition. Our results may suggest that Asian carps are negatively influencing native planktivore body condition, and future research should focus on determining whether food is limited in the Illinois River for native planktivores and other fish species.

C19-13

Is the impact of an invasive species on ecosystem properties altered by differences in native fish diversity?

Michael Carey[1] (presenting), David Wahl[1]. [1]Illinois Natural History Survey, Champaign, IL, United States, [2]University of Illinois Urbana-Champaign, Urbana, IL, United States

Aquatic communities have been dramatically altered by invasive species with devastating impacts on native biodiversity and ecosystem function. Native biodiversity can mitigate the effects of an invader and needs to be considered when predicting the impact of invasive species. Common carp (*Cyprinus carpio*) are a ubiquitous, invasive fish that influences fish communities and ecosystem processes. Predicting the effects of carp is difficult, because most studies have not accounted for diversity differences within invaded systems. We examined the effect of carp across a range of fish richness in mesocosm tanks with both an additive and substitution design. The fish treatments were chosen to represent the nested subset patterns observed in fish communities of Illinois lakes. Carp reduced fish production in both experimental designs. In the additive design, the magnitude of decrease in fish biomass between carp and no carp treatments decreased with increasing fish richness. Fish richness was important in explaining native fish production in the substitution design, but was overwhelmed by the carp effects. Examining the influence of invasive species across a gradient of diversity furthers our understanding of how biodiversity governs ecosystem function by connecting biodiversity ecosystem function theory with invasion ecology.

C19-14

Effect of the invasive predator, *Bythotrephes longimanus*, on growth of fishes in Ontario lakes

Leah James[1] (presenting), Shelley Arnott[1], John Casselman[1]. [1]Queen's University, Department of Biology, Kingston, Ontario, Canada

The introduction of non-native species into new habitats is among the most significant drivers of change in freshwater ecosystems. One invader, *Bythotrephes longimanus*, is a large, predatory invertebrate from Eurasia that was introduced into the Great Lakes in the mid 1980s and has since spread into as many as 90 inland lakes in Ontario and the northeastern United States. Bythotrephes is an important exotic species because at certain times of the year, it can consume a large proportion of the total zooplankton production and may impact the availability of zooplankton prey to other predators such as forage fish. Changes in food availability at these lower trophic levels (zooplankton) may affect the flow of energy up the foodweb. Despite this, we know very little about how the addition of Bythotrephes into lake ecosystems may affect fish communities. Here, we examine the effect of Bythotrephes invasion on a number of metrics including catch per unit effort (CPUE), condition, growth (through the examination of calcified aging structures) and diet of lake herring (Coregonus arterii) collected from 8 invaded and 4 reference lakes in the Muskoka-Parry Sound area. Preliminary analyses indicate no significant difference in the abundance and condition of lake herring in invaded and reference lakes ($P>0.05$). We expect the effect of Bythotrephes on growth patterns and diet of lake herring to be considerable. Increased knowledge regarding the effect of Bythotrephes on growth of forage fish is pertinent to furthering our understanding of its impact on food web dynamics.

C19-15

Natural history of introduced northern snakehead in the Potomac River catchment: implications for control.

Nicolas W. R. Lapointe[1] (presenting), Paul L. Angermeier[2]. [1]Department of Fisheries and Wildlife Sciences, Virginia Polytechnic

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Northern snakehead (NSH) (*Channa argus*), recently established a population in the Potomac River catchment. This large, piscivorous, air-breathing fish may pose substantial risk to native fishes. To understand the natural history of this invader, we studied its dispersal ability, habitat use, feeding habits, diet, spawning, and growth. We implanted 49 fish with radio transmitters in October 2006, and tracked them through summer 2007. Habitat and measures of water quality were recorded at random and NSH locations. We captured NSH for gut-content analysis from May to August 2007. Additionally, we captured co-occuring North American species to determine diet overlap. Nests were discovered and monitored, taking larval samples daily. Larval growth was measured, and adult growth was measured through recapture of tagged fish. Approximately 1/3 of tagged NSH dispersed (some over 40 km) just prior to the start of the spawning season in May. NSH preferred shallow (<1.5 m) habitats with thick cover. They fed during daylight, almost exclusively on fishes. Indications of spawning were observed from May to September, and guarded nests were found in thick Hydrilla verticillata. It would be most effective to focus control efforts on the pre-spawning and spawning periods, in shallow habitat with plenty of cover.

C19-16

Combining habitat suitability and introduction risk to predict the invasion of smallmouth bass

Sapna Sharma[1] (presenting), Leif-Matthias Herborg[1]. [1]Université Laval, Québec, Québec, Canada, [2]Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada

The introduction of non-indigenous species has resulted in wide-ranging ecological and economical impacts. Predictive modeling of the introduction and establishment of non-indigenous species is imperative to identify high-risk regions of invasion to effectively manage non-indigenous species and conserve native populations. A non-native species of concern is the smallmouth bass (*Micropterus dolomieu*). The intentional and unintentional introduction of the smallmouth bass has negative impacts on the native fish community, including cyprinids, lake trout, and salmonids populations. We developed and validated species introduction, habitat suitability, and introduction and establishment models using classification trees and stepwise logistic regression models for lakes in Ontario and British Columbia. Densely human populated areas and larger surface areas successfully identify lakes associated with the introduction of smallmouth bass. Climate, lake morphology, and water chemistry variables define suitable smallmouth bass habitat. The combined introduction and establishment model identified 138 lakes that are currently at high risk in British Columbia to the introduction and establishment of smallmouth bass populations. This stresses the need to focus management efforts on these watersheds to control introduction of non-indigenous species to conserve native fish populations.

C19-17

Effects of nonnative species on food web structure and variability in the Gila River drainage, New Mexico

Tyler Pilger[1] (presenting), Keith Gido[1], David Propst[2]. [1]Kansas State University, Manhattan, KS, United States, [2]New Mexico Department of Game and Fish, Santa Fe, NM, United States

Native fishes in the Gila River basin have experienced severe declines in abundances that coincided with the occurrence of several nonnative fishes, including smallmouth bass, *Micropterus dolomieu* and yellow bullhead, Ameiurus natalis. There is currently little understanding of food web interactions and the spatial scales of those interactions in the Gila River. Our study aimed to quantify food web interactions among native and nonnative fishes both among habitats of a study reach and among eight study reaches using both dietary analysis and stable isotopes. Specifically, we evaluated how variation in nonnative species abundances was associated with native species diets and food web structure within and among these reaches. Stomach data from 2007 (289 stomachs re(presenting) 13 species) indicate aquatic invertebrates were the primary food for native and most nonnative fishes, but yellow bullhead, brown trout, and smallmouth bass also consumed fishes. Stable isotope analysis corroborated evidence of adult nonnative piscivory and possible reliance on benthic invertebrates. Pianka's index of diet overlap for yellow bullhead showed higher variability within (O = 0.47 to 0.51) than among study reaches (O = 0.92). These data are to assess an ongoing nonnative removal program evaluating the influence of nonnatives on native communities and food webs dynamics.

C19-18

The Behavior of spawning phase sea lampreys from Middle River, WI in their relation to a low-head barrier

Sara Ruiter[1] (presenting), Jill Leonard[1]. Northern Michigan University, Marquette, MI, United States[1]

It is uncertain what occurs after sea lampreys (*Petromyzon marinus*) encounter low-head sea lamprey barriers during upstream migration. It is important to determine where sea lampreys go after this encounter to assess their likelihood of reproduction. PIT tags were implanted into 107 spawning sea lampreys from Middle River (WI) after they encounter a low-head sea lamprey barrier. Fish were released and relocated in the river with a portable PIT tag reader wand. The spawning season was divided into 4 tagging periods to examine behaviors in relation to temperature during different times of the spawning run. An antenna was placed at the lower end of the river to continually track emigration out of the river; three nearby rivers were monitored to see if emigrating lamprey entered them. Within Middle River, 95% of the tagged sea lamprey stayed in the river after encountering the barrier. There was a large amount of spawning habitat available and many nests were observed in the river. Movement of these animals in the river is positively related to temperature; emigration and the number of trapped lamprey increased as temperatures increased. The barrier reduces the amount of habitat available, but sea lampreys are successfully spawning below the barrier.

C19-19

Field trials for the use of sea lamprey migratory pheromone as an attractant within tributary systems

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Two pheromones have been identified that guide sea lamprey migratory and spawning behavior. Recent research has focused on the factors that mediate behavioral responses to pheromones. Our research focused on the pheromone produced by stream-resident larvae that has been shown to attract pre-spawning sea lamprey to a spawning stream. Field trials were conducted to determine whether migratory-phase sea lamprey could be redirected from a stream with a resident population of larvae into a smaller side stream, using migratory pheromone. Migratory pheromone was collected from sea lamprey larvae and applied to the side stream at approximately 7x the mainstem concentration on alternating nights. Traps were set in both streams; passive integrated transponder (PIT) tags and stationary antennae were used to track movements. The sea lamprey did not respond to the pheromone: 99% of 250 tagged and 97% of 251 untagged lamprey were captured in the mainstem trap and there was no difference between treatment and control (no pheromone applied) nights. Average times to pass each antenna and measures of indecisive behavior did not differ significantly between control and treatment nights. These results indicate that the stream discharge likely plays a major role in stream selection; laboratory experiments are being conducted to elucidate this relationship.

C19-20

Young of year planktivore dynamics: distributions of native rainbow smelt in relation to non-native alewife in Lake Champlain

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Rainbow smelt (*Osmerus mordax*) have historically been the dominant pelagic planktivore in Lake Champlain, and are likely native to this lake. Lake Champlain now supports a growing non-native alewife (*Alosa pseudoharengus*) population as well. Every two to three weeks, we conducted acoustic surveys, physically sampled fish, and measured abiotic environmental conditions in the main section of the lake during day and night from June through September. Our goal was to understand habitat use and seasonal dynamics of these two fish populations focusing on the young-of-year (YOY) of both species Alewife YOY were not observed until late July in 2007, whereas YOY rainbow smelt were present in the epilimnion in June. Light intensity and water temperature were the two proximate environmental variables associated with behavior (e.g. schooling) and vertical distribution for both YOY rainbow smelt and alewife. Dense schools were formed under bright light conditions, but fish were dispersed at lower light levels independent of time of day. Although YOY alewife generally preferred warmer depths, including offshore surface-water, distribution of YOY rainbow smelt and alewife overlapped at times. The recent addition of alewife to the lake has increased the complexity of the food web in Lake Champlain.

C19-P-1

Aquatic Invasive Species: Watercraft Inspection at International Borders in NW Ontario

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One of the primary pathways for the introduction of Aquatic Invasive Species (AIS) into NW Ontario and the Lake Winnipeg watershed is via the Rainy River – Lake of the Woods – Winnipeg River systems. In the summer of 2007 Fisheries and Oceans Canada initiated a program inspecting watercraft for AIS at the international borders of Fort Frances (International Falls, MN), and Rainy River (Baudette, MN) in NW Ontario. A short survey (n=647) of fishers was conducted as boats were inspected. Fishers were primarily from Minnesota and Wisconsin, some travelled from as far away as Texas. The survey found that 54% of last launch lakes were listed as AIS infested; many lakes contained multiple AIS. Fishers primarily purchased live bait en route to their destination. Most fishers disposed of bait on land; however 8% gave bait to other fishers and 7% disposed of bait directly into the lake. We removed small amounts of vegetation from boats and trailers; fortunately no Zebra Mussels of other potential AIS were

detected.

C19-P-2

Growth responses of fish species of multiple trophic levels to a zebra mussel (*Dreissena polymorpha*) invasion in a shallow, eutrophic lake

Eric Katzenmeyer[1] (presenting), Clay Pierce[1], Mike Colvin[1]. [1]Iowa State University, Ames, IA, United States

Effects of zebra mussels have been well documented in the Great Lakes and large rivers, but studies on small, isolated water bodies are less common. Zebra mussel invasions can have profound effects on the benthic and pelagic zones of lakes, and this can impact fish species from multiple trophic levels. We are quantifying such effects by examining responses in growth from fish of multiple trophic levels in Clear Lake, Iowa. By back-calculating length at age of fish of different ages, we can produce a growth history for fish and compare growth rates before and during zebra mussel invasion. To date we have collected aging structures from five species of fish, which are being processed in the lab, to acquire age and annual growth data. Our research will lead to a better understanding of the impacts zebra mussels have on shallow, eutrophic lakes and how fish growth responds to these changes.

<u>C20. Stream and River Communities</u>

C20-1

Longitudinal variability in rivers: implications for survey design

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The riverscape concept favors study of an entire river and a recommended number for probability sampling designs is 50 sites. However a riverscape census of an entire river and a 50 site sample are both daunting undertakings for most institutions, and they limit the number of rivers that can be sampled with limited resources. On the other hand, a handful of samples near bridges underestimates the ecological variability expressed by a large river. We sought to determine the number of sites that would yield relatively precise estimates of ecological condition for raftable rivers 100-200 km long and 20-120 m wide. We used a probability design to select 20 sites on each of two rivers in Washington (Chehalis, Okanogan) and four rivers in Oregon (Willamette, Malheur, Umpqua, Sprague). We selected rivers to include those draining cold deserts, dry and wet forests, and agricultural plains. All sites were sampled by a four person crew from two rafts. Crews collected physical and chemical habitat and fish and macroinvertebrate assemblage data at each site through use of EMAP-West methods. The reach length for each site was 50 times the mean wetted width of the channel, and crews sampled 1-2 sites per day depending on site size and the distance between sites and access/egress locations. The data indicate considerable ecological change among upper and lower sites in some rivers and little in others, as well as variability in biological assemblages associated with local changes in macrohabitat types. Based on preliminary analyses on these six rivers, our data suggest a high degree of spatial autocorrelation between sites that are < 10-40 km apart. This autocorrelation needs to be considered when designing river monitoring surveys.

C20-2

Can less stream distance be sampled in depauperate regionswhen estimating fish species richness?

Yoichiro Kanno[1] (presenting), Jason Vokoun[1]. [1]University of Connecticut, Storrs, CT, United States

We examined the amount of electrofishing required to estimate species richness in species-poor streams in Connecticut (mean richness = 10 species/site). Study streams were divided into 10 subreaches, each equaling to 5 times the mean wetted channel width (50 times in total). Single-pass electrofishing was conducted during summer low flow discharge. Stream lengths 30-35 times the mean channel width were required to capture 90% of species observed, and estimated species richness indicated that further sampling might yield additional new species. The observed level of sampling effort required was comparable to those reported from other species-rich regions. This observation was explained by ubiquitous occurrence of rare species (i.e. singletons and doubletons). Numerically more abundant species (i.e. common species) did not show evidence of subreach selection, perhaps because subreaches were simply a multiple of stream widths and each subreach usually contained a mixture of habitat types. Our results suggest that low species richness alone is not a rationale to justify less sampling effort and it is important to recognize the sporadic occurrence of rare species in assessments of the electrofishing effort required to estimate species richness.

C20-3

Detection and occupancy probabilities for monitoring Missouri River fishes

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Objectives of the Missouri River pallid sturgeon monitoring program include detecting trends in abundance and responses to management actions of several rare species. Accomplishing this goal using relative abundance may be limited by high variability and inadequate sample size which result in low statistical power. Occupancy models use presence/absence to estimate the probability a site is occupied (ψ), and account for variable detection probabilities. Sampling with the most efficient gear in habitats with high occupancy can increase sampling efficiency to achieve the monitoring program's objectives. Detection probabilities (p) were estimated by gear type (gill net, trammel net, and otter trawl) for five species by maturity class (juvenile and adult) caught during October-June, 2003-2006. Gill nets had the highest p for all adult fishes (blue sucker 0.29, channel catfish 0.16, sauger 0.17, pallid sturgeon 0.02, and shovelnose sturgeon 0.73) and juvenile shovelnose sturgeon (0.65). Juvenile blue sucker and pallid sturgeon had similar, but low (≤0.05) p for all gear types. Otter trawls had the highest p for juvenile channel catfish and sauger at 0.46 and 0.19, respectively. Probability of occupancy for various habitat types will be estimated using samples taken with the most appropriate sampling gear for each species.

C20-4

Ecology of South American migratory fish: a perspective from the Rithron

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Migratory fish of the large rivers of South American often support well developed fisheries. In the lower De la Plata basin, a typical potamic riverscape, these species undergo extensive migrations during the late spring and summer as water level increases. However, this migration pattern is different in rivers, such as the Pilcomayo. For example, the sabalo (*Prochilodus lineatus*) starts migrating from the mid reaches of the Pilcomayo River when water level recedes in the fall. This species swims across cascades, rapids and riffles to enter the upper basin where it remains for several months until spawning. The Pilcomayo sabalo population differs from stocks in the lower De la Plata basin because it exhibits higher natural mortality, faster growth, and is dominated by 2- and 3-year old cohorts that support an extensive artisanal and commercial fishery. Seasonal hydrological patterns and longer-term patterns tied to El Niño and La Niña appear to regulate fishery yield and migratory cohort structure. The contrasting migration and life history pattern between the Pilcomayo and lower De la Plata Basin populations shows the influence of the rithron on the evolution of life history strategies of South American river fishes.

C20-5

Factors influencing the distribution and density of Puerto Rico stream fishes

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Puerto Rico is known for marine fisheries, but its freshwater habitats support a substantial number of species with fishery value. We conducted research in Puerto Rico streams to estimate stream fish populations and model their patterns related to physical habitat at multiple spatial scales. We employed a standardized fish sampling protocol using three-pass removal backpack or barge electrofishing at 81 stream sites to quantify fish and crustacean populations and measured instream, riparian, and water quality parameters. We quantified density of 24 fish species (10 native) and 15 crustacean species (11 shrimp, 3 crabs, 1 crayfish). The most abundant fish species were *Agonostomus monticola* (mountain mullet), *Poecilia orri* (mangrove molly), *Poecilia reticulata* (guppy) and *Sicydium plumieri* (sirajo goby). Mean fish species richness was 5.14 species per site, ranging from one species at three sites to 11 non-native species at one site. Based on our results and habitat measurements at the instream, riparian, and watershed scales, we developed a series of models explaining variation in fish community structure among sites and basins. This research is among the most comprehensive to study stream fishes and habitat in Puerto Rico and may facilitate outreach efforts and fishery and ecosystem management to sustain fish communities.

C20-7

The structure and function of riverine fish assemblages: natural and anthropogenic effects

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The Ohio River forms from the confluence of the Allegheny and Monongahela rivers in Pittsburgh, PA. These three rivers comprise a range of different habitat types: primarily glacially-deposited gravel and cobble in the Allegheny River, sand and mud in the Monongahela River, and a combination of the two in the Ohio River. All three rivers are impacted by lock-and-dam systems, while the Allegheny and Ohio rivers are also subject to large-scale commercial gravel dredging which, in addition to removing the substrate, can increase the river depths from 4-7 m to 20 m with corresponding changes to hydrodynamics, sediment dynamics, and nutrient flow. Riparian land-use includes relatively pristine forest in the upper Allegheny drainage, as well as mixed agriculture, light and heavy residential and commercial, and large-scale industry in other reaches. Sampling fishes throughout the Pennsylvania reaches of these rivers using a combination of gill-nets, benthic trawls, and electrified benthic trawls, we then used multivariate techniques in to parse out the relative effects of the various anthropogenic and natural variables on the structure and function of the

fish assemblages throughout these rivers.

C20-8

Long-term surveys of fish populations in two estuaries – are the changes substantial and consistent or transient and random?

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Impingement studies were conducted at power plants located on two estuaries in Texas. Five plants were located on Galveston Bay and one was located on Sabine Lake. The majority of impingement studies were conducted during the 1970's. The objective of this study was to determine whether there had been a consistent, substantial change in time or space in the fish populations in the two estuaries since the impingement studies were conducted. Surveys of the fish populations in the two estuaries have been conducted by Texas Parks and Wildlife Department since the early 1980's and continues through the present. These long-term datasets were studied to evaluate trends in the fisheries in each of the two estuaries. Results indicate that a consistent set of species dominate the populations with little evidence of consistent, substantial change in either time or space. Seasonal patterns in impingement rates at the CWISs were apparent and were often consistent with shifts in the ambient population.

C20-9

Abiotic conditions in contrasting environments: an examination of Canadian Precambrian Shield lotic communities

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Low-order lotic systems of the Canadian Precambrian Shield include an extensive portion of Ontario's many waterways that remain relatively unstudied, particularly concerning fish species composition. The geology of the Precambrian Shield - namely, large outcroppings of ancient metamorphic and igneous rock that were exposed to the surface during the glacial period – has a large influence on the abiotic conditions of aquatic systems. These differences are especially striking in comparison to non-Shield areas, particularly in the transition zone in south-central Ontario. In this study, we sampled small-order streams in central Ontario in order to assess the fish and macroinvertebrate community composition and abiotic conditions of Shield lotic systems in this area. This data was assessed with multivariate methods in order to elucidate both biotic and abiotic patterns between sites. In addition, comparisons to sites in south-central Ontario are made in order to examine changes in abiotic conditions and fish species composition along the transition zone of the Shield.

C20-10

Dynamics of fish diversity in the Tonawanda Creek Watershed of Western New York State.

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Tonawanda Creek is a 6th order warmwater stream located in the Lake Erie – Niagara River watershed draining some 1678 km² of lands covering five counties in western New York State. During the 2005 sampling season, researchers at the State University of New York at Brockport sampled the fish communities at 68 sites on 29 day trips expanding some 96 river miles of the main stem including the Erie Canal below Pendleton, NY and several sites on five of the major tributaries in the basin. Excluding suspected Lepomis hydrids and unknown juvenile fry, a total of 21,310 individuals comprising 63 species were identified including two rare and five exotic fishes. Data analysis revealed only 23 of 63 spp (~37%) found in the watershed were reflective of fishes comprising > 1% relative abundance. Cyprinids dominated overall catches with 23 species, followed by centrarchids (11), percids (8), and catostomids (6), respectively. Catch per unit effort was highly variable ranging from 1 to 98, as was Simpson Diversity Index values (0.353-0.930), calculated per site in the watershed. Species composition appears to align with the River Continuum Concept. However, certain watershed trends such as fish richness (decrease little upstream) and relative fish abundance (increases upstream) are suspected to have been caused by various anthropogenic pressures on these fish communities. The findings of this study have already assisted with the ongoing management of native stream fishes in New York State.

C20-11

Fish assemblages on gravel bars in the Arkansas River

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We examined temporal and spatial variability of fish assemblages on 18 gravel bars in the Arkansas River. Gravel bars were stratified by depth and distance from an upstream lock and dam. Fish assemblages on each gravel bar were trawled three times from August to November 2007. Each sample consisted of duplicate trawls with a 3-m Herzog Armadillo trawl. Water quality and substrate samples were collected in conjunction with fish samples. Preliminary results indicate that gravel bar habitat in the Arkansas River is primarily utilized by ictalurids, centrarchids, cyprinids, and percids. Fish species richness was significantly different between shallow and deep gravel bars ($P < 0.0001$) and between summer and fall ($P = 0.0002$). Catch per unit effort

(CPUE) for the three most abundant species (blue catfish, channel catfish and silver chub) was analyzed for differences among depths, distance strata, or seasons. There were no differences in CPUE among depths ($P = 0.7930$, $P = 0.8758$) distance strata ($P = 0.4905$, $P = 0.0694$) or seasons ($P = 0.5578$, $P = 0.8189$) for blue catfish and channel catfish. There were differences in CPUE among depths ($P < 0.0001$), distances ($P = 0.0005$), and seasons ($P < 0.0001$) for silver chub.

C20-12

Ecosystem effects of fish diversity and food web structure interact with habitat heterogeneity in experimental streams

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Both biodiversity and trophic structure may affect ecosystem function. Understanding the interacting effects of biodiversity and trophic structure on ecosystems is a major impediment towards predicting the consequences of biodiversity loss. To test these interactive factors, we assembled fish communities with different composition and diversity within a trophic level (3 invertivore species) and different trophic structures (piscivore presence or absence) in large outdoor experimental streams. Response variables included aspects of ecosystem structure and function (algal accrual measured as chlorophyll a and ash free dry mass, algal filament length, benthic organic material accumulation, macroinvertebrate assemblage structure, gross primary productivity, community respiration, and net ecosystem metabolism). Piscivores had both direct (consumption) and indirect (habitat use) effects on experimental assemblages, which differed among invertivore species and cascaded down to algal communities (e.g. invertivore*piscivore*habitat interaction for periphyton chl a, $P = 0.0351$). Invertivore composition/diversity, trophic structure and time since disturbance significantly affected most measures of ecosystem structure and function, and all structural responses differed among pool and riffle habitats (all $P < 0.05$), often with interactions among factors. Our results indicate ecosystem effects of biodiversity depend on trophic structure, and may differ spatially in heterogeneous ecosystems due to complex direct and indirect effects.

C20-14

Young-of-year fish community structure and habitat use along the upper channelized reach of the Missouri River

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The abundance and community structure of young-of-year (YOY) fishes in dominant habitats is critical to understanding the ecology of lotic systems. We used a multivariate approach to assess YOY fish communities in dominant habitats (e.g. Inside Bend, Outside Bend, Channel Crossover, Secondary Channel, etc.) along the upper channelized portion of the Missouri River from data collected as part of an ongoing monitoring effort. All fish were collected using an otter trawl in a standardized approach. Forty-one fish species were collected in 2005 and 2006 from two different river segments and nine dominant habitats. Our results indicate large-scale differences in fish community structure above versus below the confluence with the Platte River, a major tributary in the area ($P < 0.01$). Similar differences in community structure also exist among habitat types as expected ($P < 0.01$). Generally, differences in abundance of YOY silver chub Macrhybopsis storeriana, channel catfish *Ictalurus punctatus*, freshwater drum Aplodinotus grunniens, blue catfish Ictalurus furcatus, and white bass Morone chrysops described up to 70% of the dissimilarity among communities found in each habitat. These abundance differences correlate with physical habitat differences and suggest that a mosaic of habitats is needed to maintain a diverse fish community.

C20-15

Where is everybody? Evaluating floodplain-dependent fish reproduction in a subtropical river system

B. Thorpe Halloran[1] (presenting), D. Allen Rutherford[1], Michael D. Kaller[1], William E. Kelso[1]. [1]Louisiana State University, Baton Rouge, LA. United States

Continuous or episodic floodpulses allow fishes access to off-channel environments as waters rise and systems shift from dry to lotic to lentic. Though the proximate effects of overbank flooding typically trigger the:[1] resetting of nutrient cycles;[2] stimulation of primary and secondary production; and, (3) increased hydrologic connectivity; it is unclear if pulses result in successful recruitment because post-flood conditions are unstable. If fishes are hedging on relatively constant floodplain microhabitats for successful recruitment, seasonal flood variability may offer sub-optimal hatching and nursery areas during peak reproductive times. To better understand the forces that shape larval fish survivorship, we examined ichthyoplankton and zooplankton in newly inundated shallow backwaters and limnetic zones over a 19-month period. Further, we analyzed the potential effects of time of year, river stage (a measure of connectivity), dissolved oxygen, temperature, hours of daylight and flow velocities on the abundance of floodplain taxa. Our observations revealed that dominant taxa have protracted spawning cycles with larvae that appear to withstand a wide degree of variation in physicochemistry regardless of the scale of inundation. The ability to "match" abundant zooplankton did not appear to be as important as the capacity for extended reproduction.

C20-P-1

Spatial and temporal variation of intermittent stream food webs derived from stable isotopes

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Stable carbon and nitrogen isotopes are widely used for studying trophic structure and energy pathways in aquatic food webs. We quantified directional changes in isotope-based niche space resulting from spatial and temporal variation in stream food webs in the Ozark Mountains of northwest Arkansas. We collected replicate samples of coarse benthic organic matter (CBOM), periphyton, macroinvertebrates, and fish at three sites along a stream gradient from March 2006 to December 2007. CBOM signatures were characteristic of allochthonous inputs and demonstrated little variation. Periphyton $\delta 13C$ values were generally more enriched compared to CBOM values, but overlap occurred at the middle and lower sites in 2006. Macroinvertebrate and fish assemblages were consistently 13C enriched at the headwater site and 15N enriched at the middle and lower sites in both 2006 and 2007. In general, consumers demonstrated a greater reliance on allochthonous production along the stream gradient and species packing was consistently greater during summer low flow conditions. Results indicated that enrichment patterns were not consistently related to watershed area and the observed variability was likely coupled with stream drying and resource availability.

C20-P-2

Predictive models for fish assemblages of eastern USA streams: implications for species loss

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Predictive models for stream fish assemblages can be used as tools for assessing whether species occur more or less frequently than would be expected in streams unaffected by human disturbance. As part of the U.S. Geological Survey's National Water-Quality Assessment Program, predictive models were developed for streams in the northeastern and southeastern regions of the U.S. In both regions, bluegill and green sunfish occurred at more than 50% of the sites sampled. This frequency of occurrence was greater than expected, suggesting that these relatively common centrarchid species may be increasing in prevalence in eastern U.S. streams. In the Northeast, the percentage of species predicted to occur more frequently ("increasers") was nearly equal to the percentage of species predicted to occur less frequently ("decreasers"). In contrast, nearly two-thirds of the species examined in the southeastern model were predicted to occur less frequently than actually observed. In general, decreaser species in both regions tended to prefer riffle areas and substrates such as gravel and cobble, whereas increaser species tended to prefer pools and backwater areas. Predictive model estimates of decreaser species may provide important insights into species potentially at risk of loss in eastern U.S. streams.

C20-P-3

Benthic macroinvertebrate communities in relation to reach contributing area in small streams in the Boreal forest of Northwestern Ontario

Robin LeCraw[1] (presenting), Rob Mackereth[2]. [1]Lakehead University, Thunder Bay, Ontario, Canada, [2]Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada

Aquatic invertebrate communities in streams are often used as indicators of environmental impairment and to be effective, natural variation in communities must be well understood. Past studies have shown large scale effects of catchment size and land use on in-stream communities as well as small scale associations with stream habitat. Riparian zone characteristics can affect stream habitat attributes including temperature, organic debris and sediment input as illustrated by experimental manipulation during logging. However, riparian characteristics are variable, even at relatively small spatial scales, and the association of this variability with stream habitat and invertebrate communities is not well studied. The objective of this study is to measure invertebrate communities, stream habitat variables, and riparian characteristics and relate these to variation in the terrestrial areas associated with each reach, or "reach contributing area" (RCA). Stream, biotic and riparian data will be compared between reaches in three size categories of RCA along small streams (100 ha basins) in the Nipigon Bay watershed. In addition to improving our understanding of the extent and sources of natural variability in aquatic invertebrate communities, results from this study will contribute to the development of more ecologically based prescriptions for forest management activities in small stream watersheds.

C20-P-4

Evaluating hydrological connections between aquatic and terrestrial systems in Northwestern Ontario streams

Lisa McKee[1] (presenting), Robert Mackereth[1]. [1]Lakehead University, Thunder Bay, ON, Canada

The Nipigon Bay watershed on Lake Superior's north shore drains a high relief landscape dominated by thin soils over bedrock. The coldwater streams in the area provide habitat for several native fish species including migratory brook trout. There is concern that forest management activities planned in the area will result in detrimental hydrologic impacts, including increases in peak flows and water temperatures. However, to evaluate such impacts we require a better description of the natural variability in stream temperature and discharge patterns, at both the watershed and reach scale. The objectives of this study are to quantify spatial variability in streambed temperatures influencing surface temperature at a reach scale and evaluate the association between this variability and characteristics of the entire watershed and landscape directly adjacent to the reach. Preliminary surveys indicate that streambed temperature varies as much as 9.0 oC over a reach of 50 m due to shading and groundwater inputs which appear to be associated with differences in the structure and composition of the riparian zone. Further study will help clarify this association and its relationship with stream fish distribution, and examine the influence of forest harvesting on stream temperature variability.

C20-P-5
Diet shift of double-crested cormorants in the upper St. Lawrence River over the past decade
James Johnson[1] (presenting), Rodger Klindt[2], Anne Bendig[3]. [1]USGS, Cortland, NY, United States, [2]NYSDEC, Watertown, NY, United States, [3]OMNI, Kemptville, ON, Canada

The number of double-crested cormorants (*Phalacrocorax auritus*) in the upper St. Lawrence River (SLR) has increased markedly since the early 1990's. In 1999, a binational study was initiated to examine the annual diet composition and fish consumption of cormorants at colonies in the upper SLR because of concerns regarding localized impacts on fish populations near colonies. Since 1999, 10,566 cormorant pellets, collected from May through October each year, have been examined from SLR colonies to estimate fish consumption and determine temporal and spatial variation in diet. Temporal variation in diet composition within a colony is low. Prior to 2006 yellow perch was the primary fish consumed by cormorants in the upper SLR. Round goby were first observed in cormorant diets in 2003 and by 2006 were the main fish consumed at 2 of the 3 colonies. Since 1999, we estimate that cormorants from these upper SLR colonies have consumed 57.4 million fish, weighing about 2 million kg.

C20-P-6
Sustainability of a multi-species fishery in the Kafue River, Zambia
Andrew Deines[1] (presenting), Jeppe Kolding[3], David Lodge[1], Patrick Ngalande[2]. [1]University of Notre Dame, South Bend, IN, United States, [2]Zambian Department of Fisheries, Chilanga, Zambia, [3]University of Bergen, Bergen, Norway

In many of the world's oceans, fisheries have been overexploited, but freshwater fisheries have rarely been examined especially in the developing world. The flood plain of the Kafue River in Zambia, Africa has been fished using both traditional and modern methods since the early 1950s. Recent large increases in the numbers of fishermen and the ubiquitous use of illegal fishing techniques has prompted local and international management agencies to assume that the fishery is overexploited. However, research suggests these types of floodplain fisheries in Africa are relatively resistant to overexploitation. Moreover, the opportunity cost is potentially very high to this developing region of a restrictive management strategy when none is required. To assess the status of the Kafue River floodplain fishery, we use several metrics of overfishing on a 53 year data set. Specifically we test whether: 1) a trend in total catch exists; 2) catch per unit effort has declined; 3) species composition has shifted to smaller bodied species; 4) total number of species caught as declined; 5) mean size of individuals has declined; 6) mesh sizes of nets has declined; 7) size and age at maturation has declined; and 8) a decrease in the time-lag between flooding cycles and catch exists. Our analyses suggest that the total fish yield on the Kafue is highly variable between years but without any obvious long term trend. Furthermore our results are not strongly consistent with other indices of fishing-down the food web or overfishing in eneral. Within the limits of the available data, we tentatively conclude that the fishery may be more sustainable than previously supposed. Nevertheless a new threat to this apparent sustainability exists: introduced Nile tilapia (*Oreochromis* niloticus) is hybridizing to an unknown extent with the native 3-spot tilapia (*Oreochromis* andersonii) and has been associated with ecological impacts on other fishes all over the world. The Kafue River may serve as an ideal case study for investigating the impacts of this invasive species.

C21. Freshwater Fish Ecology
C21-1
Demographics and seasonal habitat use of white catfish (*Ameiurus catus*) and channel catfish (*Ictalurus punctatus*) in the Delaware River estuary
David Keller[1] (presenting). [1]Rutgers University, Camden, NJ, United States

In the Delaware River estuary, native white catfish (*Ameiurus catus* Linnaeus 1758) have appeared to decline as the introduced channel catfish (*Ictalurus punctatus* Rafinesque 1818) has become more abundant. Drastic changes in ratios of channel catfish to white catfish have been documented over the last 20-30 years. However, these ratios are not representative of the entire freshwater estuary and have not included tributary habitats used by both catfish species. To determine the current status of these populations and the habitats they use, we surveyed four zones of the Delaware River estuary from March to November 2007. Hoop nets (N=481) were set in mainstem river, lower tributary, and middle tributary habitats. Upper tributary habitats near the head-of-tide were angled (N=44). Catfish were present in all zones and habitats during all seasons, abundances will be presented. For the study area as a whole, the ratio of channel catfish to white catfish was 2.9 to 1. Channel catfish and white catfish inhabiting the mainstem river had a 3.6 to 1 ratio, much lower than a 25.5 to 1 ratio documented in the early 1990's. Mortality, growth rates, catch-per-unit-effort, and aspects of life history will be presented in the contexts of habitat use and stock status.

C21-2
Quantifying impacts of striped bass recovery on anadromous alosines in the Connecticut River
Justin Davis[1] (presenting), Eric Schultz[1]. [1]University of Connecticut, Storrs, CT, United States

Striped bass (*Morone saxatilis*) is an ecologically and economically important marine finfish distributed along the eastern seaboard of the U.S and Canada. Populations of this top-level predator have increased to historic levels in recent decades, prompting concerns about impacts on prey populations. In the Connecticut River, annual returns of anadromous alosines (blueback herring Alosa aestivalis, alewife *Alosa pseudoharengus*, and American shad A. sapidissima) have drastically declined in the last two decades. Increased seasonal presence of striped bass over this period suggests that heavy predation during vernal migrations may account for alosine declines. In order to quantitatively test this hypothesis, we sampled striped bass (*Morone saxatilis*) in the Connecticut River during spring 2005-07. Here we present analysis of diet composition and per-capita consumption rates. Diet composition varied with striped bass size, shifting to predominantly alosine prey among larger (> 60 cm TL) individuals. Approximately 21% of the striped bass population fed heavily on alosines. Striped bass daily ration estimates (% body weight/day) ranged from 0.1-1.6 % for herring and 0.8-7.0% for shad. Future analyses will combine these results with mark-recapture abundance estimates to quantify population-level consumption of anadromous alosines by striped bass.

C21-3

Maternal and paternal influences on larval production characteristics of white bass

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Domestication of white bass makes selective breeding programs possible. We conducted a diallelic study using five female and five male white bass. Eggs from each cross were examined for fertilization, with 20 incubated in individual vials until hatching. Temperatures of the vials were measured daily. Eggs were also hatched in individual McDonald hatching jars in recirculating systems. Temperature was taken every 6 h until hatching was complete, then once daily. Fifty larvae from each cross were photographed within 3 h of hatching, and again at 5 dph. Fertilization and hatch rates ranged from 39% to 100% and 0% to 50%, respectively. Average (SD) temperature in the vials was 18.5 (0.3) □C, and in the recirculating systems was 18.6 (0.8) □C. Length at hatch varied significantly among female ($F=113.52$, $df=3$, $P<0.001$) and male ($F=3.46$, $df=4$, $P=0.008$) brood stock. The interaction term was also significant ($F=4.49$, $df=12$, $P<0.001$). Length at 5 dph varied significantly among female brood stock ($F=363.85$, $df=3$, $P<0.001$) and the interaction term ($F=21.05$, $df=12$, $P<0.001$). At 5 dph, there was a 0.7 mm difference in length between the fastest and slowest growing crosses. This suggests selective breeding might be used to improve larval characteristics.

C21-4

Regional and temporal variability in recruitment, growth, and mortality of river herring (*Alosa aestivalis* and *A. pseudoharengus*) larvae in Roanoke River, North Carolina

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The Roanoke River serves as a major spawning and nursery area for many diadromous fishes including river herring (*Alosa aestivalis* and *A. pseudoharengus*). Major declines in the adult river herring stocks have resulted in strict regulations, moratoriums, and the adoption of fishery management plans. Temporal and spatial variability in distribution, growth, and mortality of river herring larvae was analyzed in Roanoke River, North Carolina. Collections were made in 1984-1990 and 2001-2003. Larvae were present in the icthyoplankton from early April through June but peak larval density was generally occurred during weeks 16 and 17. Mean annual larval density (#/100m3) was higher but more variable from 1984-1990 than during 2001-2003. Mean density ranged from 0.0 (1987) to 177.5 (1985) and from 3.0 (2001) to 12.6 (2002). The highest mean density occurred in 1986 (177.5). However by 2001 the mean density had declined to 3.0. Instantaneous growth rates of larvae 5-15 (Notochord length mm) significantly decreased from 0.17 in 1984 to 0.04 in 2003. Total instantaneous mortality rates for 1984 (0.17 16%/d) and 1986 0.15 (14.2%/d) were significantly higher than all other years highest in 1984 (0.17, 15.6%/d) and by 2003 (0.08, 7.6%/d). Growth was not significantly related to larval mortality. The patterns observed during this study suggest that other factors may be responsible recruitment variability observed in the early life history of river herring in Roanoke River.

C21-5

Natal homing in Lake Erie white bass: master navigators or lost wanderers?

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Understanding philopatry (natal homing) in large scale, complex systems is critical for understanding population connectivity, potential colonization patterns, and genetic structure of fish populations. In the spatially complex western basin of Lake Erie, white bass undergo seasonal migrations to spawning habitats located in three large tributaries and a series of near shore reef complexes in western Lake Erie. To investigate philopatry in Lake Erie white bass, we used the distinct, naturally occurring otolith elemental marker from the Sandusky River spawning region to determine the percentage of adult white bass that both originated and spawned in the Sandusky River. Equal numbers of male and female spawning adult white bass were collected over two spawning seasons and the proportion of philopatric individuals were compared as a function of fish sex and spawning season. Results suggest 15-30% of these adult fish were not philopatric and suggest the Lake Erie white bass stocks maintain substantial population connectivity and are not genetically distinct populations.

C21-6
Channel catfish population dynamics in the Platte River, Nebraska
Tony Barada[1] (presenting), Mark Pegg[1]. [1]University of Nebraska-Lincoln, Lincoln, NE, United States

Catfish angling is a very important part of the Platte River fishery and provides significant economic input for Nebraska, yet little is known about their population dynamics in this system. Therefore, our objective was to assess population dynamics of channel catfish, the most sought after sportfish species in the Platte River. We used a fixed site sampling approach at 10 sites to assess catfish populations throughout the Platte River during 2006. Each site was sampled using a suite of gears (hoop nets, trotlines, electrofisher) during three seasons (spring, summer, fall). We examined population characteristics including relative abundance, size structure, age and growth, condition and mortality. Gear comparisons were also made to assess differences in relative efficiencies and fish size distributions. All sampling methods collected different size distributions of catfish with 25-mm hoop nets providing the highest catch rates. Our analyses also suggest highest relative abundances of channel catfish in the lower Platte River. The lower Platte River is subjected to extreme water level fluctuations due to present management strategies (i.e. pulsing), but aquatic habitat is available year-round compared to the central Platte River that has often been seasonally dry. Information gained from the assessment will be important in aiding management decisions for the Platte River as well as other similar riverine systems in Nebraska and the Midwest.

C21-7
Migratory patterns of American shad transported above dams on the Roanoke River, NC
Julianne Harris[1] (presenting), Joseph Hightower[2]. [1]North Carolina State University/North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC, United States,[2]United States Geological Survey/North Carolina State University/North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC, United States

Dams block access to spawning habitat for American shad in numerous rivers including the Roanoke River, NC. In this system, American shad spawn below the lowest dam, at Roanoke Rapids; however, suitable spawning habitat also exists above the third lowest dam. To examine movements and spawning activity in reservoir and riverine areas above dams, American shad were collected in 2007, tagged with transmitters, and transported to upstream habitats. Movements were determined by stationary receivers and manual tracking and spawning was evaluated by plankton sampling for eggs. Fish transported earlier and at cooler water temperatures had higher survival. Many fish made up- and down-stream movements within a reservoir. Approximately 10% of those released in reservoirs migrated to riverine habitats, for a maximum upstream migration distance of 47 rkm. Some individuals moved downstream through dams, with estimated turbine mortality rates of 5-32%. To date, no American shad eggs have been collected in the upper river, but individuals reached riverine areas during the seasonal period and temperature range when spawning occurred at Roanoke Rapids. Trap and transport may be one option for restoring American shad to historic spawning areas presently blocked by dams.

C21-8
Migratory energetics of American shad (*Alosa sapidissima*), an iteroparous anadromous fish
Theodore Castro-Santos[1] (presenting), Benjamin Letcher[1], Stephen McCormick[1]. [1]S.O. Conte Anadromous Fish Research Center; USGS-BRD-Leetown Science Center, Turners Falls, MA, United States

This paper presents an individual-based modeling exercise, in which migratory American shad (*Alosa sapidissima*) ascend the Connecticut River, spawn, and return to the marine environment. We use an integrative approach, incorporating data and assumptions of bioenergetics, reproductive biology, and behavior to improve our understanding of the effects of migratory delays and thermal alterations on distribution, spawning success, and survival. The model is complex, incorporating 62 randomly varying covariates. We quantify the uncertainty within and among these covariate's effects, and explore both how the covariates are likely to affect performance over a range of likely values, and how the uncertainty underlying them influences their predicted effects. Individual and reproductive behavior, physiology, and energetics strongly affected both the distribution of spawning effort and the likelihood of survival to the marine environment. Delays at dams (to both up- and downstream migrations) had dramatic effects on spawning success, driving a) total fecundity and its variance; and b) spatial extent of spawning. Delays, combined with downstream triggers also determined the likelihood of survival to the marine environment. In the absence of migratory delays, migratory distance had little effect on survival, but it did strongly influence both total fecundity and the spatial distribution of spawning effort. In the presence of delays, spawning was largely restricted to the immediate vicinity of dams; in the absence of delays, spawning was distributed along the migratory corridor and throughout the available habitat, with most spawning occurring in the most upstream reaches. Warming the river caused reductions in migratory distance and survival. More research is needed on reproductive biology, behavior, and energetics to adequately understand the interplay of migratory delays and thermal alterations on shad populations;

nevertheless, this exercise suggests that warming rivers through thermal discharge and climate change, and creating obstacles to migration in either direction can have significant detrimental effects to populations of American shad.

C21-9
Blue sucker movements and resource selection in the Middle Missouri River
Ben Neely[1] (presenting), Mark Pegg[2], Gerald Mestl[1]. [1]Nebraska Game and Parks Commission, Lincoln, NE, United States, [2]University of Nebraska - Lincoln, Lincoln, NE, United States

Little is known about movement patterns and habitat use of blue suckers *Cycleptus elongatus*. Telemetry was used to document movements and habitat use of 50 blue suckers in the Middle Missouri River, Nebraska, USA in 2007. Combined acoustic/radio transmitters were surgically implanted into the abdominal cavity of fish ranging from 621 to 839-mm total length in March (N = 10) and October (N = 40) 2007. Blue sucker movements were variable with downstream dispersals to 159-km for March implanted fish and upstream dispersals to 330-km for October implanted fish. Distance dispersed was related to fish mass (P=0.06). Relocated fish were most often found within 10 m of bankline and near large woody debris. Summer home ranges (95% use distributions) varied from 0.8-ha to 21.8-ha for the March implanted fish. Blue suckers are a highly mobile species in spring and fall, though they remain relatively sedentary through summer. Researchers should consider the mobile behavior of blue suckers when studying the species.

C21-10
Wisconsin's contemporary muskellunge genetic resources and implications for management activities
Brandon Spude[1] (presenting), Brian Sloss[1], Ed Murphy[1], Marty Jennings[1]. [1]UW - Stevens Point, Stevens Point, WI, United States

The Wisconsin Department of Natural Resources' (WDNR) muskellunge management goals include maximizing angling opportunities while preserving a population's genetic integrity. The WDNR manages muskellunge through regulations (bag limits and length limits) and a prolific stocking program including supplemental stocking that can threaten the genetic integrity of a population. In the 1990's, genetic research showed low polymorphism and little genetic structure in upper Midwest U.S. muskellunge populations resulting in a more-or-less default watershed delineation. Our objective was to delineate the contemporary stock structure of Wisconsin's naturally recruiting muskellunge populations to provide a more effective framework for managing the muskellunge resource. We used microsatellite genotyping (14 loci) of 39 populations ($n \approx 50$/population) across the native range of muskellunge in Wisconsin. Genetic stock identification of populations with no documented stocking since 1990 showed an east-west split consistent with major watersheds (Chippewa River and Wisconsin River). Two management units, the upper Chippewa River and Lake Superior, were not congruent with recovered genetic units suggesting contemporary watershed boundaries are not sufficient surrogates for the genetic structure of Wisconsin's muskellunge. Continued research aimed at delineating and resolving muskellunge stock boundaries within the state will provide for more accurate and efficient management of Wisconsin's muskellunge resource.

C21-P-1
They were everywhere! Estimates of historic eel distribution during the early 20th Century in New York State
Leonard Machut[1] (presenting), Dawn Dittman[1], James Johnson[1]. [1]USGS Tunison Laboratory of Aquatic Science, Cortland NY, United States

American eel is still considered one of the more widespread fish species in the eastern half of North America. However recent data suggest that eel populations are in severe decline in numerous portions of the range. To fully comprehend the extent of eel declines and the impact on current aquatic ecosystems, it is essential that the eel's historic distribution be accurately estimated. Using reports of early missionaries, naturalists, and statewide surveys, in conjunction with eel life history traits and known migratory barriers, we were able to provide a mapped estimate of eel distribution throughout New York State in the early 20th century. This is a conservative estimate of likely actual historical distribution, because we did not include areas of likely eel inhabitation that lacked any observations. Our mapping and habitat estimates show that eel were able to immigrate into extensive areas of the major NY basins (except for the Alleghany and Lake Erie watersheds) and into the headwater streams and lakes of most river systems.

C21-P-2
Where are they now? Current observations of American eel in New York State
Dawn Dittman[1] (presenting), Leonard Machut[1], James Johnson[1]. [1]USGS Tunison Laboratory of Aquatic Science, Cortland NY, United States

Historically a widely distributed species, the American eel was estimated to have made up 25-50% of the nearshore fish biomass in inland lakes of New York. Alterations of stream connectivity, begun at the time of European settlement and continuing through present day, through the construction of man-made barriers (dams, culverts, etc.) have increased stream fragmentation such that the eel has been functionally extirpated from numerous historic watersheds. We document the current distribution of American eel throughout major basins of New York State in relation to historic estimates and discuss likely reasons for stock declines. Eel that

were historically widely distributed throughout the whole Susquehanna River watershed into its headwaters, throughout the Lake Ontario watershed, and throughout large portions of the Lake Champlain watershed are now rare or functionally extirpated. Within the St.Lawrence River, eel are more rarely encountered than at any time in historic records. In addition, although eel are still well represented in the Hudson River estuary and Delaware River watershed, significant sections of these basins are now inaccessible to American eel.

C21-P-3
Influence of drought, temperature and didymosphenia geminata on brown trout size structures in the Black Hills, South Dakota
Daniel James[1] (presenting), Steven Chipps[1]. [1]South Dakota State University, Brookings, SD, United States

Didymosphenia geminata (didymo), an invasive diatom, was first reported from Rapid Creek in 2002. After the appearance of didymo, brown trout standing stock (kg/ha) decreased by about 60% in Rapid Creek. During this period, drought conditions also affected trout production in the Black Hills, making it difficult to evaluate the influence of didymo on brown trout biomass and growth. We conducted a comparative analysis of brown trout populations in streams with and without didymo in an attempt to isolate effects of didymo on brown trout biomass and size-structure. The three study sections; Rapid Creek in Rapid City, Rapid Creek below Pactola Reservoir and Spearfish Creek in Spearfish Canyon, all experienced low flows due to drought. High summer stream temperatures were recorded only from Rapid Creek in Rapid City. Rapid Creek below Pactola was the only section of stream to experience nuisance blooms of didymo. Brown trout size-dependent biomass histograms were created to compare differences in size structures from the early drought to the late drought/post didymo time periods. Spearfish Creek experienced a 63% decline in biomass of 200-299 mm brown trout with drought as the only factor. Biomass in Rapid Creek below Pactola declined 85% with drought and didymo presence as factors. Biomass in Rapid Creek within Rapid City declined 86% with drought and high stream temperatures as factors. Didymo appears to reduce brown trout biomass in fish 200-349 mm long.

C21-P-4
Analysis of Rio Grande silvery minnow nursery habitat utilization for habitat restoration projects
Michael Porter[1] (presenting). [1]US Army Corps of Engineers, Albuquerque, NM, United States

The Rio Grande silvery minnow (Hybognathus amarus) is an endangered fish species currently found in 170 miles of the Rio Grande in New Mexico. Successful recovery of endangered species depends on identifying the major factors that result in declining populations. Ongoing studies suggest that silvery minnows use inundated floodplains as nursery habitat; therefore, recruitment of silvery minnows corresponds to the level of floodplain inundation during spring runoff. The nursery habitat concept links silvery minnow early life history to changes in river channel morphology and hydrology. Recent studies have documented silvery minnow spawning in inundated riparian areas on pointbars and backwaters. In 2007, a total of 2,836 silvery minnow eggs were collected in kicknet (2,546) and seine 784) samples. There were 324 adult silvery minnows collected proximate to the nursery areas. Geographic information systems (GIS) provide tools for evaluating inundated nursery habitat features for silvery minnow recruitment. Annual variations in spring runoff water levels over the elevation range of habitat features limits study site availability. Combining a before–after, control–impact (BACI) approach with impact versus reference sites (IVRS) at several habitat restoration sites provides a broader perspective on habitat use. These life-history-habitat studies will illustrate ecologically important processes for maximizing recruitment that lead to population stability for successful recovery of the silvery minnow.

C21-P-5
Feeding ecology of lake whitefish larvae in eastern Lake Ontario
James Johnson[1] (presenting), James McKenna[1], Timothy Wallbridge[1], Marc Chalupnicki[1]. [1]USGS, Cortland, NY, United States

We examined the feeding ecology of larval lake whitefish (*Coregonus clupeaformis*) in Chaumont Bay, Lake Ontario during April and May, 2004-2006. Larvae were collected with towed meter nets offshore and with larval seines along the shoreline. Larval feeding periodicity was examined from collections made at 4-h intervals over 24-h. Inter-annual variation in diet composition (% dry weight) was low, as was spatial variation among collection sites within the bay. Copepods (86.1%), primarily cyclopoids (68.7%), were the primary prey of larvae over the 3 year period. Chironomids (7.5%) and cladocerans (6.4%, mainly daphnids – 5.5%) were the other major prey consumed. Food consumption of lake whitefish larvae was significantly lower at night (i.e. 2400 h and 0400 h). Substantial variation in diet composition occurred over the 24-h diel study. For the 24-h period, copepods were the major prey consumed (41.4%) and their contribution in the diet ranged from 13.8% (0400 h) to 74.5% (0800 h). Chironomids made up 37.7% of the diel diet, ranging from 8.0% (0800 h) to 53.8% (1200 h). Cladocerans composed 15.5% of the diel diet, contributing 0.1% (2400 h) to 46.9% (1600 h). In Chamount Bay the larval lake whitefish fed primarily during the day on copepods.

C21-P-6
Survival and growth of brook trout stocked as eggs and fry
James Johnson[1] (presenting), Timothy Wallbridge[1]. [1]USGS, Cortland, NY, United States

The first summer survival and growth of brook trout (*Salvelinus fontinalis*) planted as eggs and fry in a tributary of Cayuga Lake, NY were examined for three years. Trout were planted in December in 20 Whitlock-Vibert (WV) boxes, each containing 300 eyed eggs. The following May, 500 fin-clipped trout fry were released in the same stream section. In autumn, a backpack electroshocker was used to capture fry to assess survival and growth. Mean survival was significantly greater for fry (19.4%) than eggs (0.4%). In autumn, mean length (TL) was significantly greater for trout released as fry (106.7 mm) than those planted as eggs (78.1 mm). When examining differences in survival rates between trout released as eggs and fry one should consider the additional amount of effort required, over five months, to rear an egg to the fry stage in a hatchery. In this particular situation it took about eleven times the effort in the hatchery to release a brook trout fry in May than it did an eyed egg in December. Although the survival of eggs in WV boxes was low, the use of this or similar techniques may warrant consideration under certain restoration or enhancement situations.

C21-P-7
Lateral distribution of fishes in the main-channel trough of a large floodplain river
Steve Gutreuter[1] (presenting), Jon Vallazza[1], Brent Knights[1]. [1]U.S. Geological Survey, La Crosse, Wisconsin, United States

Worldwide, the channels of major rivers have been extensively altered and mitigation strategies for those actions require fundamental information, including how fishes use space. We trawled within parallel paths distributed across the width of the deep main-channel trough of the Mississippi River to identify how the lateral distribution of fishes responds to variations in flow, water temperature and commercial shipping traffic. From those data, we identified factors affecting the lateral distribution of fishes using generalized mixed-effects models based on negative binomial-normal distributions for catch counts. Shovelnose sturgeon were persistent channel residents that remained concentrated along the main-channel centerline regardless of flow, temperature and traffic. Other persistent residents showed either no distinct pattern in lateral distribution, persistently concentrated along the deep channel margins, or varied in lateral distribution with flow. Many species opportunistically occupied the main-channel trough, and especially the outer margins, when flows did not exceed the annual median in our study area. Surprisingly, large adult bluegill, which are conventionally viewed as limnophils, opportunistically occupied the deep channel margins and were the second-most abundant species in our samples. Our results are consistent with the hypothesis that resources in the main channel trough are important to many species.

C21-P-8
A proposed monitoring framework for bull trout wildlife habitat areas in the Peace Region of British Columbia
Nick Baccante[1] (presenting). [1]B.C Ministry of Environment, Frt St John, BC, Canada

Bull trout (*Salvelinus confluentus*) is a fish species in the Salmonid family widely distributed in B.C. They are Blue-listed, which means their populations are declining throughout their global range, mostly in the Pacific North-west States and parts of Alberta. In the Peace Region of B.C. we have numerous healthy populations of Bull trout, but because of their high vulnerability to angling over-exploitation and habitat degradation, we maintain restrictive regulations. Spawning congregations are particularly vulnerable because of the ease with which they can be identified visually. One tool we have available in the Ministry of Environment to protect these spawning areas, is the designation of Wildlife Habitat Areas (WHA). These are spatially defined areas, on Crown Land, established through the Identified Wildlife Management Strategy under the Forest and Range Practices Act of British Columbia. Wildlife Habitat Area is a mapped area with specific habitat attributes, encompassing significant biological occurrences or features. The designation of WHA's, provide a warning flag whenever other government agencies outside Ministry of Environment are faced with development proposals which may encroach WHA's. This acts as an early warning system in the referral process between government agencies. However, there are many limitations on our ability to manage impacts within WHA's. Therefore, each case is dealt with individually, often using adaptive management, mitigation and any other tool that is available, to try and avoid or minimize impacts. The objective of this project is to: develop a simple, cost-effective framework for monitoring the effectiveness of Bull trout WHA's. It needs to be simple so that it can be easily understood by both professionals and anyone else who may be causing impacts or affected by them. Cost-effectiveness is directly related to our Ministry's ability to implement this approach. A costly, complicated methodology is much less likely to be implemented, particularly over the long-term. The proposed framework is based on risk assessment. A GIS analysis of landscape disturbances and a review of available fisheries data provided the basis for measuring risk. The risk scores are then used to determine priorities for further field work. Finally, monitoring the effectiveness of a WHA is a concept, in reality we monitor effects that have impacts on a WHA, and will affect its effectiveness in doing what it was intended to do, i.e. protect Bull trout populations.

C21-P-9
Assessing changes in the inland lake fish communities in Bruce Peninsula National Park, Ontario
Cavan Harpur[1] (presenting), Harold Harvey[1], Nicholas Mandrak[1], Scott Parker[1]. [1]University of Toronto, Toronto, Ontario, Canada

Studies often attribute observed changes in biological communities to direct anthropogenic perturbation, often based on limited knowledge of the range of natural variation in the community. The paucity of natural variation may lead to erroneous conclusions and consequent management actions. To determine the temporal variation of, and factors influencing, fish communities in Bruce Peninsula National Park, 25 small, shallow, remote inland lakes were sampled in 2007 using the same protocol as a study completed in 1973. The morphology and isolation of these lakes, and lack of direct human impacts, make them a model system for studying natural variation in fish communities. Multivariate analyses were used to detect changes in the fish communities between study periods and to identify factors influencing these communities. Preliminary results indicate that some species (e.g. banded killifish) have expanded in distribution and abundance while others have declined (e.g. white sucker), and that the morphology of some lakes has changed substantially as a result of beaver activity and climate fluctuations. Results from this study will provide resource managers with a better understanding of the factors that influence natural community dynamics and provide a baseline of variation that supplies context for observed changes that may require management.

C21-P-10

Analysis of measured and gap-predicted abundances of American eel in the upper Delaware River

Leonard Machut[1] (presenting), Barry Baldigo[2], James McKenna[1], Mari-beth DeLucia[3], Dawn Dittman[1], George Schuler[3]. [1]US Geologic Survey, Cortland, NY, United States, [2]US Geologic Survey, Troy, NY, United States, [3]The Nature Conservancy, Cuddebackville, NY, United States

Riverine gap analysis combines basin, channel, water, and riparian characteristics with fish survey records to classify stream segments and predict potential abundance and distribution of aquatic species. The accuracy and efficacy of model outputs, however, are undefined. Fish communities at 15 sites in tributaries to the upper Delaware River were surveyed in 2006-07 and measured American eel abundances were compared to that predicted by gap analysis to assess accuracy of model predictions and the need for recalibration. At each study site, resident fish were collected from three near-bank seine-blocked sub-reaches using three successive passes with a backpack electroshocker. Quantitative estimates of density at Neversink River sites showed that gap analysis predicted no eels at about half the sites below the Neversink Reservoir where 0.5 to 7.2 eel/100 m2 were found. Excluding sites above the reservoir, gap analyses under predicted densities on average by 4.0 to 4.9 eel/100m2 (using maximum and minimum predictions). Gap analysis may be most accurate for predicting where eel are likely to be found, when a correction factor is included, rather than estimating where eel would not. Reasons for observed discrepancies, suggestions for model improvement, and the need for additional calibration surveys are discussed.

C21-P-11

Reproductive life history variation in Great Lakes naturalized rainbow trout populations

Micale Prévost[1] (presenting), Tom Johnston[2], Lee Haslam[2], Peter Addison[3]. [1]Laurentian University, Sudbury, Ontario, Canada, [2]Ontario Ministry of Natural Resources, Sudbury, Ontario, Canada, [3]Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada

Rainbow trout have been introduced into the Great Lakes since the late 1800s and naturalized populations are now well established throughout the basin. We hypothesized that reproductive characteristics among adults within these populations would vary with both ontogeny and energetic status, and that reproductive characteristics among populations would have diverged to match the particular environments they inhabit. We examined variation in reproductive traits of rainbow trout spawning stocks across the Great Lakes to test the predictions that: i) reproductive investment is positively related to both adult size and body condition within populations, and ii) reproductive investment declines across the Great Lakes from southern (Erie, Ontario) to northern (Superior) populations. Within populations, gonad size (gonadosomatic index, GSI) was positively related to adult size but not to body condition in both males and females. Neither ovary nor testes lipid contents were significantly related to adult size or body condition. Egg size was positively related to female size but not to body condition. Among populations, there was significant variation in both GSI and gonad lipid content in both sexes, and in egg size in females, but the pattern of this variation did not follow the north-south gradient we had predicted.

C21-P-12

Willingness to pay: an essential component of a cost-benefit analysis to support regulatory decisions

May Raad-Young[1] (presenting). [1]HDR Decision Economics, Ottawa, Ontario, Canada

Government agencies whether federal, provincial or state are increasingly relying on cost-benefit analyses to appraise the value of goods and services that are of an intangible nature. The focus on preserving and investing in natural resources whether it is the preservation of species at risk, management of parks, water quality or protection of habitat or natural resources has shifted from a straight economic evaluation of costs and benefits using available market data to that of including valuation from citizens using stated preference methods such as contingent valuation or choice modelling. Incorporating people's estimated value or "willingness to pay" to retain such non-market services or goods involves directly surveying people and eliciting their valuation through a series of thoughtfully designed questions. While this method is still controversial in some circles, it is of one the few methodologies available to capture all types of benefits arising from a non-market good or service. This poster presentation will provide an overview of the value of incorporating willingness to pay estimates as part of a cost-benefit analysis to support regulatory decisions that impact goods and services of an intangible nature using examples drawn from the natural resources sector.

C21-P-13
Use of chemical signatures of otoliths of St. Lawrence River-Lake Ontario corridor (SLRLO) American eel to determine habitat use and migratory behaviour
John Fitzsimons[1] (presenting), Brian Fryer[2], Guy Verrault[3], Remi Tardif[3]. [1]Fisheries and Oceans Canada, Burlington, Ontario, Canada, [2]University of Windsor, Windsor, Ontario, Canada, [3]Ministère des Ressources Naturelles et de la Faune du Québec, Rivière-du-Loup, Quebec, Canada

Up until the 1980s, Lake Ontario supported one of the largest aggregations of large, fecund female American eel in North America but the population has since undergone a precipitous decline. No single cause of the population decline has been identified, though barriers to migration, overfishing, loss of critical habitat, exotic species, and environmental changes in their freshwater and marine habitat, may be involved. Determining the relative importance of each requires an understanding of habitat use and migratory behaviour. As chemical signatures of otoliths have been used for this purpose in Japanese eel, we investigated their use in differentiating habitat use and migratory behaviour of individual American eel in SLRGO. For this we collected elvers from an upstream passage facility, yellow eels from Lake Ontario, and silver eels from immediately below the passage facility as well as 400 km downstream in the estuary of the St. Lawrence River. Otoliths were removed, processed, and temporal changes in strontium, barium, zinc, magnesium and calcium contents of otoliths in combination with age data examined with laser ablated inductively coupled plasma mass spectrometry. The work revealed age and habitat-specific variation that was element specific that will be useful in determining habitat use and migratory behaviour.

C21-P-14
Movement patterns and fish passage of redband trout in the Donner und Blitzen River, Oregon, U.S.A.
Matthew Anderson[1] (presenting), Guillermo Giannico[1], Steve Jacobs[1]. [1]Oregon State University, Corvallis, OR, United States, [2]Oregon Department of Fish and Wildlife, Corvallis, OR, United States

Redband trout (*Oncorhynchus mykiss*) in the Donner und Blitzen River seem to exhibit a variety of migratory strategies prior to spawning. The objectives of this study were to examine redband trout spawning migration, the resulting seasonal distribution patterns, and the effects of irrigation diversion dams on fish passage. Radio telemetry and PIT tagging were used to track adult trout movements for 15 months starting on March 2007. Spawning migration timing, travel distance, and spawning location were determined based on radio telemetry tracking of 75 trout. Large scale movement patterns of over 1,000 trout were also monitored at four PIT tag antenna stations. Timing of migratory movements was compared to stream flow and temperature. Summer residence locations of trout and stream temperature were monitored for evidence of a possible temperature limitation to trout distribution. Upstream fish passage was evaluated at three diversion dams using arrayed PIT tag antennae to determine whether redband trout movements were delayed or prevented by the structures. Results to date suggest spawning timing and locations overlap for fish that reside in different locations in the river, and that passage delays may influence the migration speed and distance of fish from the lower river.

<u>C22. Fish Culture</u>
C22-1
Tank culture of sunshine bass fingerlings without using rotifers
Gerald Ludwig[1] (presenting), Steve Lochmann[1]. [1]HKD Stuttgart National Aquaculture Research Center, Stuttgart, Arkansas, United States, [2]University of Arkansas at Pine Bluff, Pine Bluff, Arkansas, United States

Previously reported protocol for culture of sunshine bass larvae to fingerling size in tanks involved an initial feeding of rotifers for several days before the larvae are weaned to feed on Artemia nauplii. Maintaining rotifer cultures requires space, time, equipment, supplies, trained culturists and the cultures are often unstable. Elimination of the use of rotifers would greatly enhance the feasibility of reliable tank culture of fingerlings and should reduce its cost. This experiment was comprised of three treatments with three replicates per treatment: larvae fed standard size Artemia nauplii (0.48 mm X 0.19 mm), larvae fed microcyst Artemia nauplii (0.43 mm X 0.18 mm), and larvae fed rotifers (Brachionus plicatilis) (0.26 mm X 0.16mm) and weaned to standard size Artemia nauplii by 11 days post hatch (dph). Sunshine bass larvae, 4 dph, were stocked into 100 L tanks at 75 larvae/L. The initial daily feeding rates were 20 rotifers or nauplii/mL. That was increased to 20/mL, twice/d at 5 dph and then changed to 10/ml, twice/d at 6dph. The experiment lasted until 14 dph. At 14 dph, 4.3 % of the larvae fed only standard Artemia nauplii survived while significantly more, 43.0%, of those fed microcyst Artemia nauplii and 93.6% of those receiving rotifers and standard Artemia nauplii survived. At 14 dph, average standard lengths (7.26 mm) of larvae fed microcysts or rotifers and standard Artemia nauplii (7.13 mm) were both significantly longer than that of larvae receiving standard Artemia nauplii (6.86 mm). During previous experiments, larvae that were not fed had 0% to 0.01% survival by the end of 11 dph. This experiment is the first time that sunshine bass have been cultured to 14 dph while being fed Artemia nauplii but without being fed rotifers.

C22-2
Stocking density effects in phase one culture of hybrid striped bass (*Morone chrysops* ♀ x *M. saxatilis* ♂, Percichthyidae)

Erica Brumbaugh[1] (presenting), David A. Culver[1]. [1]Ohio Sate University, Columbus, Ohio, United States

Variable survival and growth of juvenile hybrid striped bass are problems for hatchery managers, and have been attributed to pond temperature fluctuations, fry stocking stresses, insufficient food, and even predation by copepods. In this study, we compared diets of HSB with zooplankton biomass at Senecaville State Fish Hatchery in eight ponds with different stocking densities (30 or 60 fry/m3) and pond volumes (2,600 to 6,000 m3). Ponds stocked with 60 fry/m3 produced more fingerlings and higher yield (30 fish/m3 and 5.75 g/m3) than did low density ponds (21 fish/m3 and 4.18 g/m3); however, survival was higher at 30 fry/m3 (70 vs. 46%). Ponds larger than 4,000 m3 produced heavier fish at harvest (0.30 vs. 0.09g). Fish diets throughout the culture period consisted of cladocerans, copepods, rotifers, insects, chironomid larvae, fish and ostracods. Total zooplankton biomass was highest in the two high stocking density ponds >4,000 m3, yielding 5.31 g/m3 and 44% survival. Future work will include laboratory experiments to examine early feeding preference (rotifers or small crustaceans) and the possibility of cyclopoid predation at levels observed in the hatchery ponds.

C22-3

Biotechnological strategy to enhance human health beneficial omega- 3highly unsaturated fatty acids (HUFA) in fishes

Garima Bajpai[1], Shiva D. Singh*[1] (presenting). [1]Central Insitute of Fisheries Education, Mumbai, India, [2]Central Insitute of Fisheries Education, Mumbai, India

Some fishes are important dietary source of long chain Omega-three C-20 (ecosapentaenoic acid, EPA, 20:5, n-3) and C-22 (docosahexaenoic acid, DHA, 22:6, n-3) fatty acids (HUFA) which are crucial to vertebrates and human health. They play pivotal roles in neural development, cardiovascular functions and in prevention of coronary heart disease. Desaturases and elongases enzymes catalyze in vivo double bond formation and chain elongation – a key regulatory step in HUFA biosynthesis. The present work was undertaken to study molecular analysis and characterization of fatty acyl delta-6 desaturase gene of Labeo rohita - an Indian major carp of global significance using biotechnological strategy. With the use of L. rohita genomic DNA and primers specific for delta-6 desaturase gene, a allele fragment of around 625 bp of above gene was amplified by PCR and cloned in E. coli / plasmid, pTZR/T vector (2.866 bp) using ampicillin selection marker. The insert, 625 bp was reconfirmed by PCR and cleavage with restriction enzymes followed by gel electrophoresis. Cryopreserved recombinants containing delta-6 desaturase gene are useful in large scale production of novel gene which, with suitable constitutive promoter, may have application in auto-transgenesis for enhancing the qualitative trait i.e. HUFA content in appropriate fishes beneficial for human health.

C22-4

Saturated lipid key to restoration of beneficial fatty acid profile in sunshine bass—a way out of the fish oil trap

Jesse Trushenski[1] (presenting), Heidi Lewis[1], Christopher Kohler[1]. [1]SIUC, Carbondale, United States

To restore nutritional value to cultured fish, fillet fatty acid (FA) composition can be tailored by transitioning from alternative lipid-based, low highly unsaturated FA (HUFA) content grow-out feeds to fish oil (FO)-based, high HUFA 'finishing' feeds before harvest. Coconut (CO), grapeseed (GO), linseed (LO), and poultry (PO) oils were evaluated in sunshine bass (Morone chrysops x M. saxatilis) grow-out feeds to assess the responsiveness of the resultant fillets to finishing. Practical feeds were formulated to contain FO or a 50:50 blend of FO and alternative lipid. Experimental feeding regimes employed these feeds with or without a finishing period. Gross production performance was unaffected by the various feeding regimes, but fillet FA profile was significantly altered. Finishing had a significant restorative effect on fillet FA composition, however, complete restoration of FO-associated profile was achieved only in the CO-fed group. Medium-chain PUFA found in GO, LO, and PO compete with HUFA for deposition in fillet tissue, impeding restoration of beneficial fillet profile during finishing, whereas the saturated FA of CO do not. Our results demonstrate sunshine bass fillets with equivalent LC-PUFA content and associated nutritional value can be produced using a reduced FO grow-out feed followed by an 8-week finishing period.

C22-5

Effect of dietary immunostimulants on immunity and disease resistance of channel catfish and Nile tilapia

Thomas Welker[1] (presenting), Chhorn Lim[1], Richard Shelby[1], Mediha Yildirim-Aksoy[1], Phillip Klesius[1]. [1]Agricultural Research Service, United States Dept. of Agriculture, Aquatic Animal Health Research Unit, Auburn, AL, United States

Research suggests that immunostimulants added to diets can improve the ability of fish to respond to disease challenge. However, the effectiveness of most immunostimulants, even within a species, can vary considerably. We have conducted several studies examining the effects of whole-cell yeast (*Saccharomyces cerevisiae*) and yeast-subcomponents (β-glucans and mannan oligosaccharides) (YYS), bovine lactoferrin, and probiotics (various bacterial species) added to diets on immune function and disease resistance in channel catfish and Nile tilapia. Results have been inconsistent. Feeding diets containing commercially available, live probiotic bacteria (Saccharomyces, Bacillus, Pediococcus, and Enterococcus sp.) did not affect immune function or improve resistance of catfish or tilapia to bacterial challenge. When fed YYS-supplemented diets, fish also did not show improvement in immune function or disease resistance after 4 or 6 weeks of feeding, but shorter feeding durations of 1 or 2 weeks appears promising in channel catfish. However, dietary supplementation of bovine lactoferrin increased survival of both channel catfish and Nile tilapia to disease challenge, possibly by limiting iron availability to the challenge bacterium. Results from these studies will be summarized and discussed. Further research is needed and continues on the effects of immunostimulants on immunity and disease resistance in channel catfish and tilapia.

C22-7

Evaluation of a pilot recirculating aquaculture system for intensive culture of red drum *Sciaenops ocellatus* in Florida

Micah Alo[1] (presenting), Angela Dukeman[1], Kerry Mesner[1], Dan Roberts[1], Josh Taylor[1], Chad Young[1], Chris Young[1].
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The Florida Fish and Wildlife Conservation Commission (FWC) developed a pilot recirculating aquaculture system (RAS) at the Stock Enhancement Research Facility (SERF) in Palmetto, Florida, to evaluate the intensive culture of juvenile red drum, *Sciaenops ocellatus*. The prototype RAS was constructed within a 98-m2 area of the existing hatchery building with access to treated seawater, temperature control, compressed oxygen, and system monitoring. This prototype system was developed to culture phase-I fish, 30-50 mm standard length (SL) to phase-III release size (130-180 mm SL) for stock enhancement research. Thirty five thousand phase-I red drum fingerlings were harvested from a 0.4-Ha pond and held in quarantine for 32-days for grading and parasite treatment within a greenhouse facility prior to stocking the pilot RAS for intensive culture. The RAS system is composed of three 12.3-m3 dual drain circular culture tanks connected to two 2-m3 sumps. Between 70-90% of tank effluent exits the side drain and is routed through a 60-u drum filter before reaching the sumps. The remaining effluent from the bottom drains are treated by radial flow clarifiers at each tank before. Both sumps have side-loops for additional water treatment by two 2-m3 biofilters filled with 1.4-m3 of media, two 300-liter degas towers, a 570-liter/minute foam fractionators, a 1,950-watt UV sterilizer, and a 1-m3/minute oxygen cone. A high survival of 95.7% and an increase of estimated total fish biomass from an initial 134.4 kg to 380.9 kg at 29-d post-stocking indicates system performance to be beneficial. Further inference of culture system and fish performance based on analysis of fixed effects (system function, ration and feeding rate) and response variables (dissolved oxygen, carbon dioxide, temperature, salinity, pH, alkalinity, nutrients (NH_3, NO_2, NO_3), BOD, and total suspended solids, fish growth and survival) is discussed.

C22-P-1

Ammonia, organics, metals, and p: monitoring hatchery water quality

Cathleen Doyle[1] (presenting), Ruth Briland[1], Kristina Carlson[1], David Culver[1]. [1]The Ohio State University, Columbus, OH, United States

Production in aquaculture operations is dependent on suitable water quality for fish growth and survival. Recent variability in Ohio's State Fish Hatchery production suggests that further research was needed to evaluate variation and suitability of hatchery water supplies. Because each water quality parameter interacts with and influences others in different ways, we characterized basic hatchery water quality at all six state fish hatcheries. We found ammonia contamination in source water, high pH and low dissolved oxygen caused by excess nitrogen and phosphorus from agricultural runoff and hatchery operations, the presence of potentially toxic Cyanobacteria (Cylindrospermopsis) and unacceptable concentrations of several metals, herbicides, and industrial chemicals. Our research found that a diversity of water quality problems exists in hatchery source waters, and suggests continued monitoring and work to identify ways to mitigate these problems will improve fish production.

C22-P-2

Improving juvenile percid size at harvest

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Larval walleye (*Sander vitreus*) and saugeye (walleye ♀ x sauger *S. canadensis* ♂) survival and growth in earthen rearing ponds is highly variable from year to year and between ponds. Preliminary monitoring revealed insufficient zooplankton forage base (<100 individuals/L) for the first 4 weeks after filling from an adjacent reservoir. We attempted to match growth of zooplankton in the ponds with the fish dietary demands by adjusting fry stocking density (30 or 50 fry/m3), and timing relative to the dates ponds were filled with lake water (concurrent vs. 2 wks before fry stocking). Results from 2006, indicate that low fish density and concurrent filling schedule produced more robust (albeit fewer) fish. In 2008 we will attempt to increase the size of fingerlings at harvest, without substantially decreasing yield, testing three fry stocking densities (20, 35 and 50 fry/m3). Experiments conducted in 2007 found that saugeye fingerlings are significantly larger than walleye at harvest. We will include both species in the experiment to determine the ideal fish stocking density to maintain high yield and robust size of both fish at harvest.

C22-P-3

Alternative lipids do not affect production performance of Nile tilapia—fatty acid metabolism similar among lean-fleshed fishes?

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Fatty acid (FA) composition of cultured finfish can be tailored by transitioning fish reared on alternative lipid-based, low highly unsaturated fatty acid (HUFA) content grow-out feeds to fish oil (FO)-based, high HUFA 'finishing' feeds prior to harvest. We have demonstrated the FA composition of the alternative lipid can affect overall finishing success and that saturated lipid maximizes HUFA augmentation during finishing of a lean-fleshed, cool water fish, sunshine bass (Morone chrysops x M. saxatilis). To determine whether similar processes of lipid utilization and FA turnover occur in a lean-fleshed, warm-water species, coconut (CO), grapeseed (GO), linseed (LO), and poultry (PO) oils were evaluated in Nile Tilapia (*Oreochromis* niloticus) grow-out feeds with respect to production performance and responsiveness to finishing. Similar to sunshine bass, weight gain (204.9 ± 8.0% over 12 weeks, mean ± SE), food conversion ratio (1.9 ± 0.1), and dress-out (87.6 ± 0.3%) of Nile Tilapia were unaffected by application of the various feeding regimes, indicating this warm-water species can effectively utilize CO, GO, LO, PO, and FO in aquafeeds. Influence of grow-out feed composition and implementation of a finishing period on fillet FA composition and the relative amenability of fillets to HUFA augmentation will be presented.

C22-P-4

Comparasion of a new alternative fish tank material

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The costs of purchasing, installing and maintaining the growout facility may represent the biggest investment cost for an aquaculture operation. Therefore, alternative materials that have the potential to maintain or increase productivity while reducing costs can have a large impact on profitability. One such material is high density polyethylene (HDPE) plastic. The costs and benefits of purchasing, installing, and operating a 2000 gallon (7560 liter) plastic “U” shaped raceway in West Virginia were estimated and compared to a traditional flat bottom concrete raceway system of similar volume in Pennsylvania. The cost of installing a 2000 gallon (7560 liter) concrete system was estimated using recent quotes from local concrete tank manufacturers. Preliminary results indicate that the plastic “U” shaped tanks are considerably (47%) less expensive to purchase, install, and operate than the comparable concrete system. This provides medium and small sized aquaculture operations with an adaptable product that lowers the cost of fish production, provides flexibility with design changes, and allows for a resale value due to the mobility of the lightweight tank. Other benefits include lower labor requirements for waste management. The solid removal manifold in the plastic tank allowed for efficient tank cleaning to occur, which ultimately helps lower operating costs and increase profitability. The study has implications for small and medium-scale aquaculture operations in West Virginia and surrounding states with similar resource endowments. The increased adoption of new materials such as HDPE will lead to increased production and regional economic development benefits.

C22-P-5

Effect of plant material dietary supplement on growth, food consumption and hematoloy in rainbow trout

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Many aquaculture facilities use vaccines, and antibiotics to prevent the outbreak of diseases. The widespread use of antibiotics has lead to the appearance of drug-resistant bacteria. In recent years, immunostimulants such as medicinal plants have been used as an alternative treatment. Fish diets fortified with medicinal plants aid in prevention of the outbreak of diseases in aquaculture facilities by heightening the innate immunity of fish. The effects of plant material supplemented feed on disease resistance were determined in rainbow trout (*Oncorhynchus mykiss*). The fish were orally administered plant material. Plant material was added to commercial fish diet in 0, 5, 10, 20, 40 g/kg doses. Experimental fish were feed twice daily to satiation for a period of 6 months with control groups fed only the commercial diet. Blood was drawn after three months and at termination for constituent analyses (PVC, differential blood count) and serum chemistry. Weights and lengths were measured weekly to determine performance. We will present data demonstrating growth performance, proximate composition and comparisons of blood parameters between experimental and control groups.

C22-P-6

EcoLE-FisH: modeling the impacts of lower trophic level-fish-human interactions on Lake Erie walleye

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Current ecological studies are slowly shifting their focus from traditional reductionism to a more holistic, integrationist approach, thereby allowing the study of complex interactions across large spatial scales. This approach is appropriate for large-lake piscivores that undergo major migrations to spawning sites in rivers and on offshore reefs. EcoLE-FisH is a two-dimensional length-depth mathematical model of Lake Erie built upon U.S. Army Corps of Engineers' CE-QUAL-W2. EcoLE-FisH incorporates the dynamics of Lake Erie's physical, chemical, and lower trophic level components, as well as adult and young-of-year walleye dynamics, and fishery management to explore the walleye recruitment process. Model results for 1997-2000 suggest that while eggs typically experienced the highest mortality rates (4.47-6.44%/day), the larval and juvenile stages were crucial in determining year-class strength each year. Low pre-spawning temperatures increased recruitment by 65% in 1999 and by 23% in 2000. The larval stage was the most responsive to thermal change, as faster warming rates associated with low pre-spawn temperatures were correlated with increased survival of YOY walleye. High pre-spawn temperatures had less predictable impact on larval survival.

Also, food availability did not influence recruitment, while the hydrodynamic transport of eggs and larvae had an unpredictable impact on recruitment.

C22-P-7

Intraspecific competition in larval lake whitefish: the interactive effect of food availability and fish density on growth rates in a laboratory setting

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Initial feeding of larval fish as they convert from endogenous to exogenous feeding can affect larval survival, growth and ultimately recruitment. Survival through this critical life stage is often the source of the highest mortality for any given fish species. Through laboratory experiments, it is possible to test factors that contribute to different levels of survival and growth. Understanding what effect food availability and larval density has on larval lake whitefish growth in experiments is vital to extrapolating density dependant intra-specific competition theories to the wild. We experimentally reared lake whitefish from eggs collected from Clear Lake located in the Allagash Watershed in northern Maine. Initial feeding consisted of 2-day old Artemia sp. In the laboratory, we tested the interactive effect of food availability and fish density had on growth of larval lake whitefish. Fish were placed into three different food availability treatments and three different fish density treatments. Fish were then reared for an eight week period following first exogenous feeding at approximately 21 days post hatch. Digital photographic sampling was performed every two weeks. Fish lengths were measured using ImageJ software and averaged as treatment groups for each sample period. Analysis of length changes over time show the varying effects that food availability and tank density has on growth. As expected, growth of lake whitefish decreased as density increased and food decreased. Likewise the opposite was true for the slowest growth rates occurring in the high density/low food treatments. The magnitude of these effects on growth rate varied accordingly to treatment levels. Expected results should identify the individual effects of food availability and fish density. More specifically, we hope to be able to identify which is the more dominant causative factor in intraspecific competition among larval lake whitefish.

C22-P-8

Assessment of fish yield in Patagonian lakes (Argentina): development andapplication of empirical models

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The relationship between fish yield and basic limnological information is important for developing sustainable management policies for lake fisheries, particularly when fish data are lacking. Most Patagonian lake fisheries lack the basic statistical information provided by bycatch and effort data. We present a simple first-order model of fish yield based on the relationship between fish biomass derived from hydroacoustic and gill-net surveys developed for 18 small Patagonian lakes. Such a model can be used to develop sound management guidelines that can be applied to the many unsampled small lakes of Patagonia for which basic limnological data are available. We also evaluated the value of well-known models developed from North American data sets. These models consistently underestimated fish yields in the Patagonian lakes, particularly as trophic level increased, illustrating the importance of using region-specific data to develop fish management guidelines. The poor predictive performance of the North American models could be related to climatic, limnological, and fish community differences between North American and Patagonian lakes.

C22-P-9

Controlling fungus during jar incubation of rosy red fathead minnow eggs

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High yields of small fathead minnows (FHM) used as feeder fish can be produced by stocking FHM fry. Fry are obtained by removing FHM eggs from substrates with a sodium sulfite solution and jar hatching, but losses to fungus during incubation remain a problem. Three rates each of formalin or hydrogen peroxide (500; 1,000; 1,500 mg/L) versus a non-treated control and three flow rates (35; 60; 85 mL/min) were tested for efficacy in controlling fungus during incubation of rosy red FHM eggs. Eggs ≤24 h-old were removed from substrates and 1-mL lots placed into 50-mL jars. Treatments consisted of once daily, 15-min, flow-though applications of formalin, hydrogen peroxide or control (60 mL/min flow rate for all) for the first study or three flow rates for the second study. Each treatment had 5 replicates. Peristaltic pumps on each jar maintained flow rates. Hemp seed bags, inoculated with fungus, were placed in the water supply tank for fungus exposure. No significant differences were found among the chemical treatments (range: 42.9 to 89.5%) and the control (range: 1.7 to 89.4%; Kruskal-Wallis H Test), given that fungus was not always evident, but the control group had replicates with the lowest hatch rates. No significant differences were found in the flow rates (Kruskal-Wallis H Test) however, there were large differences in ranges between the 35 ml/min (range: 79.1 to 86.0%) and the other two higher treatment rates (range: 1.3 to 87.8%). Future research on chemical/flow rate interactions is planned.

C23-P-1

Reproductive success of reconditioned steelhead kelt

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Parentage analysis was used to determine the reproductive success of reconditioned steelhead trout (*Oncorhynchus mykiss*). One male and two female kelts were reconditioned and released in October of 2005. Originally collected from Omak Creek (Okanogan River drainage, Washington) as broodstock in spring of 2005, fish were air spawned prior to reconditioning and release into Okanogan River. Volitional return to Omak Creek above a semi-permanent weir was shown for the reconditioned male. Parentage assignment using 16 microsatellite loci was used to assign three juveniles collected in 2007 to the reconditioned male. An additional seven juveniles collected in 2006 were assigned to the reconditioned kelts, but at lengths consistent with the first spawning event in the hatchery. This study demonstrated that it is possible for steelhead broodstock to be reconditioned and successfully spawn in the wild in subsequent years. The study is ongoing at multiple sites to determine the reproductive success of reconditioned kelts and the potential of this strategy to assist in recovery of ESA listed steelhead populations.

C23-P-2

Pumpkinseed habitat morphs in freshwater reservoirs of Portugal: a result of sympatric divergence?

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The pumpkinseed (*Lepomis gibbosus*) is a North American species that was introduced into Europe in the late 1800s, and has since undergone rapid expansion in parts of its non-native range. In Portugal, pumpkinseeds occupy freshwater reservoirs that contain fluvial and lacustrine zones with varying trophic environments. These reservoirs offer unique possibilities for morphological diversification of pumpkinseeds because of the range of habitats, the dearth of native predators and competitors and the possibilities for planktivory in these fluctuating environments. Our previous work has shown that strong morphological differences exist between pumpkinseeds occupying four unique habitats within these reservoirs. Given that the introduction of pumpkinseeds into Portugal occurred within the last 50 years, any genetic differentiation among habitat ecotypes found in the reservoirs could likely be result of sympatric divergence. Using microsatellite markers, we tested the prediction that if pumpkinseeds have diverged sympatrically, then genetic differentiation between pumpkinseeds from the four habitats will be low compared to the variation between reservoirs. Results from the genetic analysis will show whether the strong morphological separation among habitats is a result of sympatric divergence or phenotypic plasticity, the latter being more likely, given the high degree of plasticity seen in native pumpkinseeds.

C23-P-3

Genetic identification of Lake Erie smallmouth bass tributary stocks and their contribution to the Lake Erie population

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Throughout the 1900's Lake Erie was being heavily polluted extirpating many fish species. Now only a few healthy fish populations remain. One species that is both ecologically and economically important is the smallmouth bass, *Micropterus dolomieu* Lacepede. Smallmouth bass have been consistently the second highest targeted sportfish by boat anglers from 1988 to 2005 (Einhouse et al. 2006). The fishery is most likely based on wild strain of smallmouth bass. However, in order to properly manage the smallmouth bass population in Lake Erie a comprehensive understanding of the population genetics is needed. Therefore; the purpose of this study is to collect genetic information from both tributary and lake spawning smallmouth bass. The information gathered will be used to investigate the genetic variability among sites. Also, it will be used to determine what the contribution of lake versus tributary spawned fish is to the local adult population. All the tissue samples have gone through the process of DNA purification. Currently the samples are being processed so that the genetic variability can be assessed using eight microsatellite loci which allow researchers to identify what populations' individual fish originate. The genetic data gathered will be contributed to an existing smallmouth bass genetic database.

C23-P-4

Genetic relationships of Suwannee bass *Micropterus notius* populations in six Florida rivers

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Suwannee bass *Micropterus notius* are endemic to Florida and Georgia. We evaluated the genetic relationships of Suwannee bass in six rivers by conducting protein electrophoresis, mitochondrial DNA (mtDNA) restriction fragment polymorphism analysis (RFLP; ND3/4 region, 6 restriction endonucleases), and mtDNA sequencing (ND2 gene). Significant levels of genetic variation were

observed among populations. Both the allozyme and mtDNA sequence data indicated that the Suwannee River and Santa Fe River (a tributary of the Suwannee River) collections were more closely related to each other than to the four western populations. Results from the mtDNA RFLP dataset were in discordance with the other two analyses in that the St Marks and Wakulla (a tributary of the St Marks) collections were more closely related to collections from the Suwannee River drainage than to samples from the Ochlockonee and Wacissa Rivers. However, extremely low RFLP haplotype diversity in the St. Marks and Wakulla River suggests that these populations passed through a population bottleneck; the loss of less abundant RFLP haplotypes during a bottleneck event would obscure the true relationships of the St Marks and Wakulla River collections to the other populations. Population bottlenecks might have occurred naturally or have been the result of a small number of bass having been stocked into drainages outside the species native range. We were unable to definitively conclude whether the Suwannee bass inhabiting three rivers where unauthorized angler releases had been suspected were introduced from other watersheds or represent natural populations.