

GLOBEC Sessions

GLOBEC-1 ENDEAVOR: Tuesday January 14, 10:00 AM - Noon

- Hal Batchelder – Workshop Introduction/Overview/Structure
- Tom Royer – *Ocean climate conditions during GLOBEC Northeast Pacific Program (NEP Long Term Observation Program (LTOP))*
- Phyllis Stabeno – *Overview of Shelf Transports in the Gulf of Alaska*
- Craig Lee – *Seaglider surveys of the Alaska Coastal Current*
- Ned Cokelet – *Factors affecting the distribution of juvenile salmon in the Gulf of Alaska: physical oceanography*
- Terry Whitledge – *Seasonal cycles of nitrate concentrations on the Gulf of Alaska shelf from the GAK4 mooring*
- Evelyn Lessard – *Seasonal and spatial dynamics of plankton communities on the Gulf of Alaska Shelf*

GLOBEC-2 ENDEAVOR: Tuesday January 14, 1:30 – 3:00 PM

- Suzanne Strom – *Seasonality in planktonic community structure, phytoplankton growth and microzooplankton grazing in the coastal Gulf of Alaska*
- Ken Coyle – *Annual cycle of zooplankton abundance, biomass and production on the northern Gulf of Alaska shelf, October 1997 through October 2000*
- Russ Hopcroft – *A comparison of copepod egg production rates in the Gulf of Alaska*
- Jeff Napp – *Secondary production and advection of shelf zooplankton in a predominantly downwelling ecosystem*
- Tom Kline – *Patterns of fish food source generation and utilization in the northern Gulf of Alaska and Prince William Sound*
- Lew Haldorson – *Seasonal and annual patterns of abundance and size of juvenile pink salmon on the shelf of the northern Gulf of Alaska*

GLOBEC-3 ENDEAVOR: Tuesday January 14, 3:30 - 5:00 PM

- Ned Cokelet – *Factors affecting the distribution of juvenile salmon in the Gulf of Alaska*
- Nick Bond – *Diagnosis of coastal Gulf of Alaska air-sea interactions using a high resolution numerical weather prediction model*
- Al Hermann – *Nested biophysical modeling of the coastal Gulf of Alaska: inferences from recent circulation results*
- Dave Musgrave – *Comparison of the coastal Gulf of Alaska circulation (3-km grid) to GLOBEC data*
- Sarah Hinckley – *Progress in 3-dimensionalization of GLOBEC coastal Gulf of Alaska NPZ model and other aspects of CGOA NPZ modeling*

GLOBEC POSTER Sessions:

MID/AFT DECKS Monday, January 13, 5:00 – 7:30 PM

MID/AFT DECKS Wednesday, January 15, 1:30 – 3:00 PM

- J. Armstrong et al. – *GOA juvenile pink salmon food habits and feeding patterns*
- R. Briscoe et al. – *Growth and survival of Auke Creek coho salmon*
- A. Byrd and R. Hopcroft – *Production of Oithona similis*
- R. Childers et al. – *Nitrate sources and sinks on the N Gulf of AK shelf*
- N. Cokelet et al. - *Factors affecting the distribution of juvenile salmon in the Gulf of Alaska: physical oceanography*
- A. Cross et al. – *Modeling bioenergetics of juvenile pink salmon in PWS and coastal Gulf of Alaska*
- S. Danielson et al. – *Variability in heat flux over the N. Gulf of Alaska shelf*
- E. Dobbins et al. – *Physical-biological models of the CA current system and the coastal Gulf of Alaska*
- E. Farley and J. Helle – *PWS juvenile hatchery pink salmon in the GOA*
- L. Haldorson and J. Boldt - *Seasonal and annual patterns of abundance and size of juvenile pink salmon on the shelf of the northern Gulf of Alaska*

GLOBEC Posters (continued)

- K. Hedstrom et al. – *Lagrangian drifters in the GOA*
- A. Hermann et al. – *Nested biophysical modeling of the coastal Gulf of Alaska: inferences from recent circulation results*
- S. Hinckley et al. – *Progress in 3-dimensionalization of GLOBEC coastal Gulf of Alaska NPZ model and other aspects of CGOA NPZ modeling*
- R. Hopcroft et al. – *Copepod egg production rates in the GOA: 1. Pseudocalanus spp. 2. Metridia spp.*
- C. Kondzela and R. Wilmot – *Origin of juvenile chum salmon in GOA coastal waters*
- N. Kachel et al. – *Nutrient supply to the GOA shelf in summer- role of troughs and banks*
- T. Kline – *Fish food source generation and utilization in N GOA and PWS*
- C. Lee and C. Eriksen – *Seaglider surveys of the Alaska Coastal Current*
- E. Lessard and M. Foy – *Seasonal and spatial dynamics of plankton communities on the Gulf of Alaska Shelf*
- H. Liu et al. – *Growth rates of Neocalanus flemingeri*
- H. Liu and M. Dagg – *Modifications of pelagic food webs by particle grazing copepods*
- E. Macri et al. – *Phytoplankton community structure in the coastal GOA*
- R. Mendelssohn et al. – *Climate trends in the N. GOA, 1950-97*
- C. Mordy et al. – *Variability of phytoplankton blooms in the N. GOA*
- J. Moss et al. – *Trophic interactions and energetics of juvenile pink salmon*
- D. Musgrave et al. – *Comparison of the coastal Gulf of Alaska circulation (3-km grid) to GLOBEC data*
- J. Napp and C. Baier – *Secondary production in a downwelling ecosystem: egg production of copepods*

GLOBEC Posters (continued)

- J. Napp et al. – *Advection of shelf zooplankton in a downwelling ecosystem: bioacoustic detection of variability*
- A. Pinchuk et al. – *GOA euphausiids*
- R. Reed et al. – *Mesoscale variability along the Kenai peninsula*
- N. Sarkar et al. – *CEOF analysis of the hydrography of the Seward Line*
- I. Schroeder et al. – *Variability of the hydrography along the Seward Line*
- L. Slater and R. Hopcroft – *Growth rates of the copepod *Centropages abdominalis**
- P. Stabeno et al. – *Along and cross-shelf flow in the GOA*
- S. Strom and B. Olson – *Seasonality in phytoplankton community in the GOA*
- M. Sturdevant et al. – *Diel feeding of juvenile salmon in Icy Strait, SE AK*
- T. Weingartner et al. – *Freshwater variability in the AK coastal current*
- T. Whitledge et al. – *Seasonal cycles of nitrate concentrations on the Gulf of Alaska shelf from the GAK4 mooring*
- W. Williams and T. Whitledge – *Model of seasonal variability in AK coastal current*

Steller Sea Lion Investigations - Sessions

FORE DECK

Factors Affecting the Population

<i>Predation</i> SSLI-1	Tuesday January 14 9:45 - 11:00 AM
<i>Disease, Parasites, & Contaminants</i> SSLI-2	Tuesday January 14 11:00 AM - Noon
<i>Disease, Parasites, & Contaminants</i> SSLI-13A	Thursday January 16 4:45 - 5:00 PM
<i>Environmental Change</i> SSLI-3A	Tuesday January 14 1:30 - 3:00 PM
<i>Environmental Change</i> SSLI-3B	Tuesday January 14 3:30 - 5:00 PM
<i>Subsistence Harvest</i> SSLI-4	Posters only
<i>Fisheries, Fish Assessment & Dynamics</i> SSLI-5	Wednesday January 15 8:00 - 9:45 AM
<i>Steller Sea Lion Biology and Ecology</i>	
<i>Population Status & Dispersal</i> SSLI-6	Wednesday January 15 9:45 AM - Noon
<i>Population & Bioenergetic Modeling</i> SSLI-7	Wednesday January 15 1:30 - 3:00 PM
<i>Diet</i> SSLI-8	Wednesday January 15 3:30 - 5:00 PM
<i>Transmitter Developments</i> SSLI-9	Thursday January 16 8:00 - 8:30 AM
<i>Nutrition and Hormones</i> SSLI-10	Thursday January 16 8:30 - 10:00 AM
<i>Feeding & Diving Ontogeny</i> SSLI-11	Thursday January 16 10:30 AM - Noon
<i>Site Specific Studies</i>	
<i>Kodiak</i> SSLI-12	Thursday January 16 1:30 - 4:15 PM
<i>Prince William Sound</i> SSLI-13	Thursday January 16 4:15 - 4:45 PM
<i>Southeast Alaska</i> SSLI-14	Friday January 17 8:00 - 9:15 AM
<i>Chiswell Island</i> SSLI-15	Friday January 17 9:15 - 10:00 AM

<i>Aleutian Island Passes</i> SSLI-16	Friday January 17 10:30 AM - Noon
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Posters Available for Viewing in Fore Deck
Monday, January 13, 5:00-7:30 PM and through Thursday, January 16

Steller Sea Lion Investigations - Presentations

TALKS

POSTERS

Session SSLI-1 Predation

Chair: Craig Matkin, North Gulf Oceanic Society

L. Hulbert et al. – <i>Pacific sleeper shark predation</i>	A. Hunter and A. Trites – <i>SSL Bibliography (All sessions)</i>
J. Straley et al. – <i>Transient Killer whales in Southeast AK</i>	
C. Matkin et al. – <i>Northern Gulf of AK Killer Whales</i>	
L. Barrett-Lennard et al. – <i>Killer Whales in Western AK</i>	
P. Wade et al. – <i>Killer Whales in Southwestern AK</i>	

Session SSLI-2 Disease, Parasites, and Contaminants

Chair: Michelle Moore, NMFS Alaska Fisheries Science Center

J. Colvocoresses et al. – <i>Monoclonal antibodies against SSL immunoglobulins</i>	K. Beckmen et al. – <i>Organochlorine exposure in SSLs</i>
M. Moore and F. Morado – <i>Effects of parasites on SSLs</i>	R. Heintz et al. – <i>Plan for evaluating contaminants</i>
A. Moles – <i>Parasites of fishes near SSL haulouts</i>	A. Holmes et al. – <i>Chromium cytotoxicity in SSL and mink</i>
S. Atkinson et al. – <i>PCB concentrations in SSL tissues</i>	

Session SSLI-3A Environmental Change

Chair: Thomas Royer, Old Dominion University

A. Capotondi et al. – <i>Changes in the Gulf of AK associated with 1975-76 regime shift</i>	M. Alexander et al. – <i>Long-term variability in the N. Pacific</i>
W. Maslowski et al. – <i>Environmental Conditions and Variability: I. Model Results</i> (See POSTER: Okkonen et al.)	W. Boeing et al. – <i>Ichthyoplankton assemblages: metrics for ecosystem change</i>
A. Miller et al. – <i>Effects of climate change on Gulf of AK circulation</i>	S. Levitus – <i>World Ocean Database 2001</i>
T. Royer et al. – <i>Climate Variability in the NE Pacific and Bering Sea</i>	G. Montaña-Moctezuma and S. Heppell – <i>Community structure and SSLs</i>
M. Doyle et al. – <i>Trends in abundance of ichthyoplankton species</i>	S. Okkonen et al. – <i>Environmental Conditions and Variability: II. Site variability</i>

P. Anderson – <i>Community dynamics in the Gulf of AK under climate regimes</i>	
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Steller Sea Lion Investigations - Presentations

TALKS

POSTERS

Session SSLI-3B Environmental Change

Chair: John Piatt – US Geological Survey

J. Vollenweider and R. Heintz –
Variability in prey quality

L. Fritz and S. Hinckley – *Review of
regime shift/junk food hypothesis*

L. Ciannelli et al. – *Patterns of walleye
pollock recruitment*

J. Piatt et al. – *Inverse regimes and
dynamics of high trophic level consumers*

V. Gallucci et al. – *SSLs and sharks:
competition*

Session SSLI-4 Subsistence Harvest

J. Fall – *Subsistence harvest in 2001*

A. Lestenkof et al. – *Benefits of real-time
harvest monitoring*

Session SSLI-5 Fisheries, Fish Assessment and Dynamics

Chair: Elizabeth Logerwell – NMFS Alaska Fisheries Science Center

E. Gregr and A. Trites – *Overlap between
SSLs and trawl fisheries*

T. Otis – *ADF&G's Cook Inlet Pacific
Herring Database*

K. Ryding et al. – *Localized fisheries and
SSL abundance*

J. Ianelli and M. Dorn – *Collecting
acoustic data on fishing vessels*

E. Connors et al. – *Cod studies in Unimak
Pass*

E. Logerwell and C. Wilson – *Prey
discrimination using acoustic backscatter*

***S. Gauthier and J. Horne – Acoustic
characteristics of forage fish***

***E. Brown et al. – Spatial variability in
GOA fish standing stocks***

***M. Lowe – Socioecological change in
Aleutian Islands***

Steller Sea Lion Investigations - Presentations

<i>TALKS</i>	<i>POSTERS</i>
<i>Session SSLI-6 Population Status and Dispersal</i> <i>Chair: Thomas Gelatt – Alaska Department of Fish and Game</i>	
J. Sease and C. Stinchcomb – 2002 AK <i>SSL surveys</i>	S. Ban et al. – <i>Oceanographic characteristics of haulouts and rookeries</i>
J. Bickham - <i>Genetic variability and population structure in Steller sea lions</i>	L. Jemison et al. – <i>Brand-resighting results in SE AK</i>
K. Pitcher et al. – <i>Eastern SSL population status</i>	
V. Burkanov et al. – 2002 W. Bering Sea/Kamchatka SSL survey	
K. Hastings and T. Gelatt – <i>Studies of branded SSL pups at Lowrie Island</i>	
K. Raum-Suryan et al. – <i>Dispersal of juvenile SSLs in AK</i>	
G. O’Corry-Crowe et al. – <i>Molecular genetics estimates of rookery dispersal</i>	
<i>Session SSLI-7 Population and Bioenergetic Modeling</i> <i>Chair: Bern Megrey – NMFS Alaska Fisheries Science Center</i>	
A. York – <i>Age structure to detect impacts on population</i>	L. Logerwell and R. Christiansen – <i>Energy density of SSL prey</i>
D. Hennen – <i>Spatial coherence and density dependence</i>	D. Thompson et al. – <i>Varying food distributions and SSL fitness</i>
A. Winship and A. Trites – <i>Bayesian approach to PVA</i>	
G. Fay and A. Punt – <i>Bayesian stochastic metapopulation model</i>	
M. Malavear and D. Sampson – <i>Modeling SSL energetics in OR</i>	
B. Megrey and S. Hinckley – <i>SSL modeling workshop</i>	

Steller Sea Lion Investigations - Presentations

TALKS

POSTERS

Session SSLI-8 Diet

Chair: Dominic Tollit – University of British Columbia

S. Farley et al. – *Isotope analyses and diet history*

C. Beck et al. – *Differences in dietary fatty acids of young SSLs*

A. Trites and R. Joy – *How many scats is enough?*

L. Hoberecht et al. – *Remote SSL blubber sampling system*

D. Tollit et al. – *Diet quantification*

T. Zeppelin et al. – *Size of pollock and mackerel eaten by western SSLs*

S. Heaslip et al. – *Size of pollock eaten in SE AK*

B. Wilson et al. – *Optimal foraging or prey selection*

Session SSLI-9 Transmitter Developments

Chair: Lowell Fritz – NMFS Alaska Fisheries Science Center

R. Andrews – *Foraging behavior instrument development*

B Dunford et al. – *Implantable radio tag for SSLs*

W. Nelson and R. Heath – *Transmitter implant methods*

Session SSLI-10 – Nutrition and Hormones

Chair: Lisa Mazzaro – Mystic Aquarium

L. Petrauskas et al. – *Stress response from implantation*

S. Kumagai et al. – *Seasonal changes in defended energy state of SSLs*

M. Myers et al. – *Hormones as indicators of well-being*

K. Mashburn and S. Atkinson – *Adrenal activity in SSL*

L. Mazzaro et al. – *Retinol, tocopherol, and lipids in SSLs*

R. Daniel and A. Trites – *Timing of molt*

D. Rosen et al. – *Food intake and physiological consequences*

Steller Sea Lion Investigations - Presentations

TALKS

POSTERS

Session SSLI-11 Feeding and Diving Ontogeny

Chair: Lorrie Rea – Alaska Department of Fish and Game

L. Rea – <i>Fatty acid levels and age at weaning</i>	M. Rehberg et al. – <i>Juvenile SSL habitat usage</i>
D. Noren – <i>Fasting capabilities of weaned SSLs</i>	V. Stegall et al. – <i>Stable isotopes indicate SSL weaning events</i>
J. Burns et al. – <i>Diving and physiology in juvenile SSLs</i>	
J. Richmond et al. – <i>Juvenile foraging ecology and survival</i>	
T. Loughlin et al. – <i>Immature SSL diving behavior</i>	
G. Thomas and R. Thorne – <i>Effects of fish density and accessibility on SSL foraging</i>	

Session SSLI-12A Kodiak

Chair: Robert Foy – University of Alaska Fairbanks (Kodiak)

P. Stabeno et al. – <i>Physico-chemical studies of GOA shelf</i>	L. Baraff et al. - <i>Distribution and habitat of balaenopterid whales</i>
A. Hermann et al. – <i>Circulation modeling of central GOA</i>	R. Foy et al. - <i>Gulf Apex Predator-prey Program</i>
M. Wilson et al. – <i>Climate, hydrography and zooplankton</i>	N. Kachel et al. – <i>Physical processes in troughs near Kodiak Island</i>
C. Hegwer et al. – <i>Nearshore fishes around Kodiak haulouts</i>	J. Pääkkönen et al. - <i>Climate, hydrography and zooplankton: modeling</i>
C. Wilson et al. – <i>Fishing and pollock interactions</i>	M. Shima et al. – <i>Optimization of SSL dive efficiency</i>
A. Hollowed et al. – <i>Distribution of pollock and capelin</i>	R. Thorne and G. Thomas – <i>SSLs and herring</i>
R. Foy – <i>Distribution of fish near Kodiak</i>	B. Witteveen – <i>Humpback whale abundance and feeding ecology</i>
B. Fadely et al. – <i>Juvenile SSL behavior in relation to prey</i>	

Session SSLI-12B Kodiak

Chair: Robert Foy – University of Alaska Fairbanks (Kodiak)

R. Foy and K. Wynne – <i>Use of prey by SSLs</i>	
K. Wynne – <i>Seasonal prey use by SSLs</i>	

C. Buck et al. – <i>Seabirds as indicators of marine conditions</i>	
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Steller Sea Lion Investigations - Presentations

TALKS

POSTERS

Session SSLI-13 Prince William Sound

Chair: Ken Pitcher – Alaska Department of Fish and Game

K. Pitcher and J. Sease – *SSL population trend in PWS*

J. Churnside – *LIDAR assessment of herring in PWS and Kodiak*

R. Thorne and G. Thomas – *Relationship between SSLs and herring*

Session SSLI-13A Disease, Parasites, and Contaminants

Chair: Michelle Moore, NMFS Alaska Fisheries Science Center

K. Beckmen – *Effects of contaminants on immune function and health of SSLs*

Session SSLI-14 Southeast Alaska

Chair: Michael Sigler – NMFS Auke Bay Laboratory

R. Spangler and K. Koski – *Ecology of eulachon*

J. Thedinga et al. – *Seasonal availability of nearshore prey to SSLs*

J. Womble and M Willson – *Fish aggregations are seasonal feasts*

L. Schaufler et al. – *Lipid variation in spawning eulachon*

R. Heintz et al. – *Herring energy and fatty acid content*

M. Sigler et al. – *SE AK SSL prey study*

A. Trites et al. – *SSL diet in SE AK*

Session SSLI-15 Chiswell Island

John Maniscalco – Alaska SeaLife Center

C. Adams and K. Coyle – *Narrowband and broadband acoustic assessment of forage fish*

J. Maniscalco et al. – *Population dynamics, maternal investment and pup mortality of SSLs*

Session SSLI-16 Aleutian Islands

Chair: Susanne McDermott – NMFS Alaska Fisheries Science Center

P. Stabeno et al. – *The Aleutian Ecosystem*

C. Ladd et al. – *Physical oceanography of the Eastern Aleutian passes*

K. Coyle – *Zooplankton and micronecton in passes*

D. Nichol - *Seasonal change in vertical migration behavior of Atka mackerel*

S. McDermott and E. Logerwell – *Atka mackerel movement and abundance: exclusion zone efficacy*

K. Rand and S. McDermott – *Seasonal changes in Atka mackerel sex ratios in passes*

E. Logerwell and S. McDermott – <i>Fishing and Atka mackerel interactions</i>	P. Stabeno et al. – <i>Flow through the Aleutian passes</i>
	P. Stabeno et al. – <i>Drifter studies in the Aleutian passes</i>

EVOS/NPRB Sessions

EVOS/NPRB-1 Marine Research

ADVENTURE: Tuesday January 14, 10:00 AM - Noon

- Jeff Short et. al – *Bioavailability Of PAH From Oil Patches And Impacts To Prey Species*
- Christian Zimmerman – *Testing Archival Tag Technology on Alaska Salmon and Steelhead*
- Richard Thorne – *Factors Governing Pink Salmon Survival in Prince William Sound*
- Gary Marty – *Role of Disease in Limiting Recovery of the Pacific Herring Population in Prince William Sound*
- Brenda Norcross - *Coordination and Planning For Herring Research*
- Gayle Hansen – *Using Voucher Specimens to Detect Biogeographic Patterns in South-Central Alaskan Seaweeds*
- A. J. Gharrett – *Two Species of Rougheye Rockfish in the Northern Gulf of Alaska*
- Lee Hulbert – *Alaska Salmon Shark Assessment Project*

EVOS/NPRB-2 Citizen Monitoring and Community Involvement

ADVENTURE: Tuesday January 14, 1:30 – 3:00 PM

- Sue Mauger – *Effectiveness of Citizen's Environmental Monitoring Program*
- Patty Brown-Schwalenberg - *Tribal Natural Resource Stewardship and Meaningful Tribal Involvement in the GEM Program*
- Dave Roseneau – *Evaluating the Feasibility of Developing a Community-Based Forage Fish Sampling Project for the EVOS GEM Program*
- Ken Adams – *Voices from the Resource Dependent Community: Bottom-up Approach to Establishing Marine Research Priorities*
- John Harper – *Coastal Habitat Mapping in the Gulf of Alaska*

- Marilyn Sigman and Joe Spaeder – *Community involvement planning in the GEM region* (no abstract)

EVOS/NPRB-3 Physical Processes and Modeling

ADVENTURE: Wednesday January 15, 8:00 – 10:00 AM

- Carl Schoch – *Mapping the Physics and Physical Processes of Marine Habitats: The First Step in a Spatially Nested Monitoring Program* (no abstract)
- Sonia Batten – *Interannual Variability in the Gulf of Alaska Plankton Populations Determined from Ship of Opportunity Sampling*
- Bill Sydeman - *Integration of Marine Bird and Mammal Observations with the CPR (NPRB)*
- Steve Okkonen – *A Monitoring Program For Near-Surface Temperature, Salinity, And Fluorescence Fields In The Northeast Pacific Ocean*
- Shari Vaughn – *Exchange between Prince William Sound and the Gulf of Alaska*
- Jia Wang – *Simulation of Seasonal Variability of the Ocean Circulation in the Gulf of Alaska*
- Bern Megrey – *North Pacific Ecosystem Metadatabase: Information for scientific and community collaboration and advancement(NPRB)*
- Sergei Rodionov – *Detecting Change in the Bering Sea Ecosystem: A New Classification Technique for the Aleutian Low (NPRB)* (no abstract)

EVOS/NPRB-4 Birds and Mammals

ADVENTURE: Wednesday January 15, 10:30 AM – Noon

- John Piatt – *Differential Response of Seabirds to Fluctuations in Prey Density*
- Lorrie Rea – *Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis (NPRB)*
- Dan Rosenberg – *Harlequin Duck Population Dynamics* (no abstract)
- Lisa Munger – *Calls of North Pacific Right Whales Recorded in the Southeast Bering Sea (NPRB)*
- J. Hildebrand – *Bering Sea Right Whale Acoustics (NPRB)* (no abstract)

- Craig Matkin et. al - *Life History and Population Dynamics of Resident Killer Whales in Alaska*

EVOS/NPRB Poster Session - MID/AFT DECKS

Monday, January 13, 5:00 – 7:30 PM and through Thursday January 16

- Brian D. Bornhold and John R. Harper- *Pilot Nearshore Habitat Mapping, Bristol Bay Alaska: Progress Report*
- Joel Cooper – *Developing an interactive water quality and habitat database and making it accessible on the web*
- Gary Drew et al. – *The North Pacific pelagic seabird database (NPPSD): Progress and prospects*
- Nora Foster and Max Hoberg – *Biodiversity of Prince William Sound: Marine invertebrates*
- J. Brooke Gamble et al – *Reproductive success of glaucous-winged gulls on Kodiak Island, Alaska*
- Ron Heintz – *Spatial and temporal variation in the lipid content of juvenile herring and sandlance*
- Meibing Jin and Jia Wang - *A 3-D Coupled Physical-Biological Model and Its Application to the Spring Plankton Bloom of 1996 in Prince William Sound, Alaska*
- Thomas Kline - *Trophic Level Implications When Using Natural Stable Isotope Abundance to Determine Effects of Salmon-Derived Nutrients on Juvenile Sockeye Salmon Ecology*
- Caroline Kompkoff and Thomas Tomaganuk - *Resource Survey for Tattler WisdomKeeper Workshop*
- Dennis Lees and William Driskell - *Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in western Prince William Sound*
- Katie Murra - *Forage Location, Diet, and Productivity of black-legged kittiwakes in 2001 and 2002 in Chiniak Bay, Kodiak Alaska*
- Danielle O'Neil and Shannon Atkinson - *Metabolic Hormone Levels of Neonatal Harbor seal (Phoca vitulina) in Rehabilitation Facilities*

- Jim Seeb et al. - *DNA Markers Describe Distribution, Migration, and Early Marine Survival of Western Alaska Sockeye Salmon in the Eastern Bering Sea* (no abstract)
- Tim Veenstra et al. - *High Seas Driftnet Detection and Tracking in the North Pacific Waters Using Satellite and Airborne Remote Sensing Technologies*
- Jia Wang et al. – *A 3-D Ocean Model in the Bering and Chukchi Seas*

Session SSL-15: Steller Sea Lion Site Specific Studies - Chiswell Island

***Use of narrowband and broadband sonar to
assess fish populations around the Chiswell Island rookery***

Charles F. Adams¹ and Kenneth O. Coyle²

¹Alaska SeaLife Center

²Institute of Marine Science, University of Alaska, Fairbanks
chuck_adams@alaskasealife.org , coyle@ims.uaf.edu

The western stock of Steller sea lions, *Eumetopias jubatus*, has decreased more than 80% since the 1970s. Nutritional stress resulting from changes in the abundance and/or distribution of prey is one of the leading hypotheses to explain this decline. The ability to accurately assess forage fish populations around Steller sea lion rookeries is critical to testing this hypothesis. Narrowband echo sounders are typically used to determine the abundance, biomass and distribution of forage fish, while concurrent trawling provides information on the species composition. New broadband sonar systems offer a promising alternative for species identification. The objectives of this study are: 1) to test the species identification ability of broadband sonar, and 2) provide baseline information on forage fish populations around the Chiswell Island rookery. The R/V *Pandalus*, equipped with a Gourock mid-water trawl, is being used for a series of acoustic/trawl surveys around the rookery. Acoustic equipment includes an HTI model 244 split beam echo sounder, which multiplexes between 38, 120, 200 and 420 kHz, and a SciFish 2000 broadband sonar system, which has a bandwidth of 110 – 190 kHz. A pilot survey was conducted from 28 July – 4 August 2002. The goals were 1) to collect acoustic/trawl data on as wide a variety of species as possible, and 2) to begin mapping forage fish populations around the rookery. Walleye pollock, *Theragra chalcogramma*, ranging in fork length from 4.5 – 38.5 cm, was the dominant species in all tows. Development of broadband species classifiers is currently underway, and three more surveys are planned for 2003. This study will provide one of the first field comparisons between narrowband and broadband acoustics, and will provide insight into the prey species available to foraging Steller sea lions around the Chiswell Island rookery.

Session EVOS/NPRB-2: Citizen Monitoring and Community Involvement

***Voices from the resource dependent community:
a bottom-up approach to establishing marine research priorities***

Ken Adams and Ross Mullins

In the spring of 2002 the Exxon Valdez Oil Spill Trustee Council (EVOSTC) funded a project proposed by two fishermen from Cordova to identify current fishery community issues and needs (unrelated to market issues), to review the suite of EVOSTC supported research relevant to the fisheries, to make recommendations for research application to address the identified issues and needs, and present fisheries priorities for future scientific planning efforts.

This project has been conducted in a workshop format with participation from marine scientists, resource managers, representatives from the harvesting and processing sectors, hatchery operators, the local native community, and the city of Cordova representatives. This effort is in effect, a bottom-up approach to establishing marine science priorities of benefit to the fisheries of the Prince William Sound region. Although the project being undertaken is incomplete, the following needs and issues have been identified by the community: 1) improved accuracy of salmon return forecasts, 2) establishment of a regional ecosystem database accessible to resource managers, enhancement personnel and the public, 3) a comprehensive and coordinated zooplankton sampling program, 4) an adequate fisheries stock assessment program, 5) continued investigation into wild stock and hatchery fish interactions as recommended by the Sound Science Review Team (SSRT). Further into this process, we anticipate being able to make recommendations for research applications to address the above issues and needs. These recommendations can be viewed as needed research and development for the local industry.

Nearly every industry needs research and development for sustainability and growth and the fisheries are no exception. Unfortunately, disconnects exist between harvesters and scientists and even between scientists, resource managers and funding organizations. The fisheries play an important role in the economies of rural Alaska and the entire state and they are dependent upon applied marine research. Unfortunately, support for this concept has been inconsistent, unacknowledged, and threatened.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

*Long-Term Variability in the North Pacific as Indicated by a Coupled Physical-
Ecosystem Ocean Model*

Michael Alexander¹, Antonietta Capotondi¹, Art Miller², Doug Neilson² and Fei Chai³

¹NOAA-CIRES, Climate Diagnostics Center

²Scripps Institution of Oceanography, University of California, San Diego

³School of Marine Sciences, University of Maine

maa@cdc.noaa.gov, mac@cdc.noaa.gov, ajmiller@horizon.ucsd.edu,
dneilson@crdmail.ucsd.edu, fchai@maine.edu

Large-scale changes in the physical environment of North Pacific Ocean have the potential to influence Steller sea lions directly or indirectly by several processes, including altering the food web. Here we examine climate-biological changes over the north Pacific rim using output from an ocean general circulation model coupled to a 10-component ecosystem model (Chai et al. 2002, Deep Sea Res.). The model covers much of the North Pacific (excluding the Bering Sea) with a horizontal resolution of 2° in latitude and ~2° longitude at high-latitudes, and 40 vertical levels. The ecosystem component includes two classes of phytoplankton and zooplankton, and nitrogen, silicon and CO₂. In a recently completed simulation, the model has been forced with observed atmospheric fields over the period 1960-1997.

The difference in upper ocean temperature between 1977-99 – 1960-1976 indicates that the upper ocean warmed by approximately 0.5°-1.2°C between 170°E-145°W along the northern edge of the basin after the abrupt climate shift in 1976. This change occurred in all months but was most notable in summer and fall. Empirical orthogonal function (EOF) analyses, is used to examine the leading patterns of temperature and biological variability over the North Pacific. All the EOFs indicated that the two phytoplankton classes and two zooplankton classes generally tended to vary in phase, suggesting common physical controls. While a strong link between North Pacific decadal-scale SST and ecosystem changes occurs along the North Pacific Transitional Zone (~30°N, 160°W), only weak SST-ecosystem links occur in the Gulf of Alaska. Instead, subsurface thermocline temperatures are more closely associated with the organized primary and secondary productivity changes in the Gulf of Alaska, where the changes began in the mid 1970s.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Marine Community Dynamics in the Gulf of Alaska Under
Historical and Future Climate Regimes***

Paul J. Anderson

NMFS Kodiak Fisheries Research Center
paul.j.anderson@noaa.gov

Linkage of species community structure to climatic changes on decadal scales in the Gulf of Alaska is investigated with analysis of long-term fishery survey data collected continuously since 1953. Data analysis supports the notion that two relatively stable community structures exist that are adapted to relatively stable alternative climatic regimes prevalent in the region. The cool community structure is dominated by pandalid shrimps and low trophic species groups such as Osmerids. Warm community structure traits indicate an abundance of gadids and other higher trophic and relatively long lived fishes. Past surveys indicated a substantial reorganization of the community structure occurred in the Gulf of Alaska after 1978. Dominance of pandalid shrimp and Osmerids in general declined and groundfish increased in the survey region. Recent survey results in 2001 and 2002 suggest that the cold community structure is now regaining prominence, at least in some survey areas of the central Gulf of Alaska. Average catch per tow for all pandalids combined increased to more than 75 kg/km in the latest surveys. Pandalid shrimp abundance at this level last occurred in survey results in 1981. The years 1995 and 1998 (the most comparable sampling effort to the 2001 survey) indicated only 20 and 13 kg/km respectively. Osmerids, as a group (mostly eulachon and capelin), increased to 2 kg/km in 2001. This is the highest relative level of abundance measured since 1992 when 2.2 kg/km were caught. Spatial segregation of the extent of community restructuring is delineated and hypotheses of possible driving mechanisms are explored.

*Session SSL-9: Steller Sea Lion Biology and Ecology
Transmitter Developments*

Foraging Behavior of Steller Sea Lions

Russel D. Andrews

Alaska SeaLife Center and Institute of Marine Science, University of Alaska Fairbanks
Russ_Andrews@alaskasealife.org

One of the hypotheses for the population decline of Western stock Steller sea lions is that they are nutritionally stressed. In order to test this and similar hypotheses, such as those related to the effects of changes in prey distribution and abundance on sea lion vital rates, it is important to understand the foraging strategies of Steller sea lions. Over 8000 dives from 15 lactating Steller sea lions have been recorded with instruments that monitor dive depth, swim speed, and stomach temperature (to indicate prey ingestion) with high temporal resolution (< 10 sec sampling rate). When combined with information on local bathymetry, these types of records allow inference regarding the type of foraging dives made (e.g., benthic vs. pelagic). Detailed information on the timing of prey ingestion also permits the examination of foraging time budgets and search strategies. Stomach temperature data also provides a rough approximation of food intake rates, and therefore one can compare these results with the predictions from optimal foraging models. I will discuss the results of such analyses and their implications for designing future studies of the effects of changes in prey availability on Steller sea lion vital rates. A decrease in one vital rate, juvenile survival, has been postulated as the most likely cause of the Steller sea lion decline. One mechanism that might lead to decreased juvenile survival would be poor foraging success of lactating females during winter and spring, and therefore low weaning weights of their offspring. It would be ideal, therefore, if mother/pup pairs could be monitored from the summer breeding season through the time of weaning in the following year. I will discuss the results of efforts to develop instrumentation and methodology for implantation of tracking devices that will facilitate longitudinal studies of the foraging behavior of Steller sea lions.

POSTER Session GLOBEC

GLOBEC Research:
Food Habits and Feeding Patterns of Gulf of Alaska Juvenile Pink Salmon

Janet L. Armstrong¹, Jennifer L. Boldt², Alison D. Cross¹, Jamal H. Moss¹, Nancy D. Davis¹, Katherine W. Myers¹, Robert V. Walker¹, David A. Beauchamp¹ and Lewis J. Haldorson²

¹School of Aquatic and Fishery Sciences, University of Washington

²School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

The Global Ocean Ecosystem Dynamics program (GLOBEC) was developed to advance our understanding of marine ecosystems and their response to climatic changes. An integral part of assessing the ecosystem of the northern Gulf of Alaska (GOA) is the analysis of the food habits and feeding patterns of abundant zooplanktivorous fish. Juvenile pink salmon have been selected for study because they are zooplanktivorous, highly abundant in the study area, and as adults support valuable commercial fisheries. In addition, pink salmon have a short two-year lifespan, which might provide a clear link between short-term climatic changes and associated biological response. We present major trends in food habits by summarizing interannual (August 1999, 2000, and 2001), seasonal (July to October 2001,) and diel (August 2000, and July and August 2001) feeding patterns based on analysis of stomach contents of juvenile pink salmon collected along the Seward Line (GAK stations 1-6) and in Prince William Sound (PWS), Alaska. Results of interannual changes in juvenile pink salmon diets indicated that prey were more diverse in 2001 compared to either 1999 or 2000. Pteropods (*Limacina helicina*) comprised the majority of prey consumed in 1999 and 2000; whereas high proportions of copepods, pteropods, euphausiids, amphipods, crabs, gastropods, and fish were consumed in 2001. Seasonal changes indicated that juvenile pink salmon consumed increasingly larger prey items from July to October 2001, in the GOA. The diet of juvenile pink salmon in the GOA was different and more diverse than diets of fish caught in PWS. In PWS during July to October, the main prey of juvenile pink salmon was amphipods. The primary prey in the GOA in July, were larvaceans and euphausiids. In August, while copepods comprised the majority of the prey, pteropods (*L. helicina*), amphipods, euphausiids, crabs, and shrimp were also important. September and October samples collected from both areas contained a high proportion of larger prey items including fish, euphausiids, and large pteropods (*Clio* sp.). Diel comparisons of stomach contents showed pink salmon fed during daylight hours with stomach fullness increasing from dawn to a maximum fullness 12 hours after sunrise, and declining thereafter. The predominant prey during all diel time periods was pteropods, (*Limacina* sp.) in the August 2000 samples from the Seward line (GAK stations 3 and 4 combined). Euphausiids were also present in the stomachs of pink salmon early in the day. Diel studies in PWS indicated that the dominant prey items in the July were larvaceans and pteropods (*Limacina* sp.), however, in August stomach samples contained predominately hyperiid amphipods. In PWS, pink salmon stomach content volume was substantially larger in August than in July 2001. Future work will integrate food habits data with fish condition and growth data, zooplankton abundance, and water temperature to develop foraging and bioenergetics models. These models will enable us to assess the habitat quality and growth conditions for juvenile pink salmon. This will contribute directly to the GLOBEC goal of understanding how pink salmon, and, therefore, tertiary production are affected by changes in ocean conditions.

*Session SSL-2: Steller Sea Lion: Factors Affecting the Population
Diseases, Parasites, and Contaminants*

Comparison of PCB concentrations in different Steller sea lion tissues

Shannon Atkinson^{1,2}, Su-Myeong Hong³, Alan Springer² and Qing Li³

¹Alaska SeaLife Center

²School of Fisheries and Ocean Sciences, University of Alaska

³Department of Molecular Biosciences and Bioengineering, University of Hawaii
shannon_ atkinson@alaskasealife.org, suhong@hawaii.edu, ams@ims.uaf.edu,
qingl@hawaii.edu

PCB contaminants are globally ubiquitous. Their impact on most marine animals is unknown, although increased research efforts are directed at the potential for decreased fertility and other negative impacts. Steller sea lions, *Eumetopias jubatus*, have had organochlorines detected in them, but an analysis of the sites of deposition of the contaminants has not been performed. Tissues from Steller sea lions harvested by native hunters in the Pribilof Islands and Prince William Sound were obtained for PCB analysis along with fresh placentas that were collected from rookeries in the Aleutian Islands and Gulf of Alaska. High-resolution gas chromatography coupled with low-resolution mass spectroscopy (HRGC/LRMS) was used to analyze 143 different PCB congeners. Lyophilized samples of blubber, kidney, liver, and placenta were extracted and purified prior to analysis by HRGC/LRMS. Relative retention index was used to develop the sum PCB concentrations for each tissue. Concentrations of sum PCBs averaged 10 times higher in blubber and liver than in kidney. The placentas contained the lowest sum PCB concentrations of any tissue analyzed. The concentrations of several blubber and liver samples were higher than those associated with visual and memory effect in humans and higher than US EPA guidelines. These preliminary results indicate that additional research should be conducted to survey the prevalence of organochlorine contaminants across the geographic range of Steller sea lions and to determine if the immune or endocrine systems are impacted by the presence of these contaminants.

*POSTER Session: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

Oceanographic characteristics of Steller Sea Lion Haulouts and Rookeries

Stephen Ban¹, Janet Porter¹, Andrew Trites¹ and Mike Foreman²

¹Marine Mammal Research Unit, University of British Columbia

²Institute of Ocean Sciences, Sidney, British Columbia

sban@interchange.ubc.ca , trites@zoology.ubc.ca

Geographic Information Systems (GIS) are powerful tools for conducting spatial analyses, and have only recently been applied to the marine environment in the context of habitat characteristics. We applied GIS techniques to determine the oceanographic characteristics that define the locations of 6 Steller sea lion rookeries and 25 haulouts in British Columbia (BC). Coastal waters of BC were divided into a grid of 500 X 500 m cells containing 4 oceanographic variables: average bathymetry, average tidal speed, summer salinity and sea surface temperature. We compared the average cell conditions within 4 distances of sea lion haulouts (1, 10, 20, and 50 nautical miles) with the mean marine conditions contained in grid cells that fell outside these areas. We also generated four predictive surfaces to describe the distribution of Steller sea lions using a logistic regression of the oceanographic variables contained within the cells of the four radii (1, 10, 20 and 50 miles). Our results suggest that oceanic conditions within 10 nm of shore determine the location of Steller sea lion haulouts and rookeries in British Columbia. These regions were associated with higher tidal speeds, higher salinity, lower surface temperatures and shallower waters—which presumably reflects high ocean productivity and hence optimum feeding areas for Steller sea lions. Further analyses incorporating biological and terrestrial factors and variable weighting of selected sites should enhance our understanding of the relationship between the environment and sea lion congregation areas.

POSTER Session: Steller Sea Lion Site Specific Studies - Kodiak Island

***Summer distribution and habitat characteristics of balaenopterid whales in Steller sea lion critical habitat, northeast Kodiak Island:
project overview and preliminary results***

Lisa S. Baraff, Robert J. Foy and Kate M. Wynne

University of Alaska Fairbanks

fslsb1@uaf.edu, foy@sfos.uaf.edu, ffkmw@uaf.edu

The goals of this study are to assess balaenopterid whale distribution and delineate high use areas in Marmot and Chiniak Bays during May to September, to characterize these areas using abiotic and biotic features, and to evaluate habitat partitioning. Research began in 2002 as part of the University of Alaska Fairbanks Gulf Apex Predator-prey project, a multi-year, integrated study addressing trophic relationships between Steller sea lions, their prey, predators, and potential competitors (e.g., whales and seabirds). Platforms included weekly whale-directed surveys, June-September, and monthly 3-day hydroacoustic prey surveys, May-September. The former emphasized data collection and environmental measurements, using CTDs and vertical zooplankton tows, at whale locations. The latter followed established transect lines, using “passing mode” line transect methods for visual observations. CTD and zooplankton sampling stations were pre-determined and mid-water trawls occurred when warranted by acoustic signal. Two-hundred-eleven hrs and 2988 km of whale-directed surveys yielded 96 humpback sightings (164 individuals), 131 fin whale sightings (239 individuals), 87 CTD casts, and 16 zooplankton tows. Thirty-six humpback sightings (68 individuals) and 48 fin whale sightings (74 individuals) were made in 55.7 hrs of visual effort, and 153 CTD casts and 24 zooplankton tows occurred during hydroacoustic surveys. Preliminary analysis indicates a significant difference in depth distribution for fin whales and humpback whales. Sighting maps show clumped distributions suggestive of high use areas. Continuing data processing includes deriving abiotic variables (depth, slope, SST, mixed layer depth, thermocline depth, pycnocline depth, stratification) and biotic variables (zooplankton composition, fish biomass and composition) to describe balaenopterid habitat and habitat partitioning in Marmot and Chiniak Bays. The ecological role of balaenopterids in this area, including as potential competitors with Steller sea lions or their prey, can best be evaluated once distribution and habitat use are defined.

Session SSL-1: Steller Sea Lion: Factors Currently Affecting the Population Predation

Dietary Specialization In Killer Whales In Western Alaska

Lance G. Barrett-Lennard^{1,2}, Craig O. Matkin³ and Harald Yurk²

¹Vancouver Aquarium Marine Science Centre

²Zoology Department, University of British Columbia

³North Gulf Oceanic Society

barrett@zoology.ubc.ca , comatkin@xyz.net , yurk@zoology.ubc.ca

One of the most striking findings from long-term studies of killer whales in Washington, British Columbia, and southern Alaska is the existence of sympatric socially- and reproductively-discrete populations referred to as residents and transients. Members of the resident population feed on salmon and other fish, and members of the transient population feed on seals, porpoises, sea lions, and other marine mammals. There is little evidence of such dichotomous population structure in other regions of the world, with the possible exception of the Antarctic. Here, we examined the population structure of killer whales in western Alaska near the eastern Aleutian Islands and the western end of the Alaska Peninsula. Our preliminary results provide two lines of evidence that two sympatric populations inhabit the area. First, mitochondrial DNA (from skin samples acquired with biopsy darts) revealed two distinct haplotypic groups, one similar to residents, the other to transients. All sampled whales within each social group had the same haplotype. Second, killer whale groups with resident-type haplotypes used calls and echolocation signals typical of residents, while those with transient-type haplotypes used sounds characteristic of transients. Furthermore, killer whales with resident-type haplotypes were only seen feeding on fish, whereas those with transient-type haplotypes attacked pinnipeds twice and were not seen eating fish. No association was seen between whales from different haplotypic groups, and no matches were found between whales from either group and whales photographed in systematic studies in southern Alaska (including the area from Kodiak Island to Prince William Sound). We conclude that the resident / transient feeding specialist population dichotomy described in Washington, British Columbia, and southern Alaska extends to western Alaska. Further study is needed to determine whether residents and transients from western Alaska are continuous with, or discrete from, corresponding populations to the east.

Session EVOS/NPRB-3: Physical Processes and Modeling

Interannual variability in Gulf of Alaska plankton populations determined from Ship of Opportunity sampling

Sonia D. Batten and David W. Welch

The EVOS GEM program and the NPRB are supporting a project that monitors the plankton populations of the Gulf of Alaska using Continuous Plankton Recorders. This project is now in its third successive year. The data have been used to describe regional and interannual variability in plankton abundances and community composition from the Alaskan shelf, across the open Gulf of Alaska to the California shelf and across to the Aleutian Islands and the southern Bering Sea. Furthermore, a pilot project was completed in 1997, before the probable regime shift of 1999. Large changes in the plankton populations have been seen, consistent with the climatic changes from warm to cooler conditions that have occurred. These changes in plankton have implications for higher trophic levels. We describe the project and the results from these first few years of sampling.

POSTER Session: *Steller Sea Lion Biology and Ecology*
Diet

Location and age class differences in the dietary fatty acids of young Steller sea lions

Carrie Beck^{1,2}, Lorrie Rea¹, John Kennish² and Sara Iverson³

¹Alaska Department of Fish and Game

²University of Alaska Anchorage

³Dalhousie University, Halifax, NS

charlotte_beck@fishgame.state.ak.us , lorrie_rea@fishgame.state.ak.us ,
afjmk@uaa.alaska.edu , Sara.Iverson@dal.ca

Evaluating the food limitation hypothesis for the decline of juvenile Steller sea lions requires knowledge of the diet composition of individuals in both the declining and stable populations. To date, all estimates of diet composition have come from scat analyses and are not specific to a particular age class. Fatty acid signature analysis is an alternative method of investigating diet composition and is based on the conservation of unique fatty acids through the marine food chain. We examined the fatty acid signature of individuals from Prince William Sound (PWS) and Southeast Alaska (SE). Blubber biopsies were taken from 13 pups and 16 yearlings in PWS and from 13 pups and 20 yearlings in SE. The extraction and identification of 68 fatty acids (FA) from these biopsies were done according to Iverson et al. (1997). Using 12 dietary FA, we conducted a discriminant function analysis to determine if animals could be identified to the correct age and location group based on their FA composition. These 12 FA accounted for $85.0\% \pm 0.15\%$ of total FAs identified. All individuals were classified to the correct age/location group with a jack-knife cross-validation error rate of 4.8%. The 1st discriminant function, which explained 51.8% of the variation between individuals, clearly separated pups from yearlings. The second discriminant function, explaining 45.9% of the variation, separated PWS animals from SE animals. These results suggest that Steller sea lions in the two areas are consuming different diets. Further investigation and examination of the fatty acid signature of prey species is required before a quantitative estimate of diet composition can be produced. The separation of pups from yearlings based on their FA composition provides further support for the use of FAs as a weaning indicator.

*Session SSL-13A: Steller Sea Lion: Factors Currently Affecting the Population
Diseases, Parasites and Contaminants*

***An Investigation of the Potential Effects of Environmental Contaminants on Immune
Function and Health in Free-Ranging Steller Sea Lions***

***Kimberlee B. Beckmen¹, Kathleen A. Burek², Kenneth W. Pitcher³, Gina M. Ylitalo⁴,
Margaret M. Krahn⁴ and Jeffrey L. Stott⁵***

¹Division of Wildlife Conservation, Alaska Department of Fish and Game

²Alaska Veterinary Pathology Services

³Division of Wildlife Conservation, Alaska Department of Fish and Game

⁴NMFS Northwest Fisheries Science Center

⁵School of Veterinary Medicine, University of California Davis

kimberlee_beckmen@fishgame.state.ak.us , fnkab1@uaf.edu ,

ken_pitcher@fishgame.state.ak.us , Gina.Ylitalo@noaa.gov, Peggy.Krahn@noaa.gov ,
jlstott@ucdavis.edu

The western stock of the Steller sea lion (*Eumetopias jubatus*) has undergone a severe population decline, but the cause(s) of this decline is not known. Environmental contaminant exposure is one of the identified putative factors. In field studies conducted during live-capture operations from 1995 to 2001, we investigated organochlorine (OC) contaminant and mercury exposure, the general health of Steller sea lions, and the development of immune function in juvenile sea lions. We optimized and validated multiple immune functional assays, which were then used to define each of the components of the immune system in relation to age. Our approach included lymphoproliferative assays, immunoglobulins levels and less specific white blood cell differential counts to demonstrate perturbations in leukocyte subpopulations and inflammatory/stress responses. By examining multiple cohorts of sea lions from different stocks, we documented the baseline for variation by individual sea lion, stock, age, and stress level in immune function. These baseline data are needed to use these assays to assess the health of free-ranging otariids. We established reference ranges for normal leukocytes subpopulations for different age groups of free-ranging juveniles. Additionally, we conducted expanded health surveys including serology, parasitology, bacterial cultures, virology, fungal cultures, testing for *Chlamydia* as well as detailed physical examinations. These investigations detected significant correlations between OC exposure and impaired immune function at several levels. Responses to mitogen stimulation using lymphoproliferative assays were negatively correlated to PCB levels. Total mercury concentrations in fur were significantly higher in sea lions from Prince William Sound than Southeast Alaska. Although the total mercury concentrations were within the toxic range of terrestrial mammals, no impact of mercury exposure on health could be demonstrated.

*POSTER Session: Steller Sea Lion: Factors Affecting the Population
Diseases, Parasites and Contaminants*

Population Survey of Organochlorine Contaminant Exposure in Steller Sea Lions

***Kimberlee B. Beckmen¹, Kenneth W. Pitcher¹, Kathleen A. Burek², Gina M. Ylitalo³
and Margaret M. Krahn³***

¹Alaska Department of Fish and Game

²Alaska Veterinary Pathology Services

³NMFS Northwest Fisheries Science Center

kimberlee_beckmen@fishgame.state.ak.us , ken_pitcher@fishgame.state.ak.us ,
fnkab1@uaf.edu , Gina.Ylitalo@noaa.gov , Peggy.Krahn@noaa.gov

Scats (feces) from Steller sea lions (*Eumetopias jubatus*) were collected on 21 rookeries over 4 years (1998-2001) to assess exposure of selected organochlorine (OC) contaminants (e.g., dioxin-like PCBs, DDTs) in the thriving eastern stock in Southeast Alaska/British Columbia (SE) as compared to the depleted western stock in Gulf of Alaska (GOA) and eastern Aleutian Islands (EAI). Concentrations of OCs in scats were used as a semi-quantitative indicator of recent exposure. Levels of OCs in scat reflect excretion of PCBs congeners in addition to recent dietary intake and thus were not used to estimate individual congeners in body depot stores. We found that OCs are present in the food web used by Steller sea lions in Alaska, as far west as the EAI. The rank order of mean OC concentrations in SSL scats was EAI > SE > GOA. The levels of OCs in scats from SE, which is the population that has increased in recent years, was intermediate in concentration compared to the two populations from the western stock. On the other hand, the relatively high PCB levels for the EAI, in comparison to the nearby GOA, are of interest as populations in both areas have decline by >80%. These data suggest that exposure to the OCs is elevated in portions of the range of the declining western stock of Steller sea lions. These findings also show that scat can be used a non-invasive indicator of contaminant exposure. Additional work is needed to determine the degree to which levels of OCs in scat can be used to estimate body burdens/tissue concentrations of OCs.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

Genetic variability and population structure in an endangered marine mammal (Steller sea lion, *Eumetopias jubatus*)

John W. Bickham¹ and Thomas R. Loughlin²

¹Dept. Wildlife and Fisheries Sciences, Texas A&M University

²NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center
j-bickham@tamu.edu, tom.loughlin@noaa.gov

We examined mtDNA control region sequences for more than 1,000 pups taken at their natal rookeries, including approximately 80% of the existing populations. A distinct phylogeographic break occurs between the western populations (Prince William Sound to the Sea of Okhotsk) and the eastern populations (Southeastern Alaska to California). We refer to these as the eastern and western stocks of Steller sea lions. A second phylogeographic break occurs between the central populations of the western stock (Prince William Sound to the Western Aleutian Islands) and the Asian populations (Commander Islands to the Sea of Okhotsk). We refer to these as the Asian and central groups of the western stock. The proposed partition of the western stock into two distinct population segments has important management implications for this species.

*POSTER Session: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

*New Metrics for Ecosystem Change:
Bio-diversity and Dynamics of Ichthyoplankton Assemblages*

**Wiebke J. Boeing¹, Janet T. Duffy-Anderson², Kevin M. Bailey², Ann Matarese²,
Jeffrey M. Napp², Susan Picquelle² and Bern Megrey²**

¹Joint Institute for the Study of Atmosphere and Oceans, University of Washington

²NMFS Alaska Fisheries Science Center

Wiebke.Boeing@noaa.gov , janet.duffy-anderson@noaa.gov , Kevin.bailey@noaa.gov ,
ann.matarese@noaa.gov , jeff.napp@noaa.gov , susan.picquelle@noaa.gov ,
bern.megrey@noaa.gov

Consequences of the 1976 climatic regime shift in the North Pacific Ocean on the ecosystem were only recognized at higher trophic levels almost a decade afterwards. Lower trophic levels (fish larvae, zooplankton, phytoplankton) might be most responsive and reflect changes due to environmental perturbations before they propagate upwards and affect higher trophic animals (e.g. Steller Sea Lions), making them potentially useful as early indicators of ecosystem perturbations. The goal of our study is to create a variety of sensitive indices to evaluate ecosystem change due to climate shifts by exploring lower trophic level dynamics, but especially in the ichthyoplankton. We will investigate the following hypotheses: (1) whether environmental changes have reduced local production and prey abundance or availability, and, (2) whether environmental changes have altered the composition of the fish community, reducing the abundance, availability, or quality of prey for Steller Sea Lions. We are analyzing 20+ years of ichthyoplankton data from the Gulf of Alaska (GOA) (collected by the Recruitment Processes Program of the Alaska Fisheries Science Center) to develop new metrics to evaluate ecosystem change. We divided the GOA into seven geographical strata to determine if some areas are more sensitive to environmental perturbations than others. The GOA is a north-south boundary region for many species, hence their spatial distribution should be especially indicative of subtle changes in the environment. We calculated the well-known Shannon-Wiener index in each geographic area to evaluate temporal (1976-2000) changes in ichthyoplankton diversity. We are in the process of developing new indices (size frequency as a measure for survival, relationship between spawning biomass and ichthyoplankton including related time lags, and the occurrence of key indicator species and rare species) which will be compared and evaluated against results from the Shannon-Wiener index. The relevance of the indices will be discussed.

***Diagnosis of Coastal GOA Air-Sea Interactions Using a
High Resolution NWP Model***

Nicholas A. Bond¹, Richard Steed² Albert J. Hermann¹, Dylan Righi¹ and Phyllis J. Stabeno³

¹Joint Institute for the Study of Atmospheres and Oceans, University of Washington

²Atmospheric Sciences, University of Washington

³NOAA Pacific Marine Environmental Laboratory

This work represents one element of a series of studies assessing air-sea interactions important to the Alaska Coastal Current (ACC) under the auspices of GLOBEC's Coastal Gulf of Alaska Program. The objective of this particular study is to construct high-resolution atmospheric fields in the coastal zone of the GOA, and determine the degree to which the ACC is sensitive to details in the local atmospheric forcing in the coastal zone. The atmospheric fields are derived from MM5 numerical weather prediction (NWP) model simulations on a 15-km horizontal grid using the NCEP/NCAR Reanalysis data set, which is on a 2.5 degree horizontal grid, as initial and boundary conditions. The MM5 simulations are a suitable method for incorporating the effects of the prominent coastal terrain of the GOA in a dynamically consistent manner. The MM5 output is used to drive ROMS numerical ocean model simulations of the ACC. The results here illustrate the nature and magnitude of the upper ocean's response to mesoscale atmospheric structures in the coastal zone, such as barrier jets. The eventual goal is to use the downscaling technique outlined here to investigate how climate changes impact the coastal GOA, and in particular the relative importance of remote, gyre-scale effects versus local, mesoscale atmospheric forcing on the ACC.

POSTER Session EVOS/NPRB

***Pilot Nearshore Habitat Mapping, Bristol Bay, Alaska:
Progress Report***

Brian D. Bornhold and John R. Harper

Coastal and Ocean Resources Inc., Sidney, British Columbia

In August 2002 a ten-day field program was conducted in northern Bristol Bay to develop protocols for effective nearshore habitat mapping using a combination of acoustic and video techniques. Three shallow nearshore areas (less than 10 m) were selected: western Ungalikthluk Bay, northeastern Summit Island and western Metervik Bay. Two deeper areas near the southern Walrus Islands in water depths of about 15-20 m were also surveyed acoustically. The techniques included 390 kHz sidescan sonar, towed seabed video and acoustic seabed characterization based on echosounding data. As part of the protocol development, different video line spacings were used in the surveys (50 m and 100 m grids). The intent of this exercise was to determine the optimal line spacing to capture accurately the spatial complexity in nearshore benthic habitats.

The nearshore substrates included bedrock, boulders, cobbles, gravels and sands. Sidescan sonar mosaics were prepared for each area from which interpreted substrate maps are produced using video groundtruth. It was found that, in addition to providing 100 percent seafloor substrate information, sidescan sonar was also able to detect concentrations of eelgrass. Video imagery allowed for determination of epifaunal and floral abundances. Acoustic seabed classification resulted in the identification of several echo classes which could be related to sidescan sonar and video results.

The deeper sites were found to be dominated by smooth muddy sands and sandy muds. Extremely poor visibility precluded collection of seabed video in these two areas.

POSTER Session GLOBEC

***Factors affecting marine growth and survival of Auke Creek, Alaska coho salmon
(Oncorhynchus kisutch)***

Ryan J. Briscoe¹, Milo D. Adkison¹ and Alex Wertheimer²

¹Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

²NMFS Auke Bay Laboratory

Ocean-basin and regional-scale fluctuations in climate have been observed in conjunction with fluctuations in salmon growth and abundance. The need exists to examine effects of local climatic trends on the growth and survival of specific stocks. Scales from Auke Creek, Alaska adult coho salmon collected at the Auke Creek Weir and archived since 1977 are being digitized and measured. Scales from juvenile coho salmon collected in Northern Southeast Alaskan waters since 1997 as part of the Auke Bay Lab's Southeast Coastal Monitoring Project (SECM) are also being digitized and measured. Using the juvenile scales as a reference, marks will be placed on the adult scales indicating when the coho transit as juveniles from Northern Southeast Alaska coastal/strait habitat into Gulf of Alaska waters. For analysis, we will attempt to further divide growth zones into four phases: early marine nearshore, early marine coastal/strait, pre-winter Gulf of Alaska, and post-winter Gulf of Alaska. Growth from the adult Auke Creek scales will be analyzed for correlation with geographically relevant biophysical parameters that are thought to have a mechanistic effect on salmon growth. Growth will also be analyzed for statistical relationships it has with size at return, marine survival, and abundance of Southeast Alaska salmon.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

***Spatial variability in biological standing stocks and sea surface temperature across the
Gulf of Alaska basin and adjacent continental shelves***

Evelyn D. Brown¹, M. A. Montes Hugo¹ and James. H. Churnside²

¹Institute of Marine Science, University of Alaska Fairbanks

²NOAA Environmental Technology Laboratory

ebrown@ims.uaf.edu , James.H.Churnside@noaa.gov

We addressed the question, “Is spatial variability in Steller sea lion population dynamics due to variability in food availability?” and the null hypothesis: Food resources are not limiting for sea lions as evidenced by the lack of a gradient in ocean biological standing stock from the west to the east. Using airborne remote sensing, we developed an index of biological standing stocks for the upper 20 m across the Gulf of Alaska (GOA) basin, adjacent continental shelves, and within two bordering fjord environments (Prince William Sound and SE Alaska). A single broadscale survey was performed over the entire region during May 2002 while finer detail was provided for two regions (Kodiak and SE Alaska) using closely coordinated ship-aircraft surveys in 2001 and 2002. Airborne instruments provided information on distribution and densities of zooplankton, fish schools, SST, and phytoplankton. Airborne and satellite data were combined and validated or interpreted using ship-buoy data. High variability was observed across the regions. Using our index of food availability, the order of regions (from high to low) was interpreted as: 1) open ocean – eastern shelf / shelf break and the western shelf (Outer Kenai), 2) the western shelf break, 3) PWS, 4) the Aleutian and E. Kodiak shelves, and 5) SE Alaska. Given SE Alaska is the only region with a stable and increasing sea lion population yet has the lowest score and given that the western shelf and break (associated with a depressed sea lion population) has relatively high score, these data do not lead to a rejection of the null hypothesis (i.e. food is not a problem). However, the Aleutian shelf had the second to lowest score and is associated with a depressed and declining population. A further synthesis of results from other studies is required to make a more thorough determination.

Session EVOS/NPRB-2: Citizen Monitoring and Community Involvement

What Constitutes Meaningful Tribal Involvement? The Struggle for Tribal Involvement in the Research and Monitoring Efforts surrounding the Exxon Valdez Oil Spill

Patty Brown-Schwalenberg

Chugach Regional Resources Commission

There are 20 Native communities in the oil spill affected area, comprising approximately 2,200 people. The Native people of these communities depend upon the land, water, and natural resources to maintain their cultural and traditional lifestyles and livelihood. The Tribes were devastated by the oil spill and its effects upon their traditional use areas and lifestyle and have requested active participation in the research and monitoring activities under the Trustee Council's Gulf Ecosystem Monitoring Program.

Tribes have been successfully practicing traditional resource stewardship techniques since time immemorial. Knowledge of population densities, critical habitat areas, harvest allocation, and harvest timing, as an example, have all been used by indigenous people to ensure the healthy continuity of their communities. Within the past 25 years, Tribes have taken this knowledge and enhanced it with western science in an effort to be active partners in the resource management decision-making process that affects those species and resources upon which they depend. Recognizing the need to become more actively involved in the management decision-making process, Tribes in Alaska, within the past 10 years, have been developing their natural resource programs as well.

The Chugach Regional Resources Commission is working with the village chiefs/presidents of its member Tribes to develop a region-wide integrated resource management plan. This plan will identify traditional harvest areas, critical species habitat areas, and other areas in the Chugach Region of cultural importance. This plan will also serve as a management tool for Tribes who hunt, fish, and gather in common areas to cooperatively address resource issues of concern. In addition, the plan will include separate goals and action plans for critical subsistence species. It is anticipated that this region-wide integrated resource management plan will be the main source of information when working with the Trustee Council and its GEM program.

Tribes are eager to become more integrally involved in the GEM Program. They also realize, however, that they lack the technical training necessary to carry out many of the biological research and monitoring projects they are interested in pursuing. The Tatitlek Village Council, in cooperation with the Chugach Regional Resources Commission, is instituting a technical training and education program for Tribal natural resource management to provide the Tribes with the tools of western science to aid in the research and monitoring process. Partnered with the traditional ecological knowledge currently held by the Tribes, the western scientific knowledge would provide the Tribes with the credibility required to gain respect by the state and federal management agency personnel. This, in turn, would allow the Tribes to take a more active and meaningful role in the GEM Program, with a belief that they are contributing in a meaningful way to the research and monitoring of the resources in their traditional use areas.

This paper discusses the efforts of the Trustee Council and Tribal Governments affected by the devastating Exxon Valdez oil spill in the Gulf of Alaska in 1989 to become more meaningfully involved in the scientific research and monitoring activities occurring in their traditional use areas.

Session SSL-12B: Steller Sea Lion Site Specific Studies - Kodiak Island

Seabird Component of the GAP Project: Indicators of Marine Conditions and Potential Competitors of Steller Sea Lions

C. Loren Buck¹, S. Dean Kildaw¹, Katie A. Murra¹, J. Brook Gamble¹ and Brian Fadely²

¹School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

²National Marine Mammal Laboratory, NMFS Alaska Fisheries Science Center

loren.buck@uaf.edu, ffdisk@uaf.edu, ftkam@uaf.edu, ftjbg@uaf.edu,

Brian.Fadley@noaa.gov

The Gulf Apex Predator-prey program (GAP) was initiated in 1998 to investigate interrelationships among Steller sea lions, their predators and competitors in Chiniak Bay on the east side of Kodiak Island, Alaska. Seabird work in GAP began in 2001 in which we 1) documented at-sea locations of blacklegged kittiwakes (*Risa tridactyla*) using radio-telemetry; 2) monitored reproductive performance of glaucous-winged gulls (*Larus glaucescens*) and blacklegged kittiwakes; and 3) collected and analyzed regurgitants of kittiwakes and bill-loads of tufted puffins for analysis of prey contents. Summer foraging areas of kittiwakes in Chiniak Bay overlapped in time and space with Steller sea lions tagged in Chiniak Bay, 2001. We monitored a total of 2071 and 2193 nests of black legged kittiwakes in 2001 and 2002, respectively. Productivity (total chicks fledged/nest attempt) of kittiwakes in 2001 (71%) exceeded that of 2002 (48%) and was greater than in any year on record. Likewise, for glaucous-winged gulls we monitored 150 nests in 2001 and 147 nests in 2002. Productivity (hatchlings/nest attempt) of glaucous-winged gulls was greater in 2001 (79%) than in 2002 (60%). The high productivity observed for kittiwakes and glaucous-winged gulls is suggestive of high forage availability in 2001. The species with the highest frequencies of occurrence in the regurgitants of blacklegged kittiwakes in both 2001 (N = 148) and 2002 (N = 96) were sand lance (*Ammodytes hexapterus*, 72% 2001; 73% in 2002) and capelin (*Mallotus villosus*, 32% 2001; 48% 2002). The most frequently occurring species in bill loads of tufted puffins (*Fratercula cirrhata*) in 2002 were capelin (65%), sand lance (26%), sandfish (*Trichodon trichodon*, 12%) and salmonids (*Oncorhynchus* spp.; 12%), respectively. Sand lance, sandfish and salmonids were in the top 7 most frequently occurring species in the scats of Steller sea lions collected from haulouts in the Kodiak area.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

*Steller Sea Lion Survey in the Western Bering Sea
and the Kamchatka Peninsula in 2002*

Vladimir N. Burkanov^{1,2}, Don Calkins^{2,3} and Thomas R. Loughlin⁴

¹Natural Resources Consultants, Inc.

²North Pacific Wildlife Consulting, LLC.

³Alaska SeaLife Center.

⁴NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center

Vladimir.burkanov@noaa.gov, don_calkins@alaskasealife.org, tom.loughlin@noaa.gov

We conducted a survey of Steller sea lions in western Bering Sea and the Kamchatka Peninsula on the m/v *Bolsheretsky* during June 16 to July 9, 2002. A total of 27 of 28 Steller sea lion sites were visited one or two times during the survey. At most sites sea lions were counted from land on locations above the animals. The approximate age and sex of hauled out animals was recorded as well. A total of 1,050 non-pups and 295 pups were counted. The abundance of Steller sea lions continues to decline in the region. Compared to 1983, the number on trend sites declined from 6,361 to 1,004, or 84.2% (4.2% annually). There is a large difference in trends of decline by areas. The greatest decline was in the Western Bering Sea. The total number of Steller sea lions dropped from 3,120 to 17 individuals (99.5%) over 20 years. Since the last survey in 1999 numbers declined 92.6%. In Eastern Kamchatka the population declined by 74.6% since 1983, and by 31.2% since 1999. The least decline occurred in the Commander Islands region. Since 1983 the abundance there has declined by 61.9%, but only by 5.9% since 1994. The differences in population trends may be related to differences in fishery activity, fishery management, and migration of Steller sea lions in those areas.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

***Diving behavior and physiology in juvenile Steller sea lions:
What are the links?***

Jennifer M. Burns, Michael J. Rehberg and Julie P. Richmond

Department of Biological Sciences, University of Alaska Anchorage
jennifer.burns@uaa.alaska.edu, michael_rehberg@uaa.alaska.edu,
asjpr7@uaa.alaska.edu

One potential cause of the decline in Steller sea lions (*Eumetopias jubatus*) is a reduction in juvenile survival, perhaps due to changes in post-weaning foraging success. However, until recently, there has been little information on the aerobic capacity of juvenile sea lions with which to model diving or foraging efficiency. Since oxygen stores and use rates determine the foraging space available to all marine mammals, we have focused our efforts on determining whether the foraging patterns of juvenile sea lions might be constrained by their physiological status.

To address this question, we have collected data on changes in body oxygen stores, and calculated age related changes in dive capacity. In comparison to adults, 1-month-old pups have significantly lower oxygen stores in both the blood and muscle (66% and 20% of adult values, respectively). As a result, pup diving capacity is less than a third that of adults, suggesting that juveniles may be constrained in their diving ability. However, determining whether reduced diving capacity significantly influences foraging success has been more difficult. While we have collected information on the diving and haulout patterns of 7 juvenile sea lions (9-12, 17-21 months of age), and documented age related changes in behavioral patterns (reduced time ashore, deeper and longer dives), older sea lions do not always dive deeper and longer than younger animals, and the vast majority of dives are well within the estimated aerobic capacity. This suggests that physiological status may play a smaller role in determining diving patterns than originally expected. We are now attempting to link specific diving patterns and locations with foraging activities, and to model the foraging space available to animals of differing aerobic capacities.

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POSTER Session GLOBEC

Production rates of Oithona similis in the Gulf of Alaska

A.G. Byrd and R.R. Hopcroft

University of Alaska Fairbanks

Oithona similis is one of the most numerous and least studied copepod species in the Gulf of Alaska. Abundance, biomass and (egg) production rates for *O. similis* were estimated in coastal and offshore water in the Gulf of Alaska during 2001 using 0.053-mm mesh plankton nets. Abundance varied between 650-2900 m⁻³, while their biomass ranged between 1.2 and 11 mg AFDW m⁻³, with biomass remaining high from late spring to early fall. Clutch size was relatively stable varying between 14 and 23 eggs per female. The percentage of females with eggs varied between 43.2% and 9.8%, with the specific egg production rates of 0.7% to 5.8% per day. Applying this rate to all stages, production rates of *O. similis* varied between 0.02 and 0.24 mg AFDW m⁻³ day⁻¹.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Environmental changes in the Gulf of Alaska associated with the 1975-76 climate
regime shift: A modeling study***

Antonietta Capotondi¹, Michael Alexander¹, Arthur Miller² and Douglas Neilson²

¹NOAA-CIRES Climate Diagnostics Center, Boulder, CO

²Scripps Institution of Oceanography

mac@cdc.noaa.gov, maa@cdc.noaa.gov, miller@horizon.ucsd.edu,
neilson@crdmail.ucsd.edu

The coincidence between the beginning of the Steller sea lion (SSL) decline in the Gulf of Alaska and the so-called “climate regime shift” recorded in the North Pacific around the mid-seventies suggests that climate-induced environmental changes may have played a role in the observed SSL decline. To link the basin-wide climate changes over the Pacific to environmental changes in the Gulf of Alaska we have analyzed the output from the ocean general circulation model (OGCM) developed at the National Center for Atmospheric Research (NCAR) as the ocean component of the NCAR Community Climate Model. The model is global, with a horizontal resolution of 2.4° in longitude and variable resolution in latitude ranging from 0.6° in the tropics to 1.2° at high-latitudes. The numerical simulation we are considering is forced with observed atmospheric fields over the period 1958-1997.

After validating the model with available observations, the differences between the periods 1977-1997 and 1958-1976 have been examined focusing on those physical factors that may significantly affect the SSL habitat, e.g. water temperature, mixed layer depth, ocean upwelling. Preliminary results show a deepening of the isopycnals (indicative of reduced upwelling) in the 40-200 m depth range along the rim of the Alaskan gyre, potentially affecting coastal regions. Seasonal changes between the 1977-1997 and the 1958-1976 periods exhibit enhanced warming in spring (March-April-May) along the western side of the Gulf of Alaska, an east-west asymmetry that may be related to the asymmetric character of the SSL decline.

POSTER Session GLOBEC

A Preliminary Look at Nitrate Sources and Sinks in the Shelf Waters of the Northern Gulf of Alaska

R. Childers, T. E. Whitedge, D.A. Stockwell and T. J. Weingartner

University of Alaska Fairbanks

Nutrient data collected in 1998, 1999, and 2000 from the northern Gulf of Alaska shelf as part of the Global Ocean Ecosystem Dynamics (GLOBEC) Gulf of Alaska Long Time Series Observation Program (LTOP) have provided preliminary data on the sources and sinks of nitrate to the shelf waters. Surface nitrate exhibited an annual cycle of spring and summer drawdown followed by replenishment throughout the winter months. First order new production estimates revealed that springtime nitrate utilization was similar among years within the shelf regimes (except over the shelf-break) with the highest rates over the inner shelf. Deep-water measurements provided evidence of a summer onshore flux of dense, nitrate-rich bottom water onto the shelf when the predominant downwelling regime relaxed. This seasonal flux created a reservoir over the inner shelf that was ultimately mixed into the upper water column through winter wind mixing. In an effort to determine the source of nitrate to the euphotic zone after summer depletion, first order calculations of vertical diffusion and surface Ekman transport were made. These estimates indicated that vertical diffusion could potentially play a much larger role in transporting nitrate to the euphotic zone over the inner shelf. There were distinct interannual differences in the chemical and physical properties across the Gulf of Alaska shelf in 1998 (El Niño) and 1999-2000 (La Niña). The water column in spring 1998 was more stratified and fresher due to high freshwater discharge and anomalously strong downwelling, consequently nitrate concentrations were notably lower in spring 1998 than those measured in spring 1999 and spring 2000. Overall, it is apparent from this data that new production is an important element for supporting the phytoplankton community, however the underlying mechanisms in transporting nitrate to the euphotic zone remain unclear.

*POSTER Session: Steller Sea Lion Site Specific Studies
Kodiak Island and Prince William Sound*

*Airborne LIDAR Measurements of Springtime Distributions of Herring in Prince
William Sound and Kodiak Island*

James H. Churnside

NOAA Environmental Technology Laboratory
james.h.churnside@noaa.gov

We measured the relative distribution of herring in parts of Prince William Sound in March 2001 and 2002 and near Kodiak Island in March 2002. Two main conclusions have been drawn from these surveys. The first is that there were many more herring in the surveyed area of Prince William Sound in 2002 than there were in 2001. The second is that the LIDAR performed better in Prince William Sound than in Kodiak. It also performed better in Kodiak later in the year. In March, most of the Kodiak population was in a very confined bay with a high concentration of dissolved organic material. In the more open part of the bay, the LIDAR detected fish. These were in schools during the day and in a broad layer at night. Sea lions and birds were observed in the same area during the day. These results and the factors affecting the performance of LIDAR are described.

*Session SSL-3B: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Patterns And Mechanisms Of Walleye Pollock Recruitment In The Gulf Of Alaska
And Implications For Steller Sea Lion Dynamics***

Lorenzo Ciannelli¹, Kevin Bailey², A. Belgrano³ and N. C. Stenseth⁴

¹University of Washington

²NMFS Alaska Fisheries Science Center

³University of New Mexico Albuquerque

⁴University of Oslo

Lorenzo.Ciannelli@noaa.gov , Kevin.Bailey@noaa.gov , belgrano@unm.edu , ,
n.c.stenseth@bio.uio.no

Walleye pollock is a primary prey item for Steller sea lions (SSL) in the North Pacific, thereby establishing a functional link between these two species. The GOA walleye pollock recruitment (age-2) time series during the last 30 years shows two main patterns: a series of episodic (3-5 years) strong year classes and a negative time trend, suggesting the possibility for different modes of variability spanning various scales. SSL are 'long-lived' organisms, and their dynamics is dominated by large-scale modes compared to that of pollock. With such premises, SSL besides being affected by the absolute biomass of pollock prey, can also be influenced by their scale of variability. In our study, we focused on the mechanisms that generate different modes of variability in pollock recruitment dynamics, and on the relative 'switches' between modes in relation to environmental changes. With the use of GAM models we identified three factors that correlate with pollock recruitment: predation, wind intensity and density-dependent survival. Additionally, with the use of a stage-survival model we simulated the effect of such factors on the dynamics of walleye pollock recruitment. Results showed that groundfish predation caused the negative time trend of pollock recruitment, while cycles were correlated with wind intensity and larval survival. Finally, there was an overall dampening effect of recruitment variability caused by density-dependent survival of age-0 fish. Taken together these results indicate that recruitment of walleye pollock is an emerging and dynamic outcome of various forcing mechanisms that operate across scales and on temporally separated stages of the pollock life cycle.

Factors Affecting the Distribution of Juvenile Salmon in the Gulf of Alaska

E. D. Cokelet, E. V. Farley Jr., C. M. Kondzela, P. J. Stabeno and J. H. Helle

Our goal is to relate the distribution of juvenile salmon to oceanographic parameters in the Gulf of Alaska. Observations were made aboard the charter fishing vessel, F/V Great Pacific, during mid-July to early August - the expected peak migration period. The study region is larger than that covered by most GLOBEC Gulf of Alaska field experiments. We occupy 11 transects across the continental shelf from near shore to >2000-m depth between Icy Point or Yakutat in SE Alaska and the southwestern tip of Kodiak Island including Shelikof Strait. Oceanographic measurements include sea-surface temperature, salinity and fluorescence from an underway, flow-through water system and vertical profiles of temperature and salinity. Ocean current is measured with an acoustic Doppler current profiler (ADCP) and via the trajectories of satellite-tracked drifting buoys launched at sea. Zooplankton are captured in bongo hauls or Tucker trawls. Juvenile salmon are caught in a 198 x 45 x 10 m (LxWxH) midwater rope trawl towed at the surface. These are identified, counted, weighed and sampled for hatchery-induced otolith thermal marks and genetic analysis to determine their natal streams. Oceanographically, the surface salinity decreases near shore in the Alaska Coastal Current. Buoys deployed there tend to remain in a narrow band near shore and to exit through Shelikof Strait. The surface salinity increases toward each transect's seaward end, and buoys launched there remain offshore and enter the Alaskan Stream. Juvenile pink salmon from Prince William Sound (PWS) hatcheries in 2000 and 2001 were not significantly related to sea surface temperature or zooplankton volumes. They were smallest at nearshore and offshore locations along the Seward and Gore Point transects. Those located offshore tended to have significantly higher condition factor than those caught nearshore or within the middle of the transect. Their condition factor was negatively related to zooplankton volume during 2000 (Bongo nets) and not significantly related to zooplankton volume during 2001 (Tucker trawl). Juvenile chum salmon migration patterns have been updated with the use of distribution data from thermally marked hatchery stocks and the first genetic stock identification analysis of juvenile salmon migrating through Gulf of Alaska coastal corridors. Results from the genetic analyses indicate that juvenile chum salmon caught east of Prince William Sound were from the Southeast Alaska/ Northern British Columbia region with smaller proportions from the Queen Charlotte Island and Washington State/Southern British Columbia regions. Those caught west of Prince William Sound were mostly from Prince William Sound and Southeast Alaska/Northern British Columbia with a small proportion from Washington State/Southern British Columbia. Juvenile chum salmon caught within Shelikof Strait were mostly from the Alaska Peninsula/Kodiak Island and Susitna River regions with a small proportion from the Southeast Alaska/Northern British Columbia region. These results from genetic analyses compare favorably with the otolith thermal mark results from Southeast Alaska and Prince William Sound hatcheries. Future analyses will include more effort to link oceanographic measurements (temperature, salinity and current) collected during Ocean Carrying Capacity/GLOBEC surveys in the Gulf of Alaska to zooplankton distributions and juvenile salmon biological characteristics (distribution, size, condition and origin).

Factors Affecting the Distribution of Juvenile Salmon in the Gulf of Alaska: Physical Oceanography

E. D. Cokelet, P. J. Stabeno and A. J. Jenkins

Our goal is to relate the distribution of juvenile salmon to oceanographic parameters in the Gulf of Alaska. Sea-surface temperature, salinity and fluorescence were measured in conjunction with zooplankton and juvenile salmon from net tows during mid-July to early-August of 2001 and 2002 - the expected peak migration period. The charter fishing vessel, F/V Great Pacific, carried a conductivity-temperature-depth probe (CTD) to measure water column stratification. An acoustic Doppler current profiler (ADCP) and satellite-tracked drifting buoy trajectories measured the ocean current. The study region is larger than that covered by most GLOBEC GoA investigations. It occupies 11 transects across the continental shelf from near shore to >2000-m depth between Icy Point in SE Alaska and the southwestern tip of Kodiak Island. Resulting maps show that the surface salinity decreases near shore in the Alaska Coastal Current. Buoys deployed there tended to remain in a narrow band near shore and to exit through Shelikof Strait. The surface salinity increases toward the transects' seaward ends, and buoys launched there remained offshore and entered the Alaskan Stream. Work is underway to remove tidal currents from the ADCP velocities via modeling in order to reveal the mean flow field and how salmon juveniles position themselves within it.

*Session SSL-2: Steller Sea Lion: Factors Affecting the Population
Diseases, Parasites, and Contaminants*

***Production and Characterization of Monoclonal Antibodies against
Steller Sea Lion Immunoglobulins***

Jennifer Colvocoresses, Bobby Middlebrooks, and Rhonda Patterson

Department of Biological Sciences, University of Southern Mississippi
Jennifer.colvocoresses@usm.edu

Evaluation of immunoglobulin isotype levels produced during the humoral immune response provides one measure of immunocompetence. Development of the capacity to perform such an evaluation requires identification, purification and biochemical characterization of immunoglobulins in the species of interest, followed by production of immunological reagents that can be used for quantitative assessments of the humoral immune response. The development/identification of such reagents for use in assays of Steller sea lion (SSL) isotype levels is reported herein. Although cross-reactive anti-dog and anti-human immunoglobulins can be used to identify Steller sea lion immunoglobulins using immunoelectrophoresis, SDS-PAGE, and Western blotting, the low affinity of the cross-reactive antibodies for SSL immunoglobulins, made it imperative to develop species specific reagents. Purification of IgG, IgM, and IgA isotypes from pooled SSL serum was achieved by the use of affinity chromatography columns: Protein G Sepharose 4 Fast Flow column (Pierce) for IgG, Immobilized Jacalin column (Pierce) for IgA, and Amino-link affinity column coupled to anti-dog IgM or Affi-Gel Protein A Agarose column (Bio-Rad) for IgM. Purified whole immunoglobulins or heavy chains electroeluted from SDS-polyacrylamide gels were used to immunize mice for the production of monoclonal antibodies using standard protocols. Hybridomas were screened using an enzyme linked immunosorbent assay (ELISA) to identify cells producing antibodies specific for the immunogens. Monoclonal antibodies against SSL IgG, IgM, gamma heavy chain, and light chains have been identified and partially characterized by ELISA, SDS-PAGE, and Western blotting. These SSL specific reagents are being used in the development of ELISA's to determine levels of individual immunoglobulin isotypes in serum of captive and wild individuals to establish baseline levels. The establishment and monitoring of levels can be an important indicator of natural or induced humoral immunodeficiencies and can be used as a tool to investigate disease in a population or in an individual.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

AFSC Pacific Cod Studies at Unimak Pass

M. Elizabeth Conners, Peter Munro and Sandi Neidetcher*

NMFS Alaska Fisheries Science Center

liz.conners@noaa.gov , peter.munro@noaa.gov , sandi.neidetcher@noaa.gov

* presenter

Current policymaking with regard to Steller Sea Lions includes concern about localized depletion of sea lion prey from spatially and/or temporally intensive commercial fishing. The Fisheries Interaction Team at AFSC has developed a field study around the intensive winter fishery for Pacific cod in waters north of Unimak Pass in the eastern Aleutian Islands. The experiment uses pot catch of cod as a measure of local abundance, both in the intensively fished area and in an adjacent “control” area within the Cape Sarichef no-trawl zone. Our goal is to compare the rate of seasonal change in abundance between sites in the treatment and control zones and quantitatively test for presence or absence of a fishing effect. This study has been in feasibility work since 2001; winter 2003 will be the first full trial of the experiment. This presentation shows the results of feasibility studies to assess the overall variability and spatial correlation structure of pot catch data, and presents briefly the final experimental design.

In addition to the localized depletion study, this research program is also being used to gather information on: 1) the design and performance of pots as a research instrument; 2) movement patterns and rates of cod around seasonal spawning aggregations; and 3) biological sampling for better understanding of cod reproductive biology. Developing research pots includes use of pot-mounted oceanographic instruments and event-logging devices to record times of fish entry. Movement patterns are being addressed with a tagging study, using both spaghetti and archival tags. Biological information collected includes observation of sex ratios, length frequencies, and frequency of occurrence of gross maturity stages (e.g. immature, nonspawning, ripe, spent) over the Jan-March period of the study. Samples are also being collected for age at maturity, fecundity, and proximate analysis.

POSTER Session EVOS/NPRB

*Developing an Interactive Water Quality and Habitat Database
and Making it Accessible on the Web*

Joel Cooper

Cook Inlet Keeper
joel@inletkeeper.org

The Citizens' Environmental Monitoring Program (CEMP) partnership have come together to form a database committee to create a consistent data management system where all citizen groups and agencies can equally share, report and review their water quality and habitat data. The overall goal of this project is to make data more accessible and more useful to decision makers, stakeholders, resource managers, and the public. The objectives include: 1) Create a consistent data management system where all citizen groups and agencies can equally share, report and review their water quality and habitat data; 2) Interface citizen-collected data with EPA's STORET to make it more useful to agencies; and 3) Make habitat and water quality data accessible on the Internet in a user-friendly, interactive format with links to GIS maps, photos and graphs. The database is being coordinated with CIIMMS to develop the interactive format for the Internet. Access to this data will help facilitate a better understanding about threats to, and solutions for, water quality and habitat. <http://www.inletkeeper.org>

Session GLOBEC-2

Annual cycle of zooplankton abundance, biomass and production on the northern Gulf of Alaska shelf, October 1997 through October 2000

Kenneth O. Coyle

University of Alaska Fairbanks

Zooplankton abundance from March through October on the northern Gulf of Alaska shelf in 1998, 1999 and 2000 was dominated by calanoid copepods; the biomass was dominated by calanoids and cnidarians. Although we sampled during the 1997-1998 El Niño, marked interannual differences in the major copepod taxa were not observed. Zooplankton abundance and species composition was influenced primarily by salinity, secondarily by the mean temperature above the thermocline. An annual biomass peak, averaging about 0.5 g wet weight m⁻³, occurred in May and consisted primarily of the oceanic copepod species *Neocalanus cristatus*, *Neocalanus plumchrus* and *Neocalanus flemingeri*. A second biomass peak, 0.5 g wet weight m⁻³, was observed in August and consisted mainly of the cnidarian *Aequorea* spp. Regression equations from the literature relating biomass and temperature to production indicate that copepod production peaked in July at about 65 mg C m⁻² d⁻¹. Although the small neritic copepods made up about 30% of the biomass, they accounted for about 60% of the total annual copepod production between March and October. Initial calculations suggest an annual copepod production on the order of 10 g C m⁻² y⁻¹, probably less than 10% of the annual primary production. The apparent resilience of the zooplankton assemblage on the northern Gulf of Alaska shelf to the 1997-1998 ENSO may have been due to its large geographic separation from the faunal boundary between zooplankton communities in the California Current and North Pacific Subarctic gyre.

Session SSL-16: Steller Sea Lion Site Specific Studies – Aleutian Islands

***Zooplankton and micronekton in passes of the
eastern and central Aleutian Islands***

Kenneth O. Coyle

Institute of Marine Science, University of Alaska Fairbanks
coyle@ims.uaf.edu

Recent studies suggest that the population trajectories of sea lions may vary with rookery location. In the vicinity of Unimak Pass and the eastern Aleutian Islands, populations are holding their own or increasing slowly, whereas in the central Aleutians, population trends are still strongly downward. This spatial variation in the population trends of sea lions provided an opportunity to compare a variety of environmental variables in the two regions, in an attempt to identify factors potentially responsible for the differences in these trends. Initial results indicate that the eastern Aleutian shelf sustains dense aggregates of euphausiids and shelf copepod species, which are rare or absent from the middle Aleutian passes, Seguam-Tanaga region, where populations are dominated by oceanic copepod species. Physical aggregation of zooplankton forage by tidally-generated eddies and fronts in or near the passes is a major concentration mechanism, particularly in the middle Aleutian region, where euphausiids concentrations are lower.

POSTER Session GLOBEC

GLOBEC Research: Modeling Bioenergetics of Juvenile Pink Salmon in Prince William Sound and the Coastal Gulf of Alaska

Alison D. Cross¹, David A. Beauchamp¹, Janet L. Armstrong¹, Jennifer L. Boldt², Nancy D. Davis¹, Lewis J. Haldorson², Jamal H. Moss¹, Katherine W. Myers¹ and Robert V. Walker¹

¹School of Aquatic and Fishery Sciences, University of Washington

²School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

We currently lack a mechanistic understanding of the carrying capacity for juvenile salmon in the Gulf of Alaska. Juvenile pink salmon (*Oncorhynchus gorbuscha*) are a major component of this region, and their abundance is heavily subsidized by hatchery production. The primary objective of this Global Ocean Ecosystem Dynamics (GLOBEC) study is to use bioenergetics model simulations to compare spatial and temporal patterns of temperature and food supply with juvenile pink salmon growth and consumption in Prince William Sound and the coastal Gulf of Alaska. We are focusing on the July–October period of their first year at sea, a critical time for feeding, growth, and survival. The energy-balance approach of bioenergetics models enables estimates of consumption over time based on predator weight change, diet, and thermal experience, and energy densities of both predator and prey. We applied monthly GLOBEC 2001 data on local ocean conditions and juvenile pink salmon diet, growth, and distribution patterns to the Wisconsin Bioenergetics Model to determine the level of consumption necessary to achieve observed growth from July to October of the pink salmon's first year at sea. Consumption estimates indicate the ecosystem's influence on juvenile pink salmon growth and condition and allow us to account for spatial, temporal, and size-specific interactions between juvenile pink salmon, their prey, and the ocean environment in future management schemes.

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

Timing of Moulting in Steller Sea Lions

Raychelle Daniel and Andrew W. Trites

Marine Mammal Research Unit, University of British Columbia
daniel@zoology.ubc.ca , trites@zoology.ubc.ca

Knowing when and how Steller sea lions shed their fur will enable moulting to be discretely placed into the sea lion seasonal cycle. It will also help to optimize the time that transmitting devices and instruments are attached to fur. Steller sea lions were observed on Lowrie Island in Southeast Alaska from July – November 2001 to document the timing and progression of moult by visual identification. Individuals were classified by direct observations and from photographs into three moult categories: not moulting, moulting, and completed moulting. The average moult start date was 26 July for adult females (17 July – 02 August, 95% Confidence intervals) and 25 August for pups (06 August – 02 September). Average moult end date was 18 November for adult females (09 November – 28 November) and 25 December for pups (08 December – 22 January). Sample sizes were insufficient to calculate exact moulting dates for juveniles and adult males. However, juveniles appeared to start moulting prior to adult females and bulls appeared to start at about the same time as pups. Based on focal sampling, the duration of the moult averaged 45.7 days for adult females and 45.0 days for pups. These findings differ from observations of captive Steller sea lions and from pelts harvested in the 1960s, and suggest that timing of moult may differ between regions.

Annual and Interannual Variability in Atmospheric Heat Flux over the Northern Gulf of Alaska Shelf

Seth L. Danielson, Thomas J. Weingartner, and Dean Stockwell

University of Alaska Fairbanks

Stratification dynamics on the Gulf of Alaska shelf are influenced by freshwater runoff, atmospheric heating and cooling, wind mixing and ocean dynamics. The influence of these processes varies seasonally and spatially. For example, the transport and dispersal of freshwater (a three-dimensional process) on the inner shelf and within the Alaska Coastal Current appears important to the onset of springtime stratification. However, over the outer shelf, the vertical exchange of heat between the ocean and atmosphere might in fact be dominant in controlling the onset of springtime stratification and therefore the spring phytoplankton bloom. Moreover, heating and cooling affects the seasonal shelf heat budget and these fluxes can structure the shelf ecosystem through the temperature dependence of metabolic rates. We computed the air-sea heat fluxes over the northern Gulf of Alaska shelf using hourly data collected from Middleton Island (PAMD) for the period of 1945-1963 and 1973-present. The PAMD data set is ideal for these calculations because it is a low-lying island situated ~80 km south of Prince William Sound and near the shelfbreak. The island's low relief and distance from shore suggest that it provides an unbiased measurement platform for the meteorological measurements used herein. We use this long-term data record to compute the mean annual cycle and interannual variations in the radiant, latent, and sensible heat fluxes and the vertical freshwater flux (precipitation minus evaporation). Our results allow us to estimate the time window in spring when stratification is likely to occur on the outer shelf assuming that freshwater contributions are unimportant to stratification. We also use these data, in conjunction with oceanographic measurements, to quantify differences in atmospheric cooling and heating and the alongshore advection of heat that occurred during the 1997-99 El Niño-La Niña transitions.

PLENARY Session: Monday, 13 Jan 11:45 AM - 12:30 PM

Bottom-up and Top-down Processes in Ecosystem Management

Douglas P. DeMaster

NMFS Alaska Fisheries Science Center
Douglas.Demaster@noaa.gov

Four recently published documents by DeMaster and Atkinson (2002), Ferrero and Fritz (2002), Pitcher (2002), and the NRC (2002) examine interactions between Alaska groundfish fisheries and the western stock of Steller sea lion. All of these documents concluded that the reported decline of the western stock of the Steller sea lion since 1990 is likely due to the interaction of multiple factors. DeMaster and Atkinson, and Pitcher concluded that the results of research conducted in the 1990s on Steller sea lion condition indices were inconsistent with the nutritional stress hypothesis and that a variety of factors were likely causing the current decline. NRC (2002) reported that "bottom-up hypotheses invoking nutritional stress are unlikely to represent the primary threat to recovery" and further noted that "Although no hypothesis can be excluded based on existing data, top-down sources of mortality appear to pose the greatest threat to the current population".

Both the NRC report and Ferrero and Fritz discuss possible research approaches needed to evaluate the merits of top-down versus bottom-up hypotheses. The NRC report specifically recommends an adaptive management approach based on a series of open and closed areas on a scale of 20 to 50 miles. Ferrero and Fritz describe the research program adopted by a collection of research organizations (i.e., University of Alaska, Alaska Department of Fish and Game, Alaska SeaLife Center, the North Pacific Universities Marine Mammal Research Consortium, and various elements of NOAA) to test the relative merits of hypotheses related to competition with fisheries, nutritional stress related to environmental change, other anthropogenic effects, predation, disease, and contaminants.

POSTER Session GLOBEC

Comparison of physical-biological models of the California Current System and the Coastal Gulf of Alaska

Elizabeth L Dobbins¹, Craig V. W. Lewis², Sarah Hinckley³ and Albert J. Hermann¹

¹Joint Institute for the Study of Atmospheres and Oceans, University of Washington

²University of California Berkeley

³NMFS Alaska Fisheries Science Center

The California Current System (CCS) and the Coastal Gulf of Alaska (CGOA) are both regions of high biological productivity. While the dynamics governing the CCS's upwelling system are fairly well understood, the reasons for high productivity on the CGOA's downwelling shelf are more mysterious. Two biological models, each embedded within the Regional Ocean Modeling System (ROMS), are being used to investigate the differences between these systems; a simple NPZD model is used for the CCS, but for the CGOA, a specialized, 10-compartment model, called GLNPZ, has been developed and tuned to conditions in the Gulf. In order to compare the biological models, independent from the different physical conditions of the regions, a pseudo 1-D test case of ROMS was developed to run with both. We compare the biological results produced by implementations of this test case, and consider implications for interregional comparisons.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Interannual Trends in Abundance of Ichthyoplankton Species in the Gulf of Alaska
During Spring, 1981 Through 2000: Exploring Linkages Between Pelagic Ecosystem
Dynamics and the Early Life History of Fish***

Miriam Doyle¹, Susan Picquelle², Sigrid Salo³, Michael Spillane³ and Phyllis Stabeno³

¹Joint Institute for the Study of Atmosphere and Ocean, University of Washington,

²NMFS Alaska Fisheries Science Center

³NOAA Pacific Marine Environmental Laboratory

miriam.doyle@noaa.gov, susan.picquelle@noaa.gov, Sigrid.A.Salo@noaa.gov,
Mick.Spillane@noaa.gov, Phyllis.Stabeno@noaa.gov

Dramatic changes in species composition and abundance have been documented among fish populations in the Gulf of Alaska during the 1980s and 1990s. A shift in ocean climate during the late 1970s is thought to have triggered the observed, subsequent reorganization of community structure in this northeast Pacific ecosystem. Little is known about the effect of fluctuations in ocean conditions on the early life history dynamics of fish species in the Gulf of Alaska and whether “regime shift” effects are detectable in the ichthyoplankton. A time-series of spring ichthyoplankton data in the Gulf of Alaska, 1978 through the present, provides an opportunity to investigate such linkages by examining interannual trends in the early life history stages of fish in this region. Retrospective analyses of these data, along with associated local and basin-scale oceanographic data, are being conducted to examine temporal and spatial patterns of ichthyoplankton species in relation to their environment. The hypothesis being addressed is that environmentally induced fluctuations in Gulf of Alaska fish populations may be modulated through the early life history dynamics of these fish and reflected in temporal trends in abundance and distribution of ichthyoplankton species. Initial analyses reveal that interannual trends in larval abundance reflect observed trends in adult biomass, associated with the late 1970s oceanographic “regime shift”, for several species including Pacific cod, arrowtooth flounder, Pacific halibut and capelin. Other species display interannual trends in larval abundance that appear unrelated to trends in adult biomass or the decadal scale oscillation in the oceanographic regime but that may be linked to shorter term variability in the pelagic environment. Special attention is being given to the interannual variation in size-frequency distribution of species of larvae in order to detect any temporal shift in timing of spawning or peak period of larval abundance over the years.

POSTER Session EVOS/NPRB

***The North Pacific Pelagic Seabird Database (NPPSD):
Progress and Prospects***

Gary Drew, David Irons, John Piatt, Jay Johnson and Shawn Stephensen

A number of large databases contain detailed information on the pelagic (at-sea) distribution of seabirds in Alaska and elsewhere in the North Pacific. In a collaborative effort between the U.S. Geological Survey, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Canadian Wildlife Service, North Pacific Marine Research Institute, and many independent investigators, we are compiling available data on the distribution of seabirds (and marine mammals) at sea. These data will be archived in raw form, and ultimately combined in a common format. Tools for analyzing and mapping the data will be developed, and we will create web-based and hard-copy products for dissemination of the data to scientists, resource managers and the general public. Pelagic seabird distribution data can be used to: model, measure or predict immediate and long-term impacts of oil pollution on marine bird populations; detect and describe long-term changes in marine ecosystems; identify fine- and coarse-scaled features of marine habitats; estimate population sizes of rare or threatened species that are impossible to census using traditional methods; examine seasonal movements and winter habitat use by seabirds; assess potential conflicts between commercial fisheries and marine birds (e.g., long-line fisheries and albatrosses); plan and manage marine reserves; and disseminate natural history information to the general public, educators, and the tourism industry. Examples of datasets and preliminary products are provided.

An Implantable Radio Identification Tag For Steller Sea Lions

**Bill Dunford¹, Scott McKinley², Royann Petrel³, Andrew W. Trites⁴, Matthew Yedlin¹
and Robert Virtue¹**

¹Electrical Engineering and Computer Engineering, University of British Columbia

²Agricultural Sciences, University of British Columbia

³Chemical and Biological Engineering, University of British Columbia

⁴ Marine Mammal Research Centre, University of British Columbia

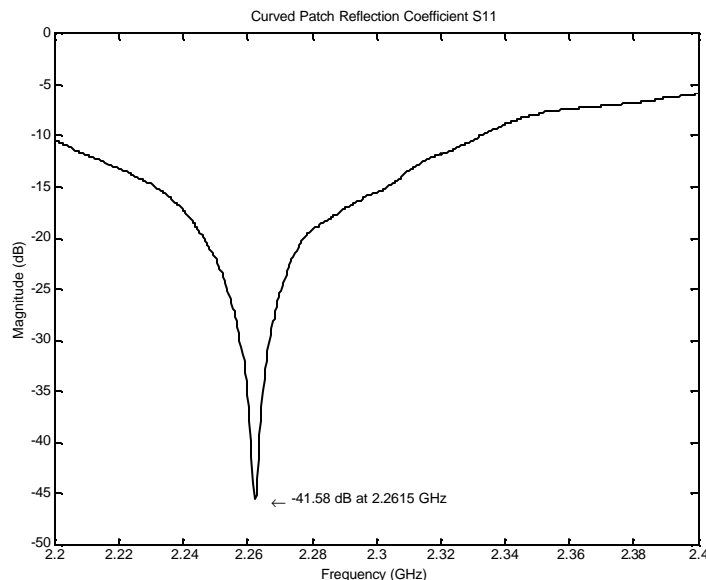
wgd@ece.ubc.ca , mckin@interchange.ubc.ca , petrell@interchange.ubc.ca ,
trites@zoology.ubc.ca , matty@ece.ubc.ca , ves@mindlink.net

A core component behind testing the leading hypotheses concerning the decline of Steller sea lions is the remote collection of data using biotelemetry technology. Current monitoring devices are glued to the fur and have an average lifetime of about 30 days.

In recognition of the need for internal devices that will last for several years, an implantable UHF radio identification tag is being developed. In meeting the significant challenge presented by the conflicting criteria of both a transmitter life of about 3 years and small device size (including power supply) the development has focused on designing a highly efficient and effective antenna, minimizing the electronics payload of the tag and reducing power requirements through a novel communications approach.

Results will be presented from a small flexible antenna. This is a biologically unobtrusive device, which performs well over the range of geometries presented by implantation in various sites in a pup growing to adulthood. The entire tag device will be about the size of a credit card. Polling stations located at Steller sea lion rookeries and haulouts could relay identification information via satellite link to a database connected to the Internet. Only tags near the station will be activated to conserve energy.

The typical response below shows that the antenna is an effective radiator when bent to a particular radius. This will be more fully explained in the final paper.



Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

Behavior of Juvenile Steller Sea Lions in Relation to Available Prey Distribution in Eastern Kodiak Island Waters

Brian Fadely¹, Robert Foy², Kate Call¹, Kate Wynne², Angie Greig³ and Jeremy Sterling¹

¹National Marine Mammal Laboratory, NMFS Alaska Fisheries Science Center

²Fisheries Industrial Technology Center, University of Alaska Fairbanks

³NMFS Alaska Fisheries Science Center

brian.fadely@noaa.gov, foy@sfos.uaf.edu, kate.call@noaa.gov,
ffkmw@aurora.alaska.edu, angie.greig@noaa.gov, jeremy.sterling@noaa.gov

To investigate relationships between behavior of sea lions and distribution of available prey, 12 juvenile Steller sea lions were captured underwater near haulouts within the Gulf Apex Predator-prey (GAP) study area in Chiniak Bay, and instrumented with satellite-linked depth recorders during March of 2001 and 2002. Corresponding hydroacoustic and trawl biomass surveys were conducted in March and May. Seasonal and interannual differences in sea lion movements, dive behavior and time at sea apparently correspond with differences in water column stratification and fish dispersal. A significantly greater proportion of dives (41%) were made during nighttime than during other periods. In 2001, one of the four animals still transmitting left the GAP area by May, dispersing northward. In March, most dives (95%) were to less than 10 m, but deepened to less than 34 m for animals remaining in May, with time at sea and number of dives increasing. In 2002, three of the five animals still transmitting moved southerly out of the GAP area by May. Animals remaining in the area spent less time at sea but made more dives than in March, and most were to less than 20 m. Sea temperatures were coldest throughout the water column in March, but by May thermal stratification set up frontal structures accumulating food in the upper surface waters, and juvenile pollock and capelin were present at depths of 20-30 m from the gully areas to shore. All pelagic fish species rose and dispersed throughout the water column at night, thus foraging sea lions would have closer access to prey but in much less dense aggregations. These relationships are being analyzed within the context of possible concurrent changes in sea lion weaning status and diving ability.

*POSTER Session: Steller Sea Lion: Factors Currently Affecting the Population
Subsistence Harvest*

The Subsistence Harvest of Steller Sea Lions by Alaska Natives in 2001

James A. Fall

Division of Subsistence, Alaska Department of Fish and Game
jim_fall@fishgame.state.ak.us

The presentation describes the subsistence takes of Steller sea lions (*Eumetopias jubatus*) by Alaska Natives in 2001 including quantity, seasons, geographic distribution, and age and sex of the harvest. Information is summarized at the state, region, and community levels, and is compared with estimates of annual takes since 1992. The research was conducted by the Division of Subsistence, Alaska Department of Fish and Game in cooperation with the Alaska Native Harbor Seal Commission and the Aleut Marine Mammal Commission, under contract with the National Marine Fisheries Service. Data on subsistence takes of harbor seals (*Phoca vitulina*) were also collected. Information derives from systematic interviews with hunters and users of marine mammals in 1,461 households in 61 coastal communities within the geographic ranges of the two species. Local researchers conducted most of the household interviews as part of regional research networks. Data from an independent project conducted by the Aleut Community of St. Paul were incorporated into the estimates.

During 2001, the estimated subsistence take of sea lions by Alaska Natives was 198 sea lions, with a 95 percent confidence range of between 162 to 282 sea lions. Of the take, 21.3 percent (42 sea lions) were struck and lost and 78.7 percent (156 sea lions) were harvested. Sea lions were taken in 19 of 62 communities. Hunters reported taking males over females by about 3 to 1, and adults (42.3 percent) and juveniles (38.7 percent) over pups (1.3 percent). Sea lion takes sharply declined from 1992 to 1995, with takes leveling off between 1996 to 2001 -- 549 (1992), 487 (1993), 416 (1994), 339 (1995), 186 (1996), 164 (1997), 178 (1998), 164 (2000), and 198 (2001). Declines in sea lion takes are associated with decreasing numbers of hunters hunting sea lions, which is probably linked to local sea lion scarcities.

POSTER Session GLOBEC

Factors Affecting Distribution, Size, and Condition of Juvenile Prince William Sound Hatchery Pink Salmon in the Gulf of Alaska, August 2000 and 2001

E.V. Farley, Jr and J.H. Helle

NMFS Auke Bay Laboratory

Variations in distribution, size and condition factor for juvenile Prince William Sound hatchery pink salmon caught in oceanic waters during August 2000 and 2001 along transects across the continental shelf of the Gulf of Alaska west of Prince William Sound were examined with respect to distance off shore, surface temperature, and zooplankton volume. Distribution, represented by catch per unit effort, was not significantly related to sea surface temperature or zooplankton volumes. Juvenile PWS hatchery pink salmon were smallest at nearshore and offshore locations along the Seward Line and Gore Point transects. Juvenile PWS hatchery pink salmon located offshore tended to have significantly higher condition factor than those caught nearshore or within the middle of the transect. Condition factor was negatively related to zooplankton volume during 2000 (bongo nets were used) and not significantly related to zooplankton volume during 2001 (Tucker trawl was used). Future analyses will link oceanographic measurements collected during Ocean Carrying Capacity surveys in the Gulf of Alaska (ADCP or current and salinity) to juvenile salmon biological characteristics (distribution, size and conditions) and zooplankton distributions.

*Session SSL-8: Steller Sea Lion Biology and Ecology
Diet*

***Application of laser ablation ICP-MS to elemental fingerprinting and isotope analysis
to evaluate nutritional history and diet of Steller Sea lion***

Sean D. Farley¹, Vicki K. Stegall¹, Lorrie D. Rea¹ and W. Ian Ridley²

¹Alaska Department of Fish and Game

²Mineral Resources Program, United States Geological Survey

Sean_Farley@fishgame.state.ak.us , Vicki_Stegall@fishgame.state.ak.us

Lorrie_Rea@fishgame.state.ak.us , iridley@usgs.gov

Abiotic and biotic factors can have profound nutritional importance to mammalian growth parameters. Generally, select biological samples will carry measures of growth conditions in the form of element deposition patterns and isotope concentrations. Metabolically inert, stable tissue products such as keratin containing nails and vibrissae, and mineralized deposits such as bone, can be used as time-integrated records of nutritional condition. Unfortunately often the physical deposition pattern in the animal is at a scale too fine to resolve with standard analytical techniques. Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICPMS) provides a means of sampling biological tissues at scales ranging from 10 to 300um sample size, and providing quantitative in situ trace and ultra-trace elemental and isotope analysis. We report the preliminary findings from application of LA-ICPMS on sea lion vibrissae, milk, and blood samples. Research supported by NMFS, NMML/NOAA and ADF&G. Samples were collected under NMFS permit # 358156400.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

A Bayesian stochastic metapopulation model for Steller sea lions

Gavin Fay and Andre E. Punt

School of Aquatic and Fishery Sciences, University of Washington
gfay@u.washington.edu

The timing and extent of the decline of Steller sea lions (*Eumetopias jubatus*) in Alaska has not been geographically uniform. To date, population modeling approaches for Steller sea lions have not tended to account for spatial heterogeneity in population trend. A stochastic, spatially-structured modeling framework based on the metapopulation concept is outlined to account for this spatial variability and as the basis for synthesizing existing information. This framework allows for density-dependent processes, demographic and environmental stochasticity in birth and death rates, catastrophic events and for impacts of unknown factors on survival and pregnancy rates. The framework is illustrated by applying it to the sea lion population in the Central Gulf of Alaska. The values for the parameters of this model, and hence the historical trend in female sea lion abundance, are estimated using Bayesian and maximum likelihood methods applied to data on historical counts of pups and non-pups, in addition to estimates of survival and age structure samples. The sensitivity of results to data set choices, and to sources of stochasticity in the model when estimating the model parameters are explored.

POSTER Session EVOS/NPRB

Biodiversity of Prince William Sound: Marine Invertebrates

Nora R. Foster and Max K. Hoberg

Basic taxonomic, biogeographic, and habitat information for 1343 species of marine of Prince William Sound were compiled into structured data sets. This species inventory is intended as a baseline from which biodiversity responses to future environmental changes can be assessed measured. The data sets include 39 possibly undescribed species, 89 range extensions, and 17 nonindigenous species. The fauna and flora of Prince William Sound is a mixture of species with biogeographic affinities that overlap the northern and northwestern Pacific as well as the Arctic and Atlantic regions.

Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

The seasonal distribution and quality of fish species within Steller sea lion critical habitat near Kodiak from 2000-2002

Robert J. Foy

Fishery Industrial Technology Center, University of Alaska Fairbanks
fnrjf@uaf.edu

The importance of seasonal, spatial and ontogenetic variability in the availability and energetic content of sea lion prey species has been noted but not well studied. This study targeted demersal and pelagic fishes within the foraging range of Steller sea lion haulouts. Multiple fish species were collected around the Long Island Steller sea lion haulout on the southeast side of Kodiak Island in March, May, July and November 2000, 2001 and 2002 during fish distribution studies for the Gulf Apex Predator-prey study. To determine species composition and relative abundance of fishes in critical habitat adjacent to Long Island, we conducted acoustic and trawl surveys. The acoustic sampling was conducted at 38 kHz on parallel east-west lines spaced 3 nm apart, extending 25 nm from the Long Island haulout. Fish species caught in the midwater tows included walleye pollock, capelin, eulachon, arrowtooth flounder, Pacific sandfish, Pacific cod and king salmon. The bottom trawls based on depth and distance from sea lion haulout strata were dominated by arrowtooth flounder, flathead sole, walleye pollock, Pacific cod, rock sole and eulachon. The proximate composition of fish around the Long Island Steller sea lion haulout differed seasonally and annually. Lipid values ranged from 0.95 to 4.7 percent in May and from 1.9 to 11.6 percent in November over 30 fish species. Moisture ranged from 76.5 to 80.7 percent in May and 69.6 to 79.5 percent in November. Protein ranged from 13.9 to 21.0 percent in May to 14.9 to 17.7 percent in November. Ash ranged from 1.5 to 3.6 percent in both May and November. Knowledge of the quality of prey around Steller sea lion haulouts will allow us to understand the relative importance of particular prey that are also key commercial fisheries so that the importance of protected Steller sea lion habitat can be evaluated.

Session SSL-12B: Steller Sea Lion Site Specific Studies - Kodiak Island

Availability and use of prey by Steller sea lions in Kodiak, Alaska in 2000

Robert J. Foy and Kate M. Wynne

Fishery Industrial Technology Center, University of Alaska Fairbanks
fnrjf@uaf.edu , ffkmw@uaf.edu

Steller sea lions population declines during past 30 years have been linked to low juvenile survival and nutrient limitations. This project addressed the hypothesis that the relative composition and abundance of prey species in the diet of Steller sea lions is directly related to availability of prey around critical haulouts in the Kodiak area. In order to test this hypothesis we determined the seasonal Steller sea lion abundance, distribution, and diet of Steller sea lions on haulouts in Chiniak and Marmot Bay. Thirteen monthly aerial surveys of 12 critical haulouts in the Kodiak Archipelago were conducted in 2000. Also 819 Steller sea lion fecal samples (scats) were collected during twelve collections from ten haulouts in the Kodiak region in 2000. We also assessed the seasonal species composition, biomass and distribution of pelagic and demersal fish species within 20 nm of Long Island in March, May and November 2000 on hydroacoustic/commercial bottom and midwater trawl surveys. Sixty-seven species of fish were collected among the 3 seasons. These were dominated by arrowtooth flounder, flathead sole, walleye pollock, Pacific cod, rock sole and eulachon making up on average the top 89% of fish caught in the bottom trawls. Twelve species of fish were caught in the midwater trawls over the 3 seasons. These included, in order of averaged abundance: walleye pollock, eulachon, capelin, arrowtooth flounder, Pacific sandfish, king salmon, sturgeon poacher, steelhead trout, dusky rockfish, prowfish, and spiny dogfish. We compared the use of prey by Steller sea lions to availability of prey both inside and outside of the 10 nm 'buffer-zones' created by the National Marine Fisheries Service to limit fishing activities inside Steller sea lion critical habitat. These data ultimately will be of practical importance to fisheries managers and will provide basic knowledge of predator/prey dynamics in the Kodiak Island region.

POSTER Session: Steller Sea Lion Site Specific Studies - Kodiak Island

Gulf Apex Predator-prey Program

Robert J. Foy, Kate M. Wynne and C. Loren Buck

University of Alaska Fairbanks

fnrjf@uaf.edu, ffkmw@uaf.edu, loren.buck@uaf.edu

The Gulf Apex Predator-prey program (GAP) addresses trophic-level questions of immediate biological and economic concern in the western Gulf of Alaska. The program's current goal is to document trophic relationships between Steller sea lions, their prey, competitors, and predators in the Kodiak region. Fundamental to the GAP program is the integration of distinct but related hypothesis-driven research projects. Although focused on sea lion concerns, GAP's interrelated studies also broadly assess the degree of dietary overlap among Kodiak's sympatric apex predators while exploring processes that drive populations of their prey within a dynamic marine environment. These studies overlap spatially and temporally, allowing synchronous collection of predator and prey data and synoptic assessment of their seasonal interactions. The GAP program is planned as a multiyear sampling effort that will allow monitoring inter-annual variability against which effects of human intervention may be compared. GAP investigators strive to facilitate synergistic linkage to related studies and efficiently broaden research beyond the scope of individual projects and have already fostered collaboration with fisheries and marine mammal researchers within the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADFG). The objectives of the GAP program in 2001 and 2002 were to 1) use systematic and adaptive fish surveys conducted in the Kodiak area to assess the seasonal species composition, distribution, abundance, and quality of prey available to sea lions, whales and seabirds; 2) conduct monthly aerial surveys and Steller sea lion scat collections in the Kodiak area to determine relative use of designated critical haulouts and describe prey species consumed by Steller sea lions; 3) identify seasonal and inter-annual patterns and changes in prey and habitat use by Steller sea lion competitors including piscivorous birds, whales and fish.

*Session SSL-3B: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***A Critical Review of the “Regime Shift/Junk Food” hypothesis for the Steller sea lion
decline***

Lowell W. Fritz and Sarah Hinckley

NMFS Alaska Fisheries Science Center

Lowell.Fritz@noaa.gov , Sarah.Hinckley@noaa.gov

It has been hypothesized that periodic changes in the climate of the North Pacific caused the decline of the Steller sea lion population observed in the 1980's by causing large increases in consumption of gadid fishes (with “low nutritional value”), and decreases in consumption of osmerid and clupeid fishes (“forage fish” with “high nutritional value”). Changes in food habits of Steller sea lions have been, under this scenario, hypothesized to have stemmed from climate-induced restructuring of fish communities and their spatial distributions. The consequences for sea lions associated with greater or lesser consumption of gadids and forage fish, respectively, are thought to have included decreased reproductive success or survival due to some sort of nutritional stress or competitive disadvantage.

We examine this hypothesis through a critical re-analysis of fishery and survey data, gadid, and clupeid recruitment and biomass time series, Steller sea lion and other otariid food habits information in the North Pacific Ocean and throughout the world, and information related to the nutritional worth of gadids vs. other prey species, including proximate analyses of prey composition as it varies seasonally and spatially. We conclude that (1) gadid populations fluctuate in abundance and were at similar levels both before and after the 1976-1977 regime shift; (2) herring populations increased in the 1980's following the regime shift; (3) it is unlikely that herring and other forage fish have ever dominated the fish community in terms of total biomass; (4) gadids have consistently been prominent parts of otariid diets in the North Pacific and other parts of the world; (5) the data which suggests that diet diversity and composition has changed radically may be biased and is certainly open to interpretation; (6) the value of any particular prey item depends on the season in which it is eaten and the energetic and foraging costs of obtaining it (at times gadids have higher energetic density than osmerids or clupeids); and (7) a diet with too high a proportion of osmerids or clupeids is known to be detrimental to many species of marine mammals and fish. While changes in the environment of Steller sea lions have certainly occurred over the last 30 years, and could have contributed to the creation of sub-optimal conditions, we conclude that it is unlikely that they, or the high proportion of gadids in the diet, are the primary causes of the recent and ongoing decline in sea lion populations.

*Session SSL-3B: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

Competitive Interactions: Steller Sea Lions And Sharks

Vincent Gallucci, Ian Taylor and Joel Rice

School of Aquatic and Fisheries Sciences, University of Washington
vgallucc@u.washington.edu, itaylor@u.washington.edu, joel_rice@hotmail.com

Competitive interactions are explored between two species where age structure has a major role. The example under study is that of Steller Sea Lions [SSLs] and salmon sharks. Part of the report deals with unraveling the life cycle of the salmon shark, about which little was known until very recently and which is believed to be an important part of the population dynamics of the SSL. Information such as salmon shark reproductive potential, abundance, bioenergetics, migration patterns and destinations are accumulated and for use in the context of the sea lion problem. Results are reported about the dynamics of Steller sea lion population growth under a suite of different competitive interactions with salmon sharks. Differential equation models are used to represent time dependent dynamical behavior and matrix difference equations are used to represent age structured dependent dynamics of both species. Contours of competitive extinction, a series of risk isopleths, are introduced and used to quantify the long term condition of populations under various realistic combinations of demographic parameters. Alternative control measures are evaluated that will increase the SSL population size. The population dynamics of the SSLs and the salmon sharks are discussed under the past PDO regime and preliminary predictions are made about possible alternative regimes.

Reproductive Success of Glaucous-winged Gulls on Kodiak Island, Alaska

J. Brook Gamble¹, C. Loren Buck², S. Dean Kildaw¹ and Edward C. Murphy¹

¹Institute of Arctic Biology, University of Alaska Fairbanks

²School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
ftjbg@uaf.edu

The consideration of piscivorous seabirds as indicators of forage availability in the nearshore of the east side of Kodiak Island is integral to the Gulf Apex Predator-prey project (GAP). Because reproductive success of seabirds is both easily monitored and has been shown to be positively correlated with available food resources, seabirds may be useful indicators of foraging conditions just prior to and during their breeding season. Reproductive parameters of seabirds that are sensitive to the influence of food supply include survivorship, clutch size, egg volume, breeding success, chick growth, colony attendance, and activity budgets of adults. In 2001 we initiated a multi-year study of the breeding biology of the glaucous-winged gull (*Larus glaucescens*) to investigate its utility as an indicator of local marine conditions. We monitored nests on three different colonies within Chiniak Bay, Kodiak Island and followed their fates on designated plots from the time of nest initiation through hatching. Mean clutch size in 2001 was 2.6 ± 0.0 (SE $n=150$) as compared to 2.5 ± 0.1 ($n=147$) in 2002. Mean egg volume of the first egg in each clutch in 2001 was $89.7\text{cm}^3 \pm 0.55$ ($n=146$) as compared to $89.5\text{cm}^3 \pm 0.52$ ($n=141$) in 2002. In 2001, 78.6% of the nests monitored hatched out at least one chick ($n= 159$) as compared to 60.1% of nests in 2002 ($n= 148$). Preliminary analysis suggests that there was not a significant difference in hatching success between 2001 and 2002 ($X^2 = 2.750$, $P = 0.093$). Further analyses are necessary to identify additional variables that effect reproductive performance of glaucous-winged gulls, and determine the utility of this species as an indicator of marine conditions.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

Acoustic Characteristics of Steller Sea Lion forage fish species

Stéphane Gauthier and John K. Horne

School of Aquatic and Fishery Sciences, University of Washington
sgau@u.washington.edu, john.horne@noaa.gov

Abundance and distribution of pelagic fish may be key factors in the decline of Steller sea lion populations. To accurately interpret acoustic surveys and scale acoustic signal to fish biomass, we need exact information on the acoustic properties of fish species. In this paper, we use Kirchhoff-ray mode (KRM) backscatter models to quantify acoustic characteristics of Bering Sea and Gulf of Alaska pelagic fish species and identify potential methods of discrimination. Five species of interest were analyzed: capelin (*Mallotus villosus*), Pacific herring (*Clupea pallasii*), walleye pollock (*Theragra chalcogramma*), eulachon (*Thaleichthys pacificus*) and Atka mackerel (*Pleurogrammus monopterygius*). Acoustic backscatter was modeled as a function of insonifying frequency, fish length, and body orientation relative to the incident wave front. Backscatter amplitude and variance estimates were compared among species and frequencies. Eulachon and Atka mackerel do not possess a gas-filled swimbladder, which resulted in lower amplitudes and increased variability. For species with a swimbladder, Pacific herring typically had lower signal to noise ratios (backscatter mean over standard deviation), while capelin had the highest values. Species-specific differences in echo amplitudes between carrier frequencies has limited potential for species discrimination, due to the relative absence of frequency dependent scattering within the range of observation (from 12 to 200 kHz).

Session EVOS/NPRB-1: Marine Research

***Distribution of two species of rougheye rockfish
in the northeastern Gulf of Alaska***

A.J. Gharrett and Z. Li

In our population genetics work, we observed two types of rougheye rockfish that had fixed differences at one microsatellite locus as well as divergent mtDNA complements. Both types were caught in many of the same hauls in some regions. These two types are surely distinct species. The ranges of these two types are not coincident; in some areas one or the other predominates. Rougheye rockfish have high commercial value and their bycatch has the potential to greatly affect the prosecution of other larger fisheries. The appearance of a new species in this management complex underscores our need to learn more about the distribution and biology of these and other groundfish species. We are conducting both microsatellite and mtDNA analysis of rougheye rockfish sampled in Prince William Sound, Resurrection Bay, and the inside waters of Southeast Alaska. We expect to learn whether one rougheye rockfish type is associated with nearshore or inside waters, but regardless the data combined with our existing data will improve our understanding of the ranges of rougheye rockfish and refine our picture of the population genetic structure in the northeastern Gulf of Alaska.

PLENARY Session: Monday, 13 Jan 3:30-4:15 PM

***Scientific Review of the Harvest Strategy Currently Used in the
Bering Sea and Gulf of Alaska Groundfish Fishery Management Plans***

Daniel Goodman

Montana State University
goodman@rapid.msu.montana.edu

In 2001 the North Pacific Fishery Management Council voted to convene an expert panel to review the ecosystem protection aspects of the fishery management plans for the Bering Sea, Aleutian Islands and Gulf of Alaska groundfish fisheries. Specific matters to be elucidated included: the basis of the harvest strategy embodied in these fisheries management plans, the role of the $F_{40\%}$ control rule, the relation to the National Standards of the Magnuson-Stevens Fishery Conservation and Management Act, and the manner in which these plans take account of ecosystem considerations. The panel reported to the Council in late 2002 (www.fakr.noaa.gov/npfmc/Reports/f40review1102.pdf). The panel found that: the harvest strategy embodied in the fishery management plans is essentially a conservative single-species MSY approach with additional ad hoc elements of conservatism that are case specific and the rationale for which is not well documented; the $F_{40\%}$ control rule is central to the systematic conservative MSY component of the harvest strategy; the ecosystem guidance in the MSFCMA National Standards lacks specificity; the Optimum Yield cap on the summed Total Allowable Catches for the Bering Sea Aleutian Islands groundfish is 15% less than the summed historic single-species MSY estimates, and the Steller Sea Lion RPAs respond to particular concerns in relation to that population, but otherwise the documentation of the harvest strategy does not articulate an explicit ecosystem standard. The panel recommended a formal Management Strategy Evaluation of the component of the harvest strategy governed by the $F_{40\%}$ control rule system. The panel recommended revisiting the determination of the Optimum Yield level, with a view to updating the information base and possibly incorporating an ecosystem standard.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

***Probability of Distributional Overlap Between Steller Sea Lions and Commercial
Trawl Fisheries in Alaska***

Edward J. Gregr and Andrew W. Trites

Marine Mammal Research Unit , Fisheries Centre, University of British Columbia
gregr@zoology.ubc.ca , trites@zoology.ubc.ca ,

We constructed a simple model to identify marine habitat used by mature female Steller sea lions (*Eumetopias jubatus*) during summer and winter in the Gulf of Alaska and Bering Sea. Commercial trawl fishing data (catch, effort and location) were combined with Steller sea lion data (counts and foraging distances) and bathymetric data to identify the potential degree of overlap in their respective distributions (i.e., the probability of fisheries and sea lions occurring together). The habitat model showed sea lions were widely dispersed at sea during winter compared to summer when they appear to be tightly distributed around rookeries and haulouts. It further showed the high relative importance of sea lion habitat in the Gulf of Alaska compared to the Bering Sea. Overlap between trawl fisheries and sea lions was higher in the winter than in summer, but was relatively low overall. Refinements to the habitat model using additional biological data on diet, foraging location and fish abundance will further enhance the ability of the model to quantitatively evaluate existing management actions, and to develop more effective means of mitigating the possible effects of fisheries on Steller sea lions.

GLOBEC Research: Seasonal and Annual Patterns of Abundance and Size of Juvenile Pink Salmon on the Shelf of the Northern Gulf of Alaska

Lewis Haldorson and Jennifer Boldt

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

Juvenile pink salmon occupy water over the continental shelf of the northern Gulf of Alaska (NGOA) for much of the summer and fall after entering nearshore marine waters in late spring. While in shelf waters they grow rapidly from less than 100-mm fork length in July to over 200 mm in October. They return to spawn in the following summer. A major objective of the GLOBEC program is to determine how variation in oceanographic conditions and plankton production affects juvenile pink salmon growth and survival while they reside in waters over NGOA continental shelf. Many juvenile pink salmon in the NGOA originate in PWS hatcheries; consequently, an estimate of marine survival is available a year after they pass through the study area. Our field program included annual samples over the continental shelf on the Seward Line in August beginning in 1999; and monthly samples on the Seward line and in Prince William Sound (PWS) from July through October in 2001. In July 2001 catches in PWS were very high, relative to the Seward Line; however, in subsequent months the distribution shifted onto the shelf, and by October very few juvenile pink salmon remained in PWS and they were in low numbers on the shelf. Highest abundance on the Seward Line occurred in August and September. In 1999-2002, pink salmon were the most abundant juvenile salmonids on the Seward Line in August. They were broadly distributed across the shelf, but were uncommon over deeper water off the shelf. Over the shelf, patterns of abundance varied annually, and August of 2002 was most anomalous with a concentration of pink salmon near the shelf edge. Juvenile chum and sockeye salmon were also common across the shelf. Mean lengths of juvenile pink salmon in August varied annually, there was also significant variation in mean length among Seward Line stations in each year. In August 2000 the largest fish occurred in the middle shelf, whereas in 2001 the smallest fish were found there. Hatcheries in PWS release around 600 million juvenile pink salmon each year, and those fish were an important component of our samples. In 2001, the proportion of hatchery fish decreased in each month, from a high of 66% in July to less than 15% by October. Marine survival of hatchery fish varied during our study, with highest survival (0.056) by those fish entering marine waters in 1999, and lower survival (<0.04) by those in 2000 and 2001. In GLOBEC pink salmon studies we will use bioenergetic modeling to determine if variation in growth and survival is related to habitat quality while juveniles occupy shelf waters of the NGOA.

Using voucher specimens to detect biogeographic patterns in south-central Alaskan seaweeds

Gayle I. Hansen¹ and Michael S. Stekol²

¹Hatfield Marine Science Center, Oregon State University, Newport

²School of Fisheries and Ocean Sciences, University of Alaska Fairbanks (Juneau)

Voucher specimens of seaweeds gathered during environmental impact studies of the Exxon Valdez oil spill and subsequent oil-tanker traffic in the area have provided enough information on the occurrence and distribution of the species for us to begin to resolve the biogeographic patterns in south-central Alaska. The 10,442 specimens and 198 sites included in this investigation contained 324 mainly intertidal seaweed species. Half of these species were widely distributed throughout the study area while a third, including many rare species, were limited to only one of the three regions investigated. Species richness varied extensively between sites and was heavily influenced by collection effort. The richest sites contained >100 species, while the most poorly collected sites were represented by only a single specimen. In order to accommodate this wide variation, the sites were merged both geographically and by dominant environmental feature for analysis. Species similarity was found to be strongest between neighboring areas and between areas subjected to similar amounts of wave exposure. Exposed outer coastal areas clustered with the most western sites segregating due to the intrusion of Aleutian species. Areas in Prince William Sound clustered with sheltered areas along the western Kodiak chain. Overall species richness was highest in areas with moderate to high but not extreme wave exposure and lowest in areas with low exposure and low salinity. Indicator species are suggested for recognizing specific habitat conditions.

Session EVOS/NPRB-2: Citizen Monitoring and Community Involvement

Coastal Habitat Mapping in the Gulf of Alaska

John Harper, Mary Morris and Susan Saupe

Coastal & Ocean Resources Inc.
john@coastalandoceans.com

Approximately 5,000 km of Gulf of Alaska shoreline (Cook Inlet, Outer Kenai and Kodiak Island) were imaged in 2001 and 2002 as part of EVOS/GEM and CIRCAC funding initiatives. Video and photographic imagery were acquired at extremely low tides and include synchronous in-flight commentary by both biologists and geologists. The imagery is publicly available and in a unique aspect of the project, has been sampled and web-posted to provide world-wide image access for the entire surveyed shoreline (<http://imf.geocortex.net/mapping/demos/cori/launch.html>). The imagery is being used as the primary data source for high resolution biophysical coastal habitat mapping. The mapping uses the BC/Washington ShoreZone Mapping protocol, which has been applied to approximately 40,000 km of shoreline in BC and Washington. The protocol is being modified to incorporate special features for Alaska, including polygon mapping for selected wide-intertidal areas and other user requests. Mapping is essentially completed at scales of 1:5,000 and incorporates over 100 data attributes for each shoreline segment. The attribute data can be used to display region-wide maps of variety of biophysical features including: shoreline type, sediment, coastal stability, eelgrass, kelp and marsh as well as derivative data such as oil spill sensitivity or sandlance spawning potential. In Washington, the data sets have been widely used by state and federal agencies in resource management (sandlance spawning habitat model), by universities as a spatial framework for more detailed research and by NGO's for stewardship monitoring programs (e.g., People for Puget Sound) and for conservation planning (The Nature Conservancy).

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

Mark-recapture studies of branded sea lions pups at Lowrie Island, Alaska

Kelly Hastings and Tom Gelatt

Alaska Department of Fish and Game

Kelly_hastings@fishgame.state.ak.us , Tom_Gelatt@fishgame.state.ak.us

In June 2001 and 2002, a total of 427 Steller sea lion pups were branded (62% of which were also tagged) at Lowrie Island and Cape Horn Rocks (~ 0.5 km distant from Lowrie Island) in Southeast Alaska. During July – October, 2001 and July – September, 2002 over 4,000 resights of these pups were collected at Lowrie Island. Systematic weekly resight surveys were conducted in which two observers simultaneously and independently read brands and flipper tags at 8-9 standard observation sites. Without consideration of brand misreading, return rates of the se pups indicated 94% and 99% of pups branded on Lowrie Island and 66% of pups branded at Cape Horn Rocks were observed on Lowrie Island on some day after the branding event. We estimated brand misread rates and examined factors affecting misread rates using resight data in which 1) both brands and tags were resighted on the same individuals and/or 2) brands and/or tags were independently read by two or more observers simultaneously. We estimated tag loss rates to 3 months of age from multiple sightings of tagged individuals. We also examined apparent survival (survival confounded with dispersal) probabilities from branding to 3-4 months of age and the probability of pups reuniting with mothers after branding using mark-recapture models. These analyses provide an initial evaluation of immediate effects of branding on survival of Steller sea lion pups. These data will be combined with future resighting data from throughout Southeast Alaska, to estimate age-specific survival of Steller sea lions.

Session SSL-8: Steller Sea Lion Biology and Ecology
Diet

Prey Size Selection of Walleye Pollock by Steller Sea Lions in Southeast Alaska (1994-99) Assessed from Skeletal Remains and the Application of Size Correction Factors

Susan G. Heaslip¹, Dominic J. Tollit¹, Tonya Zeppelin², Ruth Joy¹, Kate Call² and Andrew W. Trites¹

¹Marine Mammal Research Unit, University of British Columbia

²NMFS Alaska Fisheries Science Center

tollit@zoology.ubc.ca

Accurate estimates of prey size eaten by Steller sea lions are required to improve estimates of diet composition and to assess the extent of dietary overlap with commercial fisheries. Size selection of walleye pollock (*Theragra chalcogramma*), a principal prey species, was evaluated by applying fork length-skeletal structure regressions to seven selected structures recovered from 531 of 1,987 scats collected in Southeast Alaska between 1994-99. As partial bone digestion will result in underestimates of fish size, we developed condition-specific size correction factors (through captive feeding experiments) to account for intraspecific bone size reduction due to digestion. For pollock and Atka mackerel (*Pleurogrammus monopterygius*), keys using loss of topographical features were developed, to assign all structures to one of three condition categories.

Most otoliths (86%) were in poor condition highlighting the need to use alternative structures. Resulting uncorrected fork length averaged only 20.2 cm (± 9.7 SD, $n=247$). Using all structures (and excluding those in poor condition) increased our estimates to 34.4 cm (± 9.7 , $n=909$, range=9.8-63.8, $n=303$ scats). Applying our correction factors increased size estimates by ~23% (mean FL=42.4 \pm 11.6 cm, range=10.0-78.1) and the number of adult fish (>45.0 cm) eaten from 16% to 44%. This increase equates to a mass contribution of 74% by adults and <0.1% by juveniles (≤ 20 cm).

A higher occurrence of adult fish were found in scats collected from rookeries along the outside coastline during June and July (74% adults, $n=126$ scats, mean FL=48.4 cm) than from haul-outs located in inside waters between October and May (52% adults, $n=163$ scats, mean FL=38.5 cm). No other clear geographical or temporal differences in the proportion of pollock age classes eaten were observed. Corrected size composition of pollock eaten by Stellers showed considerable niche overlap (52% overall) with the size sought by the small commercial pollock trawl fishery in the region.

POSTER Session GLOBEC

Modeled Lagrangian Drifters in the Gulf of Alaska

K. Hedstrom¹, D. Musgrave¹, A.J. Hermann² and E.L. Dobbins²

¹University of Alaska Fairbanks

²Joint Institute for the Study of Atmospheres and Oceans, University of Washington

We have carried out a model simulation of the Gulf of Alaska at 3 km resolution. Within this model, Lagrangian drifters were released in groups of twenty, at depths of 5 and 50 meters. The drifters were reinitialized every season so that seasonal and interannual variability can be assessed. Many of the drifters were started in Prince William Sound. Of these, some left through Montague Strait and others left through Hinchinbrook Entrance, both groups getting caught up in the Alaska Coastal Current. The drifter tracks will be analyzed in terms of vertical motions, vertical shear, and seasonal cycles.

Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

***Seasonal Abundance and Diversity of Nearshore Fishes around
Steller Sea Lion Haulouts of Kodiak Island***

Cathy Hegwer, Brenda Konar, Susan Hills and Kate Wynne

School of Fisheries and Ocean Science, University of Alaska Fairbanks
fsclh@uaf.edu, bkonar@ims.uaf.edu, shills@ims.uaf.edu, fkwm@uaf.edu

Presence of nearshore fishes is important to Steller Sea Lion pups as they learn foraging behavior and increasingly supplement their milk diets during weaning. We hypothesized that there was a difference in the nearshore fish species composition and abundance between haulout and non-haulout sites. SCUBA based surveys were conducted in the nearshore waters adjacent two Steller Sea Lion haulouts of Kodiak Island at 9 m, 15m, 21m, 27m and 33m depth profiles to quantify seasonal fish diversity and abundance, as well as to collect habitat information about these nearshore areas. Identical surveys were also conducted at two areas of similar exposure, but which are not historical SSL haulouts. Although heavy seas prevented sampling on occasion, a total of 278 thirty meter transects were done in the five sampling periods. Abundance of fishes was analyzed seasonally at the various depths at both SSL and non-SSL sites. We found lower abundance of fishes at the Steller haulout sites, particularly at the 9m, 15m, and 21m depths during the summer sampling periods. MDS and Cluster analysis were used to further explore the patterns that were seen. Analysis of seasonal patterns indicates a greater abundance of fishes during the summer sampling periods. Lower abundance and more even distribution patterns were seen in the winter months.

*Spatial and temporal variation in the lipid content of
juvenile herring and sand lance*

Ron Heintz

NMFS Auke Bay Laboratory

Examination of lipid dynamics holds promise for identifying critical periods that affect the recruitment of forage fish. Little is known about the factors influencing their production, but recent reports indicate variation in prey quality translates to fine-scale spatial variation in forage fish energy density and recruitment. Variation in energy density is driven by variation in lipid content, suggesting lipid analysis as a tool for examining recruitment processes.

Spatial variation in the lipid content of young-of-the-year (YOY) Pacific sand lance (*Ammodytes hexapterus*) and herring (*Clupea pallasii*) was examined by collecting fish from six locations in Prince William Sound (PWS), Alaska between July 15 and August 2, 1997. Herring ranged between 8% and 10% lipid (dry weight) and sand lance between 9% and 16%, fish from sites in southwestern PWS generally had the highest lipid contents. These data indicate fine-scale spatial variation in energy density of juvenile herring is detectable at least two months earlier than previously reported.

Temporal patterns in the lipid content of age-0 and age-1 sand lance differed and were suggestive of energy allocation strategies driven by life history demands. Age-0 and age-1 sand lance, were collected bi-weekly from Kachemak Bay, Alaska during the summer of 1998. Lipid content of age-0 sand lance initially declined by 50% between May 22 and July 9, remained constant in mid-summer until metamorphosis was complete and increased in late August. In contrast, lipid content of age-1 sand lance increased nearly 5-fold between May 22 and July 9. No age-1 sand lance were observed after that date, but previous reports demonstrate gonadal recrudescence begins in this age class after this period with concomitant decreases in lipid content. These data suggest the importance of energy gains in early spring in the recruitment of sand lance.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Disease and Contaminants*

*A Science Plan for Evaluating the Role of Contaminants in the
Decline of Steller's Sea Lions*

Ron Heintz¹, Mace Barron² and Margaret M Krahn³

¹NMFS Auke Bay Laboratory

²PEAK Consulting, Longmont, CO

³NMFS Northwest Fisheries Science Center

Ron.Heintz@noaa.gov , Peggy.Krahn@noaa.gov , macebarron@hotmail.com

After nearly three decades of decline the western stock of Steller's sea lions (SSL) was listed as an endangered species in 1997. While the cause of the decline in the 1970's and 80's has been attributed to nutritional stress, recent declines are unexplained and may result from other factors including the presence of environmental contaminants. SSL tissues show accumulation of butyltins, mercury, PCBs, DDTs, chlordanes and hexachlorobenzene. SSL habitats and prey are contaminated with additional chemicals including mirex, endrin, dieldrin, hexachlorohexane, dioxin compounds, cadmium and lead. In addition, many SSL haulouts and rookeries are located near other hazards including radioactivity, solvents, ordnance and chemical weapon dumps. PCB and DDT concentrations measured in a few SSL during the 1980's were the highest recorded for any Alaskan marine mammal. Some contaminant exposures in SSL appear to be elevated in the Gulf of Alaska and Bering Sea compared to southeastern Alaska, but there are insufficient data to evaluate geospatial relationships with any certainty. While exposure to PCBs and DDTs may be declining, SSL may be exposed to a multitude of other contaminants that have not been monitored. The impacts of these exposures on SSL remain unknown because causal effects have not been established, and field studies with SSL have been limited in scope and have not yet linked contaminant exposures to adverse animal health or population effects. Several biomarkers may prove useful for monitoring exposure, but much more work remains to establish their utility in SSL. We conclude that there are insufficient data to reject the hypothesis that contaminants play a role in the continued decline of SSL, and present a coordinated plan which can relate key biological, ecological and laboratory toxicity data.

Session SSL-14: Steller Sea Lion Site Specific Studies – Southeast Alaska

Variation in the Energy Content and Fatty Acid Composition of Herring from Southeastern Alaska

Ron Heintz, Johanna Jill Vollenweider, Marie Larsen and Larry Holland

NMFS Auke Bay Laboratory

Ron.Heintz@noaa.gov, Johanna.Vollenweider@noaa.gov, Marie.Larsen@noaa.gov,
Larry.Holland@noaa.gov

Herring are an important forage species for apex predators in the Gulf of Alaska, but many factors influencing herring life history are unknown. Coupling an understanding of energy dynamics with evaluations of fatty acid composition can provide insight into factors influencing herring growth, reproduction and survival. For example, seasonal variation in energy content reveals critical periods of energy depletion or replenishment. The magnitudes of these fluxes ultimately influence growth and reproduction. The fatty acid composition of an organism reflects the composition of its diet, thus changes in the fatty acid composition reflect shifts in diet. Combining these concepts provides an opportunity to evaluate how seasonal variation in herring diets influences the maintenance of energy density. Consequently, we sampled herring from two locations in southeastern Alaska with the intent of characterizing seasonal variation in their energy density and determining if there is a seasonal component to the variation in their fatty acid composition.

Fluxes in herring energy density ($P < 0.001$) are greatest over summer and winter and during these periods fatty acid compositions change significantly. Energy density of adult herring was highest in September (2.29 ± 0.07 Kcal/g) and remained at that level through early December. Between December and March energy density decreased by more than 30% and remained at this minimum throughout the spring. Thus, adult herring were at an energetic minimum at the time they began spawning. Energy costs incurred between December and March were likely associated with gonadal recrudescence and diminished food supplies. However, the relative large concentrations of C20:1n9 and C:22:1n11 in herring fatty acids suggest they had access to high quality prey in December. These data suggest supplies of high quality prey in winter are insufficient to meet the high cost of gonadal development. Consequently, reproductive success is more likely controlled by energy obtained the previous summer.

Juvenile Salmon Migrations along the Continental Shelf in the Gulf of Alaska

Jack Helle

NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory

Research on the migration and growth of juvenile salmon in the coastal areas in the Gulf of Alaska was initiated in 1964 by the Fisheries Research Institute of the University of Washington under contract to the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS). These studies continued through 1968. Salmon production in Alaska increased to record levels in many areas after the mid-1970's. This large increase in numbers of salmon coincided with changes in coastal ocean conditions and resulted in adult salmon becoming smaller and older. These changes in size and age at maturity of salmon suggested that there may be limits to the carrying capacity of the North Pacific Ocean for salmon production. The NMFS Alaska Fisheries Science Center, Auke Bay Laboratory in Juneau, Alaska, initiated an Ocean Carrying Capacity (OCC) research program in 1995 to address the causes of these changes in salmon populations.

One portion of the OCC program was directed at research on juvenile salmon in the coastal areas and was coordinated with biologists at the Pacific Biological Station in Nanaimo, British Columbia. OCC juvenile salmon surveys in 1996-98 covered the coastal areas of the Gulf of Alaska from southern southeast Alaska to Attu Island in the western Aleutian Islands. In 2000 OCC juvenile salmon surveys concentrated on the northern Gulf of Alaska. In 2001 the OCC program collaborated with NOAA oceanographers from the Alaska Fisheries Science Center and the Pacific Marine Environmental Laboratory in Seattle to work with U.S. GLOBEC (Global Ocean Ecosystem Dynamics) to focus on the relation between physical and biological oceanographic factors and juvenile salmon distribution in the Gulf of Alaska. These OCC/GLOBEC studies are concentrated in the northern Gulf of Alaska between Yakutat and western Shelikof Straits.

The shelf environment outside of Prince William Sound (PWS) and extending westwards to Kodiak Island is a section of a coastal corridor through which juvenile salmon from many locations further south (SE Alaska, BC, WA and OR) migrate, as well as the first "ocean" experienced by pink salmon exiting from PWS. Physical and ecological conditions (temperature, stratification, productivity, prey concentration and energy density, predator abundance and activity, etc.) in this region have significant impacts on the growth and survival of juvenile salmon. The influence of certain oceanographic processes, e.g. eddies, on the migration of juvenile salmon leaving Prince William Sound also will be discussed.

OCC expanded their research effort in 1999 to include research on juvenile sockeye salmon in Bristol Bay. In 2002, OCC undertook a major expansion in juvenile salmon research to include the coastal waters of the eastern Bering Sea from Bristol Bay to Norton Sound. In addition, OCC collaborated with Japan and Russia through the North Pacific Anadromous Fish Commission (NPAFC) in 2002 to initiate BASIS (Bering-Aleutian Salmon International Survey), a coordinated international research program aimed at understanding the relation between ocean conditions in the Bering Sea and salmon biomass.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

Spatial Coherence and Density Dependence In the Decline of the Steller Sea Lion

Daniel Hennen

Montana State University
hennen@rapid.msu.montana.edu

The National Marine Fisheries Service time series of adult counts of Western Alaska Steller sea lions was analyzed to estimate population growth rates and population sizes at 31 individual rookeries. The results show evidence of density dependence in the decline during the 1981-1991 period. Principal components analysis based on estimated growth rates show spatial coherence on the scales of 0 - 225 km, motivating a subdivision of the Western Alaska stock into 9 spatial groupings. This arrangement was compared with others in order to determine the “best fit”, using Mahalanobis’ distance, from each groups center, with cross validation, as a fitting criteria.

*Nested biophysical modeling of the Coastal Gulf of Alaska:
inferences from recent circulation results*

A. J. Hermann¹, D. B. Haidvogel², E. L. Dobbins¹, S. Hinckley³, P. J. Stabeno⁴, D. Musgrave⁵ and K. Hedstrom⁵

¹Joint Institute for the Study of Atmospheres and Oceans, University of Washington

²Rutgers University

³NMFS Alaska Fisheries Science Center

⁴NOAA Pacific Marine Environmental Laboratory

⁵University of Alaska Fairbanks

As part of the Northeast Pacific GLOBEC program, we have developed a set of nested physical and biological models at basin (North Pacific: NPAC at 40 km resolution), regional (Northeast Pacific and Bering Sea: NEP at 10 km resolution), and local (Coastal Gulf of Alaska: CGOA at 3 km resolution) scales. These models are nested in one direction, with each finer-scale domain receiving its boundary conditions from a larger-scale model. This allows us to investigate basin-scale influences on coastal transport, lower trophic level biological dynamics, and, ultimately, salmon life histories. Following a brief overview of our techniques for nesting, we examine several aspects of the circulation fields derived thus far. Eulerian characteristics of the upwelling and downwelling regions in the regional NEP model are examined via EOF analysis; monthly timeseries of the dominant spatial modes of SST and SSH are compared with monthly climate indices such as the PDO and ENSO. In earlier NEP results without NPAC-derived boundary conditions, a significant correlation between modeled coastal SSH and observed ENSO is evident, suggesting that this correlation can be present even with only local wind forcing. In the CGOA domain, Eulerian currents and salinity fields exhibit statistical features observed by the LTOP moorings and drogued drifters. Specifically, a 5-6 day periodicity is evident in the results from the fall, which may be due to advection of baroclinic instabilities. Also in the CGOA, the histories of the depth, temperature and salinity of simulated Lagrangian floats are examined as a function of release time, location and depth, and compared with drogued drifter tracks. The resulting tracks suggest the spatial pathways of nutrients, plankton, and juvenile fish in different seasons.

Spatially nested circulation modeling of the Coastal Gulf of Alaska: inferences from results in the vicinity of Kodiak Island

A.J. Hermann¹, D. Haidvogel², E. L. Dobbins¹, P. J. Stabeno³, D. Musgrave⁴ and K. Hedstrom⁵

¹Joint Institute for the Study of the Atmosphere and the Oceans, University of Washington

²Institute of Marine and Coastal Sciences, Rutgers University

³NOAA Pacific Marine Environmental Laboratory

⁴Institute of Marine Science, University of Alaska

⁵Arctic Region Supercomputing Center, University of Alaska

hermann@pmel.noaa.gov , dale@imcs.rutgers.edu , dobbins@pmel.noaa.gov , stabeno@pmel.noaa.gov , musgrave@ims.uaf.edu , kate@arsc.edu

We have constructed a set of nested models of coastal dynamics, designed to include basin-scale (North Pacific [Npac, 40-km resolution]) regional (Northeast Pacific and Bering Sea [NEP, 10-km resolution]) and local (Coastal Gulf of Alaska [CGOA, 3-km resolution]) influences on coastal transport. All are nested in one-way mode, with each finer-scale domain receiving its boundary conditions from a larger-scale model. Recent simulations include passive, three-dimensional Lagrangian float tracking. Following a brief overview of our nested approach, we examine several aspects of the circulation fields derived thus far with animations for areas near Kodiak Island. Eulerian currents and salinity fields from the NEP and CGOA models exhibit statistical features observed at moorings; in particular, the CGOA model exhibits a 5-6 day periodicity in the fall, which may be due to advection of baroclinic instabilities. Lagrangian histories of depth, temperature and salinity in the CGOA vary as a function of release time, release location and release depth. Cross-shelf transport is associated with near-surface Ekman flux, and steering by submarine canyons. Near the coast, floats tend to track the Alaska Coastal Current and its deformation by eddies. Near the shelf break, floats have a stronger tendency to follow the bathymetry, including transit into (and out of) canyons on Albatross Bank. Offshore, floats are swept along by the Alaskan Stream; adjacent floats in a cross-shelf line are strongly sheared and dispersed by that current. These tracks suggest spatial pathways of nutrients, plankton, and juvenile fish in different seasons near Kodiak.

Progress in 3-dimensionalization of GLOBEC CGOA NPZ model and other aspects of CGOA NPZ modeling

S. Hinckley¹, A. Hermann² and E. Dobbins²

¹NMFS Alaska Fisheries Science Center

²Joint Institute for the Study of Atmospheres and Oceans, University of Washington

This past year we have made substantial progress in the ecosystems modeling of the GOA for GLOBEC. The structure of the model has been improved in 3 ways. First, we have revised the trophic linkages in the model (GLNPZ) to separate pathways through small and large phytoplankton and microzooplankton, as was recommended at the last CGOA PI meeting. Second, we have extended the original coastal model to include oceanic applications by implementing an iron limitation function. This will allow biology to be simulated within water masses moving on and off the CGOA shelf. Third, GLNPZ has been incorporated directly into the Regional Ocean Modeling System (ROMS) in order to take advantage of its superior advection, mixing, and boundary conditions, and its ability to run on massive parallel computers. Results from this new code in 1D compare well with those from the original C code. GLNPZ within ROMS has been run on nested grids of increasing resolution. The larger grid, 12 km resolution from California to Russia, provides boundary conditions to the 3 km grid that stretches from Queen Charlotte Island to Unimak Pass. We discuss here some issues in development of the nested 3D models, describe the accomplished simulations, and analyze the 3D model results with respect to Seward Line LTOP data. In addition, we've begun exploring how to compare these biological modeling results with other GLOBEC sponsored models in the California Current System (CCS). Powell and Lewis have also used ROMS with a simple NPZD model to estimate production in the CCS. Preliminary comparisons have been completed between 1D versions of their NPZD model and GLNPZ; though the model structures are different, results indicate that comparison of regional dynamics will be possible with certain caveats.

POSTER Session: *Steller Sea Lion Biology and Ecology*
Diet

Sampling Steller Sea Lion Blubber Using a Remote Biopsy System

Laura Hoberecht¹, Daniel J. Vos² and Glenn R. VanBlaricom¹

¹School of Aquatic and Fishery Sciences, University of Washington

²NMFS, NOAA, Anchorage

llitzky@u.washington.edu, Daniel.Vos@noaa.gov, glennvb@fish.washington.edu

One of the leading hypotheses for the decline of the western stock of Alaskan Steller sea lions (*Eumetopias jubatus*) is nutritional stress. A tool for the study of pinniped diet, which utilizes comparisons of an animal's blubber fatty acid composition with the fatty acids found in potential prey items, has recently been introduced. This technique requires a full depth blubber core. Up to this point, blubber sampling of Steller sea lions has only been conducted on physically restrained animals or carcasses. This can make the systematic sampling of healthy individuals of sub-adult and older age classes intractable. Remote systems have been used in the past to collect skin and hair samples and to deliver pharmaceuticals to animals. However, this technique has never before been used to collect blubber samples from Steller sea lions. During 26 June – 01 July 2002, we used a remote biopsy system to sample 23 Steller sea lions near Kodiak Island, AK. A Barnett Wildcat III recurve crossbow (150 lb. draw weight) outfitted with tethered biopsy darts was used to collect samples. A three part biopsy head was designed to screw into a standard crossbow bolt (8-32 threads). The head consisted of a stopper piece, a biopsy tip, and a retention device. Stoppers were drilled with a hole for tether attachment. Biopsy tips had a 6 mm diameter and lengths of either 35 or 50 mm. The retention devices consisted of three barbed prongs of varying lengths. Twenty-five animals were struck with biopsy darts, 23 strikes collected tissue samples, 20 samples contained blubber, and 3 blubber samples contained the full depth cores (confirmed by trace muscle collection). To achieve penetration, darts had to be fired = 15 m from animals. A higher powered dart delivery system could increase the firing range and dart depth penetration.

***Effect of Ocean Conditions on the Cross-shelf Distribution of Walleye Pollock
(*Theragra chalcogramma*) and Capelin (*Mallotus villosus*)***

Anne B. Hollowed¹, Christopher D. Wilson¹, Phyllis Stabeno² and Sigrid Salo³

¹NMFS Alaska Fisheries Science Center

²NOAA Pacific Marine Environmental Laboratory

³Joint Institute for the Study of the Atmosphere and the Oceans, University of Washington

anne.hollowed@noaa.gov , chris.wilson@noaa.gov , stabeno@pmel.noaa.gov ,
sigrid.a.salo@noaa.gov

Acoustic trawl surveys were conducted in 2000 and 2002 as part of a multi-year, multi-disciplinary experiment off the eastern coast of Kodiak Island in the Gulf of Alaska. The spatial distribution of walleye pollock (*Theragra chalcogramma*) and capelin (*Mallotus villosus*) differed and appeared to be related to differences in habitat preferences. Drogued satellite drifters and moored current meters revealed that flow through submarine troughs was steered by the topography, with inflow along the upstream, eastern edge and outflow along the downstream, western edge of the troughs. In all three years, continuous underway sea surface temperature samples and water column profiles showed the presence of a mid-trough front in Barnabas trough. In both troughs, at distances less than approximately 12 nm from shore, the water column was well mixed, while a well-defined mixed layer was present beyond approximately 12 nm from shore.

Acoustic survey data identified four acoustic sign types: age-1 pollock, adult pollock, capelin and capelin-age-0 pollock mix. The spatial distribution of these sign types appears to be influenced by the oceanographic and topographic features of the two troughs. Adult pollock were broadly distributed throughout Chiniak trough. In Barnabas trough, adult pollock were aggregated on the coastal side of the frontal systems in regions where summer wind events produced high levels of production. In 2000, capelin occurred with age-0 pollock. In Chiniak trough, capelin were most abundant along steep topographic gradients at the edges of the trough and in a deep region near Cape Chiniak. In Barnabas trough, capelin-age-0 mix (2000) or capelin (2001 and 2002) concentrations were observed in slope water intrusions over the outer to middle shelf. Results suggest that different processes control the habitat preferences of walleye pollock and capelin. Capelin appear to be associated with cool slope water intrusions and topographic gradients while walleye pollock appear to select habitats based on the availability of prey.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Disease and Contaminants*

*Hexavalent Chromium Cytotoxicity Is Organ and Species Specific for
Steller Sea Lion and Mink Cells*

*A.L. Holmes¹, S. S. Wise¹, J. A. Little¹, H. Xie¹, M. Bozza², M., Moreland¹, D. J. St.
Aubin³, J. L. Dunn³, S. Atkinson^{2,4}, F. Gulland⁵, S. Bursian⁶ and J. P. Wise Jr.¹*

¹Bioscience Research Institute, University of Southern Maine

²Alaska SeaLife Center

³Mystic Aquarium Institute for Exploration and Sea Research Foundation

⁴University of Alaska Fairbanks

⁵The Marine Mammal Center, Sausalito, CA

⁶Department of Animal Science, Michigan State University

The western population of the Alaskan Steller sea lion is continuing to decline for unknown reasons. The fact that this decline is limited to this population strongly suggests that there may be an environmental factor involved. Environmental contaminants, particularly metals, may be one factor playing a role in this decline. We are examining the toxicity of a range of metals to cell lines established from major organ systems of the Steller sea lion. Currently, we have established cultures of testes, skin, liver, kidney and lung cells. Our initial metal toxicity experiments indicate that hexavalent chromium Cr(VI) is variably cytotoxic to Steller sea lions depending on the organ involved. For example, 2.5, 5, 10 and 25 uM sodium chromate induced 100, 71, 44 and 2 % relative survival respectively in skin fibroblasts, but 38, 18, 3 and 0 % relative survival in lung fibroblasts and no survival at any of these concentrations in liver fibroblasts. Thus, skin is more resistant to Cr(VI) than lung cells, and liver cells are the most sensitive of the three. It has been proposed that mink are a suitable surrogate model for studying contaminant effects on the Steller sea lion. To compare the response of the two species to metal toxicity, we isolated a primary mink skin fibroblast cell line and tested it. We found that 2.5, 5, 10 and 25 uM sodium chromate induced 37, 0.8, 0.1 and 0 percent relative survival respectively in mink cells. Thus mink cells were 89-440 times more sensitive at moderate to high doses and 2.7 times more sensitive at relatively low doses. This suggests that mink are a suboptimal model for studying the effects of metals in Steller sea lions. This work was supported by grant NA16FX1412.

Session GLOBEC-2

A comparison of copepod egg production rates in the Gulf of Alaska

R. R. Hopcroft

University of Alaska Fairbanks

Egg production rates of the common copepod species in the Gulf of Alaska will be summarized. Data will include *Oithona similis*, *Pseudocalanus mimus*, *Pseudocalanus newmanii*, *Acartia longiremis*, *Centropages abdominalis*, *Metridia pacifica*, *Metridia okhotensis*, *Calanus pacificus*, *Eucalanus bungii*, and *Neocalanus flemingeri*. The seasonal patterns of production will be contrasted and related to their life history strategies.

POSTER Session GLOBEC

***Egg production rates of *Pseudocalanus mimus* and
Pseudocalanus newmanii in the Gulf of Alaska***

R. R. Hopcroft, C. Clarke and A. I. Pinchuk

University of Alaska Fairbanks

Copepods are the essential linkages between phytoplankton production and fish in marine ecosystems. Numerically, the abundance of *Pseudocalanus* in the Gulf of Alaska is only exceeded by *Oithona similis*, but owing to its larger size, the majority of the year-round copepod production is likely contributed by *Pseudocalanus* species. In order to better understand their importance, egg production rates of the two *Pseudocalanus* species in the Gulf of Alaska were examined over 2001 and 2002. Both average clutch size and female length varied seasonally in both species, with peaks in May during the spring phytoplankton bloom. During May clutches averaged 30-40 eggs (~60-90% of the female's weight), compared to seasonal means of 15-18 eggs (~45% of the female's weight). Yet, from May through October, daily specific egg production rates remained relatively constant at 10-16% for *P. mimus* and 10-20% for *P. newmani*. Although clutch size suggests production should be highest in May, the impact of subsequently smaller clutches were offset by a greater percentage of females producing clutches on a daily basis. It appears that higher summer/fall temperatures resulted in shorter egg carrying times and hence a higher clutch turnover rate. As water cooled, and chlorophyll dropped, daily specific egg production rates fell to only few percent over the winter and into early spring.

POSTER Session GLOBEC

***Egg production rates of *Metridia pacifica* and *Metridia okhotensis*
in the Gulf of Alaska***

R. R. Hopcroft, C. Clarke, A. I. Pinchuk and A. G. Byrd

University of Alaska Fairbanks

Copepods of the genus *Metridia* are among the more abundant large bodied zooplankters in the Gulf of Alaska and Prince William Sound, and are known to be important prey of fishes. Egg production rates of the two *Metridia* species in the Gulf of Alaska were examined over 2 years. Preliminary experiments in 2001, using traditional techniques, indicated unusually low egg production. On 7 cruises in 2002, we used a new incubation system that separates females from their eggs and allows observation of eggs that remain undisturbed from the time they were laid. Observations indicate *Metridia* eggs are unusually thin-shelled, such that many shells (up to 100%) break down during incubation, leading to severe underestimates of egg production for this genus in the past. *Metridia* lays distinct clutches of eggs in early morning (~dawn), with some producing clutches daily. Up to 100 eggs were laid per clutch by *Metridia pacifica*, up to 150 were laid by the larger *Metridia okhotensis*. At individual stations, egg-producing females averaged specific egg production rates up to 25 and 36% respectively, with equivalent population rates up to 18 and 20%. Egg production by *Metridia pacifica* continued throughout most of the year, while *Metridia okhotensis* was more confined to the spring. In most cases, egg production was coupled to the cycles of primary productivity.

Salmon shark geographic movements, depth preferences and diet in the Gulf of Alaska and eastern North Pacific Ocean

Lee Hulbert and Jeep Rice

NMFS Auke Bay Laboratory

Salmon sharks, *Lamna ditropis*, are the predominant apex fish predator in the boreal North Pacific, yet very little is known of their geographic movements, depth preferences and diet in the eastern North Pacific Ocean. We report the movement behavior obtained from tagging of salmon sharks with conventional tags and satellite transmitters, abundance estimates from aerial surveys, and consumption estimates from diet analyses of salmon sharks caught in Prince William Sound. We acquired satellite-derived movement data from 13 of 16 (81%) satellite tags and the recapture of 4 of 246 (1.6%) conventionally tagged salmon sharks. The sharks we tracked demonstrated three modes of movement: focal foraging movements, foraging dispersals, and dedicated migrations. In Prince William Sound, large salmon shark aggregations are associated in time and space with peak adult Pacific salmon (*Oncorhynchus* spp.) spawning migrations during July and August. Focal foraging movements, characterized by sharks aggregating at adult Pacific salmon concentration areas, are random and constrained to relatively small geographic regions. As the salmon runs taper off, the sharks disperse; some wander from the focal foraging areas but continue to forage in Prince William Sound and the Gulf of Alaska into autumn and winter months, while others undergo deliberate, often nearly linear southeasterly migrations hundreds to thousands of kilometers toward the west coasts of Canada and the U.S. Foraging salmon sharks often showed a bimodal preference for depths of 0-2 m and 40-60 m; migrating sharks often showed a bimodal preference for depths of 0-2 m and 200-500 m.

Pink and chum salmon are the principle prey during summer months in Prince William Sound, but the sharks have a varied diet even when salmon are abundant. From systematic aerial survey counts we estimated 2000 salmon sharks were at the surface of Port Gravina on August 16, 2000. We estimate these sharks consumed 243,000 kg of prey during a 45 day residency in Port Gravina in 2000.

*Session SSL-1: Steller Sea Lion: Factors Currently Affecting the Population
Predation*

Pacific Sleeper Shark Predation of Steller Sea Lions

Leland Hulbert, Michael Sigler and Chris Lunsford

NMFS Auke Bay Laboratory

Lee.Hulbert@noaa.gov , Mike.Sigler@noaa.gov , Chris.Lunsford@noaa.gov

The objective of this study is to determine whether sleeper sharks prey on Steller sea lions, and if so, estimate the predation rate. Evidence of shark predation on Steller sea lions would identify a source of Steller sea lion mortality.

The final cruise of the study was completed in May 2002, coinciding with the period when sea lion pups are weaned and therefore potentially more vulnerable to shark predation. Longline gear was used to capture sleeper sharks in the central Gulf of Alaska near Steller sea lion rookeries at Marmot Island, Sugarloaf Island, Outer Pye Island, and Seal Rocks. Ninety-nine sleeper sharks were collected for stomach samples and 24 were tagged and released with archival satellite tags. Tag data provide sleeper shark geographic and vertical movement information, which will be compared to Steller sea lion movements to determine if their habitats overlap in time and space. We are analyzing the fatty acid composition of tissue samples to determine if fish vs marine mammal prey in shark diet can be discerned. DNA analysis is being used to identify questionable prey items that may be of marine mammal origin. Forensic pathology methods are being used to infer whether the sharks had consumed living marine mammal prey or carrion.

A combined total of 198 sleeper shark stomach contents were analyzed from samples collected in August 2001 and May 2002. Marine mammal tissue comprised 31% and 34% of sleeper shark diet by percent weight during August and May, respectively. Stomach content analysis found no direct evidence of sea lion parts. DNA identification of questionable marine mammal tissue samples collected during both cruises is pending.

Data from 12 archival tags have been recovered. Endpoint locations from the tags show the sharks had typically moved less than 100 kilometers from the release locations. Archived depth data shows that sleeper sharks regularly traverse over 100 meters per day and sometimes come to the surface at night.

POSTER: Steller Sea Lion: Factors Currently Affecting the Population Literature

*An annotated bibliography of scientific literature (1751-2000) pertaining to Steller sea lions (*Eumetopias jubatus*) in Alaska*

Andrea M. J. Hunter and Andrew W. Trites

Marine Mammal Research Unit, University of British Columbia
hunter@zoology.ubc.ca , trites@zoology.ubc.ca

We compiled an annotated bibliography of Steller sea lion literature which identifies the areas of research that have been undertaken between the years 1751-2000, and whether or not they address the leading hypotheses proposed to explain the population decline in Alaska. We identified 272 scientific papers with a primary research focus on Steller sea lions. Of these, 111 articles were peer-reviewed publications in scientific journals, and 161 were other forms of publication (e.g., technical reports, unpublished reports, dissertations, etc.). The total number of Steller sea lion articles published per decade has risen exponentially from 4 in the 1940s to 128 in the 1990s. The bulk of scientific studies have focused on population distribution, population dynamics, ecology, census data, nutrition and behavior. Subject areas that have received low research attention include predation on Steller sea lions, captive studies, metabolism and parasitology. Only 59 of the 272 scientific articles contained information relevant to testing one of the 12 hypothesized causes of the Steller sea lion decline. The most frequently addressed hypothesis concerned juvenile mortality (25 papers). This was followed by starvation, competition with fisheries, human predation and regime shifts. Only 1 of the 272 articles addressed the role that killer whale predation may be playing in the decline of Steller sea lions. Between 1751-2000, over 9,228 pages pertaining to Steller sea lions have been printed (1,148 pages of primary publications and 8,080 pages of other publications). The relative number of articles that address or provide significant information to assess hypothesized causes of the population decline are few (< 30% of the sea lion literature per decade).

*POSTER Session: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

*Using Fishing Vessels to Collect Acoustic Data for Scientific Purposes:
Preliminary Results from Midwater Trawlers in the Eastern Bering Sea Walleye
Pollock Fishery*

James Ianelli and Martin W. Dorn

NMFS Alaska Fisheries Science Center

Jim.ianelli@noaa.gov , martin.dorn@noaa.gov

Recent technological advances allow placement of scientific-quality echosounders on commercial fishing vessels and recording of the acoustic backscatter from these echosounders for subsequent analysis. Potential applications of this new data source are now being explored and include conducting informal surveys for real-time management of fisheries on spawning stocks, investigating the foraging behavior of fishing fleets, and studying spatial and temporal patterns of fish and zooplankton distribution. Here we report on a project to log acoustic backscatter data on midwater trawlers fishing for walleye pollock in the eastern Bering Sea, with the objective of evaluating fishing impacts on endangered Steller sea lions. Since our interest is in fine-scale spatial and temporal changes in abundance (i.e., tens of kilometers and weeks), work to date has focused on evaluating the spatial coverage of the data, and examining the general characteristics of cruise tracks and uncalibrated backscatter (UBS) data. Preliminary results shows good correspondence with survey data during the same period. However, technical problems related to data processing need to be resolved.

*POSTER Session: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

***Preliminary Report on Steller Sea Lion Brand-Resighting
Results in Southeast Alaska***

***Lauri Jemison, Kim Raum-Suryan, Ken Pitcher, Grey Pendleton, Jamie King, and
Tom Gelatt***

Alaska Department of Fish and Game
lauri_jemison@fishgame.state.ak.us

The Alaska Department of Fish and Game (ADFG) began branding Steller sea lions, *Eumetopias jubatus*, in 1994 to permanently mark animals, allowing recognition of individuals throughout their lives. Using mark-recapture models, resighting individuals over time will allow estimates of life history parameters such as survival, recruitment, and dispersal. In Southeast Alaska (SEA), 1,615 pups were branded on their natal rookeries in June 1994, 1995, 2001, and 2002. Ninety-four older pups and juveniles were branded in 2001-2002. In 1999, ADFG began dedicated brand-resighting cruises in SEA. Rookeries and haulouts were approached by skiff; observers used binoculars (8-14X) to conduct counts and read brands. Number of animals observed, brand number and quality, brand verification check, and status (*e.g.*, female with pup) were recorded. In 2000, resight effort increased to 3 weeks and expanded geographically, including northern British Columbia and all haulouts and rookeries in SEA. Digital photography (Nikon D1 digital camera with 70-300mm lens) was adopted to document and confirm brand observations; when possible, every branded animal was photographed. The 2002 resight cruise was lengthened to allow greater coverage of British Columbia and allow multiple visits to larger sites. In June 2002, we visited 37 sites, observed approximately 10,700 SSLs, and sighted 310 unique brands, accounting for 23% of the 1,373 animals branded through 2001. A 10-day cruise in August 2002 allowed us to determine whether new animals would be sighted during a different time of year. We observed 90 unique brands; 33% had not been seen during the June 2002 cruise. In August, we resighted 39% of 318 pups branded at their natal rookery during June 2002. Photographs and standardized methods are essential to obtaining reliable brand-resightings. With four years of consecutive brand-resight data, we are in the early stages of collecting large amounts of life history data of known-age individuals.

A 3-D Coupled Physical-Biological Model and Its Application to the Spring Plankton Bloom of 1996 in Prince William Sound, Alaska

Meibing Jin and Jia Wang

A 3-D coupled biological-physical model of Prince William Sound (PWS) was developed to simulate the spring plankton bloom. The physical model is based on an existing 3-D circulation model developed from the SEA (Sound Ecosystem Assessment) project under forcing of monthly heat flux, freshwater discharge of a line source, daily wind, Alaska Coastal Current (ACC) inflow/outflow and tide. The biological model consists of four compartments: 1) (dissolved organic nitrogen + nitrite) DIN, 2) (phytoplankton) P, 3) (zooplankton) Z, and 4) (detritus) D. A mixed layer model is introduced to calculate vertical mixing caused by wind stirring and surface cooling. The spring plankton bloom in 1996 was simulated using this coupled model. The model exhibited a spring plankton bloom, which is a feature of a steadily repeating annual cycle of phytoplankton population. The spring phytoplankton bloom starting and ending time and its magnitude compared well with field observations at several layers from 0 m to 50 m at a Station AFK in the sound. In the western sound, the bloom occurred earlier, but was less intensive, and the bloom depth was shallower than in the east. In the central, eastern sound and Montague Strait, the plankton blooms occurred following the bloom in the western sound, but stronger and deeper, thus, the phytoplankton bloom lasted longer. There was a shallower but higher phytoplankton concentration core related to an anticyclonic gyre in the eastern sound at the beginning of the bloom, and disappeared later as circulation changed.

POSTER Session GLOBEC

***Nutrient Supply to the GOA Shelf in Summer:
The Role of Troughs and Shallow Banks***

***N. B. Kachel¹, N. A. Bond², J. A. Napp³, C. W. Mordy¹, S. A. Salo¹, P. J. Staben¹ and
David P. Wisegarver²***

¹NOAA Pacific Marine Environmental Laboratory

²Joint Institute for the Study of Atmospheres and Oceans, University of Washington

³NMFS Alaska Fisheries Science Center

Satellite imagery of ocean chlorophyll distributions in the Gulf of Alaska indicate that from mid to late summer, productivity offshore of Kodiak Island is extremely high relative to the surrounding shelf waters. The bathymetry to the south and east of Kodiak Island is characterized by multiple banks and troughs. Hydrographic transects during four cruises in 2001 and 2002 focused on Portlock Bank, a shallow (~50-m), broad plateau to the east of Kodiak Island. These hydrographic casts revealed a well-mixed water column with significant concentrations of nutrients. Some of the satellite-tracked drifters (drogued at 40-m depth) deployed in the region were trapped over the bank during much of the summer and were advected off the bank only when strong storms began in the fall. The significant concentrations of nutrients over the bank indicate a continual replenishment of nutrients. Nutrients are transported far onto the shelf in two nearby troughs, Amatouli and Stevenson. This deep water in the troughs is likely the source of nutrients observed on the bank and is introduced to the bank through bottom processes up the sloping sides of the troughs.

Physical Processes in the Troughs near Kodiak Island

Nancy B. Kachel¹, Calvin W. Mordy¹, Sigrid A. Salo² and Phyllis J. Stabeno²

¹Joint Institute for the Study of the Atmosphere and Ocean, University of Washington

²NOAA Pacific Marine Environmental Laboratory

nkachel@pmel.noaa.gov , mordy@pmel.noaa.gov , salo@pmel.noaa.gov ,
stabeno@pmel.noaa.gov

Physical processes in the troughs south of Kodiak Island interact with those on the adjacent banks to prolong primary production during the summer and to sustain the rich ecosystem there. Chlorophyll patterns derived from SeaWiFS images show higher production over Albatross Bank than in adjacent troughs (Barnabus or Chiniak) that cut into it. Mooring results show flow is onto the shelf on the east, and off the shelf on the west. Trajectories of satellite-tracked drifters (drogued at 40-m) show flow into and out of Stevenson and Chiniak Troughs, in contrast to the pattern at Barnabus, where up-canyon flow turns southwest, continuing parallel to the Kodiak Island coastline. Strong tidal mixing within the troughs is evident in the mooring records. In addition, the shelf-break front is advected up and down canyons. Time series of nitrate concentrations indicate that the canyons are a source of nutrient-rich bottom water that is eventually advected onto the banks. There, stratification is frequently broken down by the combination of wind and tidal mixing, thereby supplying nutrients to the euphotic zone to support sustained production throughout the summer.

Understanding the mechanisms that control the on-shelf flux of nutrient rich waters is essential to determining the impact of climate variability on the bottom-up processes and, thus, ecosystem productivity. The richness of the ecosystem near Kodiak Island depends on production at the bottom of the food web, so any decrease in production would cascade through the entire ecosystem, impacting higher trophic levels including the sea lions.

Patterns of fish food source generation and utilization in the northern Gulf of Alaska and Prince William Sound region from natural stable isotope abundance: results from SEA and GLOBEC (1994 to 2002)

Thomas C. Kline, Jr.

Prince William Sound Science Center

A recurrent cross-shelf stable isotope gradient with low $\delta^{13}\text{C}$ values diagnostic of “off-shore” pelagic production in the northern Gulf of Alaska was based upon observed temporal and spatial patterns in the isotopic composition of terminal feeding stages of *Neocalanus cristatus* from the GOA and Prince William Sound (PWS) region. PWS $\delta^{13}\text{C}$ values had a relatively narrow isotopic range. There was, however, significant isotopic variation in the Gulf among years. Nevertheless, $\delta^{13}\text{C}$ values < -21.5 were only found off-shore. $\delta^{13}\text{C}$ values similar to those found in PWS were found consistently at station GAK1, located downstream in the Alaska Coastal Current from PWS, and occasionally at other stations. The pattern of these occasional occurrences is consistent with eddy patterns observed in satellite images. When the data from among all the years were pooled there was a good correlation between the nitrogen and carbon stable isotopic composition. The regression slope was ~ 0.5 instead of ~ 3.4 , the expected slope if isotopic fraction was primarily due to trophic level effects. Isotopic variation was thus more likely due to variation in isotopic discrimination by algae. Gulf isotopic extremes varied by year with the most enriched values occurring during 1996 and the most depleted values occurring during 2001. The most isotopically enriched values were observed when uncharacteristically calm and sunny weather prevailed. Based on stable isotope analysis, juvenile fishes from within PWS consisted, in part, of offshore carbon. The proportion of offshore carbon in fishes varied considerably among years. During fall 1995, juvenile fishes consisted almost entirely of Gulf carbon. The proportion of off-shore origin *Neocalanus* diapausing (over-wintering resting phase) within the deep area of PWS in fall 1995 was $\sim 90\%$. These observations suggest that changes in off-shore zooplankton production occurring at inter-decadal time scales can potentially impact coastal wasters such as PWS, since off-shore production can be an important subsidy.

Trophic Level Implications When Using Natural Stable Isotope Abundance to Determine Effects of Salmon-Derived Nutrients on Juvenile Sockeye Salmon Ecology

Thomas C. Kline, Jr.

Prince William Sound Science Center

The amount of nitrogen contributed by anadromous and semelparous Pacific salmon, marine-derived nitrogen (MDN), relative to other sources, was estimated for sockeye salmon juveniles rearing in nursery lakes of the Karluk and Kvichak rivers (Alaska) from their nitrogen stable isotope abundance using an isotope mixing model (IMM). Because trophic level (TL) as well as MDN can lead to nitrogen-15 enrichment, it is critical to know, for the IMM, the TL of juvenile sockeye salmon (JSS) during their lacustrine life history phase. The initial a priori TL of 3.0 overestimated MDN. Regressing salmon escapement with stable isotope ratio and incorporating an updated herbivore isotope fractionation factor suggested that the TL of Kvichak JSS was 3.7. This TL value and the difference in carbon and nitrogen stable isotope ratios between JSS and net zooplankton suggested that the TL of net zooplankton was 2.6. Using TL = 2.6 for net zooplankton and the difference in stable isotope ratios between Karluk JSS and net zooplankton suggested that JSS TL was 4.3. These latter TL values suggested that the mean MDN for the Karluk system during the late 1980s and early 1990s was 67%, which was approximately half of that predicted using earlier fractionation and TL values. Sample isotopic variation and variation due to instrument error were minor in comparison to TL uncertainty involved in data modeling. Nonetheless, nitrogen stable isotope data provide a means for assessing MDN that can range significantly within and among systems.

POSTER Session EVOS/NPRB

Resource Survey for Tatitlek WisdomKeeper Workshop

Caroline Kompkoff and Thomas Tomaganuk

Chugach Regional Resources Commission has established a Community WisdomKeeper Series to promote exchanges of information between the oil spill region's Tribes and those involved in the Gulf Ecosystem Monitoring (GEM) program. A principal idea behind the WisdomKeeper meeting is that meaningful community participation in a workshop is unlikely to happen without substantial preparation in the community before the workshop. To prepare the community for the Tatitlek workshop in November, 2002, students at the Tatitlek High School undertook a project to interview community members about the meeting topic: What constitutes a healthy marine environment and what changes have been observed? The students presented the results of their survey on the evening preceding the workshop. The students' survey results served as the structure for the workshop discussion. This poster presents the results of the resource survey for the Tatitlek WisdomKeeper workshop.

POSTER Session GLOBEC

***Factors affecting the distribution of juvenile salmon in the Gulf of Alaska:
Origin of juvenile chum salmon from Gulf of Alaska coastal waters, 2001***

Christine Kondzela and Richard Wilmot

NMFS Alaska Fisheries Science Center, Auke Bay Laboratory

We provide updated information on salmon migration patterns in the Gulf of Alaska, relying upon migration and distribution data from thermally marked chum salmon hatchery stocks and the first genetic stock identification analysis of juvenile salmon migrating through this coastal corridor. Juvenile chum salmon were collected July 17 to August 6, 2001 at eleven transects between Icy Point in northern SE Alaska and southwestern Kodiak Island. Most chum salmon from Alaska were caught just beyond major coastal exit corridors; few fish were caught on the seaward side of Kodiak Island and preferentially migrated through Shelikof Strait. Over one-third of the chum salmon examined were thermally marked from one of three hatcheries: Wally Noerenberg in Prince William Sound (PWS) and Macauley and Hidden Falls in SE Alaska. East of PWS, 40% of the chum salmon were thermally marked from SE Alaska hatcheries. West of PWS, 60% of the chum salmon were thermally marked from the Wally Noerenberg hatchery and 21% from the SE Alaska hatcheries. The genetic analysis generally corroborated the thermal mark results. Chum salmon from the Washington/southern British Columbia stock group were found in low frequency in the Kenai Peninsula transects and fish from the Queen Charlotte Islands were recovered from both the transects east of PWS and the southern Shelikof Strait transect. Upper Cook Inlet stocks were abundant in the northern Shelikof Strait transect.

*POSTER Session: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

Seasonal changes in defended energy state in Steller sea lions

Saeko Kumagai, David A.S. Rosen and Andrew W. Trites

Marine Mammal Research Unit, The University of British Columbia
kumagai@zoology.ubc.ca , rosen@zoology.ubc.ca , trites@zoology.ubc.ca

The effect of under nutrition on energy reserves is probably not consistent in animals that display large seasonal differences in physiology and behavior. In some animals fat mass is dependent on season rather than energy ingestion. Changes in absolute or relative body condition (fat mass) may therefore not reflect changes in animal health. If changes in lipid reserves reflect seasonal changes in the physiological set point (rheostasis), animals may differentially defend energy reserves due to decreased energy intake at different times of the year. This may be partially mediated through changes in the hormonal feedback mechanism that provides signals on body condition. Thus, there may be critical periods during the year when low energy intake may have significant effects on particular aspects of sea lion health and vital rates, such as reproduction. Similarly, the efficacy or interpretation of biochemical indicators of metabolic status and body condition may be affected by these natural seasonal cycles in a sea lion's energy budget. This study has been examining how low energy intake affects sea lion energy balance, hormone cycles, and health at different times of the year. Seven female captive Steller sea lions (two 5-yo and five 2-yo) are being fed energetically equivalent sub-maintenance diets of herring or walleye pollock (intake proportional to initial body mass) for 9 days, 4 times a year. Serum samples, body condition (through deuterium dilution), and resting metabolic rate are obtained before and after each trial. Thyroid and reproductive hormones are analyzed for indicators of the interactions between energy balance and reproduction. Until recently, the biochemical feedback mechanism between body condition and energy intake was unknown. This study analyzes the newly discovered hormones leptin and ghrelin, which are likely key hormones in the relationship between metabolic rate, energy intake, energy expenditure, and body condition.

Physical Oceanography of the Eastern Aleutian Passes

Carol Ladd¹, George Hunt, Jr.², Calvin Mordy¹, Ron Reed³, Sigrid Salo³ and Phyllis Stabeno³

¹Joint Institute for the Study of the Atmosphere and Ocean, University of Washington

²Department of Ecology and Evolutionary Biology, University of California, Irvine

³NOAA Pacific Marine Environmental Laboratory

Carol.Ladd@noaa.gov, glhunt@uci.edu, Calvin.W.Mordy@noaa.gov,

Ronald.K.Reed@noaa.gov, Sigrid.A.Salo@noaa.gov, Phyllis.Stabeno@noaa.gov

Two research cruises (June 2001 and May-June 2002) were undertaken in the eastern Aleutian Islands on the R/V Alpha Helix. These cruises constituted an integrated multidisciplinary examination of the environment in the habitat of the endangered western population of the Steller sea lion (*Eumetopias jubatus*).

During June 2001, 116 CTD casts were taken in and around the eastern Aleutian passes. Nutrient and fluorescence data were also collected. Four along-pass sections (Unimak, Akutan, Amukta, and Seguam Passes) and two across-pass sections (Seguam and Amukta) detailed the water properties and geostrophic transport within the passes. During May-June 2002, data were again collected in the four passes explored in 2001. In addition, three more passes (Umnak, Samalga, and Tanaga) were also sampled in 2002.

Properties of the surface waters during both 2001 and 2002 illustrate dramatic spatial variability in the region. Surface waters in the North Pacific tend to be warmer and fresher than surface waters on the Bering Sea side of the Aleutian Islands. In addition, water properties are highly variable within each ocean basin from east to west along the Aleutian chain. In the North Pacific, surface waters tended to be significantly warmer and fresher east of Samalga Pass than to the west in both years. Surface nutrient concentrations also exhibited substantial differences with low nutrient concentrations (NO₃, PO₄, and SiO₄) east of Samalga Pass and higher concentrations west of Samalga Pass. These data suggest that Samalga Pass may be the western limit of the Alaska Coastal Current during the summers of 2001 and 2002. Water properties, transports, and nutrient concentrations will be compared between the 7 passes. Evidence of tidal mixing within the passes and its influence on surface nutrient concentrations will be discussed.

Seaglider Surveys of the Alaska Coastal Current

Craig M. Lee¹ and Charles C. Eriksen²

¹Applied Physics Laboratory, University of Washington

²School of Oceanography, University of Washington

Seaglider operations in the coastal Gulf of Alaska began on 24 October 2002 with the successful deployment of a single vehicle (SG009) near the entrance of Resurrection Sound. Following launch, SG009 moved southward along its designated survey track, where it quickly encountered the Alaska Coastal Current (ACC). Fresh, cold coastal discharge formed a 10-20 m thick buoyant surface layer (salinities of 24-28, temperatures of 8-9°C and elevated backscatter, perhaps reflecting the water's terrestrial origins), with freshening often extending as deep as 50 m. Frequent southward and southwestward wind events with sustained speeds of 30-40 knots accelerated both the buoyant surface layer and the underlying ACC. SG009 encountered depth average speeds within the ACC of up to 0.4 m s⁻¹, with surface layer velocities frequently attaining speeds of 1.0-1.5 m s⁻¹. Energetic flows extended to the seabed, with strong backscatter signals suggesting active resuspension of particulates. These depth-average speeds exceed Seaglider's navigational capabilities, and SG009 was carried downstream as it crossed the ACC. Preliminary analysis of the Seaglider section extending 90 km south of Resurrection Sound indicates an ACC width of at least 50 km and a transport of over 3 Sv, an order of magnitude larger than that anticipated from previous reports. Significantly, SG009 has maintained communications and navigation through several strong storms, with winds gusting to 60 knots and seas reaching 9 m. At the time of this writing (15 November 2002), the vehicle is moving slowly eastward, maintaining a course that keeps it just offshore of the ACC. An onshore section will be attempted to the southwest of Montague Strait.

POSTER Session EVOS/NPRB

Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in western Prince William Sound

Dennis C. Lees and William B. Driskell

Littoral Ecological & Environmental Services

As late as 1997, NOAA data from a limited number of long-term intertidal sites in western Prince William Sound suggested that bivalve assemblages in mixed-soft sediments treated with high-pressure (HP) warm- or hot-water washing methods remained severely damaged in terms of species composition and function. An EVOS Trustees Council study was initiated during summer 2002 to assess the generality of (or recovery from) this apparent injury. Following completion of sample analyses, a finding that our earlier conclusions were accurate will indicate that: 1) a considerable proportion of mixed-soft beaches in treated areas of the sound remains extremely disturbed; and 2) these beaches are functionally impaired in terms of their ability to support foraging by damaged nearshore vertebrate predators such as sea otters. The results may also provide insight into the potential need for restoring beach sediments to reestablish biodiversity and natural function in these assemblages.

Thirteen (13) reference beaches, twenty-three (23) oiled beaches, documented as having received HP washing, and four (4) NOAA sites were sampled with 0.009 m² cores and 0.25 m² excavations to evaluate recent recruitment, population density, and size structure of the bivalve assemblage. A preliminary view of the long-term effects of HP washing on species composition, population density, and population size structure will be presented based on samples from the 0.25 m² excavations.

*Seasonal and spatial dynamics of plankton communities
on the Gulf of Alaska shelf*

Evelyn J. Lessard and Michael S. Foy

University of Washington

The size-structure, taxonomic composition and seasonal dynamics of the lower trophic food web can be highly responsive to physical forcing and, in turn, exert strong influences on zooplankton growth, fecundity, and nutritional state. Examining the temporal changes and spatial variability of the lower food web structure over seasonal and interannual cycles is critical to understanding bottom-up controls on salmon production and ecosystem responses to climate change. The goal of this project is to determine seasonal and spatial variability in abundance, biomass and composition of the autotrophic and heterotrophic plankton (<0.200-mm in size) and to interpret these distributions in the context of physical and biological data collected on the GLOBEC LTOP and Process cruises. Highlights of results from sampling on the 2001 LTOP cruises will be presented. Throughout the year, there were generally three distinct plankton communities at inner shelf, middle shelf and outer shelf/slope regions. However there was very high degree of heterogeneity in both autotrophic and heterotrophic biomass, species and community structure across the shelf over short (<10-km) distances. Diatom blooms were generally restricted to inshore stations in mid-April to late June, but they also sporadically occurred on the outer shelf, perhaps fueled by upwelling at the shelf edge. In terms of biomass, small phytoplankton (<5 μm) generally dominated mid shelf and outer shelf stations, even in early spring. Cyanobacteria biomass was significant in late spring through summer, particularly in the middle and offshore regions. Heterotrophic protist biomass increased in response to phytoplankton development and reached high levels by late summer. The heterotrophic biomass was dominated by dinoflagellates and ciliates, particularly very large ones; these were observed to ingest a wide range of prey (cyanobacteria to large diatoms). As microzooplankton are the major herbivores in this coastal system and important prey for zooplankton, these two microplankton groups may play a central role in food web dynamics throughout the year.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Subsistence Harvest*

The Benefits of Real-Time Harvest Monitoring

Aquilina D. Lestenkof¹, Phillip A. Zavadil¹, Michael T. Williams² and Steve A. MacLean²

¹Aleut Community of St. Paul Island, Tribal Government Ecosystem Conservation Office

²LGL Alaska Research Associates, Inc.

aquilina@tdxak.com, pazavadil@tdxak.com, mwilliams@lgl.com, smaclean@lgl.com

The Benefits of Real-Time Harvest Monitoring will be a poster presented in the session “Factors Currently Affecting the Steller Sea Lion Population (synthesis): Direct Human-related Mortality.”

Unangan (Aleuts) are customary traditional hunter-consumers of qawax, Steller Sea Lion (*Eumetopias jubatus*) in the Bering Sea. Traditional monitoring was part of a “take only as needed” system that effectively met community needs. Modern management needs require accurate recording of harvests. Retrospective surveys are currently used to tabulate harvest levels in areas where managers are not present year round.

Retrospective surveys may result in inaccurate harvest estimates due to many uncontrollable factors including reluctance to report struck and lost animals, and hunters’ memories of multiple hunting events (Mahoney & Sheldon 2000). The logistics of retrospective surveys may also lead to inaccurate and incomplete data. Seven communities account for 80% or more of the statewide sea lion harvest during 1992 - 2000 (Wolfe 2001). No data were collected for 57% of the harvesting communities in 2000, however data from 1998 was substituted to estimate the 2000 harvest (Wolfe 2001). Retrospective surveys do not provide long-term estimates of harvests with sufficient resolution to withstand the scrutiny that the subsistence harvest of Steller sea lions will face if the western stock continues to decline.

Real-time monitoring and reporting by local community members more accurately characterizes the marine mammal harvest in each community. In addition to more accurate harvest estimates, real-time monitoring can result in more complete datasets and the opportunity to identify other factors influencing the population. In the Mackenzie Delta, data collected from harvested beluga increased from 24% to over 90% of the harvested animals when local monitors were responsible for data collection.

The hunter-based nature of real-time monitoring provides a mechanism for the resource users to be active partners in the collection of biological data used to assess the well-being of the animals on which they depend.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***World Ocean Database 2001:
An Ocean Profile-Plankton Database for the study of Environmental Change***

Sydney Levitus, M. Conkright, T. O' Brien, T. Boyer, C. Stephens, R. Locarnini, H. Garcia, P. Murphy, D. Johnson, O. Baranova, J. Antonov, R. Tatusko, I. Smolyar and R. Gelfeld

NOAA National Oceanic Data Center
Sydney.Levitus@noaa.gov

We describe the World Ocean Database 2001 (WOD01), which is a global, integrated, database containing ocean profile and plankton data. WOD01 contains vertical profiles of temperature, salinity, oxygen, nutrient, and chlorophyll at both "observed" levels as well as these same data profiles vertically interpolated to "standard" levels. In addition, there are data of plankton biomass, composition, and abundance. Data are from Ocean Station Data (OSD) casts, High-Resolution Conductivity- Temperature-Depth (HCTD) casts, Expendable Bathythermograph profiles, Mechanical Bathythermograph profiles, and instrumented Elephant Seals, among others. All data are available on-line (www.nodc.noaa.gov) as well as being available on CD-ROM. This database has been used to produce the World Ocean Atlas 2001 (WOA01) which represents gridded climatologies of the variables in WOD01. WOD01 and WOA01 (and their antecedents) have been frequently used in diagnostic studies to describe interannual-to-decadal variability of the world ocean and as initial and boundary conditions in numerical simulations of the world ocean. The database continues to grow in size as a result of data archaeology and rescue projects that locate and digitize historical data, from real-time data from projects such as the Global Temperature-Salinity Profile Project and the TAO project, and through regular national and international data submissions and exchanges.

POSTER Session GLOBEC

***Growth Rates of *Neocalanus flemingeri* in the Northern Gulf of Alaska
in 2001 and 2002***

H. Liu¹, C. Clarke² and R. R. Hopcroft²

¹LUMCON

²University of Alaska Fairbanks

Copepods of the genus *Neocalanus* are primary target species of the Alaskan GLOBEC program because they are believed to be critical links between phytoplankton and salmon production. Growth and development rates for copepodites of *Neocalanus flemingeri* were estimated in coastal and offshore waters during the spring of 2001 and 2002 in the northern Gulf of Alaska. Growth was similar between both years, with the duration of each of the first 4 copepodite stages approximately 10 days at 5-6°C. Corresponding growth rate appears to decline with stage, from approximately 0.13 to 0.07 per day. Prior to the onset of the spring bloom, growth and development rates were much lower. Thus, food concentration also explained a significant proportion of the variability in growth and developmental rates.

POSTER Session GLOBEC

Direct and indirect modifications of pelagic food webs in the Gulf of Alaska by the particle grazing copepods *Neocalanus flemingeri*, *N. plumchrus* and *N. cristatus*

Hongbin Liu and Michael Dagg

LUMCON

Three species of large calanoid copepods of the genus *Neocalanus* dominate mesozooplankton biomass throughout the subarctic Pacific and its marginal seas in the spring and early summer. All three species of *Neocalanus* are particle-grazing copepods that consume both phytoplankton and microzooplankton. As a part of the GLOBEC CGOA Process Study, we conducted grazing experiments during cruises in April, May and July 2001. On each cruise, 4 locations in the coastal water of the Gulf of Alaska were occupied to study the effects of *Neocalanus* spp. grazing on the structure of the pelagic web. In these experiments, live *Neocalanus* were placed into 2-L polycarbonate bottles filled with natural seawater and incubated on deck for 24 hours. Bottles without *Neocalanus* were also incubated as controls. Chlorophyll a concentrations in 3 size classes (<5, 5-20 and >20 μm) were measured for each incubation bottle at the beginning and end of each experiment. Additional samples were preserved for enumerating and identifying phytoplankton and microzooplankton. Based on the chlorophyll analyses, all three species of *Neocalanus* fed primarily on phytoplankton cells larger than 20 μm . In April, CIV and CV of *N. cristatus* and *N. flemingeri* were abundant in the surface waters. Mean clearance rates are 186 and 432 ml copepod-1 d-1 for CIV and CV *N. cristatus* and 63 and 205 ml copepod-1 d-1 for CIV and CV of *N. flemingeri*. In May, all three species were abundant and the mean clearance rates were 492, 148 and 146 ml copepod-1 d-1 for CV of *N. cristatus*, *N. flemingeri*, and *N. plumchrus*, respectively. The abundance of all three *Neocalanus* species was low in the surface water in July and most of them were not feeding. Direct effects of *Neocalanus* spp. grazing on microzooplankton are currently being determined. Indirect effects of *Neocalanus* spp. grazing were also apparent. In many experiments, especially ones with low total concentrations of phytoplankton, there was an increase in cells of <5- μm in size. We attribute this to a reduction in their mortality from larger microzooplankton associated with *Neocalanus* predation on larger microzooplankton. In some cases, this cascade effect can be seen in the picoplankton and bacteria populations also. As additional samples are analyzed, more detailed understanding of the direct and indirect effects of *Neocalanus* spp. grazing on pelagic food webs will become more apparent.

*POSTER Session: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

Energy density of Steller sea lion prey in western Alaska: species, regional, and seasonal differences

Elizabeth A. Logerwell¹ and Ruth A. Christiansen^{2*}

¹NMFS Alaska Fisheries Science Center

²School of Marine Affairs, University of Washington
libby.logerwell@noaa.gov , ruthc2@u.washington.edu

*presenter

The energy density of prey fish is a necessary component of foraging models that show how changes in prey abundance or distribution (natural or fishery-related) might impact the feeding success of Steller sea lions. Although values of fish energy density can be found in the literature, data are not available for many species that sea lions eat. This is particularly true for specific geographic regions or seasons. The goal of this Fishery Interaction Team project was to fill these gaps by collecting fish that are common in sea lion diets, but for which energy density data is unavailable during the seasons and in the regions that sea lions eat them. Fish were collected during AFSC research cruises in the Gulf of Alaska, Aleutian Islands and eastern Bering Sea during winter and summer. The lipid, protein, carbohydrate, ash and water content of the collected fish were determined in the laboratory and energy density was calculated from the results. These data are presented in tables so that scientists can readily incorporate the necessary energy density values into their foraging models. Scientists are also invited to contact us to request specific data. In addition to providing modelers with data, our work shows that energy density varies not only with fish species, but with region, season and fish reproductive status. We thus caution against building a foraging model with prey energy density values that are not specific to the time and place the model represents.

Session SSL-16: Steller Sea Lion Site Specific Studies – Aleutian Islands

***Interactions between commercial fishing and Atka mackerel:
a pilot study to resolve the experimental design***

Elizabeth A. Logerwell and Susanne McDermott

NMFS Alaska Fisheries Science Center

libby.logerwell@noaa.gov , susanne.mcdermott@noaa.gov

The goal of this research is to characterize the effects of commercial fishing on local abundance and movement of Atka mackerel. The Fishery Interaction Team at AFSC has been conducting tag release-recovery studies of Atka mackerel in the Aleutian Islands since 1999. Results have provided valuable insight into the effectiveness of trawl exclusion zones at preventing prey shortages for Steller sea lions foraging on Atka mackerel. Tag recoveries in previous years have occurred during and after the commercial fishery, so it is not possible to assess the effect of the fishery on the resulting estimates of local abundance and movement. In the future, we plan to collect tag recovery data both before and after the commercial fishery so that we can compare local abundance and movement rate with and without a potential fishery effect. We conducted a pilot study in summer and fall 2002 in the area of Seguam Pass. Tagged Atka mackerel were released inside and outside the 20-nautical mile trawl exclusion zone in June. Tagged fish were recovered by a chartered fishing vessel both before and after the September commercial fishery. We examine these data to determine whether the numbers of tag releases and recoveries would be sufficient to detect a fisheries effect. We also evaluate whether the trawl exclusion zone is a suitable control for variability in local abundance and movement due to causes other than fishing.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

***Discrimination of Steller sea lion prey fish using frequency-dependent acoustic
backscatter***

Elizabeth A. Logerwell and Christopher D. Wilson

NMFS Alaska Fisheries Science Center
libby.logerwell@noaa.gov, chris.wilson@noaa.gov

This work is part of the Fishery Interaction Team's research to evaluate the effect of commercial fishing activity on the prey availability to Steller sea lions in the Gulf of Alaska. We use acoustic methodology to assess the distribution and abundance of sea lion prey, so one challenge is identifying the species composition of mid-water scatterers, predominantly juvenile pollock and capelin. The difference between mean volume backscattering strength at 120 and 38 kHz (MVBS) has been used by researchers to acoustically discriminate between macrozooplankton species, and between macrozooplankton and fish or small zooplankton. We examined whether MVBS could be used to discriminate between aggregations of juvenile pollock and capelin. Acoustic data at 38 kHz and 120 kHz were collected in the Gulf of Alaska during August 2000 and 2001. Scattering layers of juvenile pollock and capelin were directly sampled by midwater trawls. Significant differences in MVBS existed for these groups at minimum integration thresholds ranging from -91 dB to -69 dB, with the greatest difference at the highest integration threshold (-69 dB). Substantial overlap occurred between the frequency distributions of juvenile pollock and capelin MVBS at the smallest scale of analysis (0.1 nmi x 5 m cells), but virtually no overlap occurred between the MVBS distributions at the largest scale (~ 1 nmi x 20 m aggregations). Thus, acoustic differencing at the scale of the fish aggregation and at high integration thresholds can be an effective technique to distinguish between juvenile pollock and capelin.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

Immature Steller Sea Lion Diving Behavior

Thomas R. Loughlin¹, Jeremy T. Sterling^{1*}, Richard L. Merrick², John L. Sease¹ and Anne E. York¹

¹NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center

²NMFS Northeast Fisheries Science Center

tom.loughlin@noaa.gov , Jeremy.sterling@noaa.gov , Richard.merrick@noaa.gov ,
john.sease@noaa.gov , anne.york@noaa.gov

*presenter

Understanding the ontogenetic relationship between juvenile Steller sea lions (*Eumetopias jubatus*) and their foraging habitat is key to understanding their relationship to available prey and ultimately their survival. We summarize dive and movement data from 13 young-of-the-year (YOY) and 12 yearling Steller sea lions equipped with satellite dive recorders in the Gulf of Alaska/Aleutian Islands (n=18), and Washington (n=7) from 1994-2000. A total of 1413 d of transmission (0 = 56.5 d, range 14.5-104.1 d) were received. We recorded 222,073 dives, which had a mean depth of 18.4 m (range of means 5.8 - 67.9 m; SD = 16.4). Alaska YOY dove shorter and shallower (mean depth = 7.7 m, mean duration = 0.8 min, mean maximum depth = 25.7 m, and maximum depth = 252 m) than Alaska yearlings (0 = 16.6 m, 0 = 1.1 min, 0 = 63.4 m, 288 m), whereas Washington yearlings dove the longest and deepest (mean depth = 39.4 m, mean duration = 1.8 min, mean maximum depth = 144.5 m, and maximum depth = 328 m). Mean distance for 564 measured trips was 16.6 km; for sea lions #10 months of age trip distance (7.0 km) was significantly less than for those >10 months of age (24.6 km). Mean trip duration for 10 of the 25 sea lions was 12.1 h; for sea lions <10 months of age trip duration was 7.5 h and 18.1 h for those > 10 months of age.

We identified three movement types: long-range trips (>15 km and > 20 h), short-range trips (< 15 km and < 20 h), and transits. Long-range trips started around 9 months of age and occurred mostly around the time of weaning while short-range trips happened almost daily (0.9 trips/day, n = 426 trips). Transits began at 7 months of age, occurred more often after 9 months of age, and ranged between 6.5 - 454 km. These yearling sea lion movement patterns and dive characteristics suggest that they are as capable as adults.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

Socioecological Change in the Aleutian Islands

Marie Lowe

Columbia University
gregmarie@arctic.net

This ethnographic study examines the effect of commercial fishing since its development in the early 1960s on the Bering Sea ecology from a social perspective. Discussions of ecological change are incomplete without examination of social influences and how ecological and social forms evolve in tandem. An inquiry into the local knowledge of residents of Unalaska Island in the Aleutian Chain was chosen as a point of reference in a study of the relationship between social and ecological change. For the purposes of this study, local knowledge is broadly defined as both life experience and perspective and was sought to answer the question: What has been the effect of industrial commercial fishing activities on the socioecology of the Unalaska area since 1960? Methodology included life history interviews, a survey and archival research. Commercial fishing development in the Bering Sea transformed Unalaska from a principally Alaska Native village dependent upon subsistence until the early 1960s, to a frontier town in the 1970s during the King Crab boom and presently to a suburban, family-oriented community today. While the residents of Unalaska were known in ancient times as the Qawalangin, or the “Sons of Sea Lions”, today many long term Unalaskan locals are part-time commercial halibut fishermen who also engage in subsistence/sport hunting and fishing. As one applied aspect of this research, Unalaskan local knowledge suggests that the place of the Steller Sea Lion in the socioecology of the Bering Sea has been influenced by both human and animal predation as well as fluctuations in the species Stellers prey upon.

Session EVOS/NPRB-3: Physical Processes and Modeling

North Pacific Ecosystem Metadatabase: Information for scientific and community collaboration and advancement

S. Allen Macklin¹ and Bernard Megrey^{2*}

¹NOAA Pacific Marine Environmental Laboratory

²NMFS Alaska Fisheries Science Center

allen.macklin@noaa.gov , bernard.megrey@noaa.gov

*Presenter

The North Pacific Ecosystem Metadatabase, currently expanding from its original Bering Sea scope, is a dynamic catalog of environmental information made available to users through the Internet. The metadatabase provides synergy among data producers, data archivists and data users by making available to people with varying backgrounds and intents the information they need to produce building blocks from which societal and scientific advances are made. Our goal is to catalog and provide instant access to all environmental data pertaining to the ecosystems of the North Pacific Ocean, its marginal seas, and coastal areas. In its present state, the metadatabase includes references to results from US GLOBEC, NPMR, EVOS, SSL and other research programs. Holdings include datasets, publications, proposals, radio programs, museum collections, and video productions. An important aspect of cooperation between the metadatabase and research programs is to follow up with investigators whose data products reach fruition after their projects have officially terminated. For example, we continue to work with NPMR projects that expired in 2001. We are partnering with the North Pacific Marine Science Organization (PICES) to identify wider holdings for the greater North Pacific Ocean. Recent improvements to the metadatabase website (<http://www.pmel.noaa.gov/mdb/np>) give the user advanced search tools for locating and delivering information. Next steps include transparent access to other databases such as the Japan Oceanographic Data Center and Alaska Resources Library & Information Services.

POSTER Session GLOBEC

Phytoplankton Community Structure and Taxon-specific Growth and Grazing Rates in the Coastal Gulf of Alaska

Erin Macri¹, Suzanne Strom¹, Jeffrey Napp² and Michael Dagg³

¹Western Washington University

²NMFS Alaska Fisheries Science Center

³LUMCON

Process studies in the Coastal Gulf of Alaska (CGOA) seek to understand how climate driven variations in the physical-chemical environment of the coastal zone affect production levels and food web structure. Microplankton abundance, composition and grazing were studied in the CGOA during cruises in April, May and July of 2001. During each cruise four core sites (inner shelf, mid shelf, outer shelf, and Prince William Sound) were occupied. These sites and dates represent a diversity of seasons and physical-chemical conditions in the CGOA. Dilution experiments in conjunction with copepod grazing experiments were used to investigate food web dynamics. Using HPLC analysis and phytoplankton pigment biomarkers we are able to look at temporal and spatial variation in phytoplankton community structure. As a means of understanding the fate of phytoplankton production under various conditions, we will also present taxon-specific growth rates of phytoplankton and grazing rates of both micro- and macrozooplankton on phytoplankton in the CGOA.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

***Modeling the energetics of Steller sea lions (*Eumetopias jubatus*)
along the Oregon coast***

Maria Yolanda Garcia Malavear and David B. Sampson*

Oregon State University

David.Sampson@oregonstate.edu

* presenter

A dynamic bioenergetic model for Steller sea lions (*Eumetopias jubatus*) was built using the STELLA simulation modeling system. The model is intended as an aid for the exploration of ecological questions regarding growth and survival of immature Steller sea lions (ages 1-3) living along the Oregon coast under different nutritional scenarios. The ultimate goals of the work are: (1) to identify features of the Oregon ecosystem that could contribute to the growth of the Steller sea lion population in contrast to the declining population in Alaska and (2) to provide a basis for examining the various hypotheses that have been put forward regarding the causes of the Steller sea lion decline in Alaska. The dynamic energetic model was composed of coupled submodels, created or adapted from the literature, that describe the energetic inputs and outputs of the animal. It is a mechanistic model based on biological principles that attempts to describe the connections and feedbacks between the different components and the allocation of energy to them under suboptimal nutrition. The model predicted that both changes in prey abundance and quality would have a more pronounced effect in one-year-old animals than in two- and three-year-old sea lions. A reduction in prey density could delay the attainment of sexual maturity, which could have a significant negative effect on the population rate of increase. The seasonal migration of Pacific whiting was shown to be very important as a biomass influx into the system. In general, the model predictions were consistent with observations of the declining population of Steller sea lions in Alaska.

Session SSL-15: Steller Sea Lion Site Specific Studies - Chiswell Island

***Population Dynamics, Maternal Investment, and Early Pup Mortality in
Steller Sea Lions at Chiswell Island***

John Maniscalco, Shannon Atkinson, Alexander Burdin and Donald Calkins

Alaska SeaLife Center

john_maniscalco@alaskasealife.org, shannon_atkinson@alaskasealife.org,
alexander_burdin@alaskasealife.org, don_calkins@alaskasealife.org

A small Steller sea lion rookery at Chiswell Island has been studied for the past four years using a remote-control video system. There has been a slight downward trend in the abundance of sea lions during this period at this site. However, interannual variations are apparent with greater numbers seen during even years. Pupping at Chiswell Island exhibits the same odd/even year trend with the number of births occurring during '99, '00, '01, and '02 being 54, 65, 52, and 64, respectively. Maternal investment parameters measured during '01 and '02 are also suggestive of a biannual cycle as '02 was better in terms of pup care with tighter synchrony of births, longer perinatal periods, shorter foraging trips, and a greater percentage of time spent on shore. We estimated that 54% of mature females at Chiswell Island gave birth in both '01 and '02, 37% gave birth in only one of those years, and 9% did not give birth in either year. Foraging trips by lactating females during the summer remained brief during the first month and a half postpartum but then increased markedly by late July suggesting a possible movement of prey resources away from the rookery. Early pup losses during '01 were mostly attributed to orca predation and estimated at 22% of pups born. During '02 orca predation was not thought to be a factor in early pup declines. However, eleven pups (17%) were lost during two storms in the month of June.

***Role of disease in limiting recovery of the Pacific herring population
in Prince William Sound***

Gary D. Marty¹, Terrance J. Quinn II², Theodore R. Meyers³ and Steve Moffitt³

¹University of California, Davis

²University of Alaska, Fairbanks

³Alaska Dept. of Fish and Game

During the past 3 decades in Prince William Sound, Alaska, the Pacific herring population has had significant events affecting population abundance about once every 4 years. The first half of this period was characterized by above average recruitment about once every 4 years. By comparison, since the 1989 Exxon Valdez oil spill the population has experienced disease outbreaks about once every 4 years (1989, 1993-1994, 1997-1998, 2001-2002). Severity of the outbreaks steadily decreased from a peak in 1993: the 2002 outbreak was mild. Each disease outbreak was followed one year later by poor recruitment of 3 year olds into the population. Significant causes of disease include: (1) filamentous bacteria and viral hemorrhagic septicemia virus (VHSV), with associated ulcers; and (2), *Ichthyophonus hoferi*, with associated systemic granulomatous inflammation. Ulcers, bacteria, and VHSV affect mostly younger fish, whereas *I. hoferi* affects mostly older fish. All three organisms are common in the marine environment, but significant disease-related mortality occurs only when environmental and population conditions are favorable for a disease outbreak. We propose that Pacific herring population health can be categorized into regimes. Strong periodic recruitment in the 1970s and 1980s occurred during a “healthy regime,” whereas periodic disease outbreaks and poor recruitment of the 1990s and early 2000s occurred during a “disease regime.” Recruitment of the 1999 year-class in 2002 was the best since the 1988 year-class in 1991; although 14% of 1999 year-class had VHSV in 2002, frank disease among these fish was minimal. If these fish escape a major disease outbreak in 2003, we have evidence that the population is returning to a healthy regime.

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

Evaluation of adrenal activity in Steller sea lion serum and feces

Kendall Mashburn and Shannon Atkinson

Alaska SeaLife Center and University of Alaska Fairbanks
kendall_mashburn@alaskasealife.org, shannon_atkinson@alaskasealife.org

As part of investigating the effects of stress and well-being in Steller sea lions, a non-invasive technique to monitor glucocorticoids as an indicator of adrenal activity was validated. To evaluate the relationship of increases in serum corticoids to those in feces, an adrenocorticotrophic hormone (ACTH) challenge was performed on captive Steller sea lions (n=3) housed under ambient conditions. Both serial blood and fecal samples were collected for radioimmunoassay (RIA). RIA results indicated that, in response to a single ACTH injection, serum corticoid concentrations increased over 200% (6.43-14.61ug/dl) in 60 minutes with a peak of over 300% at 135 minutes and a return to 60 minute concentrations by 240 minutes. Peak fecal corticoid concentrations were reflected in over a 1900% increase over baseline (89.98-1769.63ng/g dry weight) 28.5h post-ACTH injection (beginning at 23.5h with a return to baseline at 48.5h). Further, utilizing HPLC, it was shown that both sexes and all age class fecal samples tested exhibited immunoreactive peaks co-eluting with radiolabeled cortisol/corticosterone(CC) added as reference tracer at fractions 40-46. However, although pups of different sexes showed corticoid metabolite profiles similar to those of free range and captive adult females (additional immunoreactivity at fractions 13-17), free-range and captive adult males exhibited different profiles (additional immunoreactivity occurring at fractions 4-5). Juvenile free-range males exhibited fecal immunoreactivity falling midway between males and females (peaks occurring at fractions 4-5 and 9-15 in addition to CC fractions). These results suggest that utilizing the current RIAs, an acute stress response in serum can be measured within 60 minutes while that of feces can be detected 23h following adrenal stimulation. This may allow us to differentiate between acute and chronic stress occurring in free-range animals through repeated fecal sampling without artifacts resulting from handling animals. Coupled with HPLC analysis, fecal corticoids potentially allow evaluation of stress in different sex/age classes.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

*Towards Understanding Environmental Conditions and Their Variability in the Gulf
of Alaska and Bering Sea – Model Results Part I*

Wieslaw Maslowski¹, Stephen Okkonen² and Terry Whitledge²

¹Oceanography Department, Naval Postgraduate School

²Institute of Marine Science, University of Alaska Fairbanks

maslowsk@nps.navy.mil , okkonen@alaska.net , terry@ims.uaf.edu

The physical environment of the sub-polar North Pacific imposes significant controls on this region ecosystem, including nutrients availability, rates of primary productivity, and population dynamics of higher trophic levels in response to environmental changes. Understanding large-scale climate variability is a key requirement for studies focused on regional effects of climate change on marine life.

Modeling of ocean and sea ice conditions provides a tool for synthesis and integration of data available from field observations and potentially for prediction of future changes. Some of the challenges in modeling the ocean between the Gulf of Alaska and the Chukchi Sea have to do with the complex land geometry and bathymetry of this region. Those include the narrow passages across the Aleutian Archipelago, Bering Strait, and the wide and shallow shelf of the Bering Sea. General circulation models (GCMs) have made significant advancements in representation of physical processes controlling the ocean dynamics and in use of modern high performance computers to solve complex oceanographic problems. These improvements allow for more adequate representation of the climatological ocean and ice conditions and their variability in the northern North Pacific.

In this talk we present results from a high-resolution coupled ice-ocean model of the Pan-Arctic region forced with realistic atmospheric forcing for 1979-2001. The model domain extends from ~30N in the North Pacific, through the Arctic Ocean, to the North Atlantic (~45N) and it is configured on a 9-km and 45-level grid. We address some of the issues related to the time-mean and seasonally-dependent ocean and sea ice circulation, shelf-basin communication, and mass and property fluxes between basins. Examples of interannual and mesoscale variability and their role in the regional environment are discussed. This presentation is expanded by a *poster presentation by Okkonen et al.*

*Session SSL-1: Steller Sea Lion: Factors Currently Affecting the Population
Predation*

***Northern Gulf of Alaska Killer Whales: Status, Population Structure, and Feeding
Habitat (Prince William Sound/Kenai Fjords/Kodiak)***

Craig Matkin¹, Lance Barrett-Lennard², Daniela Maldini³ and Eva Saulitis¹

¹North Gulf Oceanic Society

²Vancouver Public Aquarium

³Alaska Sea Life Center

comatkin@xyz.net , barrett@zoology.ubc.ca, daniela_maldini@alaskasealife.org

In Prince William Sound and Kenai Fjords, Alaska, a long-term photo-identification and behavioral database extends back into the mid 1980s. Although systematic work was initiated in Kodiak only this past season, there is evidence of substantial overlap in the killer whale populations in the three areas. Based on association, genetics, and acoustics we have identified four populations: Alaska residents, AT1 transients, Gulf of Alaska transients, and offshores. The percentage of transients and percentage of encounters with transients is much smaller in the northern Gulf of Alaska, than in southeast Alaska. It is not clear whether transient numbers have declined in the northern Gulf of Alaska, however, many groups have not been sighted in years. Resident killer whales in the northern Gulf have been increasing at a rate of 3.3%/year for the past two decades and feed exclusively on fish, primarily Chinook and coho salmon. The declining AT1 group transients feed primarily on harbor seals and Dall's porpoise, and have never been observed feeding on Steller sea lions. Only the infrequently encountered Gulf of Alaska transients have been observed feeding on sea lions. Of the 29 known and 20 possible (genetics lacking) GOA transients identified, only 9 have been observed feeding or attempting to feed on Steller sea lions. For these whales Steller sea lions were the target of most observed kills and harassments. Observations are limited (n=28) and encounters with Gulf of Alaska transients are infrequent, but it appears in this region a small number may specialize (at least seasonally) in preying on sea lions, while others do not include sea lions in their diet. Some calculations suggesting the impact of these whales on Steller sea lions can be made, however, additional observations are needed to assess the extent of killer whale predation on Steller sea lions.

Life History and Population Dynamics of Resident Killer whales in Alaska

C.O. Matkin¹, P.F. Olesiuk², G.M. Ellis² and E.L. Saulitis¹

¹North Gulf Oceanic Society, Homer, AK

²Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, BC

Life history parameters were derived for resident killer whales in Alaska based on long-term photo-identification studies conducted during 1984-2001. Females matured at about 15 years of age, produced an average of 5.3 calves during a 30-year reproductive lifespan, and had a mean life expectancy of 38 years and maximum longevity of roughly 60 years. Mean life expectancy of males was about 33 years, but ages of the oldest males could not be determined. The life history parameters were developed into a sex- and age-structured population model, which predicted the population would increase at 2.7% per annum and be comprised of 51% juveniles, 23% mature males, 22% reproductive females and 5% post-reproductive females. The population actually grew at 3.3% per annum, and was comprised of 51% juveniles, 19% mature males, 24% reproductive females, and 7% post-reproductive females. The population biology of Alaskan killer whales was remarkably similar to that observed in B.C. and Washington State during the 1970s and 80s, which increased at 2.9% and was comprised of 50% juveniles, 19% mature males, 21% reproductive females, and 10% post-reproductive females. One notable difference was that females in Alaska experienced a more abrupt increase in mortality as they approached reproductive senescence, resulting in reduced longevity. During the Alaskan study, however, the proportion of post-reproductive females declined from 11% to 5%, suggesting it represented a period of atypically high mortality for older females. These baseline population models provide a useful construct for understanding the demographic effects that result from changes in the status of populations with respect to carrying capacity, as well as various anthropogenic impacts. We illustrate this for AB-pod, which lost animals following the Exxon Valdez oil spill in 1989, and according to the model has continued to exhibit low productivity because the losses involved animals with high reproductive potential.

Session EVOS/NPRB-2: Citizen Monitoring and Community Involvement

Effectiveness Of Citizens' Environmental Monitoring Program

Sue Mauger

Cook Inlet Keeper

Cook Inlet Keeper has analyzed five years of past data from the Keeper's Citizens' Environmental Monitoring Program (CEMP): the first consistent, credible, and coordinated community-based water quality monitoring program in Alaska. Keeper determined if sampling frequency, methods, parameters, and site selection are effective at meeting the monitoring objectives of detecting significant changes in water quality over time. The results have been used to develop recommendations to improve CEMP, which will benefit future citizen-based programs around the Gulf of Alaska.

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

***Comparison of Serum Retinol, Tocopherol and Lipid Levels in Free-Ranging Steller
Sea Lions and Their Prey from the Eastern and Western Stocks***

Lisa M. Mazzaro¹, David J. St. Aubin, Richard M. Clark² and Harold C. Furr³

¹Mystic Aquarium

²Department of Nutritional Sciences, University of Connecticut

³Craft Technologies, Wilson, NC

lmazzaro@MysticAquarium.org , rclark@canr1.cag.uconn.edu ,
hfurr@crafttechnologies.com

Nutritional stress associated with changes in prey abundance has been identified as a likely factor in the decline of the Steller sea lion (*Eumetopias jubatus*) in part of its range. Investigations into this hypothesis have focused on food availability, caloric composition and various energetic concerns arising from both these issues. Though food quality is recognized as an important issue in the consideration of nutritional stress, little attention has been directed to the specific nutrients that might bear on health and productivity. This research effort focuses on vitamin A and E, which are both known to play a role in reproductive success. In view of the recognized differences in proximate composition between the historically preferred (herring), and the present, more commonly available (pollock), diets of Steller sea lions, these fat-soluble vitamins may be of particular importance. Our working hypothesis is that vitamin A and E levels, in both Steller sea lions and their prey, are lower in the declining western stock than in the stable eastern stock. Although statistical differences in vitamin and lipid levels between the eastern and western stocks (and between regions) were found, they were opposite of our prediction that they would be lower in the declining population. Additionally, vitamin levels were found to be within normal ranges for captive and free-ranging pinnipeds. Moreover, prey analysis revealed that pollock contains as much or more vitamin A and vitamin E as do other prey fish. Comparisons of pups (< 2 months) to one and two year old sea lions showed significant decreases in tocopherol, and tocopherol/lipid ratios with age. We conclude that for the investigated age groups neither vitamin A nor vitamin E deficiency appears to be a problem. More work is needed however to investigate nutritional status in adult animals and transfer of vitamin A and E from mother to pup via milk.

Session SSL-16: Steller Sea Lion Site Specific Studies – Aleutian Islands

***Estimates of Atka mackerel movement and abundance based on tagging data:
Are trawl exclusion zones effective?***

Susanne McDermott and Elizabeth A. Logerwell

NMFS Alaska Fisheries Science Center

susanne.mcdermott@noaa.gov , libby.logerwell@noaa.gov

To determine whether trawl exclusion zones are effective at preventing prey shortages for Steller sea lions, information is needed about: 1) local abundance of fish, and 2) movement rates of fish into and out of the zones. This information will help determine whether the zones protect sufficient quantities of prey and whether fisheries impact fish abundance inside the exclusion zones. The Fishery Interaction Team research project described here uses mark recapture methods to estimate local abundance and small-scale movement of Atka mackerel relative to trawl exclusion zones in the Aleutian Islands. A pilot tagging study was conducted in 1999, the results of which showed that tagged Atka mackerel survived well and that the fishery reported tagged fish. Full-scale tagging studies were initiated in 2000 in the Seguam Pass area. Atka mackerel are tagged and released inside and outside the trawl exclusion zone in early summer. Recoveries of tagged fish occur in fall. Tagged fish are recovered by the fishing fleet outside the exclusion zone and by a chartered fishing vessel inside the exclusion zone. To estimate movement and abundance from the field data, we developed an integrated tagging model that uses maximum likelihood to estimate all parameters simultaneously. Confidence intervals around model estimates of biomass and movement rate were large in 2000, so tagging effort was greatly increased in 2002 in order to increase the precision of the estimates. Model results to date indicate that there is little movement of Atka mackerel from inside to outside the Seguam Pass trawl exclusion zone. This suggests that the trawl exclusion zone is effective at preventing fisheries outside from impacting fish abundance inside. Results also indicate that Atka mackerel abundance is ~ 118,000 metric tons inside the trawl exclusion zone and ~ 82,000 metric tons outside. A sea lion foraging model is needed to evaluate whether these are sufficient quantities of prey.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

Report from the First International Steller Sea Lion Modeling Workshop

Bernard A. Megrey and Sarah Hinckley

NMFS Alaska Fisheries Science Center

bern.megrey@noaa.gov , sarah.Hinckley@noaa.gov

The first international Steller sea lion modeling workshop was held in Seattle Washington on September 24-25, 2002. Two separate modeling teams, funded by the Alaska Fisheries Science Center Steller Sea Lion Coordinated Research Program, attended with the goal to (1) review the range of potential bioenergetics and foraging behavior models that could be applied to Steller sea lions, (2) examine the extent to which these models are being researched to address important management issues for Steller sea lions, (3) discuss the current research and report progress and potential areas of difficulties, and (4) encourage the development of synergistic links between different groups researching bioenergetics and foraging behavior models in Steller sea lions. Attendees consisted of researchers from the Alaska Fisheries Science Center (AFSC), the Sea Mammal Research Unit (SMRU, St-Andrews University, Scotland, UK), the National Marine Mammal Laboratory (NMML) and the University of Washington (UW).

This presentation will review the workshop findings and communicate the workshop deliberations and recommendations and resulting action plan to those interested in modeling the life history, population biology and vital population processes of the Steller sea lion population. In summary, the workshop attendees saw a compelling need to encourage communication between modelers of Steller sea lions in order to prevent overlap of models and redundancy of effort, encourage complementary modeling approaches and collaborations, facilitate the use of common information to develop these models, ensure that models developed are appropriate to the overall goals of the coordinated Steller sea lion research program, and guarantee that the Steller sea lion modeling work undertaken by various researchers meets the needs of those who must manage this endangered species.

POSTER Session GLOBEC

Climate Trends in the Northern Gulf of Alaska, 1950-97

Roy Mendelsohn, Steven J. Bograd, Franklin B. Schwing

NOAA Pacific Fisheries Environmental Laboratory

State-space decompositions and subspace identification methods are used to examine long-term trends and variations in the seasonal phase and amplitude of surface atmospheric and oceanographic parameters in the Gulf of Alaska. Sea surface temperature, north-south and east-west wind stress, and wind speed cubed are analyzed over a regular grid of sites for the period 1950 through 1997. The aim of the analysis is to see whether observed changes in surface ocean conditions can provide mechanistic explanations for the changes in the Steller Sea Lion populations. The entire Gulf region is examined in order to differentiate climate forcing of distinct Steller populations.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Modeling the effects of Climate Change on Gulf of Alaska circulation patterns and
their possible impact on plankton and Steller Sea Lion community structure***

Arthur J. Miller¹, Douglas J. Neilson¹, Emanuele di Lorenzo¹, Frank Schwing², Steven Bograd², Michael Alexander³, Antonietta Capotondi³, David L. Musgrave⁴ and Kate Hedstrom⁵

¹Scripps Institution of Oceanography, University of California

²NMFS Pacific Fisheries Environmental Laboratory

³NOAA-CIRES Climate Diagnostics Center

⁴Institute of Marine Science, University of Alaska Fairbanks

⁵Arctic Region Supercomputing Center, University of Alaska Fairbanks

miller@horizon.ucsd.edu, dneilson@ucsd.edu, manu@horizon.ucsd.edu,
fschwing@pfeg.noaa.gov, sbograd@pfeg.noaa.gov, maa@cdc.noaa.gov,
mac@cdc.noaa.gov, musgrave@ims.uaf.edu, kate@arsc.edu

One possible cause of the decline in Steller sea lions in the Gulf of Alaska is climate related shifts in ocean circulation affecting *in situ* biological processes. Specifically, the sea lion's decline in the western Gulf of Alaska coincides with the 1976/1977 regime shift observed in the North Pacific Ocean. Interestingly the decline was restricted to the Gulf of Alaska west of Cape Suckling; east of this the populations are stable. We are currently analyzing 10 year Regional Ocean Model System (ROMS) model runs at 16km and 8km resolution. Various eddy-resolving simulations using NCEP reanalysis wind stress products are in progress. Statistical equilibrium runs using wind stress climatologies for pre-shift (1970-1976) and post-shift (1977-1982) periods are meant to identify the changes in mean circulation and mesoscale eddy statistics that can affect biological productivity. Hindcasts from the early 1950s through the late 1990s are meant to identify the basin-scale circulation adjustment processes before and after the shift. Changes modeled in the eastern versus western Gulf of Alaska are highlighted and used to identify potential impacts on plankton community structure and distributions which may ultimately affect the sea lion populations in the region.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change and Fisheries*

*Are changes in Steller sea lion populations related to community structure?
An application of loop analysis*

Gabriela Montaña-Moctezuma¹ and Selina Heppell²

¹Instituto de Investigaciones Oceanológicas. Universidad Autónoma de Baja California

²Oregon State University. Corvallis, Oregon.

Gabriela_Montano@hotmail.com, Selina.Heppell@orst.edu

Qualitative Analysis or Loop Analysis will be used to assess the effects of fishing and climate change on Steller sea lions, their prey, and other members of the community web. Loop analysis begins with a qualitative community matrix, which corresponds to the Jacobian matrix used in dynamic system analysis. The models are represented as signed digraphs that are built from the biological knowledge of the system or by obtaining the data from field observations. Unlike traditional food web analyses, which require detailed information about the strength of direct and indirect interactions, loop analysis relies on a simple matrix of + (positive interactions), - (negative interactions), and 0s (no interaction). Analytical techniques recently described by Dambacher et al. (2002, Ecology and American Naturalist) allow us to determine the community-wide responses to a “press” perturbation that alters the abundance of a community member.

A description of the technique will be presented as well as how it will be used to examine the role of community structure in determining Steller sea lion population changes after a disturbance affects one or more species in the community. The response of each community member to disturbance will be analyzed in alternative community webs to understand the role of direct and indirect effects when different community networks are considered. Alternative models will be generated to reconstruct communities in the Gulf of Alaska and Bering Sea based on the different hypotheses that have been suggested in the literature. Alternative community webs may elucidate why some populations are declining while others are not, based on their response to changes in the biotic community.

*Session SSL-2: Steller Sea Lion: Factors Currently Affecting the Population
Diseases, Parasites and Contaminants*

Parasites of Fishes near two Steller Sea Lion Haulouts in Southeastern Alaska

Adam Moles

NMFS, Auke Bay Laboratory
Adam.Moles@noaa.gov

Fish serve as intermediate hosts for a number of larval parasites that have the potential of maturing in marine mammals such as Steller sea lion. We examined the prevalence of fish parasites near two Steller sea lion haulouts in southeastern Alaska to serve as a baseline for similar studies in central and western Alaska. Species examined included capelin, Pacific herring, Pacific sandlance, and rock sole from Benjamin Island and dusky rockfish, Pacific herring, Pacific sandlance, Pacific cod, and eulachon from near the Brothers Islands. In addition, parasite fauna were enumerated from walleye pollock both near shore and off shore of both haulouts. From the 104 fish examined, fifteen parasite taxa were identified, six of them larval parasites: the cestode *Nybelinia surmenicola*, the nematodes *Anisakis simplex*, *Contracaecum* sp., and *Pseudoterranova decipiens*, and the juvenile acanthocephalans *Corynosoma strumosum* and *C. villosum*. Some of these parasites, quite harmless as larvae in fish, are known to be harmful to mammalian final hosts. The larval cestodes and nematodes were present in most of the fish examined, as they are in most common marine fishes of Alaska. Only the acanthocephalans were rare in southeastern Alaska fishes. Other potentially harmful larval parasites were not found among fish at the two haulouts.

*Session SSL-2: Steller Sea Lion: Factors Currently Affecting the Population
Diseases, Parasites and Contaminants*

Evaluation of the Effects of Parasites on Steller Sea Lions in Alaska

Michelle M. Moore and J. Frank Morado

NMFS Alaska Fisheries Science Center

michelle.m.moore@noaa.gov , frank.morado@noaa.gov

Parasitism could be a factor affecting the recovery of Steller sea lions (SSL) in Alaska. Parasites may also serve as biological indicators of population distributions and diet. The first goal of this research is to identify and assess potentially detrimental parasites in SSL. The second goal is to compare SSL parasite fauna between rookeries, and contrast the parasite fauna of four important SSL prey species caught in proximity to rookeries. In 2001-2002, 385 samples were received for analyses. These included 60 frozen and 90 formalin-fixed scat samples from 11 rookeries in the Gulf of Alaska (GOA) and Aleutian Islands (AI); 55 formalin-fixed fecal samples from SSL captured in the AI, GOA, and southeastern Alaska (SEA); four frozen intestines collected from pups that died during capture in SEA; and 176 frozen fish collected near four rookeries in the AI. Parasites are being concentrated from scat and fecal samples by formalin/ethyl acetate sedimentation, and parasite types in each sample are being identified and quantified. Larval parasites are being extracted from dissected fish and preserved for identification and quantification. Preliminary results have identified two major parasites with potential detrimental effects on the health of pups and juveniles. These parasites are hookworms (*Uncinaria* sp.) and lungworms (*Parafilaroides* sp.). Adult hookworms were found in the intestines of all four pups from SEA, and lungworm larvae were identified and quantified in scat and fecal samples from the AI, GOA, and SEA. Ongoing analysis of formalin-fixed scat samples will determine the occurrence of lungworms in the AI. Lungworms were not recoverable from frozen scat samples. Hookworm and lungworms cause direct mortality and/or reduced fitness in other species of pinnipeds. The effects of these parasites on SSL are not known. Further research is proposed to determine the prevalence and impact of hookworms in SSL pups, and the occurrence and severity of lungworm infestations in all ages of SSL in Alaska.

POSTER Session GLOBEC

***Timing and Mesoscale Variability of
Phytoplankton Blooms in the Northern GOA***

C. W. Mordy¹, S. A. Salo¹, J..A. Napp² and P. J. Staben¹

¹NOAA Pacific Marine Environmental Laboratory

²NMFS Alaska Fisheries Science Center

Seasonal dynamics of primary production are strikingly different offshore of Kodiak Island compared to other regions of Gulf of Alaska (GOA). In general, high nutrient concentrations in early spring are observed over the entire shelf due to winter entrainment and onshore Ekman flow of nutrient rich water from the basin. The spring bloom persists until nutrient concentrations become limiting, and, thereafter, chlorophyll concentrations remain low. A dramatic exception is offshore of Kodiak Island where chlorophyll concentrations remain high all summer, suggesting distinctive mechanisms of nutrient supply. We compare mesoscale and interannual variability in sea-surface chlorophyll over the GLOBEC domain from 1998 to 2002 using in-situ data and time-series of SeaWiFS satellite imagery. To examine interannual variability of production from spring to fall, two week composites were examined from May to September in each year. These images also reveal the relevant extent to which eddies and filaments contribute to chlorophyll production. To better examine seasonal variability, five-year averages were generated at 2 week intervals. Sustained production over the shallow banks and troughs off Kodiak Island is a clear indication of a stable localized nutrient source. These results are compared to time series from moorings and other in situ data

POSTER Session GLOBEC

GLOBEC Research: Quantifying the Trophic Interactions and Energetics of Juvenile Pink Salmon in the Gulf of Alaska and Prince William Sound

Jamal H. Moss¹, Dave A. Beauchamp¹, Alison D. Cross¹, Katherine W. Myers¹, Nancy D. Davis¹, Janet L. Armstrong¹, Robert V. Walker¹, Lewis J. Haldorson², Jennifer L. Boldt², Mikhail Blikshiteyn², Edward V. Farley³, Steve E. Ignell³ and John H. Helle³

¹School of Aquatic and Fishery Sciences, University of Washington

²School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

³NMFS Auke Bay Laboratory, Alaska Fisheries Science Center

Pink salmon are one of the predominant planktivores in the Gulf of Alaska and are a culturally and economically important species in the North Pacific. The goal of our Global Ocean Ecosystem Dynamics (GLOBEC) research is to quantitatively model spatial and temporal patterns in distribution, feeding, food supply, and growth by juvenile pink salmon in Prince William Sound and the coastal Gulf of Alaska. Field data collected over multiple years during GLOBEC cruises provide broad spatial coverage around the coastal, shelf, and off-shelf regions of the Gulf of Alaska during mid-July through mid-August, as well as enhanced temporal resolution in Prince William Sound and along the Seward Line during July-October. By applying this mechanistic approach within a spatial-temporal framework over multiple years, we hope to develop a functional understanding of the relative importance of climate, oceanographic conditions, and planktivore density and distribution on the growth and survival of juvenile pink salmon. Two complementary approaches are being taken to model feeding and growth of juvenile pink salmon in the Gulf of Alaska. The first method will estimate the daily consumption rates required to satisfy the measured growth rates of pink salmon, based on diet, growth, and temperature data collected during GLOBEC cruises, and other sources. Consumption demand at each sampling station will be compared to concurrent estimates of the food supply (numerical zooplankton density, biomass, and energy density for edible-sized zooplankton) collected from surface-towed Tucker trawls. The second method will develop a spatially-explicit model to estimate growth potential for juvenile pink salmon at each station during each cruise. A spatially-explicit model of growth potential uses a foraging model to link data on environmental conditions (temperature, light, turbidity) and prey density (number of edible-sized prey m⁻³) to a bioenergetics model of fish growth to predict the per capita growth potential available in a grid cell. Growth potential will vary among cells based on geographic differences in prey density and environmental conditions. Pink salmon feed visually on planktonic or neustonic prey, and detection can vary as functions of light, turbidity, prey size and contrast. The first step in model development has been to define initial boundaries to constrain the visual foraging model to relevant times, depths, and environmental conditions associated with the observed diel feeding chronology of juvenile pink salmon. These feeding patterns help define the appropriate spatial and temporal dimensions of the prey field and limit the availability of prey to just the depths and times associated with salmon feeding. Diel stomach fullness data from multiple sampling dates were consistent with a daylight feeding pattern. Prey were predominantly large zooplankton (>1.5 mm) or insects. Turbidity levels were low in both the Gulf of Alaska (0.2-1.3 NTU) and Prince William Sound stations (0.3-1.0 NTU) during the July through October 2001 cruises. Average light extinction coefficients measured during midday (0900-1500 hours) ranged from 0.160 to 0.301 m⁻¹. Based on these preliminary results, the visual foraging model will limit feeding by pink salmon to daylight hours in 0-10 m depths with low turbidity. Field data inputs will include: sea surface temperature adjusted to 0-10 m depths from CTD data; prey fields will be limited to the numerical density of edible-sized zooplankton (> 1.0 mm) available during daylight in 0-10 m depths. Prey density will be converted to consumption rates using visual encounter rates and/or an experimentally-derived functional response curve. Initially, uniform zooplankton densities will be assumed within each spatial cell but will vary among cells. The model will estimate growth potential (grams growth per gram body weight per day) for specified sizes of juvenile pink salmon within a cell based on the temperatures and prey densities measured during the cruises. To link with other biological models, estimates of numerical density and size structure of edible-sized zooplankton during daylight in surface waters (0-10 m) will be needed as an output from NPZ models, and the temporal-spatial scales for linking these models should be resolved.

Calls of North Pacific right whales recorded in the southeast Bering Sea

Lisa Munger, Sue Moore, John Hildebrand, Sean Wiggins and Mark McDonald

North Pacific right whales (*Eubalaena japonica*) may be the most endangered baleen whale population on the planet. A remnant population, estimated in the tens of animals, has been observed each summer since 1996 in the southeastern Bering Sea, from ship-based and aerial platforms. These platforms provide photographic and observational data, estimates of population size and genetic affinities, but cannot describe seasonal occurrence patterns. In October 2000, the Scripps Institution of Oceanography (SIO) and the National Marine Fisheries Service (NMFS) deployed four bottom-mounted autonomous acoustic recording packages (ARPs) near right whale sighting locations in the Bering Sea. These instruments passively recorded low frequency (5 to 250 Hz) underwater sounds for up to seven months. The recordings have been analyzed for right whale calls by examining spectrograms and by implementing automated detection software. Right whale calls were seen in recordings from early November 2000, indicating a later seasonal presence in the Bering Sea than previously suspected. Future analysis will include more detailed determination of seasonal call occurrence, as well as tracking the movements of calling whales using call arrival times on three or more instruments. Additional acoustic and visual data from the 2002 NMFS cruise in the Bering Sea will be combined with ARP data to characterize right whale calling patterns and estimate the number of animals present based on calls detected. We will examine oceanographic data for the Bering Sea region to correlate right whale occurrence with oceanographic parameters and characterize right whale habitat. Finally, we will analyze the ARP recordings of other baleen whale species in the Bering Sea, including fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera noveangliae*), and describe their seasonal calling patterns.

Forage Location, Diet, and Productivity of black-legged kittiwakes in 2001 and 2002 in Chiniak Bay, Kodiak Alaska

Katie A. Murra¹, C. Loren Buck¹, S. Dean Kildaw¹, J. Brook Gamble² and Cory T. Williams¹

¹School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

²Department of Biology and Wildlife, University of Alaska Fairbanks

ftkam@uaf.edu, loren.buck@uaf.edu, ffsdk@uaf.edu, ftjbg@uaf.edu, fnctw@uaf.edu

Food abundance and availability is widely regarded as the most important factor determining productivity of black-legged kittiwakes (*Rissa tridactyla*). We hypothesized that kittiwakes sharing foraging locations would have similar diets and reproductive success. Trends in locations of foraging and diet samples collected from kittiwakes in Chiniak Bay (Kodiak Island, Gulf of Alaska) show little overall variation from 2001 to 2002, yet productivity (chicks fledged/nest attempt) declined markedly (0.71, 0.48, respectively). Inter-colony and inter-year variation in productivity may be explained by predation, storm events, phenology of forage availability, total forage abundance or forage site fidelity. A greater number of eggs survived through hatch in 2001 than in 2002 (0.67, 0.51, respectively), possibly due to increased predation pressure or cooler, wetter conditions in 2002. The proportion of capelin (*Mallotus villosus*) in regurgitants collected from chicks peaked nearly two weeks earlier in 2001 than 2002, potentially leading to greater fledging success in 2001 (0.77 vs. 0.69). In both 2001 and 2002, radio-tagged kittiwakes tended to maintain fidelity with respect to foraging locations, most often remaining near their nesting colonies and within the 20nm habitat deemed critical to Steller sea lions. As such, kittiwakes may compete with Steller sea lions and may serve as indicator of general marine conditions and forage fish availability.

POSTER Session and Session GLOBEC-3

***Comparison of the Coastal Gulf of Alaska Circulation (3-km grid)
to GLOBEC Data***

D.L. Musgrave¹, K. Hedstrom¹, A. J. Hermann² and D. B. Haidvogel³

¹University of Alaska Fairbanks

²Joint Institute for the Study of Atmospheres and Oceans, University of Washington

³Rutgers University

Results from the 3-km grid model of circulation of the Gulf of Alaska shows very good agreement with the features observed by moorings, hydrography and satellite. We will present the comparisons as well as general concepts derived from the model and what they mean for the replenishment of nutrients in the surface waters of the shelf waters in the GLOBEC LTOP areas. Noteworthy aspects include the interaction of the eddy field with the bathymetry, steering of bottom flows by canyons, and the path of the Alaska Coastal Current.

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

***Thyroid and Cortisol hormones as an indication of metabolic function and well-being
in Steller sea lions (*Eumetopias jubatus*)***

***Matthew J. Myers^{1,2}, Lorrie D. Rea^{2,3}, Kendall L. Mashburn^{1,2} and
Shannon Atkinson^{1,2}***

¹Institute of Marine Science, University of Alaska Fairbanks

²Alaska SeaLife Center

³Alaska Department of Fish and Game

matthew_myers@alaskasealife.org, lorrie_rea@fishgame.state.ak.us,
kendall_mashburn@alaskasealife.org, shannon_atkinson@alaskasealife.org

The purpose of this study was to investigate serum thyroid and cortisol concentrations in Steller sea lions. Seasonal concentrations were examined in captive and free-ranging sea lions in an attempt to develop a suite of measurements that provide a reliable index by which an animal's metabolic status could be measured. Thyroid hormones, thyroxine (T4) and triiodothyronine (T3), function primarily to regulate metabolism and contribute to the maintenance of homeostasis in mammals. Seasonal variation in captive sea lions (non-pups) of both thyroid hormones indicated enhancement of the metabolic rate in summer. However, these animals are kept in a stable environment with a prescribed diet. Total T4 hormones from free-ranging sea lions (non-pups) were elevated (mean 15.98 ng/ml \pm 6.44ng/ml) above captives (mean 12.41 ng/ml \pm 6.98 ng/ml), indicating environmental impacts on metabolism beyond those experienced by captive animals. Cortisol can be elevated in association with changes in an animal's environment and is used here as a barometer of stress in sub-populations. Interestingly, cortisol concentrations were also elevated in summer months in captive sea lions (non-pups). Cortisol concentrations from free-ranging sea lions (non-pups) were elevated (mean 99.13 ng/ml \pm 47.24 ng/ml) above captives (mean 80.78 ng/ml \pm 33.66 ng/ml) suggesting environmental impacts on the well-being of free-ranging sea lions (non-pups). A pup comparison between two subsequent years (2000 and 2001) revealed significant inter-annual differences. Average cortisol concentration in Western stock pups was significantly lower (mean 82.02 ng/ml \pm 33.16) in 2000 than in the following year (mean 107.66 ng/ml \pm 20.24) . A similar trend occurred in Southeastern pups with cortisol in 2000 significantly lower than in 2001. In 2001, an additional sampling protocol provided samples from Russian pups that were higher than the Western pup concentrations.

Secondary production in a downwelling ecosystem: egg production rates of *Calanus marshallae* and *Pseudocalanus* spp. in the coastal Gulf of Alaska, 2001

J.M. Napp and C.T. Baier

NMFS Alaska Fisheries Science Center

The highly productive coastal Gulf of Alaska ecosystem is anomalous among the world's most productive systems in that the dominant winds produce downwelling at the coast for most of the year. To understand the interaction of climate and trophic dynamics that affect the transfer of energy to pink salmon (*Oncorhynchus gorbuscha*) juveniles migrating out of Prince William Sound, we examined egg production rates of several copepod taxa in April, May, and August of 2001 during GLOBEC Process cruises. *Calanus marshallae* was abundant only during the May cruise, and was restricted to Prince William Sound and the Alaska Coastal Current. All females were ovigerous and egg production rates were approximately 40 eggs female⁻¹ day⁻¹ with a clutch interval of 1-3 days. *Pseudocalanus* spp. females were approx. 10X as abundant during the May cruise as *Calanus*. In general, *P. newmani* dominated in Prince William Sound and *P. mimus* dominated in the ACC and middle shelf. Clutch size (as number and volume) increased with female prosome length, although for the same prosome length, *P. newmani* tended to have larger clutch volume than *P. mimus*, despite similar clutch size between the two species. Individual egg production rates were lower in August than April and May, but total egg production was nearly equivalent for the three time periods due to an increase in female concentration in August.

Advection of shelf zooplankton in a predominantly downwelling ecosystem: bioacoustic detection of the dominant modes of variability

J.M. Napp¹, C.F. Greenlaw², D.V. Holliday² and P.J. Staben²

¹NMFS Alaska Fisheries Science Center

²NOAA Pacific Marine Environmental Laboratory

The highly productive Gulf of Alaska shelf ecosystem is unique in that the dominant mode of wind forcing produces downwelling at the coast for most of the year. The persistent downwelling may, in part, explain how large calanid copepods with oceanic affinities (*Neocalanus* spp.) enter the coastal domain. *Neocalanus* spp. play an important role in the trophodynamics of the shelf ecosystem, especially in the transfer of energy to hatchery-raised and wild pink salmon (*Oncorhynchus gorbuscha*) from Prince William Sound. To test the hypothesis that transport of zooplankton is highly correlated with wind events, we deployed an 8-frequency acoustic device (TAPS-8; 104-3000 kHz) from a single mooring on the Seward Line in the coastal Gulf of Alaska. The TAPS-8 is suitable for size-abundance estimation of zooplankton from ca. 0.25-mm to > 25-mm total length. We present preliminary bioacoustic data from our first deployment and recent recovery (May-September 2002) highlighting important modes of variability in total zooplankton biovolume, and the time series of winds from an adjacent mooring. In addition, we describe the biovolume distributions of individual *Neocalanus* spp. developmental stages as well as other taxa whose biovolume distributions may overlap that of *Neocalanus* spp.

*Session SSL-9: Steller Sea Lion Biology and Ecology
Transmitter Developments*

A Study to Evaluate Transmitter Implant Methodology

Albert Wendell Nelson and Robert B. Heath

Colorado State University
albert.nelson@colostate.edu , rheathdvm@aol.com

The project scope of work is to investigate implant methodology in sheep that would result in the development of techniques to implant transmitters in Steller Sea Lions to allow long-term tracking of free ranging animals.

The project is focused on the percutaneous antenna with a transmitter in a subcutaneous position. Four groups of six sheep have been used to determine problems related to this type of implant. Skin and mucous membrane were investigated as epithelial sources to line the subcutaneous pouch created to contain the transmitter.

Excellent epithelialization was obtained with both skin and oral mucous membrane mesh grafts by five weeks. The epithelial grafts were well adhered to the graft bed in two weeks but little new epithelial cell proliferation had occurred. Ten of the twelve transmitters implanted in this group eroded through the pouch wall during the third to fourth month after implantation. There was no evidence of pouch wall breakdown in the other two sheep 11 months after implantation.

Necrosis of the pouch wall is related to the physical shape of the implant and the stretch and compression of the pouch surface against the implant edges. Compression of the pouch wall against the implant appeared to result in erosion of the epithelial lining allowing infection to gain access to the tissues of the wall and to assist in the destruction of the pouch wall and the external skin cover. The necrosis of the pouch wall was prevented when the transmitter profile was low compared to the normal position of the skin in the area resulting in a smooth transition of the skin profile from the adjacent area to the top of the implant.

The mock transmitter design was modified to provide a lower profile and a sloped peripheral edge to avoid a vertical shoulder. Twelve sheep were implanted with mock transmitters with a sloping edge design and have not shown evidence of pouch wall necrosis during a post operative period of six weeks to six months.

**Seasonal change in vertical migration behavior of
Atka mackerel in Seguam Pass, AK**

Daniel G. Nichol

NMFS Alaska Fisheries Science Center
dan.nichol@noaa.gov

In July 2000, 117 Atka mackerel *Pleurogrammus monopterygius* were released with data storage tags in Seguam Pass, Alaska. These tags collected depth (pressure) and temperature data. Thus far, 13 tags have been recovered. Fish were at liberty from 42 to 407 days. Five of the thirteen fish were males that displayed apparent nest guarding behavior. One male spent more than 4 months with limited vertical movements away from the bottom. Nest-guarding periods began as early as June 4 and ended as late as December 12, with depths ranging from 99 to 151 m. All fish displayed distinct diurnal behavior, with all vertical movements away from the bottom occurring during daylight hours only (Nichol and Somerton (Mar. Ecol. Prog. Ser. Vol. 239: 193-207, 2002). Fish were completely inactive and on the bottom during night-time periods. Depths at which fish remained on the bottom during nighttime ranged from 90.7 m to 246.7 m. Daytime vertical excursions, however, ranged from below 320 m to the surface. Due to the shorter day-length periods during winter months, Atka mackerel spent longer periods on the bottom than at other times of the year. This seasonal change in the amount of time that Atka mackerel spend on the bottom may explain why Atka mackerel decrease in importance as a prey for Steller sea lion during winter months.

Session EVOS/NPRB-1: Marine Research

Coordination and Planning For Herring Research

Brenda L. Norcross and Michele Frandsen

Institute of Marine Science, University of Alaska Fairbanks

In FY 2000, the EVOSTC funded a one-year project to conduct a workshop to identify important questions that remain about herring and questions that can and cannot be answered (Project 00374 "Coordination and Planning for Herring Research). An EVOSTC 1999 Herring Workshop was held in Anchorage, AK 15-16 November and hosted by Bob Spies, Chief Scientist and Phil Mundy, GEM Science Director. The objective of the workshop was to address the following questions: 1.) What are the elements of the monitoring and research program for the next two years, and for the 21st century? 2.) How can EVOSTC best collaborate with scientists in other agencies and the university to serve the public interest in herring management? and 3.) What is the role of herring in the ecosystem, and the place of this species in an ecosystem monitoring and research program?

The 1999 Herring Workshop was very rewarding scientifically and confirmed that excellent research has been conducted and that more needs to be done. Most researchers agreed that additional research and monitoring needs to be done. Another workshop was necessary to finish discussion of the above objectives as well as discuss new ideas and research goals. The general consensus seemed to be that there is much information and data already collected that need to be analyzed and that the various components need to be synthesized. A science plan needed to be generated for future herring funding under EVOSTC. This presentation will summarize the results of Project 00374 and identify future herring research needs.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

***Fasting Capabilities in Weaned Juvenile Steller Sea Lions:
Influence of Body Condition and Activity***

Dawn P. Noren

National Marine Mammal Laboratory, NMFS Alaska Fisheries Science Center
Dawn.Noren@noaa.gov

The decline in the Steller sea lion population may be linked to a decline in the number of juveniles. Thus, it is important to quantify physiological capabilities and constraints of this susceptible portion of the population. Because limitations in prey availability may also contribute to the Steller sea lion decline, it is important to understand fasting capabilities of juveniles. For most fasting animals, lipid catabolism is the preferred energetic pathway to ensure that protein is spared. However, marine mammals also have a compounding pressure to conserve lipid stores. The main site of lipid storage in these animals is the blubber layer, which is not only an important energy source during fasting, but is also their primary thermal barrier when at sea. To explain how protein and lipid reserve allocation and maximum fasting duration are influenced by body condition and activity, I developed a dynamic state variable model. The parameters of the model were selected to meet conditions faced by weaned, unsuccessfully foraging 1-2 year old Steller sea lions. The model incorporates the independent effects of body mass and protein mass (the two state variables) on survival and accounts for fitness consequences of utilizing either lipid or protein during the fast. The results predict that maximum fasting duration decreases with increased time spent in the water. Furthermore, animals with lower percentage fat of total body mass (%TBF) have limited fasting abilities. Specifically, the maximum fasting duration for sea lions with <10 %TBF is <10 days when 70% of each day is spent in water. Lipid and protein allocation are also influenced by %TBF, with leaner sea lions catabolizing higher levels of protein. The results suggest that lean juvenile Steller sea lions may be especially susceptible to relatively short term reductions in prey availability due to their limited fasting abilities.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

*Using Molecular Genetics to Estimate Dispersal Rates Between
Steller Sea Lions Rookeries*

**Greg O’Corry Crowe¹, Barbara L. Taylor¹, Marc Basterretche¹, Thomas R. Loughlin²,
Thomas Gelatt³ and John W. Bickham⁴**

¹NMFS Southwest Fisheries Science Center

²NMFS Alaska Fisheries Science Center, National Marine Mammal Laboratory

³Alaska Department of Fish and Game

⁴Texas A&M University

Greg.O’Corry-Crowe@noaa.gov , Barbara.Taylor@noaa.gov ,

Marc.Basterretche@noaa.gov , Tom.Loughlin@noaa.gov ,

Tom_Gelatt@fishgame.state.ak.us , j-bickham@tame.edu

The estimation of rates of dispersal among rookeries is important to understanding both the decline of Steller sea lions (*Eumetopias jubatus*) in parts of their range and the effects of various management scenarios on recovery. Direct estimation is difficult in such a long-lived mammal, requiring the tracking of many known individuals throughout their entire lives. Patterns of variation at selectively neutral genetic markers can be influenced greatly by patterns of dispersal and thus offer an alternative and potentially more efficient method of estimating dispersal rates. We have developed a case-specific simulation technique that uses mitochondrial DNA (mtDNA) data in the parameter estimation framework. We have found that acceptably precise estimates of dispersal required both high sample size and relatively long mtDNA sequences. We sequenced 532 bp of mtDNA’s control region for 60-106 individuals per rookery from 3 adjacent rookeries in the Western stock that have witnessed some of the most dramatic declines and 2 rookeries in the Eastern stock, where numbers are increasing. Estimated annual dispersal among eastern rookeries ranged from 0.1% to 1% corresponding to 5 to 50 females dispersing each year among rookeries on the order of 2,500 females, indicating that rookeries in Southeast Alaska are demographically connected. This agrees with independent evidence of the close historical relationships and evidence from branding studies of continued connectivity between rookeries in this region. Conversely, dispersal rates between rookeries in the Western stock were about 0.01% corresponding to << 1 female per year among rookeries that historically comprised 4,000 to 15,000 females. Such low levels of dispersal were surprising and indicate that neighbouring rookeries are, in effect, demographically separate entities. These dispersal estimates, together with their uncertainty, can be used in Population Viability analyses and other models of population dynamics, as well as aiding in the identification of management units.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

*Towards Understanding Environmental Conditions and Their Variability in the Gulf
of Alaska and Bering Sea – Model Results
Part II: Site-Specific Seasonal, Interannual, and Interdecadal Variability*

Stephen Okkonen¹, Wieslaw Maslowski² and Terry Whitledge¹

¹Institute of Marine Science, University of Alaska Fairbanks

²Oceanography Department, Naval Postgraduate School

okkonen@alaska.net , maslowsk@nps.navy.mil , terry@ims.uaf.edu

Seasonal, interannual, and interdecadal variability in the pathways by which nutrients are transported from the deep ocean onto the continental shelf in the western Gulf of Alaska and central Bering Sea are investigated using the Naval Postgraduate School (NPS) regional coupled ice-ocean model. Seasonal and interannual variability associated with specific locations, phenomena, and circulation features investigated with the NPS numerical model include:

- Alaskan Stream inflow through Aleutian Island passes
- roles of eddies, canyons, and fronts
- oceanographic conditions at Seguam Pass, Unimak Pass, and Shumagin Islands.

Animations of model results from the *Maslowski et al. oral presentation* will also be available for viewing.

***A monitoring program for near-surface temperature, salinity, and fluorescence fields
in the Northeast Pacific Ocean***

Stephen Okkonen¹ and Tom Royer²

¹Institute of Marine Science, University of Alaska Fairbanks

²Center for Coastal Physical Oceanography, Old Dominion University

A thermosalinograph was installed (July 2002) on the T/V Polar Alaska as a proof-of-concept project to demonstrate the use of a crude oil tanker as platform from which to acquire measurements of oceanographic field variables (near-surface temperature and salinity) between Valdez, Alaska and California.

The principal research objectives associated with this project are to:

- Identify the seasonal migration and evolution of frontal features associated with the Alaska Coastal Current, shelf break, and mesoscale eddies in the northern Gulf of Alaska.
- Identify the dominant length scales of variability (and seasonal modulation of those length scales) characterizing the near-surface temperature and salinity fields along the shipping corridor.

Measurements acquired to date will be presented and preliminary analyses will be discussed.

Metabolic Hormone Levels of Neonatal Harbor seal (*Phoca vitulina*) in Rehabilitation Facilities

Danielle R. O'Neil and Shannon Atkinson

Alaska SeaLife Center

Neonatal marine mammals are more inclined to suffer from immunosuppression due to abandonment, malnourishment and anthropogenic contaminants. Analysis of hormone concentrations and body condition via morphometrics can give an indication of an animal's physiology. Hormones such as cortisol and thyroxine, if levels are altered due to such stresses on a neonate, can cause changes in metabolic rate, calcium absorption and blood pressure control. This study examined cortisol and thyroxine (T4) levels in neonatal harbor seals in two rehabilitation facilities. In addition, permanently captive harbor seals housed at the Alaska SeaLife Center were also assayed for comparison in terms of animals in a captive life situation. The hormones were assayed using radioimmunoassay techniques. The data collected from these assays are being used to form baseline values on pups that are admitted into the rehab facilities. Preliminary results indicate that total T4 concentrations ranged from 0.7 to 11.4 ng/ml in animals age 2 days to 14 weeks. Cortisol concentrations ranged from 2.3 to 76.4 ng/ml. Cortisol levels in rehab animals suggest high variability based on circadian cycles, health status and feeding regimes. High levels of total T4 at weaning suggest a change in metabolic rate due to diet adjustment. Spikes in cortisol and thyroxine were expected at times of weaning. This is shown in approximately of 47.2% weaned pup samples, where N=all pups, n= pups with peaked hormone ranges (N=36, n=17). The highest cortisol concentrations were found in the most compromised neonates and usually found in the samples collected directly prior to death. In captive animals, total T4 ranges spanned from 0.8ug/dL to 6.3 ng/ml, with highest levels seen in the mid to late summer season. Captive cortisol levels ranged from 0.61ng/ml. Baseline information on the immune system and standards of hormone values in seals is necessary for any further investigation of immunocompetence of the species.

*POSTER: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

***Improving Access to ADF&G's Lower Cook Inlet Pacific Herring Stock Assessment
and Commercial Fishery Databases, Including Observations of Steller Sea Lions***

Ted Otis

Alaska Department of Fish and Game, Division of Commercial Fisheries
Ted_Otis@fishgame.state.ak.us

Several of the research objectives outlined by the National Marine Fisheries Service to focus Steller sea lion research and recovery efforts were directed at improving knowledge of prey species:

- Need for expanded knowledge of prey base, stock dynamics (i.e., spatial/temporal distributions, seasonal movement patterns, etc.)
- Develop methods for monitoring catch of forage fish at the species level
- Conduct studies associated with commercial fishing that characterizes the prey field before, during, and after fishing.

Many of these objectives can be pursued by mining existing data. The Alaska Department of Fish and Game (ADF&G) has conducted aerial surveys to assess the springtime (April 20-June 10) distribution, abundance, and spawning timing of herring in Lower Cook Inlet's Kamishak Bay since 1978. Surveyors also frequently noted the number and location of sea lions and other marine mammals as indications that herring were in the area. Unfortunately, much of this geo-referenced information was "trapped", available only as notations drawn onto the paper maps surveyors used to document their observations. This project synthesized ADF&G's LCI herring stock assessment and commercial fishery information into an ArcView GIS database that can be queried for the following types of information:

- Number and size of observed herring schools by date or area
- Number and magnitude of herring spawning events by date or area
- Commercial catch (tons) of herring by date or area
- Number, size, and location of herring schools observed before, during, and after commercial fisheries
- Number of sea lions observed by date or area

The Kamishak Bay Herring Data Synthesis CD is expected to have utility to researchers attempting to better understand GOA herring population dynamics, as well as the relationship between Steller sea lions, commercial fisheries, and one of their shared prey species.

POSTER Session: Steller Sea Lion Site Specific Studies – Kodiak Island

***Climate Variability, Hydrography, and Zooplankton Availability:
Bioenergetics modeling approach of forage fishes***

Jari-Pekka Pääkkönen¹, Matthew Wilson¹, Dave Beauchamp² and Kevin Bailey¹

¹NMFS Alaska Fisheries Science Center

²School of Aquatic and Fishery Sciences, University of Washington

Jari.paakkonen@noaa.gov , matt.Wilson@noaa.gov , Kevin.bailey@noaa.gov

Bioenergetics modeling is being used to integrate fish distribution, size and diet data for evidence of geographic variation in the production of Steller sea lion (*Eumetopias jubatus*) prey. Oceanographic features (e.g. fronts) may be associated with high productivity and therefore represent optimal sea lion foraging areas. The study is based data collected during September 2000 and 2001 between Shumagin Islands and Shelikof Strait.

Data will be input to bioenergetics model to estimate fish growth potential and prey demand relative to the plankton standing stock under various modeling conditions. Modeling will start with pollock (*Theragra chalcogramma*) due to data and model availability. Bioenergetics will be used on capelin (*Mallotus villosus*) and eulachon (*Thalichthys pacificus*) to determine possible competition of food resources with pollock. The juvenile walleye pollock model will be described. Preliminary result of variation of pollock diet data will be presented. Modeling objectives will be discussed in terms of their contribution to our understanding of Steller sea lion prey production.

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

***Corticoid assay validation to determine stress response assessment of surgical
implantation of telemetry transmitters in otariids***

***Lisa Petrauskas¹, Shannon Atkinson¹, Frances Gulland², Kendall Mashburn¹,
Jo-Ann Mellish¹, Denise Greig² and Markus Horning³***

¹Alaska SeaLife Center and Institute of Marine Science, University of Alaska Fairbanks

²The Marine Mammal Center

³Laboratory for Applied Biotelemetry and Biotechnology, Texas A&M University:

lisa_petrauskas@alaskasealife.org, shannon_atkinson@alaskasealife.org

gullandf@tmmc.org, kendall_mashburn@alaskasealife.org,

joann_mellish@alaskasealife.org, greigd@tmmc.org, horningm@tamug.edu

Implanted telemetry transmitters are likely to gain increasing importance in the study of marine mammals. Surgical implantation of telemetry devices may increase corticoid production as an indicator of stress; methodology to evaluate glucocorticoid levels is needed to manage possible stressful activities. The focus of this project is to validate and compare existing methods to measure steroid hormones in marine mammals and subsequently quantify stress responses to surgical procedures and telemetry implantation in rehabilitated California sea lions. The use of California sea lions as a surrogate species satisfies the National Marine Fisheries Service recommendation to use healthy rehabilitated animals in lieu of taking animals from wild populations. Routine rehabilitation procedures were selected to serve as controls for telemetry implantation samples that may be available opportunistically via other projects. Control samples obtained thus far are: a: restraint blood draw (n=5); b: anesthesia, no surgery (n=5); c: anesthesia, invasive surgery (n=1); d: anesthesia, corneal edema repair (n=6). Feces were collected up to 72hrs prior and 72hrs post procedure. Serum was obtained during each procedure. Corticosterone was measured in extracted fecal samples by double antibody radioimmunoassay (RIA). Cortisol was measured in serum samples by direct assay using solid phase RIA. Each RIA has been successfully validated with standard methods including HPLC. HPLC results indicate that both corticosterone and cortisol are metabolites in serum, while corticosterone is the primary metabolite in feces. Preliminary results indicate substantial individual variation in corticoid response to various procedures. However, group c produced a noticeable increase in fecal corticosterone in response to amputation of a front flipper digit. Results analyzed thus far indicate that corticosterone measured in feces may be a suitable indicator of corticoid production. Additional samples are being collected to determine if feces is an appropriate indicator of a stress response to a given surgical procedure.

Session EVOS/NPRB-4: Birds and Mammals

***Differential response of seabirds to fluctuations in prey density
or, “Mama, don’t let your babies grow up to be kittiwakes”***

John F. Piatt

As part of the EVOSTC-funded APEX project, one group of biologists measured the composition, abundance and distribution of forage fish around 3 seabird colonies in Cook Inlet over 5 years while another group measured parameters of biology, behavior and physiology in common murres and black-legged kittiwakes at the 3 colonies. I will describe some of the main findings of these investigations, and highlight the differential responses of the 2 seabird species to changes in prey density. Murres and kittiwakes are adapted quite differently for dealing with fluctuations in prey abundance; important differences include body size, foraging mode, clutch size and chick development. Kittiwakes always appear to be working maximally, and have little discretionary time to compensate for declining prey density. Variability in prey abundance translated directly ($r^2=0.89$) into variation in fledging success. Murre breeding success can be buffered by reallocation of discretionary time and was a very poor indicator of food supply, whereas ‘loafing time’ better reflected ($r^2=0.65$) prey density. As predicted by life history theory, both murres and kittiwakes minimized variability in their own body condition ($CV<10\%$), and in growth of chicks ($CV<25\%$) in the face of high variability in prey abundance ($CV=80\%$ among 15 colony-years). Both species exhibited moderate variability ($CV=25-40\%$) in laying and hatching success, and in foraging effort. Variability in kittiwake breeding success ($CV=87\%$) tracked prey variability, while murre breeding success did not ($CV=29\%$). This may explain why murre breeding success in the Pacific is consistently high ($CV<41\%$), whereas kittiwakes are much more variable ($CV<110\%$). Implications of these differing strategies will be discussed.

*Session SSL-3B: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

Inverse production regimes and inverse population dynamics of three high trophic-level consumers in the North Pacific

John F. Piatt¹, G. Vernon Byrd², Ken Pitcher³ and Steven R. Hare⁴

¹Alaska Science Center, US Geological Survey

²Alaska Maritime National Wildlife Refuge, US Fish and Wildlife Service

³Alaska Department of Fish and Game

⁴International Pacific Halibut Commission

john_piatt@usgs.gov, vern_byrd@fws.gov, Ken_Pitcher@fishgame.state.ak.us,
hare@iphc.washington.edu

Evidence suggests that Coho salmon (SAL), Steller's sea lion (SSL) and tufted puffin (TUPU) populations in northern (Gulf of Alaska, Aleutians) and southern (CA, OR, WA, BC) regions exhibit inverse population trends: When northern populations increase, southern populations decrease, and vice versa. This effect may be moderated in transitional areas (SE Alaska or BC) and there are some local exceptions (e.g., SSL populations in s. CA). One hypothesis for this large-scale geographic pattern is that overall ocean productivity reflects climate forcing of primary production in the Subarctic and Subtropical Gyres - which respond in opposite directions to changes in strength of the Aleutian Low pressure system. An assumption is that ocean productivity exerts significant bottom-up control over the productivity of higher trophic level consumers such as SAL, TUPU and SSL. If so, and since these species have broadly overlapping distributions, centers of abundance and diets, we should not be surprised that they all exhibit similar inverse patterns among regions. Curiously, however, they also exhibit inverse trends within regions: While SSL declined dramatically during the 1980s and 1990s in most of Alaska, TUPU and SAL increased dramatically (there is a strong negative correlation between TUPU and SSL population trends throughout their range). Several hypotheses can be advanced to explain the inverse pattern among species: 1) All species are subject to over-riding anthropogenic effects which generate artificial 'pattern'; 2) Population trends are driven mostly by juvenile, adult survival in wintering areas (n. central Pacific for TUPU, SAL; continental shelf for SSL); 3) Dramatic decline of SSL has resulted in surplus food for TUPU in breeding areas (density dependent, competitive interaction); 4) Ocean conditions favor different prey bases for TUPU and SSL— small differences adequate to favor one species over another. We will consider evidence for and against these different hypotheses.

POSTER Session GLOBEC

***Distribution and growth of euphausiids
in the Northern Gulf of Alaska***

A.I. Pinchuk, R.R. Hopcroft and K.O. Coyle

University of Alaska Fairbanks

Euphausiids (krill) are important food items of fish, seabirds and whales: consequently, it is important to understand their seasonal cycles. The interannual, seasonal and spatial abundance, distribution and population dynamics of the euphausiids *Thysanoessa inermis*, *Thysanoessa spinifera*, *Thysanoessa longipes* and *Euphausia pacifica* were studied in the Northern Gulf of Alaska during production season from 1997 to 2000. The greatest abundance of juveniles, males and females of *T. inermis* and *T. spinifera* were observed in March-April and in August on inner shelf, especially when a strong shelf break front was developed. In contrast, *Euphausia pacifica* tended to be more abundant on outer shelf in August-October. Dense aggregations of *T. longipes* were observed in Prince William Sound in March. The spawning of *T. inermis* and *T. longipes* occurred in April-May, while *E. pacifica* spawned from July through October. The spawning of *T. spinifera* was extended from April through October. The spawning of *T. inermis*, *T. longipes* and *T. spinifera* appeared to be closely related to the phytoplankton spring bloom on inner shelf, while the spawning of *E. pacifica* occurred later in season. The life span of *Thysanoessa* spp. appeared to be just over 2 years; the life span of *E. pacifica* was more difficult to determine. The euphausiid growth rates were maximal between April and August coinciding with the spring and summer phytoplankton blooms. *T. inermis*, *T. spinifera* and *T. longipes* showed a significant increase in abundance from 1998 to 2000 indicating progressing favorable conditions on the inner shelf.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

Status of the Eastern Steller Sea Lion Population

Ken Pitcher¹, Robin Brown², Steve Jeffries³, Lloyd Lowry⁴ Mark Lowry⁵, Peter Olesiuk⁶, Wayne Perryman⁵, John Sease⁷ and Charles Stinchcomb⁵

¹Alaska Department of Fish and Game

²Oregon Department of Fish and Wildlife

³Washington Department of Fish and Wildlife

⁴Hawaii beach bum

⁵NMFS Southwest Fisheries Science Center

⁶Fisheries and Oceans Canada

⁷NMFS Alaska Fisheries Science Center

ken_pitcher@fishgame.state.ak.us , wayne.perryman@noaa.gov , john.sease@noaa.gov , charles.stinchcomb@noaa.gov

The eastern population of Steller sea lions is comprised of animals born on rookeries in Southeast Alaska, British Columbia, Oregon, and northern California. While the western U.S. population has declined by 80+% over the past 25 years, the eastern stock has increased substantially in Southeast Alaska, British Columbia, and Oregon. Major declines have occurred in California, particularly in the south, however there are indications of recovery at the far northern California sites. The total eastern population now numbers over 40,000 animals and comprises about 55% of the North American population whereas in the 1970s it made up only about 10% of the total. The three largest rookeries in North America; the Forrester Island complex, Hazy Islands, and the Scott Islands complex are all in the eastern population. Much of the increase that has been observed in the eastern stock is likely the result of limitations on directed take resulting from protective legislation in both Canada and the United States.

Session SSL-13: Steller Sea Lion Site Specific Studies – Prince William Sound

***Equivocal Indicators of Steller Sea Lion Population Trend in
Prince William Sound, Alaska***

Ken Pitcher¹ and John Sease²

¹Alaska Department of Fish and Game

²NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center
ken_pitcher@fishgame.state.ak.us , john.sease@noaa.gov

The Steller sea lion population in Prince William Sound, Alaska has been portrayed as one of the most rapidly declining segments of the western U.S. population during recent years. This appears to be supported when examining counts of nonpups on rookeries and haulouts in the region. However counts of pups on Seal Rocks, the major rookery in the Prince William Sound area, show little or no decline since the 1970s unlike nearly all other rookeries in the western population. These data suggest little decline in the “resident” Steller sea lion population and we hypothesize the large decline observed in nonpup numbers is largely a result of a reduction in the presence of immature and nonbreeding animals from the adjacent Central Gulf of Alaska where numbers of pups born on rookeries have declined by about 90%. There is also limited support for the hypothesis of immigration of breeding animals to the Prince William Sound area.

POSTER Session: Steller Sea Lion Site Specific Studies – Aleutian Islands

***Seasonal Changes in Atka Mackerel Sex Ratios in
Seguam and Tanaga Passes during 2002***

Kimberly Rand and Susanne McDermott

NMFS Alaska Fisheries Science Center

kimberly.rand@noaa.gov, susanne.mcdermott@noaa.gov

FIT (Fisheries Interaction Team) has been conducting tag release-recovery studies on Atka mackerel in the Aleutian Islands since 1999. Because Atka mackerel are an important prey item to the Steller sea lion, tagging models are used to estimate local abundance and movement rates within Seguam and Tanaga passes where the commercial fishery takes place. An accurate tagging model will help measure the effectiveness of trawl exclusion zones. To incorporate data into the best possible model, it is also important to understand whether there are differences in abundance or movement by sex. We examined Atka mackerel length and sex frequency data from three research charters conducted by the AFSC during the 2002 field season. Using these data in a GIS map, seasonal changes in the sex ratio were observed in both Seguam and Tanaga passes. Changes in spatial aggregations by season might be explained by Atka mackerel's unique spawning behavior. We do know that Atka mackerel males guard nests in shallow water during the spawning months (August-October). We also examined differences between sexes relative to depth. In observing the differences in movement between the sexes, we suggest that it is important to construct a sex-specific tagging model.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

Dispersal and movement patterns of juvenile Steller sea lions in Alaska

Kimberly Raum-Suryan, Michael Rehberg, Kenneth Pitcher, Grey Pendleton and Thomas Gelatt

Alaska Department of Fish and Game, Division of Wildlife Conservation

kraumsuryan@charter.net , michael_rehberg@fishgame.state.ak.us ,
ken_pitcher@fishgame.state.ak.us , grey_pendleton@fishgame.state.ak.us ,
tom_gelatt@fishgame.state.ak.us

Recent developments in capture techniques have permitted broad-scale deployments of satellite transmitters to study the at-sea distribution and movement patterns of juvenile Steller sea lions (*Eumetopias jubatus*). These developments are particularly important because reduced juvenile survival is hypothesized to be one of the primary factors contributing to the decline of Steller sea lions in western Alaska (west of 144° W). We examined the relationship of at-sea trip duration, distance, and interhaulout movements with age, sex, stock, and season in the decreasing western stock (WS; Prince William Sound, Kodiak, Aleutian Islands, Alaska) and the increasing eastern stock (ES; Southeast Alaska). We deployed 103 satellite transmitters (29 WS, 74 ES) on juvenile (1.6 – 35.1 mo) Steller sea lions (46 male, 57 female) between March 1998 and November 2001. Deployment length averaged 66 d for all animals, 75 d (range 10 -144 d) in the WS and 62 d (range 3 -190 d) in the ES. Sea lions were tracked during all months of the year from March 1998 through March 2002 (excluding Sept.-Oct. 1998 and April-July 1999). Overall, at-sea trip duration, distance, and interhaulout movements increased with increasing age. Pups dispersed from rookeries to other haulouts (up to 120 km away) as early as 2.5 mo. During central-place trips (to and from the same haulout), the majority (81%) were of short range (< 15 km) and short duration (< 20 h). In contrast, individual movements between haulouts ranged from 3 to 511 km. Although interhaulout movement was variable in all seasons, dispersal and movement among haulouts as well as at-sea trip duration and distance all increased during spring and early summer (April through July). We found no significant difference in at-sea distribution or movements between western and eastern stocks.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

Differences in blubber levels of the fatty acid 20:1n-11 suggest free-ranging Steller sea lions (*Eumetopias jubatus*) ingest prey at a younger age in Prince William Sound than sea lions captured in southeast Alaska

Lorrie D. Rea

Alaska Department of Fish and Game, Wildlife Conservation
Lorrie_Rea@fishgame.state.ak.us

Blubber levels of the fatty acid 20:1n11 were used to identify prey ingestion by young Steller sea lions (*Eumetopias jubatus*, 2 to 26 months of age) captured in Prince William Sound (PWS), AK (n=46) and southeast Alaska (SEA) locations (n=69). Since this fatty acid tends to be underrepresented in Steller sea lion milk (2.30 ± 0.2 wt % n=10) compared to marine fish, a threshold level of 7 weight % was used to indicate ingestion of some marine prey. Based on this threshold, 100% of animals captured in PWS that were 10 months or older (n=33) showed evidence of fish ingestion. In contrast, only 1 of 69 animals captured in SEA (2 -19 months of age) indicated fish intake. At 2 months of age, PWS pups had significantly higher body fat content ($4.4 \pm 1.6\%$) than SEA pups ($1.8 \pm 1.4\%$, $p < 0.001$). However, at 14 to 15 months of age there was no significant difference between PWS ($18.3 \pm 9.7\%$) and SEA ($17.1 \pm 6.5\%$) juveniles due to the large variability in body composition seen in both regions at this age (3% to 33.5%). Some of this variability in body fat content in PWS animals can be explained by the evidence of milk ingestion in some juveniles (n=3) in addition to independent foraging. These three individuals ranged in body fat content from 27 to 33.5%. Given that high 20:1T11 levels were found in these three nursing juveniles, additional variables will be required to distinguish fully weaned animals from those consuming both milk and prey. Concurrent and ongoing research on quantitative fatty acid signature analysis and stable isotope analysis are expected to refine our ability to determine the time of weaning and the proportion of diet consumed as milk for each animal. Funded by NOAA (NA17FX1079) to ADFG.

Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis

Lorrie Rea^{1,2}, John Kennish³ and Carrie Beck²

¹Alaska Department of Fish and Game

²Environment and Natural Resources Institute, University of Alaska Anchorage

³Department of Chemistry, University of Alaska Anchorage

Since the mid 1970's there has been a continuous decline in populations of Steller sea lions (*Eumetopias jubatus*), in the Gulf of Alaska, Aleutian Islands and the Bering Sea. Three hypotheses invoke food limitation as the cause of reduced reproduction and juvenile survival. To evaluate the food limitation hypothesis we must be able to determine which prey species are important to the diet of Steller sea lions in these areas on a seasonal basis.

Quantitative fatty acid signature analysis (QFASA), allows the diet of a predator to be inferred based on its fatty acid composition and the distinct fatty acid composition patterns in the lipids of prey species. Ongoing studies at the Alaska Department of Fish and Game (ADF&G) and the National Marine Mammal Laboratory (NMML) collect blubber, blood and ingested milk samples from free-ranging juvenile Steller sea lions to compare the FAS of individual sea lions based on age, season and geographical area. Studies undertaken by ADF&G, Dalhousie University, NMML, University of Alaska Kodiak Gulf Apex Predator program, NMFS Auke Bay Laboratory, University of British Columbia, and University of Washington are measuring the FAS of prey species to determine the seasonal and geographic variability of fatty acid composition of prey throughout the inhabited range of Steller sea lions in Alaska.

The primary objective of this project is to facilitate the collaborative analyses and publication of these otherwise separate data sets to identify those prey species that contribute significantly to the diet of juvenile Steller sea lions during their first 2 years of life. Using QFASA and other multivariate statistical analyses, the diet of Steller sea lions within Southeast Alaska, the Gulf of Alaska and the Bering Sea ecosystems will be examined and will provide valuable information required for management and conservation decisions regarding this species.

POSTER Session GLOBEC

Mesoscale Variability along the Kenai Peninsula

R. Reed¹, N. Kachel¹, C. Mordy¹, J. Napp² and P. Staben¹

¹NOAA Pacific Marine Environmental Laboratory

²NMFS Alaska Fisheries Science Center

In May 2001 and 2002, five hydrographic lines were occupied, including the Seward Line and the Gore Point Line. In addition to measuring temperature, salinity, fluorescence, chlorophyll and nutrients, net tows were made along these lines to collect zooplankton. Using these data we compare the mesoscale variability in this part of the GLOBEC domain, and also compare 2001 to 2002. Baroclinic flow during both years was weak to moderate. The freshwater core of the Alaska Coastal Current was evident near the Kenai Peninsula, with small-scale features occurring over the middle and outer shelf. Concentrations of chlorophyll varied both spatially and temporally, complicating attempts at synoptic interpretation. Nutrients were inversely correlated with chlorophyll, with weaker correlations occurring with temperature and salinity.

POSTER Session: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny

Developing methods to describe Steller sea lion (*Eumetopias jubatus*) juvenile habitat usage at varying temporal scales.

Michael J. Rehberg and Jennifer M. Burns

Department of Biological Sciences, University of Alaska Anchorage
michael_rehberg@uaa.alaska.edu, afjmb4@uaa.alaska.edu

One hypothesized cause of Steller sea lion (SSL, *Eumetopias jubatus*) population decline in the western Alaska stock is reduced juvenile survival caused by limited access to prey. To understand the impact of these possible prey limitations, we should understand where and when juveniles use different segments of their habitat. We are deploying Satellite Relay Data Loggers (SMRU, U. St. Andrews) on juveniles to test the hypotheses that SSLs utilize their habitat in a spatially and temporally non-random fashion, and that diving behaviors differ among habitats used.

We are investigating patterns of habitat use at 4 temporal scales: central-place haulout, trip to sea, diving bout and individual dive. After bouts have been identified using diving behavior, we will identify geographic areas within which activity is concentrated. Comparisons among these areas will identify differences in habitat use.

Results from juveniles tagged in November 2001 and February 2002 suggest that SSLs moving among different habitat areas alter their behavior. A female yearling reduced her maximum diving depth (225 to 68 m), duration (328 to 264 sec.) and proportion of day spent diving (0.52 to 0.31) when she changed her central-place haulout by 40 km. A male yearling remaining at the same initial haulout showed little change in these behaviors. A male young-of-year increased its maximum diving depth (80 to 146 m), duration (240 to 328 sec.) and proportion of day spent diving (0.19 to 0.39) when he changed from a pattern of near-haulout trips to a long-range inter-haulout movement pattern.

We are refining the technique for studying habitat use and modifying our sampling protocols prior to deployments in the western Gulf of Alaska and Aleutian Islands in March and April 2003.

This project is funded by NOAA SSLRI Grant NA17FX1414, and research is conducted with the cooperation of NOAA NMML and ADF&G.

Session EVOS/NPRB-1: Marine Research

Bioavailability of PAH from oil patches and impacts to prey species

Stanley Rice, Jeffrey W. Short and Mandy Lindeberg

NMFS Auke Bay Laboratory

The extensive beach surveys conducted by Auke Bay Laboratory (ABL) in western PWS during 2001 estimated that about 28 acres of intertidal beach remained contaminated. This estimate was more than twice the estimate following the 1993 shoreline assessment surveys. To address whether this lingering oil is still bioavailable, we deployed several hundred monitoring devices (LDPEs) in an array within and around known subsurface oil patches. Prey species (mussels, other invertebrates, and crescent gunnels) were also collected for analyses of PAH, DNA damage, and cytochrome P4501A . This study will allow for the determination of bioavailability of oil within an oil patch, within a bay, and possibly within a region of the spill. Preliminary results do indicate that oil from known subsurface patches is locally bioavailable. This part of the project will aid interpretation of current and future impact studies on sea otters and harlequin ducks conducted by DOI-USGS.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

Steller sea lion foraging ecology is an important factor in juvenile survival

Julie P. Richmond¹, Jennifer M. Burns¹ and Lorrie D. Rea²

¹University of Alaska Anchorage

²Alaska Department of Fish & Game

asjpr7@uaa.alaska.edu , afjmb4@uaa.alaska.edu , Lorrie_Rea@fishgame.state.ak.us

The survival of juvenile Steller sea lions is likely strongly influenced by their post-weaning foraging success. Several factors influence the diving and foraging ability of marine mammals: increased oxygen stores prolong aerobic metabolism, increased oxidative enzyme concentrations provide for more efficient use of fuels, and decreased metabolism slows rate of fuel consumption. However, in young animals, foraging ability may be physiologically limited due to low total body oxygen stores and a high mass specific metabolic rate.

To examine the development of diving physiology in Steller sea lions we monitored changes in blood oxygen stores, muscle oxygen stores, and muscle enzyme concentrations. Blood oxygen stores were determined by measuring hematocrit (Hct), hemoglobin (Hb), and red blood cell counts (RBC), while muscle oxygen stores were determined by measuring myoglobin concentration and muscle mass. Lactate Dehydrogenase (LDH), Citrate Synthase, and b-Hydroxyacyl Dehydrogenase (HOAD) concentrations were assayed to investigate the anaerobic versus aerobic enzyme profiles of muscle. Hct, Hb, RBC, and Mb values indicate that nursing animals have decreased oxygen storage capacity in comparison to adults. Muscle myoglobin loads in 1-month-old pups are significantly lower than that of adults ($p < 0.001$). Additionally pups show no variation in concentration of Mb, HOAD, CS and LDH between swimming and non-swimming muscles ($p > 0.05$) whereas adults show significant elevation in swimming muscles. These findings suggest that the physiology of young Steller sea lions is immature and may constrain dive behavior. The developmental hypothesis will be further explored with the analysis of fiber type composition. Research supported through a grant provided by CIFAR (NA17RJ1224) and with a co-operative agreement through NOAA and ADF&G (NA17FX1079).

*Session SSL-10: Steller Sea Lion Biology and Ecology
Nutrition and Hormones*

Limitations to Food Intake and Potential Physiological Consequences

***David A. S. Rosen, Arliss J. Winship, Rebecca L. Barrick, Chad A. Nordstrom,
Dominic J. Tollit and Andrew W. Trites***

Marine Mammal Research Unit, University of British Columbia
rosen@zoology.ubc.ca

A major element of our captive Steller sea lion research program is designed to determine the potential impact of nutritional stress due to changes in prey availability or composition. One set of recently completed experiments examined the effect of short-term high-fat (herring) and low-fat (Atka mackerel) sub-maintenance diets on Steller sea lion condition and health. Two juvenile females were alternately fed sub-maintenance, isocaloric diets of either species for 4 weeks. As expected for isocaloric diets, rates of body mass loss were equal for the two diets. However, the animals lost a greater proportion of their mass from lipid reserves when they were on a low-fat diet. This suggests that the consequences of short-term decreases in food intake may be greater when consuming a low-lipid diet. Certain hematological parameters, which may be useful as biomarkers in the field, changed in a regular fashion and some even seemed indicative of the prey type/source of mass loss.

Another experiment investigated the maximum ingestion capacity of young sea lions. It compared actual ingestion rates with those predicted from bioenergetic models, and examined the capacity for sea lions to compensate for changes in types and abundances of prey. Four juvenile sea lions consumed more capelin (~15% body mass) than herring (~9% body mass) when they were given unrestricted access to food every day, sufficient to compensate for capelin's lower energy content. The sea lions also ate 60% more herring when fed every other day versus daily feeding, but were not able to significantly increase the amount of capelin they consumed. When food was available every day, intake levels were equal to that predicted by our bioenergetic model. However, this study suggests that younger Steller sea lions may have difficulty consuming sufficient quantities of lower energy prey, particularly when prey is not available on a daily basis.

Session EVOS/NPRB-2: Citizen Monitoring and Community Involvement

***Evaluating a Community-Based Forage Fish Sampling Project
for the EVOS-GEM Program***

David G. Roseneau and G. Vernon Byrd

In 2002, we evaluated the feasibility of developing community-based studies to help monitor capelin (*Mallotus villosus*) and Pacific sand lance (*Ammodytes hexapterus*) populations in the spill area during the long-term Gulf Ecosystem Monitoring (GEM) program. Information from our previously successful 1995-1999 APEX forage fish pilot project that used stomach contents from sport-caught halibut to sample forage fish populations in Kachemak Bay – lower Cook Inlet was provided to people in several oil spill communities to find out if there was local interest in participating in similar studies during GEM. Members of several communities (Nanwalek, Port Graham, Seldovia, Seward, Tatitlek, and Kodiak) expressed high levels of interest in helping to set up and work on these types of long-term forage fish monitoring projects. They also expressed considerable interest in helping to set up and run pilot studies using stomachs from several kinds of locally caught predatory fish (e.g., halibut, flounder, cod, lingcod, rockfish, and salmon) to help demonstrate that they could collect useful data on important forage fish species for the GEM program.

Session GLOBEC-1

Ocean Climate Conditions during GLOBEC Northeast Pacific Program (NEP) Long Term Observation Program (LTOP)

Thomas C. Royer, Chester E. Grosch and Nandita Sarkar

Old Dominion University

A time series of temperature and salinity versus depth to 250 m at the mouth of Resurrection Bay, Alaska (60°N, 149°W) (GAK1) is used to establish the climatic conditions for the Northeast Pacific GLOBEC Long Term Observation Program (LTOP). The modes of hydrographic structure are determined and their responses of the first two modes to regional and remote forcing are considered. The first two vertical modes of the hydrographic structure at GAK1 contain significant changes during the GLOBEC sampling program. Mode 1 temperature and salinity had sudden changes in 1998 as possible responses to either ENSO or winds. For temperature and salinity mode 2, there is a simultaneous response to ENSO followed by a delayed response in the temperature mode. These simultaneous responses must be atmospherically forced though the exact mechanism is uncertain. However in 1998 there was a significant decrease in the upwelling (increased downwelling). The delayed thermal response is due to the propagation of coastal Kelvin wave.

*Session SSL-3A: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

Validation of Climate Variability in the Northeast Pacific and Bering Sea

Thomas C. Royer, Chester E. Grosch and Isaac Schroeder

Center for Coastal Physical Oceanography, Old Dominion University
royer@ccpo.odu.edu, chet@ccpo.odu.edu, isaac@ccpo.odu.edu

Coastal freshwater discharge, coastal hydrography, NCEP reanalysis data, and barometric pressure observations from buoys are examined for their ability to estimate variability especially regime shifts in the North Pacific. The coastal hydrography contains signals of ENSO events especially in the thermal structure at depth. The second vertical mode of salinity variability also contains a response to ENSO. However, the responses are not consistent for all of the ENSO events, which could be a result of the coarse temporal sampling. Additionally the hydrography demonstrates the cool early 1970s and the relatively warm 1980s and 1990s.

The NCEP precipitation and temperature data for Southeast and Southcoast Alaska do not represent the actual measurements in these two regions. Both the means and variances of the two data sets are significantly different from each other. Therefore the NCEP data should be used with caution in this rugged coastal terrain.

Sea level pressure records, one from 1974 to 2001 in the Gulf of Alaska and another from 1987 to 2001 in the Bering Sea were examined for low pressure events. At both locations, since 1996 there have been significant increases in the occurrence of low pressure (storm) events. Both the number of storms and the variability of numbers of storms increased recently.

We are testing the behavior of the Alaska freshwater discharges and Sitka and St. Paul Island air temperatures to determine whether they are linear and normal. All fail the tests for linearity and normality. This is probably due to the multiplicative interactions of the long period (10 to 20 or more years) components with shorter period (2-7 years) components. We are also in the preliminary stages of the analysis of comparing the coastal sea level observations with the satellite altimetry measurements for 1993-2001 with the purpose of using historical sea levels to infer changes in ocean circulation.

*Session SSL-5: Steller Sea Lion: Factors Currently Affecting the Population
Fisheries, Fish Assessment and Dynamics*

***Empirical relationships between localized fisheries trends and
Steller sea lion abundance***

Kristen E. Ryding, John R. Skalski, P. Dillingham and T. J. Miller

School of Aquatic and Fisheries Sciences, University of Washington
kristen@cbr.washington.edu, jrs@cbr.washington.edu, dillingh@cbr.washington.edu,
tjmiller@u.washington.edu

Responding to the research needs recommended by NMFS on Steller sea lion (*Eumetopias jubatus*) population decline, this project focuses on the analysis of historical data to examine the relationships between fish abundance and sea lion population trends. Data on sea lion abundance from 54 trend rookeries and haulouts along the Alaska coast from 1985 to 2000 are used in the analysis. Fish density data were obtained from triennial bottom trawl surveys conducted by NMFS within a 40 mile radius of the trend rookeries and haulouts. Four fish species were used in the preliminary analysis: Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), Atka mackerel (*Pleurogrammus monopterygius*) and arrowtooth flounder (*Atheresthes stomias*). Regression analysis was used to estimate fish abundance in the years where no trawl surveys were conducted. Sites were grouped into 34 unique populations based on geographic proximity and similarities in temporal trends as a method to remove spatial correlation between sites. Using the populations as replicates, regression analysis was performed to examine relationships between local population trends of sea lions and commercial fish densities. Preliminary results indicate a negative relationship between walleye pollock density and sea lion population growth rates, and a positive relationship with arrowtooth flounder densities. The effect of localized fishing effort on sea lion trends is also being examined to further explain historical patterns.

POSTER Session GLOBEC

Complex Empirical Orthogonal Function (CEOF) Analysis of the Hydrography Along the Seward Line from 1997 to 2002

Nandita Sarkar, Chester E. Grosch and Thomas C. Royer

Old Dominion University

Complex Empirical Orthogonal Function (CEOF) Analysis of the temperature, salinity and density structures has been carried out for the set of hydrographic stations along the Seward Line in the northern Gulf of Alaska at standard depths, to a depth of 200 m. The time series of the hydrographic data extends from 1997 to 2002. Hydrographic sampling is carried out about 7 times a year and the data are interpolated for even temporal resolution. Spectral analysis using the Maximum Entropy Method (MEM) and wavelet techniques have been used to yield information about the dominant frequencies in their energy spectra. The length of the time series (approximately 5 years) limits the resolution of these techniques to higher frequency components. These analysis techniques permit the detection and assessment of the relative magnitudes of stationary and propagating modes on the Alaskan shelf.

POSTER Session: Steller Sea Lion Site Specific Studies – Southeast Alaska

Lipid Variations in Spawning Eulachon

Lawrence Schaufler, Johanna Jill Vollenweider and Ron Heintz

NMFS Auke Bay Laboratory

Lawrence.Schaufler@noaa.gov, Johanna.vollenweider@noaa.gov, ron.heintz@noaa.gov

We determined the fatty acid and proximate compositions from eulachon (*Thaleichthys pacificus*) captured from September 2001 to May 2002 from Berners Bay in Southeastern Alaska. Steller sea lions congregate and cooperatively forage on the annual pre-spawn aggregation of eulachon in this area. Analyses of fatty acid and proximate compositions for the eulachon indicated seasonal and lifestage-dependent variations. Pre- and post-spawn eulachon contained high levels of lipid, averaging 11.7% of wet weight. Saturated and monounsaturated fatty acids were highly prevalent, while very low levels of essential fatty acids (EFAs) were observed. Though eulachon may represent a significant portion of the Steller sea lion diet before migration to rookeries for mating, eulachon may not provide adequate levels of essential fatty acids for healthy pup development.

POSTER Session GLOBEC

*Annual Spatial Variability of the Hydrographic Structure
Along the Seward Line*

Isaac D. Schroeder, Thomas C. Royer and Chester E. Grosch

Old Dominion University

Temperature, salinity and density data along the Seward line in the northern Gulf of Alaska are analyzed for seasonal variability. The Seward line starts at the inner shelf (GAK1) and extends a distance of 213-km to the edge of the continental slope (GAK13). The hydrographic stations are spaced at varying distances ranging from 2 to 20-km. The temporal coverage is from 1997 to 2002 with approximately 7 cruises per year. Orthogonal reduction techniques, Normal Mode Analysis (NMA) and Empirical Orthogonal Functions (EOF) are used to find dominate seasonal modes and to relate these variations to the seasonal forcing functions of heat flux, freshwater discharge and wind.

PLENARY Session: Monday, 13 Jan 2:15-3:00 PM

***From physics to fish:
The global climate connection to the Gulf of Alaska ecosystem***

Franklin B. Schwing

NOAA Pacific Fisheries Environmental Laboratory

Since 1998, a number of Alaska salmon stocks have been dramatically reduced relative to levels in the previous several decades, causing severe economic downturns in many coastal communities. In contrast, many Oregon and Washington salmon fisheries appear to be recovering from decades of poor returns. This reversal of fortune is not an isolated case. The California sardine fishery made famous by John Steinbeck's Cannery Row, which collapsed in the 1940s, has in recent years returned to a population level sufficient to support commercial fishing again. For centuries, populations as distinct as Baltic Sea herring and Japanese sardine have waxed and waned. Were these changes a product of fishing and fishery management, or were other forces at work? Scientists know the earth's climate fluctuates on long time scales, and that ecosystems are not stable by nature. The structure of marine ecosystems, which includes the population size, geographical distribution, and health of commercially important fish stocks, varies with climate. Whether natural or anthropogenic in its source, climate change is a critical force driving environmental change, including the physical processes that dictate ecosystem dynamics in the Gulf of Alaska. The sensitivity of the coupled physical-biological system to climate variability implies great sensitivity to climate change. It is a foregone conclusion that impending climate change will have a major impact on resource availability in the future. The goal of the US GLOBEC Northeast Pacific program, sponsored by the National Science Foundation and the National Oceanic and Atmospheric Administration, is to evaluate and project the consequences of climate change on the coastal marine ecosystems of the Gulf of Alaska and California Current. We can observe climate variations on interannual (for example, El Niño) and multidecadal scales; the latter are termed climate regime shifts. The effects of regime shifts appear to be amplified in the northeast Pacific, and have been associated with significant changes in fishery resources and their socioeconomic consequences. While regional environmental conditions ultimately shape the ecosystem and individual populations, conditions on a local scale are connected to a global pattern of climate oscillations. Thus, ocean temperatures in the western tropical Pacific and the snow pack in Asia may be factors in the changing state ecological state of the northeast Pacific. Moreover, evidence suggests that regional stocks fluctuate in synchrony with a number of other stocks globally, through these global climate connections. However these large-scale climate signals are manifested in an ecosystem at much smaller spatial scales. Global climate change interacts with the unique regional character of ecosystems, resulting in a heterogeneous response by the ecosystem. Climate change feeds into specific processes, for example coastal upwelling and upper ocean stratification, which directly affect marine populations on a regional level. The key to understanding how climate change shapes marine fish populations is in understanding how the energy of large-scale change cascades down to ecosystem scales, and what ecosystem-scale physical processes and features are affected by climate variability. This presentation will highlight: the principle patterns and features of global climate variability and climate change; the mechanisms by which climate change impacts the physical state of the northeast Pacific; link regime shifts to changes in marine ecosystems; and speculate on how climate change may lead to shifts in fish populations.

*Session SSL-6: Steller Sea Lion Biology and Ecology
Population Status and Dispersal*

2002 Surveys of Steller sea lions in Alaska

John L. Sease¹ and Charles Stinchcomb²

¹NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center

²NMFS Southwest Fisheries Science Center

john.sease@noaa.gov, charles.stinchcomb.noaa.gov

The National Marine Mammal Laboratory (NMML) and the Southwest Fisheries Science Center (SWFSC) conducted surveys of Steller sea lions across Alaska during June and July 2002. The NMML surveyed non-pups in the western stock from the eastern Gulf of Alaska through the western Aleutian Islands from 14 to 25 June using 35-mm oblique photographs. Pups were counted at 21 western-stock rookeries during two simultaneous ship-based expeditions from 24 June to 10 July. Land-based field parties counted pups at three other rookeries (Fish I., Marmot I., and Ugamak I.), and counts from June and July 2001 were used for seven other rookeries in an effort to minimize disturbance. The SWFSC surveyed the eastern stock in Southeast Alaska from 4 to 6 July, counting pups and non-pups from medium-format (5-inch) vertical photographs.

Numbers of non-pup Steller sea lions at the 84 western-stock rookery and haul-out trend sites increased by 5.5% from 2000 to 2002. This was the first region-wide increase observed during more than two decades of systematic surveys. Despite this increase, however, the 2002 count was still down 5% from 1998 and 34% from 1991. The long-term trends have been an average decline of about 4% per year. The composite 2001/2002 pup count for the western-stock showed continuing decline in pup production. For the Kenai-to-Kiska index area, the area with longest series of region-wide counts, pup numbers were down 8% from 1998 and 42% from 1990/1991. Numbers of non-pups in Southeast Alaska increased by 1% from 2000 to 2002. Numbers of pups in Southeast Alaska increased by about 11% from 1998 to 2002. These changes are consistent with long-term trends of approximately 2% per year for non-pups and 3% per year for pups.

POSTER Session: Steller Sea Lion Site Specific Studies
Kodiak

Comparison of Steller Sea Lion Diving Behavior Relative to Spatial Distributions of Walleye Pollock and Capelin

Michiyo Shima¹, Anne Hollowed², Brian Fadely², Chris Wilson², Jeremy Sterling² and Kate Call²

¹School of Aquatic and Fishery Sciences, University of Washington

²NMFS Alaska Fisheries Science Center

mshima1@hotmail.com , Anne.Hollowed@noaa.gov , Brian.Fadely@noaa.gov , Chris.Wilson@noaa.gov , Jeremy.Sterling@noaa.gov , Kate.Call@noaa.gov

Because the relationships between foraging behavior and prey availability are poorly understood for Steller sea lions, ecosystem modelers must base parameters on theoretical relationships. To improve understanding of these relationships, and to explore the potential for commercial fisheries effects on local fish abundance we compared Steller sea lion dive behavior to potential prey fields derived from acoustic mid-water trawl surveys in Chiniak and Barnabas troughs on the east side of Kodiak Island, Alaska. Field observations during August 2001 and 2002 were used to map the vertical and spatial distribution of two species of potential sea lion prey, walleye pollock (*Theragra chalcogramma*) and capelin (*Mallotus villosus*). To compensate for spatial and temporal differences in the fish fields the study region was partitioned into six sub-regions with a day and night vertical distribution within each partition. Fish were not evenly distributed throughout the study regions and exhibited marked diurnal shifts in vertical distribution. Juvenile sea lions captured and instrumented at Cape Chiniak (2001 $n=1$, 2002 $n=2$) traveled within the Chiniak trough study area, with most dives shallower than 34 m and made during the 2100-0900 h period. Examination of dive behavior during unique trips, however, showed that sea lions occasionally targeted depths much deeper (50-100 m) than average. Juvenile sea lions instrumented near the Barnabas trough (2001 $n=2$, 2002 $n=5$) did not utilize the trawl survey areas. Analyses of location-matched dive behavior with fish distribution are being conducted, and implications for modeling foraging behavior explored.

Southeast Alaska Steller Sea Lion Prey Study

Michael Sigler, Johanna Vollenweider and David Csepp

NMFS Alaska Fisheries Science Center, Auke Bay Laboratory

Mike.Sigler@noaa.gov, Johanna.vollenweider@noaa.gov, Dave.Csepp@noaa.gov

Steller sea lion abundance is decreasing in central and western Alaska, but increasing in southeast Alaska. This study conducts seasonal measurements of prey abundance and nutritional quality in southeast Alaska. This study is a comparison to similar studies around the Kodiak Archipelago and proposed for the Krenitzin Islands (Unimak Pass area). The questions are: 1) What are the characteristics of the **available** prey field (prey, bathymetry, oceanography) within the study area. 2) What are the characteristics of the areas where sea lions are diving, the **utilized** prey field? Are these areas of high prey densities? 3) Which prey field is better represented by sea lion scats, the available or utilized prey field? The methods employed include acoustic and mid-water trawl surveys, ROV and beach seine surveys, chemical analyses of prey energy density and nutritional quality, scat collections (UBC & UA), aerial surveys of sea lion haulouts (UA), and satellite tagging of sea lions (ADFG, NMML).

Three preliminary conclusions are: 1) Prey abundance is concentrated: 45-75% of prey were concentrated in 10% of Frederick Sound during May, September, and December 2001. 2) Overwintering herring aggregations in Frederick Sound and lower Lynn Canal may be important energy sources for Steller sea lions during winter. Herring were concentrated and found throughout winter 2001/2002 at certain, known locations (e.g. on the east side of Benjamin Island; a seasonal Steller sea lion haulout is located on the west side) and were at their highest energy density of the year. 3) Spawning aggregations of eulachon appear to be important energy sources for Steller sea lions during spring. Peak sea lion abundance at Berners Bay, the site of an eulachon pre-spawning aggregation, was 949 animals. Sea lion abundance increased as eulachon began concentrating in Berners Bay, peaked as eulachon abundance peaked, and decreased as the eulachon moved upriver. Eulachon energy density was greatest during the period of highest sea lion abundance.

POSTER Session GLOBEC

Growth and development rates of the copepod *Centropages abdominalis* in the subarctic Pacific

L. M. Slater and R. R. Hopcroft

University of Alaska Fairbanks

Copepods, the dominant oceanic mesozooplankton, play a critical role in food web dynamics and thus energy resources available to higher trophic levels, such as salmon. We determined the growth and development rates of the neritic copepod *Centropages abdominalis* from the Gulf of Alaska under excess food conditions in the laboratory. Growth was measured by examining the daily change in size frequency, while development was determined by following daily changes in stage distribution. At 5°C, the total development time was ~57 days. As we expected, the total development time at 7°C was faster, taking ~49 days. At these temperatures, the average growth rate was 10-12% d⁻¹. Differences in rates between stages will be discussed.

Ecology of Eulachon (*Thaleichthys pacificus*) in the Antler River, Berners Bay, Southeast Alaska

Robert E. Spangler¹ and K V. Koski²

¹U.S. Forest Service, Anchorage, AK;

²NMFS Auke Bay Laboratory;

rspangl@fs.fed.us , K.Koski@noaa.gov

Eulachon ecology and their association with Steller Sea Lions was studied in the estuary of the Antler River, a tributary to Berners Bay, Southeast Alaska. The spawning run in 2002 commenced on 19 April and continued until 21 May. Sea lions were observed in the river from 22 April to 7 May with the peak of 120 animals occurring on 27 April. This corresponded with high CPUE of eulachon in the river and sea lion abundance in Berners Bay. Life history characteristics (length, weight and fecundity, and age) data were determined. Males (n=202; mean, 189 mm, 46.2 g) were on average longer and heavier than females (n=59; mean, 177mm, 39.4 g). Fecundity averaged 29,242 eggs/female (SE=1960). Most males (n=177) were age 3 (57.6%) followed by age 2 (26.6%), age 4 (10.2%), age 5 (5.1%), and age 6 (0.6%). Although females (n=42) were somewhat younger they followed a similar trend, with most being age 3 (52.4%) followed by age 2 (28.6%), age 4 (14.3%), age 5 (2.4%), and age 1 (2.4%). Radio telemetry was used to characterize spawning migration and spawning habitat. The maximum migration up the Antler River was approximately 4 km and 99 percent of all observations were found in the lower 2 km section of river. Mean daily temperatures during the spawning run varied from 3.03 to 5.45 C with a mean of 4.16 C for the entire time period. Spawning habitat was characterized by gravel (2-25mm) and areas of moderate velocities (0.2-0.6 m/s). Pre- and post-spawning eulachon were sampled for lipids. Preparations were made for establishing a eulachon population monitoring program. Future work will also include estimating adult abundance using mark-recapture and investigating larval production as an indirect index of population strength.

Session GLOBEC-1

Overview of Shelf Transports in the GOA

P. J. Stabeno

NOAA Pacific Marine Environmental Laboratory

Since May 2001, moorings have been deployed at 25 sites in the Gulf of Alaska, over 50 satellite-tracked drifters have been deployed. There have been two dedicated hydrographic/sampling cruises, together with four cruises during which moorings were deployed. This work has been done as part of GLOBEC, Steller Sea Lion Research and Fisheries Oceanography Coordinated Investigations. We introduce the results of this data collection effort in a series of posters and examine the results in context of mechanisms in which nutrients are resupplied to the shelf.

POSTER Session GLOBEC

Along-shelf and Cross-Shelf Flow on the GOA Shelf

P. Stabeno¹, N. Bond², A. Hermann² and N. Kachel¹

¹NOAA Pacific Marine Environmental Laboratory

²Joint Institute for the Study of Atmospheres and Oceans, University of Washington

Since May 2001, flow on the Gulf of Alaska shelf between Prince William Sound and the east end of Kodiak Island has been measured using moorings and satellite tracked drifters. Trajectories from approximately 50 satellite-tracked drifters have been examined, along with the data from moorings that were deployed at 25 sites. Currents, temperature and salinity were measured at each mooring site. The transport in the Alaska Coastal Current is significantly correlated with local winds, with maximum transport occurring in winter and minimum transport in the summer. Most of the flow along the Kenai Peninsula continues down Shelikof Strait, with the remainder continuing southeastward along the southern coast of Kodiak Island. Comparisons of near bottom flow are made with results from the numerical model. Cross-shelf flow is common in the vicinity of the Seward Line, while farther eastward at Gore Point the transport is along shelf. Flow in Amatouli, Chiniak and Barnabas Troughs is typically onshore on the eastern side and offshore on the western side.

Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

Physical and Chemical Measurement along GOA Shelf

Phyllis Stabeno¹, N. Bond², A. Hermann², N. Kachel², C. Mordy² and S. Salo¹

¹NOAA Pacific Marine Environmental Laboratory

²Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
stabeno@ pmel.noaa.gov , bond@ pmel.noaa.gov , hermann@pmel.noaa.gov ,
nkachel@pmel.noaa.gov , mordy@pmel.noaa.gov , salo@ pmel.noaa.gov

Since May 2001, a series of moorings have been deployed over the Gulf of Alaska shelf. They have provided insight into the processes that influence on-shelf flow in troughs, including Chiniak and Barnabas, that have been a center of Steller sea lion research by NMFS focusing on the impact of fishing. The troughs are similar in size and orientations and apparently play an important role in the advection of nutrient rich water onto the shelf (see *poster Kachel et al.*). From the examination of satellite images it is evident that this shelf, southeast of Kodiak Island, supports higher production throughout the summer compared to other regions of Gulf of Alaska (GOA). This sustained production is likely a clear indication of a stable localized nutrient source (see *poster Mordy et al.*). A front is evident in the troughs, which appears to influence the spatial distribution of fish.

The Aleutian Ecosystem

Phyllis Stabeno¹, George Hunt, Jr.², Carol Ladd³, Calvin Mordy³ and Sigrid Salo¹

¹NOAA Pacific Marine Environmental Laboratory

²Department of Ecology and Evolutionary Biology, Univ. Calif., Irvine, CA 92697-2525

³Joint Institute for the Study of the Atmosphere and Ocean, Univ. Washington, Seattle, WA 98195-4235

Phyllis.Stabeno@noaa.gov , glhunt@uci.edu , Carol.Ladd@noaa.gov ,
Calvin.W.Mordy@noaa.gov , Sigrid.A.Salo@noaa.gov

Since May 2001, there has been a focus on research in the Aleutian Islands. This study is the first multi-disciplinary integrated examination of the ecosystem in the critical habitat of the western population of the Steller sea lion. In addition to a series of moorings that were deployed in the Aleutian Passes, two cruises (one in May/June of 2001 and the second in 2002) were conducted to examine the productivity near the sea lion rookeries and document the number of killer whales along the Aleutian chain. The ecosystem cruises focused on seven passes with differing widths and depths: Unimak Pass (~20km wide, water depth ~50m), Akutan Pass (~10km by 50m), Umnak Pass (~10km by 60m), Samalga Pass (~30km by 200m), Amukta Pass (~70km by 400m), Seguam Pass (30km by 160m), and Tanaga Pass (~39km by 235m). The cruises documented several important findings:

- Contrary to earlier beliefs, the Alaska Coastal Current extends as far west as Samalga Pass
- There is a pronounced east-west gradient in primary production and zooplankton abundance and in species composition of marine birds and their diets
- There is a strong spatial and temporal variability in species composition and abundance of cetaceans.

A detailed discussion of the water properties measured on during the ecosystem cruises is provided in a poster entitled “*Physical Oceanography of the Eastern Aleutian Passes*”, *Ladd et al.*

The moorings revealed strong flow through the passes. Maximum speeds were measured in Seguam Pass and at times exceeded 350 cm s⁻¹. Such strong currents provided the energy to mix the water column to depths of 300m. This is an important mechanism for introducing nutrients into the euphotic zone. A detailed discussion of the currents and surface productivity can be found in two posters “*Flow through the Aleutian Passes*”, *Stabeno et al.*, and “*Drifter Studies in the Aleutian Passes*”, *Stabeno et al.*

Flow through the Aleutian Passes

Phyllis Stabeno¹, Carol Ladd², Calvin Mordy² and Sigrid Salo¹

¹NOAA Pacific Marine Environmental Laboratory

²Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
Phyllis.Stabeno@noaa.gov, Carol.Ladd@noaa.gov, Calvin.W.Mordy@noaa.gov,
Sigrid.A.Salo@noaa.gov

Beginning in May 2001, moorings were deployed in the Aleutian Passes (two in Akutan Pass, one in Unimak Pass, four in Amukta Pass and two in Seguam Pass). These moorings were replaced twice, resulting in 18 months of data at each site. In addition five, year-long moorings were deployed across the Alaskan Stream. These are the first moorings to be deployed in the Aleutians to study the flow through passes together with how the position and strength of the Alaskan Stream modifies that flow. Mean transport in each of the passes is northward, from the North Pacific into the Bering Sea. Flow in the passes is strong, with maximum speeds ranging from ~150 cm s⁻¹ in Akutan Pass to >350 cm s⁻¹ in Seguam Pass. It is clear from the hydrographic measurements from the ecosystem cruises (see *poster by Ladd et al.*) that deep mixing results from these currents. The nutrient rich water found in the Alaskan Stream below 100 m is mixed upward into the water column, and thus the nutrient concentrations at 100 m are higher in the Bering Sea than in the Gulf of Alaska. The mixing that occurs in these passes is critical to the high productivity that is characteristic of the Bering Sea. An immediate result of northward flux of nutrient rich water is high primary production observed along the northern slope of the Aleutian Arc. We will also examine the relationship between transport through Amukta Pass and Seguam Pass, and the strength of position of the Alaskan Stream.

Drifter Studies in the Aleutian Passes

Phyllis Stabeno¹, Carol Ladd² and Sigrid Salo¹

¹NOAA Pacific Marine Environmental Laboratory

²Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
Phyllis.Stabeno@noaa.gov, Carol.Ladd@noaa.gov, Sigrid.A.Salo@noaa.gov

During the last two years, over 100 satellite-tracked drifters have been deployed in the North Pacific. This is a major addition to the more than 200 drifters that have been deployed historically in this region. Most drifters are drogues at ~40m, below the direct influence of the wind. We use both the historical database and the recent drifter results to examine preferred paths of flow. The Alaskan Stream is evident in drifter trajectories from the head of the Gulf of Alaska westward to Amchitka Pass. The trajectories vary temporally. Sometimes the Alaskan Stream's westward flow is interrupted by southward re-circulations, while other times a significant portion flows through the Aleutian Passes. We use this extensive data set to relate the preferred paths of the Alaskan Stream to atmospheric forcing and oceanic conditions. The flow through the Aleutian Passes is an important mechanism supplying nutrients to the euphotic zone of the Bering Sea (see *poster of Stabeno et al.*). Changes in flow through the passes could impact this nutrient supply and hence the productivity of the region.

*POSTER Session: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

***Stable isotope fluctuations in Steller sea lion (*Eumetopias jubatus*) vibrissae
indicating weaning events***

Vicki K. Stegall, Sean D. Farley, Lorrie D. Rea and Kenneth Pitcher

Alaska Department of Fish and Game, Wildlife Conservation

Vicki_Stegall@fishgame.state.ak.us , Sean_Farley@fishgame.state.ak.us ,
Lorrie_Rea@fishgame.state.ak.us , Kenneth_Pitcher@fishgame.state.ak.us

Current hypotheses for the decline of Steller sea lion populations have focused on nutritional stress and its effect on juvenile survival. The potential effect(s) of nutritional stress may be expressed in neonate cohorts as shorter nursing times, changes in times of weaning, and related foraging shifts by young. This study examined the fluctuations in stable isotope ratios contained within vibrissae, and relates those changes to parturition, the onset of nursing, and the shift from milk to live prey. Stable-carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope ratios were examined in serum, milk, and longitudinally in vibrissae collected from free-ranging Steller sea lions ranging in age from 1 month to 2 years. Vibrissae samples for seven animals (2 pups and 5 juveniles) from Prince William Sound have been analyzed. Pup vibrissae were partitioned into in-utero and ex-utero sections. In-utero vibrissae sections exhibited depletion of both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of 1.5‰ and 1.7‰, respectively. Ex-utero, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ immediately became enriched by 2.1‰ and 3.0‰, respectively, suggesting the occurrence of nursing. The $\delta^{15}\text{N}$ nursing signature was a trophic level higher (enriched 4.4‰) than the mean $\delta^{15}\text{N}$ value of milk ($n=36$) at 15.3 ± 1.1 , further supporting the finding of a nursing signature. Isotope values along the length of the juvenile vibrissae show a depletion in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ (2.0-2.7‰ and 4.0-4.9‰, respectively) and suggests a diet shift from nursing. The nitrogen isotope values at the base of the vibrissae (composed of living tissue at the time of collection) did not differ from blood (17.8 ± 1.6 and 17.7 ± 1.4 , respectively). Additional analyses will increase sample size and compare values between the endangered and threatened Steller sea lion populations of Alaska.

*Session SSL-1: Steller Sea Lion: Factors Currently Affecting the Population
Predation*

***Transient Killer Whales in Southeastern Alaska:
Who are they? What are they eating?***

***Janice M. Straley¹, Dena R. Matkin², Christine M. Gabriele³, Graeme M. Ellis⁴ and
Lance G. Barrett-Lennard⁵***

^{1,3}University of Alaska Southeast

²PO Box 22, Gustavus, Alaska USA 99826

³Glacier Bay National Park and Preserve

⁴Fisheries and Oceans Canada

⁵Vancouver Aquarium Marine Science Centre

Jan.Straley@uas.alaska.edu , denamatkin@hotmail.com , Chris_Gabriele@nps.gov ,
Ellisg@pac.dfo-mpo.gc.ca , barrlenl@vanaqua.org

From 1984 to 2001, 134 different transient killer whales have been photo-identified in southeastern Alaska by two independent research groups and the National Park Service. The number of transient killer whales identified each year ranged from a low of zero in 1985 to a high of 78 in 2000. Group size ranged from one to 23 whales. Whales were sighted in every month of the year, with most sightings occurring during the summer. New whales continue to be sighted, however, the 'discovery' of new whales slowed to just three whales in 2001 from a peak of 19 whales in 1988. The transient killer whales observed in southeastern Alaska were all linked by association with the West Coast Community, which ranges from southeastern Alaska to California, until 1997 when transients, which only had been sighted previously in the northern Gulf of Alaska, began to be sighted in southeastern Alaska. Transient killer whales were seen harassing harbor seals, harbor porpoises, Dall's porpoises, Steller sea lions, minke and humpback whales and sea birds. There were 34 successful kills observed with 14 (41%) harbor seals, 8 (23%) harbor porpoises, 5 (15%) Steller sea lions, 5 (15%) sea birds, 1 (3%) Dall's porpoise and 1 (3%) minke whale killed. These kill rates were similar to previously reported rates along the west coast of North America with the exception of sea birds, which was higher in our study. One moose was killed by unidentified killer whales. There was a notable lack of harassment and predation upon sea otters, which are common in the study areas. We conclude that transient killer whales in southeastern Alaska are year round foraging specialists upon marine mammals, including Steller sea lions.

PLENARY Session: Monday, 13 Jan 9:45-10:30 AM

Planktonic processes in the coastal Gulf of Alaska: interconnections with weather, ocean conditions, and salmon production

S. Strom¹, J. Napp², M. Dagg³, L. Haldorsen⁴ and R. Hopcroft⁵

¹Western Washington University

²NMFS Alaska Fisheries Science Center

³LUMCON

⁴School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

⁵University of Alaska Fairbanks

The central goals of the GLOBEC process studies in the coastal Gulf of Alaska are 1) to understand how weather and ocean processes affect production at the base of the food web, and 2) to understand how transfer of that production to larger consumer species is regulated. To that end, we have conducted a series of oceanographic research cruises in the region offshore of Seward, Alaska. Spring in the coastal Gulf is a time of intense blooms of phytoplankton (single-celled algae, the dominant plant life in marine waters). Waters over the inner continental shelf support high amounts of large phytoplankton cells (diatoms), while outer shelf waters support lesser quantities of mainly small cells (flagellates and photosynthetic bacteria). This inshore-offshore difference, important in determining which consumers can feed directly on the phytoplankton, may be established by the availability of iron and/or other plant micronutrients. This picture is complicated by the interplay among coastal topography and bathymetry, alongshore currents, tides, and winds. This interplay lead to vigorous exchange of water masses across the shelf, so that phytoplankton production in any one location is intensely variable in time. Late summer and early fall is the time of highest juvenile pink salmon abundance on the shelf. During this season, freshwater run-off combined with heating from the sun creates a shallow, low-salinity surface layer depleted in plant nutrients. Classically such ecosystems are thought to support low phytoplankton productivity. However, the combination of high light availability in this surface layer with periodic nutrient injection by winds, eddies, tides, and other processes may be key to generating unexpectedly high amounts of summer production in the coastal Gulf. Characteristics of the late summer food web important in determining the availability of prey for juvenile pink salmon will be discussed. Changes in weather and, over the longer term, climate in the coastal Gulf of Alaska will alter patterns of precipitation, runoff, and mixing. The close interconnections between these processes, phytoplankton production, and availability of prey for larger consumers gives rise to an ecosystem in which fish production depends strongly on climate conditions.

Seasonality in planktonic community structure, phytoplankton growth and microzooplankton grazing in the Coastal Gulf of Alaska

Suzanne Strom and Brady Olson

Western Washington University

We conducted GLOBEC process cruises to the coastal Gulf of Alaska (CGOA) during April, May and July 2001. Depending on station and season, we encountered conditions ranging from well-mixed to strongly stratified, cold to warm (5 to 14°C) and "blue" to "green" (chlorophyll 0.2 to 6- $\mu\text{g L}^{-1}$). The highest phytoplankton cell division rates (over 1.4 doublings per d) were observed in April, when waters were cold. Macronutrient limitation of phytoplankton growth was observed as early as May in Prince William Sound and on the inner shelf, leading to lower in situ growth rates; by July nutrient limitation was evident everywhere except the outer shelf. All phytoplankton size fractions exhibited nutrient limitation, although growth of the largest cells (>20 μm) was usually the most strongly affected. Microzooplankton grazing was, on average, equivalent to phytoplankton growth for all phytoplankton <20 μm , meaning that essentially all production by small phytoplankton was consumed by microzooplankton (mainly protists). For phytoplankton >20 μm (mostly chain diatoms), microzooplankton grazing mortality was lower and seasonally variable, averaging 42% of phytoplankton growth in April, 60% in May, and 80% in July. This increase in protist-caused diatom mortality appeared to be related to the seasonal increase in the biomass of large heterotrophic dinoflagellates. Grazing interactions involving diatoms and heterotrophic dinoflagellates were also seen in field samples analyzed by FlowCAM. Data from the three process cruises reveal a fundamental difference between inner and outer shelf planktonic processes, with the mid-shelf variably exhibiting both sets of conditions. Phytoplankton blooms on the outer shelf during 2001 process cruises consisted entirely of <5 μm phytoplankton, with the cyanobacterium *Synechococcus* an important component, while inner shelf blooms were dominated by chain diatoms. This difference was reflected in macronutrient levels: while July nitrate levels were extremely low across the shelf, outer shelf silicate levels remained relatively high into July 2001. Outer shelf blooms were never observed to develop biomass levels comparable to inner shelf diatom blooms, probably because of strong microzooplankton grazing control of small outer shelf cells. A fundamental question is, What regulates the partitioning between outer shelf small cell-dominated and inner shelf large-cell dominated blooms in the CGOA?

POSTER Session GLOBEC

Diel Feeding of Juvenile Pink, Chum, and Coho Salmon in Icy Strait, Southeastern Alaska, May-September 2001

Molly Sturdevant, Emily Fergusson, Joseph Orsi and Alex Wertheimer

NMFS Alaska Fisheries Science Center, Auke Bay Laboratory

Studies of diel feeding periodicity and gastric evacuation rates were conducted by Auke Bay Laboratory, National Marine Fisheries Service, on juvenile pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon in Icy Strait, Southeast Alaska from May-September 2001. These process studies were part of the Southeast Coastal Monitoring (SECM) Project conducted in marine waters of the northern region of southeastern Alaska since 1997 and funded in part by GLOBEC. Objectives were to monitor diel feeding intensity and prey composition monthly for each species and to monitor evacuation of food from the gastric tracts of juvenile pink and chum salmon in May and July. We sampled monthly at the SECM Icy Strait transect, by beach seining in May and by surface trawling at one station 6.4-km offshore in later months. For the diel feeding study, we examined up to ten individuals per species every three hours between 0400 and 2200 each month. Catches of juvenile coho salmon were sufficient to conduct diel studies only in June and July but were never sufficient to conduct gastric evacuation studies. Juvenile salmon fed actively during all diel periods in all months; stomach percent fullness averaged 50-100% and prey percent body weight (%BW) averaged 1-4% for each species. Of the 220 pink, 226 chum, and 137 coho salmon stomachs examined, only two empty stomachs were observed. Diel patterns in feeding were evident for pink and chum salmon in June and July and for coho salmon in July, with mean fullness index and %BW increasing from minima in the morning to maxima late in the day. Diet composition changed monthly and prey frequencies (percent numbers) changed diurnally. Juvenile pink and chum salmon predominantly ate small and large calanoid as well as harpacticoid copepods in May, larvaceans and euphausiids in June and July, and larvaceans and hyperiid amphipods in August and September. Juvenile coho salmon diets were comprised of decapod larvae and fish in June and July. For the gastric evacuation study, we held juvenile pink and chum salmon in live tanks without food and sacrificed sub-samples of up to ten individuals at intervals between 1 and 32 hours from the time of capture. We examined 152 chum and 171 pink salmon stomachs from May and 159 chum and 104 pink salmon stomachs from July. Stomachs averaged 70% fullness at the onset of experiments conducted at 7-9°C in May and at approximately 12°C in July. We evaluated the decline in stomach contents over time to compute gastric evacuation rates for the two months. Results of both process studies will be used to derive biophysical input parameters for bioenergetic models and to continue to build our understanding of the trophic relationships and growth of juvenile salmon en route to the Gulf of Alaska.

Integration of Marine Bird and Mammal Observations with the East-West Continuous Plankton Recorded Program: An Introduction and Progress Report

W.J. Sydeman, K.D. Hyrenbach, K.H. Morgan, P.P. Yen, M. Henry, S. Batten and D. Welch

A multi-decadal program to sample subsurface plankton along a 7,000 km east-west trans-Pacific route began in 2000. We initiated a program in May of 2002, under the auspices of the NPRB, to integrate marine bird and mammal (MBM) observations with CPR sampling. Two transects have been completed thus far (May-June, September-October), with three more planned for 2003 (March-April, May-June, September-October). Our short-term goals are to: (1) develop standardized MBM survey methods for large and high-speed (~ 20 knts) voluntary observing ships (VOS), (2) characterize seasonal variation in MBM communities associated with water masses and transitions zones in the North Pacific Ocean and south Bering Sea during 2002-2003, and (3) assess the spatial coherence between zooplankton and MBM abundance, and species assemblages. Preliminary results indicate that quantitative MBM observations are feasible from VOS by slightly modifying standard survey methodologies using detection functions of perpendicular distance from the trackline to account for changes in species identifications. Using these modified survey methods, approximately 112,000 MBM were observed during the May-June survey, with almost 90% being dark shearwaters (Sooty Puffinus griseus, and Short-tailed Puffinus tenuirostris). MBM assemblages varied in abundance, composition and diversity between the Gulf of Alaska, southern Bering Sea, and the Oyashio/Kuroshio (western North Pacific) regions. Our long-term goal is to study changes in MBM assemblages, predator-prey habitat associations, and ecosystem linkages (phasing and transitions) in the North Pacific Ocean, relative to climate variability on multiple temporal scales. This information will provide resource managers and policy makers with a better understanding of the spatial and temporal dynamics of marine species distributions and the predictability of wildlife-habitat associations in oceanic systems.

POSTER: Session: Steller Sea Lion Site Specific Studies – Southeast Alaska

***Seasonal Availability of Nearshore Prey to Steller Sea Lions at
Two Haulouts in Southeastern Alaska***

John F. Thedinga, Scott W. Johnson, and David J. Csepp

NMFS Auke Bay Laboratory

john.thedinga@noaa.gov , scott.johnson@noaa.gov , dave.csepp@noaa.gov

Steller sea lion (SSL) abundance is decreasing in central and western Alaska, but is increasing in southeastern Alaska. Hypotheses for the decline in part of their range include decreased food availability and lower diet diversity. In 2001, we initiated a seasonal comparison study at two SSL haulouts in southeastern Alaska to 1) identify prey available in nearshore waters <100 m deep, and 2) serve as a comparison to similar studies in areas where SSL are in decline. Study areas were Benjamin Island, a seasonal haulout used by up to 800 SSL, and Brothers Islands, a year-round haulout used by nearly 1,300 SSL. At each haulout, available prey species were inventoried by beach seine (15 sites), jig (15 sites), and with an ROV (8 dives) in summer and winter. Regardless of sampling method, total catch (all spp.) was greater in summer than in winter at both haulouts, and greater at Brothers Islands than at Benjamin Island. At Brothers Islands, total seine catch in July 2001 and 2002 was nearly 85,000 fish of 37 species compared to 7,200 fish of 37 species at Benjamin Island. Total seine catch in March 2002 was <350 fish at each haulout (<25 species). Seine catches were dominated by juvenile pollock and sandlance in summer and armorhead sculpin, tubesnout, and rock sole in winter. Jig catches ranged from 8 to 2 fish per rod hour in summer and winter, respectively. Fish captured by jig were larger (>190 mm 0 FL) than fish captured by seine (<100 mm 0 FL). Jig catches were dominated by armorhead sculpin, Pacific cod, dusky rockfish, pollock, and yellowfin sole. No species were observed with the ROV that were not captured by seine or jig. Sixteen species we captured have been identified in SSL scat at either haulout. Less available prey in nearshore areas in winter may force SSL to travel farther and longer from haulouts to forage.

*Session SSL-11: Steller Sea Lion Biology and Ecology
Feeding and Diving Ontogeny*

Density and accessibility as factors in the foraging behavior of Steller sea lions

Gary L. Thomas¹ and Richard E. Thorne²

¹Rosenstiel School of Marine and Atmospheric Sciences, University of Miami

²Prince William Sound Science Center

gthomas@rsmas.miami.edu , thorne@pwssc.gen.ak.us

We examined prey depth, school density, overall abundance, location and time of year as potential factors in Steller sea lion (*Eumetopias jubatus*) foraging behavior in order to understand why Steller sea lions targeted herring (*Clupea pallasii*) rather than juvenile or adult pollock (*Theragra chalcogramma*) during the extended winter period in Prince William Sound, Alaska. We discovered that the number of Steller sea lions associated with herring concentrations was positively correlated with herring abundance and negatively correlated with the depth of peak school density. Herring school densities were high even at night, ranging between 0.1 to 0.9 kg/m³. The depth of the peak density of the herring schools at night ranged from 7 to 30 m. Highest numbers of Steller sea lions were associated with the more near-surface distributions. In contrast, juvenile pollock densities averaged about 0.01 kg/m³ and adult pollock densities averaged about 0.0001 kg/m³. Juvenile pollock were distributed slightly deeper than herring during night, and considerably deeper during day. Adult pollock were distributed below 150 m day and night. We conclude that accessibility is a critical factor in Steller sea lion foraging behavior, and that the energetics of capture is probably at least as important as the caloric value of the prey.

*POSTER Session: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

Implications of varying food distributions for fitness in Steller sea lions

David Thompson, Jason Matthiopoulos, Cristiana Letteri and Ian L. Boyd

Sea Mammal Research Unit, University of St Andrews, UK

d.thompson@smru.st-and.ac.uk , jm37@st-and.ac.uk , ckl@st-and.ac.uk ,
ilb@st-and.ac.uk

Several resource-related hypotheses have been put forward to explain the observed decline in the population of Steller sea lions. To be plausible they require significant levels of inter-specific competition between sea lions and fisheries and/or intra-specific competition between sea lions. Sea lions of different sizes/ages have different travelling and diving abilities. They are therefore unequal competitors. Modelling intra-specific competition requires the subdivision of the population into classes containing animals of similar competitive abilities i.e. a structured population. For long-term population modeling, this classification must also take into account that different animals have different vital parameters. Few of the physiological or demographic parameters have been quantified, so uncertainty will be a major characteristic of this exercise. To be useful, models must carry parameter uncertainty into estimates of uncertainty for its predictions. In short, we require a stochastic, structured, spatially explicit model of long-term population dynamics. The currency for this entire framework is energy.

The project is subdivided into three broad research areas:

- Given a sea lion's location and energetic state and a depth distribution of prey, how will it distribute its diving effort, and how much will it extract from that location in one time unit?
- Given a sea lion population structure and spatial distribution of prey, how should each class of sea lions distribute its foraging effort in 2D space? How much energy will an individual, of a particular class, extract from the environment in the medium term?
- Given the amount of energy collected by an individual in the medium term, how does its state change and how does the population structure change as a result?

Here we describe models relating mass specific energetic costs to diving and foraging behaviour and investigate their consequences in terms of profitability of different prey distributions. We then describe a model of distribution of foraging effort by competing predators based on distribution of units of habitat usage. Finally we describe a stochastic dynamic population model with growth, survival and fecundity.

Factors Governing Pink Salmon Survival In Prince William Sound, Alaska

Richard E. Thorne

Prince William Sound Science Center

Each spring, several hatcheries in Prince William Sound (PWS) release hundreds of millions of pink salmon fry (*Oncorhynchus gorbuscha*), which move toward the Gulf of Alaska along well-documented, inshore migration corridors. Their survival is known to depend on the zooplankton food availability and predator abundance. We used a multi-frequency acoustic system to make synoptic measures of zooplankton and fish predators during the spring bloom periods of 2000-02. The zooplankton biomass during the spring bloom is dominated by large-bodied calanoid copepods, primarily genus *Neocalanus*. Net catches of these large copepods showed excellent correlation with the high-frequency backscatter. We were able to document many features of the zooplankton population distribution and abundance. We found major differences between 2000 and 2001. Overall zooplankton abundance was much lower in 2001. The two most abundant fishes in PWS, walleye pollock (*Theragra chalcogramma*) and Pacific herring (*Clupea pallasii*), are known to exhibit prey switching behavior between zooplankton and small fish, including juvenile salmon. These fishes undergo post-spawning migrations into areas where the juvenile salmon are located. We found contrasting predator distributions between the two years. In 2000, the predators were widely distributed. In 2001, they showed pronounced near-shore orientation, perhaps reflecting piscivorous feeding behavior in response to the lower zooplankton abundance. Preliminary returns of adult pink salmon also show a substantial and corresponding difference between the two years. The impact appears to be greater on the wild fish stocks than the hatchery stocks. The difference may be the result of the more extensive feeding of the hatchery fry prior to their release. The perspective for 2003 returns is discussed based on the third year of monitoring in 2002.

***Spatial and Numerical Relationships between Steller Sea Lions
and Pacific Herring in Prince William Sound, Alaska***

Richard E. Thorne¹ and Gary L. Thomas²

¹Prince William Sound Science Center

²Rosenstiel School of Marine and Atmospheric Sciences, University of Miami
thorne@pwssc.gen.ak.us , gthomas@rsmas.miami.edu

Our previous observations of intense nighttime foraging by Steller sea lions (*Eumetopias jubatus*) on Pacific herring (*Clupea pallasii*) prompted concerns that the importance of herring for Steller sea lions might be underestimated. We conducted an extensive three-year, multi-season study of the association of Steller sea lions, herring and walleye pollock (*Theragra chalcogramma*) in Prince William Sound, Alaska. The effort included 12 week-long acoustic surveys with associated midwater and purse-seine sampling of the fish stocks, and 14 aerial surveys plus vessel-based visual and infrared census of Steller sea lions. We found nearly 100% spatial coincidence of Steller sea lions with overwintering herring concentrations, and 0% spatial coincidence of Steller sea lions with overwintering pollock concentrations. We found that Steller sea lions began to target herring concentrations in early November. The foraging activity peaked in early March. Steller sea lion foraging on spawning herring in April had been previously documented. An examination of historic databases showed that Steller sea lion counts in PWS declined 86% between 1989 and 2000, while herring declined 88%. Abundances of the two animals also tracked over the previous 15 years. We conclude that the availability of energetically efficient overwinter forage is a critical factor governing the abundance of Steller sea lions in PWS.

POSTER: Session: Steller Sea Lion Site Specific Studies – Kodiak Island

Associations between Steller sea lions and Pacific herring around Kodiak

Richard E. Thorne¹, Gary L. Thomas² and Matt Foster³

¹Prince William Sound Science Center

²Rosenstiel School of Marine and Atmospheric Sciences, University of Miami

³Alaska Department of Fish and Game

thorne@pwssc.gen.ak.us , gthomas@rsmas.miami.edu ,
matt_foster@fishgame.state.ak.us

We conducted surveys during January and March 2002 to examine spatial associations between Steller sea lions and overwintering Pacific herring concentrations around Kodiak Island. A third cruise is planned for November 2002. The January survey covered the northwestern quarter of Kodiak Island. An overwintering concentration of herring was located in Uganik Inlet. The estimated biomass was 13,071 mt. Seventy Steller sea lions were enumerated around the school by the aerial surveys. Foraging activity was primarily at night, with rafting during daylight hours, a similar pattern to that previously observed in Prince William Sound. The second survey in March was a repeat of the first survey, covering the northwestern quarter of Kodiak Island. Again, an overwintering concentration of herring was found in Uganik Inlet. The biomass estimate was 8,179 mt. Foraging activity by Steller sea lions was more intense than the January survey. Over 300 Steller sea lions were counted within Uganik South Arm where the herring were concentrated. Foraging activity was still primarily at night, but daytime foraging was also observed on shallower herring schools at the head of the inlet. In addition, while the sea lions were primarily rafting during daytime, we did observe one transitional haulout on a rocky beach in South Arm. Over 100 Stellers sea lions were observed on the beach at this location on one occasion. The Stellers sea lions on the beach were a mixture of adult males, females and juveniles.

*Session SSL-8: Steller Sea Lion Biology and Ecology
Diet*

Diet Quantification of Steller Sea Lions - Scat and Fat

Dominic J. Tollit¹, Susan Heaslip¹, Sarah J. Iverson², David A. Rosen¹ and Andrew W. Trites¹

¹Marine Mammal Research Unit, University of British Columbia

²Department of Biology, Dalhousie University, Halifax, Nova Scotia
tollit@zoology.ubc.ca

A clear understanding of trophic relationships is the backbone to any ecosystem approach to management. We are taking a multi-faceted approach using a combination of captive, laboratory and field-based research to quantify the diet of Steller sea lions.

Controlled captive feeding experiments were undertaken with walleye pollock, herring, pink salmon and sandlance (with ongoing studies with coho salmon, Atka mackerel and squid) to assess inter- and intra-specific variability in passage rates and recovery of hard remains in scats. Skeletal structures were distributed over 3.24 scats/meal (± 1.36 SD, range 1-6). Pollock occurred in relatively more scats/meal leading to significantly higher overall recovery levels. Generation of fork length to skeletal structure regressions and experimentally derived condition-specific size correction factors has allowed for a more accurate assessment of prey size selection by Stellers and niche overlap with commercial fisheries. Monte-Carlo simulations using both experimental and field data will assess biases and confidence intervals across different diet quantification techniques.

Blubber quantitative fatty acid signature analysis (QFASA) has begun to be used elsewhere as an alternative or complementary technique to assess pinniped dietary history. To date, we have completed 11 feeding trials to evaluate the technique's ability to describe a mixed diet and to provide information on fatty acid turnover and deposition. Data were also collected to provide Steller-specific calibration coefficients (CCs) required for QFASA. Preliminary results indicate that SSL CCs are quite comparable to those previously obtained from phocid seals, although those obtained from SSL may be more reliable due to the longer-duration of this control study. QFASA correctly identified the major components of a mixed diet and were generally able to correctly separate different batches of herring ingested. However, evidence of minor false positives were also noted, depending on the modeling technique used. Further work is required to assess the best modeling approaches.

Diets of Steller Sea Lions in Southeast Alaska

Andrew W. Trites¹, Donald G. Calkins² and Arliss J. Winship¹

¹Marine Mammal Research Unit, University of British Columbia

²Alaska SeaLife Centre, Seward, Alaska.

trites@zoology.ubc.ca , don_calkins@alaskasealife.org , winship@zoology.ubc.ca

Diet of Steller sea lions was determined from 1,565 scats collected at rookeries and haulouts in southeast Alaska from 1993 to 1999. The most common prey of 61 species identified (i.e., those that occurred in more than 5% of all scats examined) were walleye pollock, Pacific herring, sandlance, salmon, arrowtooth flounder, rockfish, skates, squid and octopus. Sea lion diets at the 3 southeast Alaska rookeries differed significantly from one another. During summer, mature females at White Sisters consumed primarily forage fish followed by gadids, while at Hazy Island, the dominant prey were gadids. Further south at Forrester Island, the diet was more evenly distributed between forage fish, salmon and gadids. However, gadids dominated the diet throughout southeast Alaska during fall, winter and spring. Summer diets of mature males (bachelor bulls) and breeding females at Forrester Island differed significantly from one another, with males consuming significantly fewer salmon, and more pollock and rockfish compared to females. The males also consumed larger pollock compared to females. Female diets from rookeries that make up the Forrester breeding complex did not differ significantly from one another. Overall, Steller sea lions in southeast Alaska consumed the greatest diversity of prey species during summer, and the least diverse during fall. Their summer diet was also more diverse than that reported for any other region of Alaska (Gulf of Alaska and Aleutian Islands).

*Session SSL-8: Steller Sea Lion Biology and Ecology
Diet*

***Dietary Analysis from Fecal Remains of Pinnipeds:
How Many Scats is Enough?***

Andrew W. Trites and Ruth Joy*

Marine Mammal Research Unit, University of British Columbia
trites@zoology.ubc.ca , joy@zoology.ubc.ca

* presenter

Diets of pinnipeds are increasingly being inferred from the bones of prey recovered from scat remains. This diet information can be used to compare diets between and within sites across years and seasons. It may also allow inferences to be made about why survival and fecundity differ. Fundamental to these analyses is the question of statistical power. In other words, how many scats should be collected to accurately quantify and compare the diet of pinnipeds? We addressed this problem using Monte Carlo simulations to analytically determine the consequence of sample size on the dietary analysis of scats using frequency of occurrence methods. We considered two questions: 1) how is the statistical power affected by sample size; and 2) what is the likelihood of not identifying a prey species. We randomly sampled predetermined numbers of scats (n=10–100) from computer-generated populations of scats containing prey of known species and frequencies of occurrences. We also randomly sampled a large database of field-collected scats from Southeast Alaska. We then used standard statistical tests such as chi-square and Fisher's exact test to determine whether differences between our samples and populations were statistically significant. Our analyses suggest that a minimum size of 60 scats is necessary to distinguish two populations with biologically significant differences in scat remains (and by inference diets). Similarly a minimum sample size of 60 scats is necessary to have reliable confidence that no important diet species are missed. These results have significant implications for the interpretation of dietary data already collected in Alaska, as well as for the design of future scat-based dietary studies.

Session EVOS/NPRB-3: Physical Processes and Modeling

***Exchange between Prince William Sound and the
Gulf of Alaska at Hinchinbrook Entrance***

Shari L. Vaughan and Shelton M. Gay, III

One of the least understood physical processes that influence the biological components of PWS is the exchange between the northern Gulf of Alaska (GOA) and Prince William Sound (PWS). The main objective of this project is to document the seasonal and interannual variability in water mass exchange between PWS and the adjacent GOA at Hinchinbrook Entrance, and to identify and understand mechanisms governing this exchange. A bottom-mounted upward-looking ADCP mooring was deployed in Hinchinbrook Entrance to create time series of velocities over four periods from 1995 to 2002 (two from 1995 to 1997 and two from 2000 to 2002). On the later deployments, the mooring was equipped with a CTD to create a time series of deep temperature (T) and salinity (S). To identify the dominant factors that govern PWS/GOA exchange, the mooring velocity and deep T/S time series will be combined with meteorological time series, numerical circulation model simulations, and physical data collected under previous and existing research programs in PWS and the GOA. Results from the four deployments are presented here.

High Seas Driftnet Detection and Tracking in the North Pacific Waters Using Satellite and Airborne Remote Sensing Technologies

Tim Veenstra¹, Jim Churnside² and William Pichel³

¹Airborne Technologies, Inc.

²NOAA/ETL

³NOAA/NESDID

In order to search efficiently for GhostNets, one needs information on where they are likely to be. This can come from (1) historical information (i.e., recent sightings in the past), (2) change sightings (i.e., where they have been sighted by Coast Guard or fishing vessels, research cruises, or aircraft), and (3) knowledge of ocean conditions conducive to collection of marine debris.

Although this project takes advantage of the first two sources of information, we rely to a great extent on the third source of information since this is the mainstay of an operational program to recapture GhostNets in the open ocean. Using historical and current satellite data, we identify and locate convergence zones (CV) in the North Pacific since these are likely places for concentration of marine debris. The same forcing factors that concentrate net locations may also concentrate biological productivity and activity. As a result, there may be a significant overlap between the location of the nets and the location of marine organisms at risk or entanglement.

We therefore identify and prioritize the most likely locations for the GhostNets at a given time. Upon creating our model, we utilize airborne remote sensing techniques, including LIDAR, gated imaging, thermal and high resolution multi-spectral imagery and synthetic aperture radar technology to search the high-risk areas to locate and map the GhostNets. The data gathered will then be available to aid in the removal or destruction of these nets. In addition, the net signature will be analyzed and compared with satellite data for continued refinement and possible future satellite detection of these nets.

*Session SSL-3B: Steller Sea Lion: Factors Currently Affecting the Population
Environmental Change*

***Seasonal and spatial variability of Steller Sea Lion (*Eumetopias jubatus*)
Prey Quality***

Johanna Jill Vollenweider^{1,2} and Ron A. Heintz¹

¹NMFS Auke Bay Laboratory

²University of Alaska Southeast

Attribution of apex predator declines in the North Pacific Ocean to the “junk-food” hypothesis implies limited availability of nutritionally adequate prey. Examination of fish quality must account for seasonal, ontogenetic and spatial variation. Lipid intake is particularly important for Steller sea lions, which must rely on large energy stores to for fasting and reproduction. Reported nutritional values are often from opportunistic collections with confounding temporal, spatial and ontogenetic effects. We report a systematic examination of the quality of sea lion prey near two haulouts in Southeast Alaska.

Marked seasonal variation in lipid content was observed for all species, with as much as a two-fold difference between seasons. Seasonal effect accounted for more than 55% of the error within species. Lipid content of eulachon was the most variable, ranging from 9.7-85.8% lipid relative to dry mass. Maximum lipid content occurred in most species in December with the exception of hake that didn't peak until March. Likewise, minimum lipid content was nearly synchronous in the spring. Results indicate fish acquire maximum energy stores prior to winter and subsequently metabolize these stores reaching a minimum in spring as animals undergo gamete recrudescence. Species-specific energy-densities tracked lipid content, with large variations explained primarily by season. Protein content peaked in December as well for all sizes of pollock and capelin, however peaked in the spring for other species. These data suggest reproductive success may be strongly controlled by fish condition prior to winter. Evidence for seasonal changes in prey quality will be combined with species-specific biomass estimates collected from a separate study, providing seasonal prey field quality available to Steller sea lions.

*Session SSL-1: Steller Sea Lion: Factors Currently Affecting the Population
Predation*

*Distribution and ecotype of killer whales in southwestern Alaska,
with a discussion of abundance estimation methods*

Paul R. Wade¹, Janice M. Waite¹, Sue E. Moore¹, Lori L. Mazzuca² and Alexandre N. Zerbini³

¹NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center

²NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center, Kodiak

³School of Aquatic and Fisheries Science, University of Washington

Paul.wade@noaa.gov, Janice.waite@noaa.gov, sue.moore@noaa.gov,
lori.mazzuca@noaa.gov, azerbini@u.washington.edu

In 2001 and 2002, NMML conducted several dedicated cetacean surveys in southwestern Alaska. The DART line-transect surveys were focused on killer whale research and systematically covered nearshore (<30nm) waters from the Kenai Fjords region to the central Aleutians. Photo-ID, biopsy, and acoustic work were initiated when killer whales were encountered. In 2001, there were 19 killer whale groups encountered (18 with photographs, 10 with biopsies). In 2002, there were 15 groups encountered (14, 7). NMML also conducted cetacean surveys as part of the Aleutian Passes oceanography study in May/June 2001-02. Survey lines through several passes in the eastern and central Aleutians lead to a total of 21 killer whale encounters in 2001 (11, 1) and 26 encounters in 2002 (16, 15), for a total across all 4 surveys of 81 encounters. NMML also placed observers on 2 other cetacean surveys in the Bering Sea and western Gulf of Alaska in 2002, leading to 42 killer whale encounters (18, 8). This leads to a total of 123 encounters in 2001-02, with photographs taken of 77 groups, and biopsy samples taken from 41 groups (a total of 71 individuals). Preliminary assignment of ecotype (resident, transient, offshore, and unknown) based on field observations, summed over the DART surveys and the 2002 Aleutian Passes survey, led to the following percentages of individual whales: 84% resident, 9% transient, 3% offshore, and 4% unknown. These (very) preliminary calculations will be revised by genetic analysis of the biopsy samples, photo-ID analysis that provides matching to known-ecotype individuals, and analysis of acoustic recordings. Genetic results will be available by the time of the symposium. The distribution of killer whales by ecotype in the study area will be presented, along with discussion of intended abundance estimation methods (both line-transect and mark-recapture) at the completion of the 3-year study.

***Simulation of Seasonal Variability of the
Ocean Circulation in the Gulf of Alaska***

Jia Wang and Meibing Jin

The relatively wide Alaska Current converges into strong and narrow Alaska Stream starting from around 148W. The seasonal variability of the ocean circulation in the Gulf of Alaska was investigated using a global model and a regional eddy-resolving model based on MITgcm. The global model has 0.2-degree horizontal resolution in meridian direction and 0.4-degree in zonal direction. The regional model has 0.01-degree horizontal resolution in meridian direction and 0.02-degree in zonal direction in the Gulf of Alaska (GOA). Half-daily atmospheric forcing from the NCEP reanalysis was used to drive the model. The simulated transport of the Alaska Stream matches observations at 180W in 1995 with a seasonal change from 20 to 25Sv in 1995. The transport at 159W is also close to 20-25 Sv. The regional model showed the relatively stable Alaska Stream and the unstable Alaska Current with high ratio of eddy/mean energy. The shelf of Seaward area is a downwelling area for most of the year because of downwelling favorable winds. Meanders were found outside Kodiak Island where the Alaska Coastal Current (ACC) and Alaska Stream meet.

A 3-D Ocean Model in the Bering and Chukchi Seas

Jia Wang, Meibing Jin, Clara Deal, Moto Ikeda, Sei-Ichi Saitoh and Nori Tanaka

The Bering Sea covers over 2 million square km of the northernmost region of the Pacific Ocean. Its borders are defined to the north by Alaska, Bering Strait and northeastern Siberia, and to the south by the arc of the Alaska Peninsula and Aleutian Islands. It is a complex semi-enclosed basin with shallow shelves, slope creaks, and deep basins. POM (Princeton Ocean Model) is applied to the Bering-Chukchi Seas with spherical horizontal coordination from 155E-155W, 50N-75N. To simulate mesoscale eddies, grid spacing is 1/10 degrees in longitude and 1/5 degrees in latitude (maximum grid spacing is 11.9km, while minimum grid spacing is 4.8km in longitude, and grid spacing in latitude is 9.3km), the total grid number is 301x301 with 15 sigma levels. The POM simulates the complex circulation systems of the Bering-Chukchi Seas. The Alaska Stream (AS) of about $30 \pm 6 \text{ Sv}$ ($\text{Sv} = 10 \text{ m}^3/\text{s}$) flows along the Aleutian Peninsula with two branches into the Bering Slope Current (BSC) and Alaskan Coastal Current (ACC). The BSC splits into two coastal currents: Anadyr Current (AC) that joins the ACC into the Chukchi Sea through the Bering Strait and the southwestern coastal current that joins the East Kamchatka Current (EKC). Alaskan Coastal Water (ACW) flows northward through Bering Strait into Chukchi Sea, joins with ACC and flows out of the northeastern boundary. Mesoscale eddies spin off from the BSC due to the interaction between baroclinic instability and continental slope. There are also many eddies around Unimak Pass, Amakta Pass and Amchitka Pass. These eddies located above complex topography have a depth range of 200 to 3000m. They have a diameter of about 150km. Mean speed is about 20cm/s, while the maximum is about 50cm/s. The interaction or exchange between the shelves and deep basins is a distinguished physical phenomenon that significantly influences primary and secondary productivity.

PLENARY Session: Monday, 13 Jan 9:00-9:45 AM

***Order and Chaos:
The Physical Structure of the Gulf of Alaska Shelf/Slope Ecosystem***

Thomas Weingartner

Institute of Marine Science, University of Alaska Fairbanks

Oceanographic conditions over the northern Gulf of Alaska shelf and slope reflect its high-latitude setting, geological history, and the large-scale atmospheric and oceanographic forcing of the northern North Pacific. In aggregate these factors contribute to moderately low water temperatures, persistent cyclonic winds, and high rates of coastal precipitation and runoff. The winds and the runoff, which are a consequence of the quasi-random storms associated with the Aleutian Low Pressure system, organize the regional circulation and thermohaline fields. Two counterclockwise circulation features dominate the region. One, the Alaska Current/Stream, flows along the continental slope, and provides the oceanic connection between the Gulf of Alaska shelf and the Pacific Ocean. This current system imports warm water from lower latitudes into the northern Gulf of Alaska and is bounded on its inshore side by a shelfbreak front. The other is the Alaska Coastal Current (ACC), which hugs the coastline as a narrow (~35 km wide), low-salinity current bounded on its offshore edge by a salinity front. Both current systems originate offshore of British Columbia and eventually feed the Bering Sea, thereby providing oceanic pathways by which organisms, contaminants and climate signals can be transmitted over broad distances. A mid-shelf region, having a weak mean, but highly variable flow, separates the inner shelf from the shelfbreak. Consequently the ACC and the slope currents are generally not in direct communication, although their water masses mix with one another over the mid-shelf domain. Imposed upon this mean structure are large seasonal variations associated with the seasonality of the Aleutian Low.

However, there are a variety of random perturbations to the marine environment that could significantly influence biological productivity in the Gulf of Alaska. These fluctuations include mesoscale, episodic phenomena having space and time scales of 20–200 km and 10–30 days, which arise due from flow instabilities and/or interactions of the mean currents with the complex shelf/slope bathymetry. Basin and larger scale variations have periods ranging from the intraseasonal to the decadal. These tend to modify the strength and trajectory of storm systems resulting in regional changes in wind and precipitation patterns. Such changes affect oceanic mixing and the transport and fluxes of heat, salt, nutrients, and organisms, which could lead to restructuring of the marine ecosystem.

*Seasonal, Interannual, and Decadal Scale Freshwater Variability
in the Alaska Coastal Current*

Thomas J. Weingartner¹, Seth L. Danielson¹ and Thomas C. Royer²

¹University of Alaska Fairbanks

²Old Dominion University

The Alaska Coastal Current (ACC) is forced by winds and coastal freshwater runoff and is the most prominent circulation feature on the Gulf of Alaska shelf. The ACC extends around the perimeter of the Gulf of Alaska linking the waters of southeast Alaska and British Columbia to the Bering Sea. It also appears to be an important migratory corridor and/or habitat for a variety of marine organisms including juvenile salmon migrating from nearshore nursery areas into the interior Gulf. We construct a conceptual model based on historical discharge and oceanographic data to estimate the annual cycle in freshwater volume and transport of the ACC. On an annual basis the baroclinic components of the mass and freshwater transports by the ACC varies seasonally with a maximum in fall and minimum in summer. The volume of freshwater within the ACC also varies seasonally although these variations are not in-phase with the transports. Freshwater content increases rapidly in July and August, remains nearly constant from August through December, decreases abruptly in early winter and then remains relatively constant from March through June. These relationships suggest that the coastal buoyancy flux due to freshwater is approximately balanced by the alongshore buoyancy flux of the ACC. We attempt to assess the role of wind-induced cross-shelf Ekman transport on the ACC freshwater budget, although reliable estimates of this flux are difficult to make because of the uncertain nature of the cross-shelf circulation field. We also find that monthly anomalies in the baroclinic components of the mass and freshwater transports and freshwater content of the ACC can be reasonably well-predicted based on a simple multiple linear regression incorporating measurements of nearshore salinity (station GAK1), freshwater discharge, and local winds as the independent variables. For example the model explains ~60% of the mass transport anomaly and ~75% of the freshwater transport and content anomalies in the ACC. This predictive model allows us to examine interannual variability in the ACC since 1970 when the GAK1 time series began. A model using only freshwater transport also has significant predictive skill (explaining ~50% of the freshwater transport anomaly), which allows us to examine interannual variability in the ACC from 1930 to the present. Finally we show that freshwater discharge into the Gulf of Alaska (and hence a proxy time series of ACC transport anomalies) can be hindcast back to 1900 using sea level pressure difference between Seward and Ketchikan. These results suggest that the first decade of the 20th century time was the driest on record, while the period from 1920-30 was the wettest.

***Seasonal cycles of nitrate concentrations on the Gulf of Alaska shelf
from the GAK4 mooring***

T.E. Whitley, S.J. Thornton, A.R. Childers, D. Musgrave and H. Statscewich

University of Alaska Fairbanks

A biophysical shelf mooring at the GAK4 location at the 250-m isobath in the Seward Line has been maintained for two years with deployment/recovery every six months. In addition to current meters the mooring includes W.S. Oceans Systems NAS-2EN nitrate instruments at two depths (11-m and 75-m), and SBE SeaCat salinity, temperature, pressure, fluorescence, light transmission and PAR sensors at three depths (8-m, 23-m and 40-m). The nitrate instrument samples every four hours and analyzes a standard once per day to provide about 1000 data records from each full term deployment.

Nitrate data records obtained during the spring bloom periods of three years clearly showed the nitrate drawdown trend with occasional “event scale enrichments” in the surface layer. During two spring periods concurrent drawdown trends were observed in the nitrate records at 75-m depth but concentrations only decreased to values of approximately twice those in the surface layer. Some “event like” periodicity of nitrate concentration was also observed in the 75-m records. Comparisons of the nitrate data with physical/optical sensors showed the set of complex processes affecting the temporal and spatial distribution of nutrient-productivity processes in the Gulf of Alaska LTOP study area. In general, nitrate and chlorophyll fluorescence showed the expected inverse relationship throughout the records. Comparison of the chlorophyll estimated by the fluorescence sensors with SeaWiFS indicates that the early bloom events were captured accurately but the later subsurface chlorophyll event was missed by the remote sensing. Fall nitrate concentrations on the shelf were observed during one deployment at 75-m which displayed a series of “event like” changes through the month of January.

POSTER Session GLOBEC

***An Idealized Model of the Seasonal Variability
in the Alaska Coastal Current***

W. J. Williams and T. J. Weingartner

University of Alaska Fairbanks

The Alaska Coastal Current (ACC) is a wind and buoyancy forced, 30-50 km-wide current of low-salinity water that flows along the coast of the Gulf of Alaska from southeastern Alaska to Unimak Pass where it enters the Bering Sea. It is a consequence of the massive, annual coastal freshwater discharge which is distributed in numerous rivers draining from coastal mountain ranges. Seasonally, the discharge is a minimum in winter and increases through the summer to a maximum in fall. The ACC can either store this freshwater, mix it offshore, or transport it to the Bering Sea. The wind-stress along the coast of the Gulf of Alaska is generally cyclonic due to the Aleutian Low. It is strong and persistent in winter and weak and more variable in summer. The ACC is unique among coastal currents because of this downwelling wind stress, the massive, distributed coastal buoyancy forcing and the relatively-deep, nearshore bottom depths. CTD sections across the ACC show the current to be narrow, deep and bottom-attached in winter; but wider, shallow and predominantly surface-trapped in summer. A simplified numerical model of the ACC is used to examine the dynamical processes that govern this seasonal cycle. We use the Regional Ocean Modeling System (ROMS) forced by a combination of downwelling wind-stress and a 'half-line' source coastal-buoyancy-influx. The origins of the ACC are represented by the beginning of the line source. For this model, the scales of time evolution, the dynamical balance and density balance, and the relative importance of cross-shelf mixing to along-shelf transport of freshwater are presented. The numerical simulations of the 'half-line' source show a narrow deep 'ACC' during winter forcing and a wider, shallow 'ACC' during summer forcing.

*Session SSL-8: Steller Sea Lion Biology and Ecology
Diet*

Optimal foraging or focused prey selection: Can individual scat samples provide information on Steller sea lion feeding strategies?

Ben Wilson, Andrew W Trites and Arliss J. Winship

Marine Mammal Research Unit, University of British Columbia
benw@sfu.ca , trites@zoology.ubc.ca , winship@zoology.ubc.ca

During a foraging trip, a Steller sea lion will encounter a variety of habitats and potential prey species. Optimal foraging theory might predict that the sea lion would consume any species it encounters that gives it net benefit. However, to catch each prey species on encountering it will require multiple and potentially conflicting foraging tactics and search images. Consequently individuals might focus their effort on specific prey or tactics instead of obtaining an optimal diet. In this study, we attempted to use information on the species composition of individual scat to investigate which of these two approaches wild Steller sea lions actually adopt. If sea lions are optimal foragers we should expect that the composition of species in individual scat would represent relatively unbiased samples of the prey among all scat at a particular haul-out site. However, if sea lions are individual or temporal specialists then we would predict that individual scat would each present a biased sample of the prey deposited at the haul-out. Scats were collected from rookeries and haulouts in southeast Alaska from 1993-1999. Over 60 prey species identified from over 1,500 scats were grouped into 8 categories (cephalopods, flatfish, forage fish, gadids, hexagramids, rockfish, salmon and others). Observed and expected frequency of occurrences of any group occurring by itself, or with another group in a single scat were calculated, along with hierarchical clustering trees of prey groups consumed by season (summer or winter) and sex (males and females). Results indicate that certain prey groups were more likely to be found alone in a single scat (e.g., gadids) than with other types of prey. Other prey groups occurred together more frequently than expected based on random association (e.g., salmon and forage fish). These preliminary results suggest that individual sea lions do not pursue a simple optimal diet but instead specialize on prey and foraging strategies. Whether individuals maintain these specializations on the long-term or flip between foraging strategies remains to be determined and will require the use of more direct techniques.

Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

Interactions between Commercial Fishing and Walleye Pollock

Chris Wilson¹, Anne B. Hollowed¹, Michiyo Shima², Paul Walline¹ and Sarah Stienessen¹

¹NMFS Alaska Fisheries Science Center

²School of Aquatic and Fishery Science, University of Washington

chris.wilson@noaa.gov , anne.hollowed@noaa.gov , paul.walline@noaa.gov ,
sarah.stienessen@noaa.gov

Results from the first two years of a multi-year fishery interaction study near Kodiak Island in the Gulf of Alaska are presented. Findings from acoustic surveys, which were conducted in August 2000 and 2001, provide important information that begins to address the question of whether the abundance and spatial patterns of various species, including walleye pollock (*Theragra chalcogramma*) are impacted by commercial fishing activities over short spatio-temporal scales. The biomass and distribution of pollock were stable over periods of days to weeks although during the second year an unusual, extremely dense, small-scale pollock aggregation was detected during one of several survey passes. Several morphological descriptors of the pollock echosign layers were evaluated to better understand whether differences at the scale of the fish aggregations occurred in response to fishing. Variography was also used to quantify pollock spatial patterns. Results from the second year, when the commercial fishery took place within the study area, do not suggest a significant link between fishing activities and changes in estimates of juvenile and adult pollock geographical distribution, biomass, and vertical distribution. It will be important, however, to evaluate whether these trends persist during subsequent years.

Session SSL-12A: Steller Sea Lion Site Specific Studies - Kodiak Island

Climate Variability, Hydrography, and Zooplankton Availability: What Determines Forage Fish Abundance Near Sea Lion Rookeries and Haulouts?

Matthew Wilson, Janet Duffy-Anderson, Kevin Bailey and Jeffrey Napp

NMFS Alaska Fisheries Science Center

Matt.Wilson@noaa.gov , Janet.Duffy-Anderson@noaa.gov , Kevin.bailey@noaa.gov , jeff.napp@noaa.gov

Steller sea lion (*Eumetopias jubatus*) populations in the western Gulf of Alaska have declined about 80% since the late 1960's. Nutritional stress may have caused most of the early, precipitous decline, and may continue to be a factor in the more gradual recent decline. Regional variation in sea lion diet corresponds with variation in the dynamics of sea lion subpopulations. Sea lions depend primarily on fish to satisfy year-round nutritional requirements. The supply of fish, in turn, results from a complex web of productivity that varies over a range of temporal and spatial scales. We report on two ongoing studies of the production of pelagic fishes that are common or energetically important components of Steller sea lion diets: walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*), and eulachon (*Thalichthys pacificus*). The first study is an examination of the distribution and diet of these fishes in relation to zooplankton and oceanographic features (e.g., fronts) for evidence of consistent geographic variation in productivity, which is relevant to sea lion foraging strategy. The study area, sampled during September 2000 and 2001, encompasses ca. 12,000 nmi² of the continental shelf between the Shumagin Islands and Shelikof Strait that includes, or is adjacent to, seven sea lion rookeries and haul-outs. Preliminary results on the distribution of fish and plankton, and fish size and diet will be presented. These data will be input to spatially explicit bioenergetic models to estimate fish growth and prey demand relative to the plankton standing stock. Modeling will start with pollock due to data and model availability. Distribution and production will be examined in relation to frontal regions and other oceanographic features. The second study examines yearling pollock of the 2000 cohort in the western Gulf for evidence that winter conditions may adversely affect their diet, condition, energy content, and growth. Preliminary results indicate that mean length-specific weight of yearling pollock (ca. 15-19 cm FL) was low during winter. Next, whole body energy content will be measured (bomb calorimetry) for evidence of a wintertime decrease in body condition, which is relevant to fish survival and quality of sea lion prey.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

Population viability analysis of the Steller sea lion: a Bayesian approach

Arliss J. Winship and Andrew W. Trites

Marine Mammal Research Unit, University of British Columbia
winship@zoology.ubc.ca , trites@zoology.ubc.ca

Estimating the probability of the Steller sea lion (*Eumetopias jubatus*) going extinct is critical to determining the species' status and for developing recovery criteria under the United States Endangered Species Act. We performed a population viability analysis (a computer simulation technique) to quantify this risk for individual rookeries in Alaska. Key features of our simulation model included catastrophes, density dependent responses, and dispersal of juvenile animals among rookeries. Model parameters were estimated using Bayesian statistical methods and historical counts of Steller sea lion pups and non-pups on rookeries. Fitting models to the count data has previously provided good estimates of population sizes, birth rates and survival rates, and yielded estimates from our PVA model that were consistent with previous studies. Probability distributions for model input parameters provided a starting point for simulating future population growth or declines. We found that catastrophe and density dependence parameters had very strong effects on the probabilities that populations might go extinct (as well as on the probabilities that they would recover). The prior probabilities we assigned to each of these parameters largely determined the outcome of the simulations and were not significantly refined by fitting the model to the count data. Overall, our Bayesian analysis provides quantitative estimates of the risk that Steller sea lions might go extinct in Alaska, and shows how dependent such probabilities are on prior assumptions about the roles that catastrophes and density dependence play in their population dynamics. The results of our study are valuable for management decision analyses of the Steller sea lion in Alaska.

POSTER: Session: Steller Sea Lion Site Specific Studies – Kodiak Island

Humpback whale (*Megaptera novaeangliae*) abundance and feeding ecology within Steller sea lion (*Eumetopias jubatus*) critical habitat in Kodiak, Alaska

Briana H. Witteveen

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
fbhl@uaf.edu

Humpback whales (*Megaptera novaeangliae*) are firmly established as apex predators in the Gulf of Alaska (GOA) and the level of prey overlap that exists between humpbacks and other apex predators, including Steller sea lions (*Eumetopias jubatus*) may be quite significant. Therefore humpback whale research is one component of the GAP project, a study of trophic interactions within Steller sea lion critical habitat in the GOA. The Kodiak Island region has been shown to support a probable geographically separate humpback whale feeding aggregation. Historic whaling records indicate this aggregation was much larger prior to exploitation. Removal and recent recovery of humpback whales may have significant effects on ecosystem dynamics. As a result, research focusing on the current and pre-whaling abundance estimation and prey consumption of both populations began in 2001. Results estimate a current population of 157 humpback whales feeding within the Long Island Steller sea lion critical habitat in Kodiak, Alaska. A pre-whaling population was estimated at 1464 whales. Biomass removal caused by humpback whales was modeled for five hypothetical diets that were created based on prey availability surveys conducted within the study area and stomach contents of commercially caught whales. Results show that currently, feeding humpback whales may be removing nearly 24,000 tons of prey annually, including 9,000 tons of juvenile pollock (*Theragra chalcogramma*) and 2,500 tons of capelin (*Mallotus villosus*). Historic populations may have been responsible for removing well over 200,000 tons of prey.

Session SSL-14: Steller Sea Lion Site Specific Studies – Southeast Alaska

Spring-Spawning Fish Aggregations: A Seasonal Feast for Steller Sea Lions

Jamie N. Womble¹, Mary F. Willson¹, Michael F. Sigler², Brendan P. Kelly¹ and Glenn R. VanBlaricom³

¹School of Fisheries and Ocean Sciences University of Alaska Fairbanks

²NMFS Auke Bay Laboratory

³School of Aquatic and Fisheries Sciences, University of Washington

ftjnw@uaf.edu, mwillson@gci.net, mike.sigler@noaa.gov, fbpk@uaf.edu,
ffbpk@uaf.edu

High-quality, ephemeral food resources, such as energy-rich forage fish, which aggregate during spring, may be particularly important prior to the energetically expensive breeding season of Steller sea lions (*Eumetopias jubatus*). We predicted that the distribution of sea lions in spring would be influenced by the distribution of spring-spawning aggregations of Pacific herring (*Clupea pallasii*) and eulachon (*Thaleichthys pacificus*). Sea lion haulouts occupied only in spring were closer to forage fish aggregations than haulouts that were occupied at other times of year. From March through May 2002, we monitored the numerical response of Steller sea lions at spring spawning aggregations of Pacific herring (n = 14) and eulachon (n = 17) in southeastern Alaska. For spawning sites that were attended by sea lions the maximum number of sea lions observed was 949 at a eulachon spawning site and 288 at a herring spawning site. Proximity to spring-spawning forage fish aggregations may influence seasonality of haulout use by Steller sea lions. Ultimately, seasonal pulses of high-energy food resources may be critical to reproductive success of individual Steller sea lions.

PLENARY Session: Tuesday, 14 Jan 8:45-9:30 AM

***Conducting marine research in a resource-dependent community:
the role of outreach***

Kate M. Wynne

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
fkwm@uaf.edu

The Steller Sea Lion Research Initiative arose from a community-based demand for better science. Members of resource-dependent communities voiced concerns to Congress that the “Best Available Data” upon which Steller sea lion-based fishery regulations were based were inadequate, especially in light of serious potential socio-economic repercussions. Congress responded with unprecedented funding and a clear message for researchers to address a broad suite of hypotheses in the pursuit of ecosystem-wide insights. Less clear but implicit from the program’s inception is the expectation that these studies are pertinent and applicable to the needs of resource users, managers, and affected communities. In this presentation I will address these expectations from my perspective as a researcher and resident member of a resource-dependent community. From this perspective, I offer a reminder to all SSLRI researchers to consider that coastal residents 1) have been active consumers and apex predators within marine ecosystems for eons, 2) are directly or indirectly affected by the quality of ‘best available scientific data’ (including SSLRI), 3) may have witnessed marine processes and change for years, 4) want to be informed and are trusting YOU to seek meaningful answers and objectively document ‘The Truth’, and 5) are anxiously waiting to hear what you have found.

Session SSL-12B: Steller Sea Lion Site Specific Studies - Kodiak Island

Seasonal prey use by Steller sea lions near Kodiak, Alaska

Kate M. Wynne

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

fkwm@uaf.edu

The frequency of occurrence (FOC) of prey remains found in fecal samples (“scats”) is used to assess and monitor the use and relative importance of fish species to Steller sea lions using Kodiak waters. Prey remains were recovered from scats collected monthly as part of the Gulf Apex Predator-prey (GAP) study, dried, and identified using all possible structures (Pacific Identifications, Inc). Contingency analyses were used to determine site-specific, seasonal, or regional variations in relative importance of individual or grouped prey species. Kodiak sea lions are currently using a diverse prey base; eight species were found in greater than 10% of 624 scats containing identifiable prey. Six dominant prey groups were found in more than 20% of scats examined: Pacific sandlance (47.8%), arrowtooth flounder (ATF, 41.1%), Pacific cod (35.6%), walleye pollock (31.6%), salmonids (28.9%), and cottids (Irish lords and sculpins: 22.6%). Seasonal patterns of prey use were found by comparing the frequency of occurrence of prey within scats collected from the same sites in four seasons. While arrowtooth flounder remains were found in >25% of scats collected in all seasons, capelin use peaked in summer (76.7% FOC) while sandlance use was greatest in winter months (61.7% FOC). Salmon use was greatest in fall months (51.2% FOC) while occurrence of cottids and Pacific cod was greatest in winter scats (31.4 and 46.6% FOC, respectively). Regional differences in prey use were found by comparing contents of scats collected on three northern (Latax Rk, Sea Otter Island, Marmot Is) and three eastern (Long Island, Chiniak, Ugak Is) haulouts. Capelin and herring were significantly more common in scats collected from northern sites while pollock were seasonally more prevalent on eastern sites.

*Session SSL-7: Steller Sea Lion Biology and Ecology
Population and Bioenergetic Modeling*

***Using Age Structure to Detect Impacts on Threatened Populations:
A Case Study Using Steller Sea Lions***

Anne E. York and Eli E. Holmes#

NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center
#Present address: Cumulative Risk Initiative, Northwest Fisheries Science Center
anne.york@noaa.gov, eli.holmes@noaa.gov

A delayed response to change is often a characteristic of long-lived species and presents a major challenge for monitoring their status. However, rapid shifts in age structure can occur even while population size remains relatively static. In this paper, time varying matrix models were used to study age structure information as a tool for improving detection of survivorship and fecundity change and status. The methods were applied to Steller sea lions (*Eumetopias jubatus*), a long-lived endangered marine mammal found throughout the North Pacific Rim. Population and newborn counts were supplemented with information on the fraction of the population that was juvenile, obtained by measuring animals in aerial photographs taken during range-wide censuses. By fitting the model to 1976-1998 data, we obtained maximum likelihood estimates and 95% confidence intervals for juvenile survivorship, adult survivorship and adult fecundity in the mid 1980s, late 1980s and 1990s. We used a series of nested models to test whether the data were best fit by a model with one, two, or three temporal changes in demographic rates, and we fit the models to different lengths of data to test the number of years of data needed to detect a demographic change. We found that the severe declines in the early 1980s were associated with severely low juvenile survivorship, declines in the late 1980s with low adult survival, while declines in the 1990s were associated with disproportionately low fecundity. We repeated these analyses, fitting only to the count data without the juvenile-fraction information, to determine whether the age-structure information changed the analysis and/or changed the certainty and speed with which demographic-rate changes could be detected. The juvenile-fraction data substantially improved the degree to which estimates from the model were consistent with field data, and significantly improved the speed and certainty with which changes in demographic rates were detected.

Session SSL-8: Steller Sea Lion Biology and Ecology
Diet

Estimating The Size of Walleye Pollock and Atka Mackerel Consumed by the Western Stock of Steller Sea Lions

Tonya K. Zeppelin¹, Katherine A. Call¹, Dominic J. Tollit², Trevor J. Orchard³ and Carolyn J. Gudmundson¹

¹NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center

²Marine Mammal Research Unit, University of British Columbia

³Department of Anthropology

Tonya.Zeppelin@noaa.gov

Size selectivity of prey by Steller sea lions (*Eumetopias jubatus*) is relevant to understanding the foraging ecology of this declining predator, but has been problematic due to the erosion and absence of skeletal elements usually used to estimate fish length. We developed regression formulae to estimate fish length from seven diagnostic bones of walleye pollock (*Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) typically recovered in Steller sea lion diet studies.

For both species, all elements showed a high degree of correlation with fork length of prey (r^2 range: 0.78 - 0.99). Fork length of walleye pollock and Atka mackerel consumed by Steller sea lions was estimated by applying these regression models to skeletal structures recovered from scats (feces) collected between 1998 and 2000 across the range of the Alaskan western stock. Experimentally derived size correction factors were applied to take into account loss of size due to digestion. Fork lengths of walleye pollock consumed by Steller sea lions ranged from 3.7 to 70.8 cm (mean = 39.3 cm, SD = 14.3 cm, n = 666) and Atka mackerel ranged from 15.3 to 49.6 cm (mean = 32.3 cm, SD = 5.9 cm, n = 1685). Although sample sizes were limited, a larger proportion of juvenile (<20 cm) pollock were found on summer (June - September) haul-outs (64% juveniles, n = 11 scats) than on summer rookeries (9% juveniles, n = 132 scats) or winter (February - March) haul-out sites (3% juveniles, n = 69 scats). A larger proportion of juvenile (<28 cm) Atka mackerel were found on winter haul-out sites in 1998 (55% juveniles, n = 38 scats) than 1999 (25% juveniles, n = 48 scats), or 2000 (15% juveniles, n = 13 scats). Considerable overlap in the size composition of both walleye pollock and Atka mackerel taken by Steller sea lions and the commercial trawl fishery was demonstrated.

Session EVOS/NPRB-1: Marine Research

Testing Archival Tag Technology on Alaska Salmon and Steelhead

Christian E. Zimmerman and Jennifer L. Nielsen

Little is known about the distribution and behavioral response of salmon and steelhead to environmental variation in the ocean. Understanding the role of environmental variation on the distribution of salmonids in marine environments requires a better understanding of movements and habitat utilization at all life history stages. With the aid of archival tags, we can document the migration and behavior of salmon and steelhead in the ocean. Testing and refinement is a critical stage in the application of new technologies to biological questions. We are currently testing the effectiveness of archival tags in collecting marine habitat data and movement of salmonids from Alaska. Our studies include application of archival tags in juvenile coho salmon and post-spawn steelhead adults. Coho salmon from the Fort Richardson Hatchery are being used as a test case to refine techniques of tag implementation, recovery, and data analysis. In 2001, we tagged 60 coho smolts with inactive tags and, in 2002, we tagged 174 coho smolts with active archival tags capable of collecting temperature and pressure data for 18 months. In 2002, we tagged 33 post-spawn steelhead in the Ninilchik River with 25 archival tags capable of recording temperature and pressure data and 8 archival tags capable of collecting temperature, pressure, and ambient light intensity data. Recovery of these tags and the data collected will provide new insights to the behavior and movements of salmon and steelhead during their marine migrations.