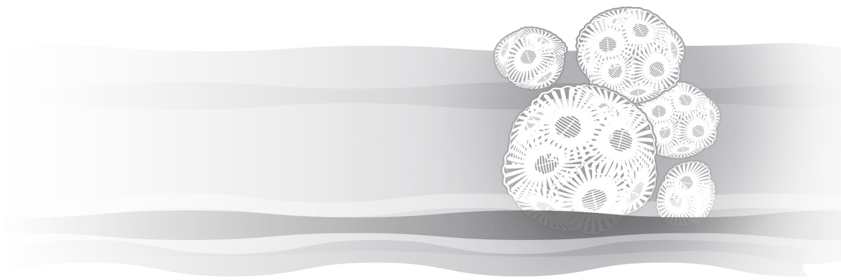


Auke Bay Labs Staff Serve at Southeast Alaska Regional Science Fair

The (Intel-affliated) Southeast Alaska Regional Science Fair was held 11-13 March 2011. This year was the 18th anniversary of a high school science fair in Juneau and had a record number of 135 projects participate. Eleven AFSC staff at Auke Bay Laboratories (ABL) served as mentors for 21 students (representing 10% of the fair projects) with research projects covering topics in ocean-acidification, bioenergetics of forage fish, the Deepwater Horizon oil spill, genetics, and invertebrate biology and toxicology. The mentors worked with their students between 20-40 hours during December through March to help plan, implement, and interpret their results in preparation for the fair. Three staff mentored more than one project. Twenty-seven staff served as judges during the fair, several of whom were also mentors. This represented 22% of all of the judges in the fair. Three staff, Lawrence Schaufler, Ron Heintz, and Bonita Nelson also serve on the executive committee.

The 2011 NOAA Marine Science Awards, sponsored by the Juneau Regional Office and ABL were presented to:

- Haley Mertz for her project "How Substrate Location Affects the Survival of Amphipods in Juneau, Alaska"
- Colin Zheng for his project "Measuring Energy in Walleye Pollock Through Bioelectrical Impedance Analysis"

The 2011 National NOAA 'Taking the Pulse of the Planet' Award was presented to:

- Erin Gaffaney and Sally Paul for their project "How Temperature Affects the Amount of Acidic Dissolution that Occurs in the Calcium Carbonate Shells of the Pacific Blue Mussel and the Butter Clam"

By Emily Fergusson

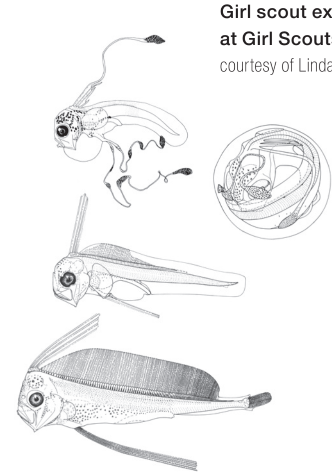
Girl Scouts Women of Science Event; Auke Bay Elementary Class

ABL fishery research biologists Emily Fergusson and Jeanette Gann and ABL contractors Bekah Olson and Liz Morgan participated in the Girl Scouts Women of Science Event on 19 February 2011 at the University of Alaska Southeast. The event was sponsored by Girl Scouts of Alaska, Juneau Service Unit. Emily led a session on marine invertebrates and introduced local girl scouts to zooplankton, including why zooplankton is important and how scientists capture and process it. The scouts looked at zooplankton under a microscope, split plankton samples using a plankton splitter, and separated size classes of plankton using sieves. In other Women of Science sessions Juneau Girl Scouts were able to experience training in marine biology, robotics, medical, dental, and engineering sciences.

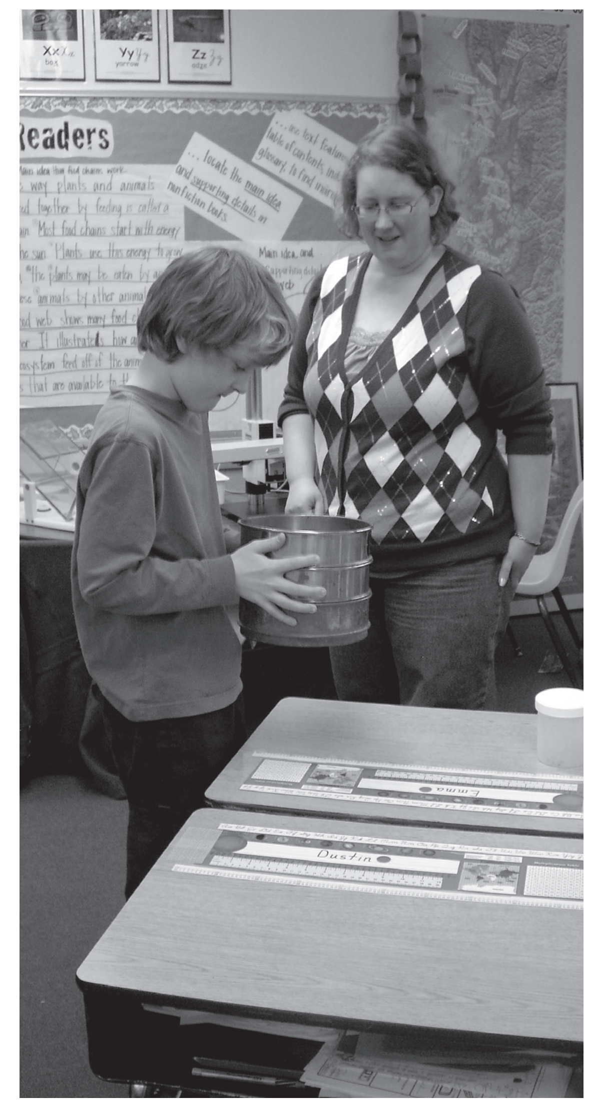
Emily also gave a guest demonstration to Mr. Dean's third grade class at Auke Bay Elementary School on 25 February. Students were taught about salmon food webs and how different trophic levels are an important part of ecosystems. They also had opportunities for hands-on experience with processing samples related to what salmon eat and to food webs in general.

By Emily Fergusson and Jeannette Gann

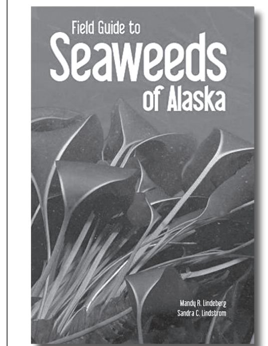
Girl scout examining zooplankton sample under a microscope at Girl Scouts Women of Science event in Juneau, Alaska. Photo courtesy of Linda Sylvester.



From left to right: Elizabeth Morgan, Emily Fergusson, Bekah Olson, and Jeannette Gann at the Girl Scouts Women of Science event in Juneau, Alaska. Photo courtesy of Carol Burrows.



Emily Fergusson demonstrates the use of sieves used for plankton sorting to Auke Bay Elementary School third graders.



AFSC Field Guide Wins Award

The 2010 publication *Field Guide to the Seaweeds of Alaska* by Mandy Lindeberg (ABL) and Sandra Lindstrom received an award from the National Association of Government Communicators (NAGC) in the Soft/Hardcover book category (content and design). The NAGC does not reveal what level award entries have won until their awards banquet at their annual convention, 9-12 May 2011, in St. Paul, Minnesota.

Transitioning of Metadata Standards

Auke Bay Laboratories (ABL) metadata coordinator Emily Fergusson participated in a metadata working group at the Stennis Space Center in Mississippi, 11-12 January 2011. The working group, comprised of 10 metadata experts and trainers, was asked to review new training materials covering the transition from the Federal Geospatial Data Committee (FGDC) metadata standard to the new International Organization for Standardization (ISO) metadata standard. The working group was lead by NOAA's National Coastal Data Development Center (NCDDC) metadata specialists Jaci Mize and Kathy Martinolich, who authored the training materials.

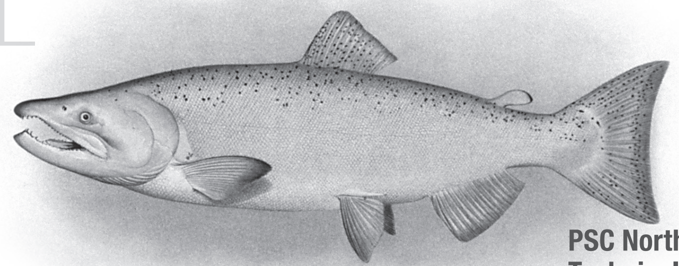
ISO is the metadata standard that NOAA Fisheries is moving towards adopting in the future. The standard is referred to as ISO 19115 which covers all relevant geographic information. The ABL datasets will require the use of the ISO 19115 with the Biological Extension which will allow documentation of both taxonomic and database structure information. When the ISO metadata standard is adopted, these training materials will be vital to ensure a smooth transition between the standards and will also minimize the learning curve for those writing metadata. A Powerpoint presentation and workbooks were reviewed and finalized by the working group and will be available for future training purposes.

By Emily Fergusson

Alaska Marine Science Symposium Salmon Workshop

A special workshop at the 2011 Alaska Marine Science Symposium held 18 January 2011 in Anchorage focused on Pacific salmon in marine waters and was designed to review research findings on life history, behavior, and population dynamics of salmon in the ocean. As a keystone species in the Gulf of Alaska, Bering Sea, and adjacent waters, Pacific salmon are subject to multiple influences in marine environments that affect behavior, survival, and annual run strength of the different species and stocks. Life history patterns of many Pacific salmon, if not most, spend more time in marine waters than in freshwater. Exceptions involve smolt species (coho, sockeye, or Chinook salmon) where extended pre-smolt freshwater rearing may lead to precocious maturation of jacks. Even pink salmon with a 2-year life cycle are pretty well fixed at 8-10 months (30% to 40%) in freshwater and 14-16 months (60%-70%) in marine waters. Some older Chinook or chum salmon may spend over 90% of their life history in the ocean.

By Bill Heard



Pacific Salmon Commission

ABL staff were involved in several bilateral Pacific Salmon Commission (PSC) activities during the last quarter. These activities included participation in the Yukon River Joint Technical Committee, the Northern Boundary Technical Committee, the Chinook Technical Committee, and the Transboundary Technical Committee Subcommittee on Enhancement.

PSC Yukon River Joint Technical Committee (JTC)

Jim Murphy attended the Yukon River Joint Technical Committee (JTC) meeting in Fairbanks, Alaska, 22-24 February 2011, and presented juvenile Chinook and chum salmon data collected during the NMFS pelagic trawl surveys in the northern Bering Sea. Jim also provided updates on salmon bycatch in the Bering Sea Aleutian Island and Gulf of Alaska groundfish fisheries. The JTC is charged with evaluating scientific data related to the harvest, population assessment, and research on Canadian-origin salmon stocks. Data are reviewed and the Technical Committee uses this information to advise the Yukon River Panel, which establishes policy for resource management of Canadian-origin salmon stocks.

Yukon River Chinook salmon have been classified by the Alaska Board of Fisheries as a stock of yield concern since 2000. Through significant reductions in commercial harvests and restrictions placed on subsistence harvests, escapement goals have been generally met throughout the Alaska portion of the Yukon River drainage. However, border passage goals established by the Yukon River Panel for Canadian-origin Chinook have not been met in 3 of the last 4 years (2007, 2008, and 2010). The combination of recent poor runs and the level of uncertainty present in pre-season and in-season assessments of run size have contributed to the failures to meet border passage agreements.

The ABL received funding support in 2011 for marine research on the juvenile life-history stage of Yukon River Chinook salmon ($370,000) by the Arctic Yukon Kuskokwim Sustainable Salmon Initiative and the Alaska Sustainable Salmon Fund. The funding will provide the 2011 assessment of juvenile Yukon River Chinook salmon and will enable the juvenile data to be evaluated in terms of recent losses in production and its potential to reduce uncertainty in pre-season assessments of adult returns.

PSC Northern Boundary Technical Committee (NBTC)

Michele Masuda and Bill Heard participated in bilateral meetings of the Northern Boundary Technical Committee (NBTC) at the Pacific Salmon Commission Post Season Meeting in Vancouver, British Columbia, 10-13 January 2011. Normally this committee meets to determine the annual allowable harvest of sockeye salmon from the Nass and Skeena Rivers in Alaska District 104 purse seine and District 101 drift gillnet fisheries, along with annual allowable harvest of pink salmon caught in Canadian boundary area net and troll fisheries. Specific formulas in the Pacific Salmon Treaty provide for limits on the number of sockeye and pink salmon that originate in one country that can be caught in fisheries of the other country. The primary focus of meetings this year, however, was to evaluate blind tests of known populations of sockeye salmon for comparing two genetic stock identification methods, DNA microsatellite and single-nucleotide polymorphisms (SNPs) and scale pattern analysis (SPA) used in identifying stock origins in mixed stock fisheries.

Stock composition estimates of Canadian fisheries historically have been derived from DNA microsatellite analyses by Fisheries and Ocean Canada and by scale pattern analysis in U.S. fisheries by the Alaska Department of Fish and Game (ADF&G). The ADF&G is now planning to shift from scale pattern analysis to genetic-based single-nucleotide polymorphism analysis of catch samples from Alaska fisheries. Blind tests of all three stock identification techniques were developed from known populations of both Canadian and Alaska stocks to validate changes from scale pattern analysis to single-nucleotide polymorphism analysis for analyzing stock compositions in Alaska fisheries.

Four stock mixtures involving known Alaska, Nass, Skeena, and Fraser sockeye populations with different percentages of each group were developed for blind test analyses using the three analytical procedures. Fraser River sockeye were included in some of the mixtures since annual variations in migration patterns cause significant numbers of Fraser sockeye to be caught in Alaska fisheries in some years, especially in the District 104 seine fishery. Results from most initial blind tests were within acceptable ranges for standard errors; however, test results in some mixtures were equivocal, suggesting the need for higher resolution which may require expanding single-nucleotide polymorphism alleles used in the initial test for clarification. Additional match sample comparison with DNA microsatellite, scale pattern analysis, and single-nucleotide polymorphism analysis will also be run to determine if there are any systematic sampling biases in these procedures.

PSC Chinook Technical Committee (CTC)

Andy Gray and ABL contractor Alex Wertheimer participated in bilateral Chinook Technical Committee discussions at the Annual PSC Meeting in Portland, Oregon, on 14-18 February 2011. These meetings focused on finalizing the report for a Chinook Salmon Total Mortality Management Regime for aggregate abundance-based management (AABM) fisheries in both countries. Wertheimer, as U.S. Co-Chair of the Chinook Technical Committee's Total Mortality Working Group (TMWG), also participated in several other bilateral discussions in fleshing out final agreements for this report. The report provides mechanisms, as required by the Treaty, for transitioning AABM fisheries based on landed catch to one based on total mortality. A total mortality management regime will account for both catch and associated incidental mortality in AABM fisheries and constrain the fishery based on the cumulative impact. The AABM fisheries involved include Southeast Alaska troll, sport and net fisheries, Northern British Columbia troll and sport fisheries, and West Coast Vancouver Island troll and sport fisheries.

Development of a total mortality management regime required the TMWG to establish ratios from the base period 1985-95 between landed catch and the associated mortalities from fishing, adjusted for a landed catch equivalency (LCE). This involved a lengthy process of developing metrics for transferring different kinds of fishing mortalities between and within different gear types into a procedure for adjusting the annual abundance index into an allowable landed catch for each AABM fishery. The abundance index, derived from annual calibrations of the CTC model, determines the allowable landed catch that is detailed in Table I of Annex IV, Chapter 3 in the Treaty. Under a total mortality regime, limits on AABM fisheries are based on total mortality rather than landed catch that requires adjusting allowable LCE under a given abundance index. Initial assumptions in the 2009 Treaty modification calling for implementing a total mortality regime in 2011 was that fishing under total mortality, additional catch limits would be imposed on most AABM Chinook fisheries. This, however, turned out not to be the case. Under a total mortality modified abundance index most AABM fisheries will be allowed an increase in LCE. The primary reason for this paradoxical outcome appears to be the required use of the 1985-95 base period as the foundation for making transitions to a total mortality regime. Adjustments to coastwide Chinook fisheries management since 1995 appear to have abrogated many of the deleterious mortality related fishing practices that were common during the base period.

An important question now is how Pacific Salmon Commissioners will deal with this issue as the Treaty requires implementation of total mortality management for AABM Chinook fisheries under the 2009 Agreement.

PSC Transboundary Technical Committee (TTC)

The Transboundary Technical Committee met on 2-4 March 2011 in Juneau. John Joyce attended as a member of the Transboundary Technical Committee Enhancement Subcommittee. Operational plans for the 2011 season were reviewed including a review of Northern Fund request for proposal status along with allocations and operational plans for funded projects. Preliminary forecasts for the Taku, Stikine, and Alsek Rivers were exchanged bilaterally with Canadian counter parts and in-season management plans were adopted. Sara Gilk from ADF&G's Gene Conservation Laboratory provided an update on the status of genetic stock identification programs for several transboundary river projects.

The Enhancement Subcommittee met to update progress on sockeye enhancement projects on both the Taku and Stikine Rivers. The Stikine Enhancement Plan and Taku Enhancement Plan are not part of the treaty process and are directly tied to the harvest share agreements between the United States and Canada. The bilateral committee set technical goals for the enhancement process and provided criteria for measuring project success. In addition, the subcommittee responded to Transboundary River Panel direction to optimize methodologies for brood stock collections and other extended rearing enhancement activities to maximize yield from enhancement projects. The panel also requested the enhancement subcommittee to optimize protection of wild stock productivity in the Tatsamenie Lake in the Taku River drainage and in Tahltan and Tuya Lakes in the Stikine River drainage.

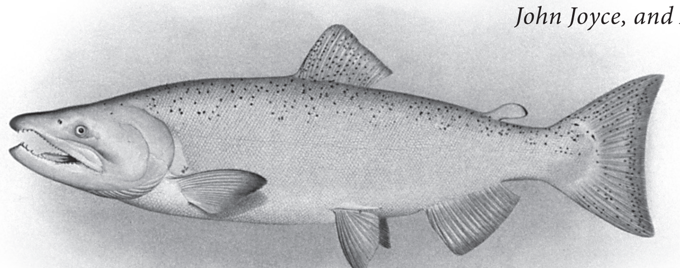
Yukon River Chinook salmon have been classified by the Alaska Board of Fisheries as a stock of yield concern since 2000.

PSC Letter of Agreement Funding Issues

Under a 1999 PSC-related Letter of Agreement (LOA), special funding is provided from Congress to the U.S. Section of the Chinook Technical Committee to support research associated with specific U.S. Chinook salmon issues. One important issue was the implementation of mass marking programs of large numbers of Chinook salmon produced in some U.S. hatcheries that could threaten the integrity of the coast-wide coded wire tagging (CWT) program that was instrumental in helping implement the Pacific Salmon Treaty. This concern came about when mass marked Chinook salmon smolts from hatcheries were identified with clipped adipose fins that originally had been sequestered for use as a visible indicator only with CWT-tagged fish. Some LOA-supported research, therefore, is directed at research associated with additional ways of marking and identifying individual groups of Chinook salmon.

Two ongoing LOA projects at ABL were recently approved for additional funding. Principal investigator Andy Gray's proposal to the U.S. Chinook Technical Committee was approved to continue work on parental based tagging of Chinook salmon at the Little Port Walter (LPW) Marine Station. This is a DNA- based technique that has important implications for an alternative to marking fish with CWTs and determining performance of individual family matings in fish stocks. Adrian Celewycz serves as principal investigator on a different LOA project at LPW. Adrian's project, designed to evaluate effects of ventral fin clips on size, age at return, and marine survival schedules of Alaska stream-type Chinook salmon, was also approved for funding in FY-11 and FY-12.

By Bill Heard, Jim Murphy, Michele Masuda, Andy Gray, Alex Wertheimer, John Joyce, and Adrian Celewyz



FMA Observer Program Activities in 2010

In 2010, 601 observers were trained, briefed, and equipped for deployment to vessels and processing facilities operating in the Bering Sea and Gulf of Alaska groundfish fisheries. These observers collected data onboard 263 vessels and at 18 processing facilities for a total of 35,263 observer days. This is only a small reduction in effort from 35,681 observer days in 2009.

New observer candidates are required to complete a 3-week training class with 120 hours of scheduled class time and additional tutelage by training staff as necessary. In 2010, the Fisheries Monitoring and Analysis (FMA) Division's Observer Program provided training for 18 new observers in Seattle and 80 new observers in Anchorage through a contract with the University of Alaska.

Returning observers are required to attend an annual 4-day briefing class prior to their first deployment each calendar year. Prior to subsequent deployments, all observers must attend a 1-day, 2-day, or 4-day briefing; the length of the briefing each observer attends is dependent on that individual's needs. FMA staff briefed 289 observers in Seattle and 214 observers in Anchorage. The 2010 workforce comprised 16% new observers and 84% experienced observers. This was an increase in returning observers when compared to 2009 when 61% of the workforce comprised experienced observers.

Observer Jason Eibner collecting species composition data. Photo credit Alaska Fisheries Science Center.

Paul McCluskey (center) and Roy Morse (left) lead observer trainees on a tour of a fishing vessel. Photo credit Alaska Fisheries Science Center.

After each deployment, observers meet with a staff member for debriefing to finalize the data collected. There were 163 debriefings in Anchorage and, due to a larger debriefing staff, 472 debriefings in Seattle. Note that the values for the numbers of briefings and debriefings do not represent a count of individual observers as many observers deploy multiple times throughout the year.

In 2010 FMA implemented electronic capture of the bird data collected by observers. In addition to collecting data from tagged birds and any birds that occur in their sample, observers document sightings of short-tailed albatross, red-legged kittiwakes, Steller's eiders, spectacled eiders, marbled murrelets, and Kittlitz's murrelets. Previously these data were recorded on paper forms only.

Observer Jason Wright measures crab. Photo credit Alaska Fisheries Science Center.

As 2010 drew to a close, staff put the final touches on the database technology used to track the inventory of all observer sampling gear. Each observer is issued sampling gear worth approximately $1,800. Ensuring that the gear is returned to our inventory is important to keeping equipment costs down. Sampling gear is issued primarily in Seattle and Anchorage, with supplemental and replacement gear available in our field offices located in Dutch Harbor and Kodiak. The database, known as the Observer Gear Inventory System (OGIS), allows us to track when and where gear is issued or returned as well as the status of the gear (e.g., deployed, eligible for deployment, turned in, out for repair). Since 2007 we have used a preliminary version of OGIS to track Personal Locator Beacons issued to observers (AFSC Quarterly Report Oct-Nov-Dec 2006) and starting in 2011 OGIS will be used to track the inventory of all observer sampling gear.

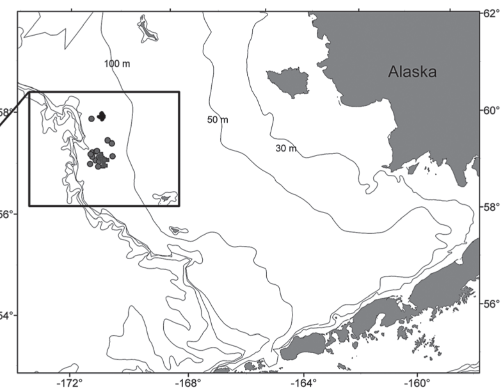
By Allison Barns with contributions from Mike Moon and Ren Narita

Red-legged kittiwake. Photo credit Alaska Fisheries Science Center.

Groundfish Assessment Program

Male Snow Crab Migration in the Eastern Bering Sea

During March 2011, RACE Division scientist Dan Nichol completed another round of snow crab (*Chionoecetes opilio*) tagging in an ongoing study to track their seasonal migrations in the eastern Bering Sea. The research, a cooperative project involving the RACE Division, the Alaska Department of Fish and Game (ADF&G), the Bering Sea Fisheries Research Foundation (BSFRF), and the Marine Conservation Alliance Foundation, is designed to address the question of whether or not adult males migrate from offshore wintering areas northwest of the Pribilof Islands (where the fishery occurs) to more inshore areas where mature females reside. A seasonal offshore migration of mature males, which is inferred from the change in their apparent spatial distribution between the NMFS summer bottom trawl survey and the winter commercial fishery, has been corroborated by a mark-recovery tagging program conducted by the ADF&G. Although this movement of mature males into deeper water during winter is firmly established, the timing and other particulars of a return inshore migration of these males have not been demonstrated. Since mature females remain in the shallower areas throughout the year, the specifics of this return migration are important because they are critical to understanding whether males continue to participate in breeding throughout their lives.



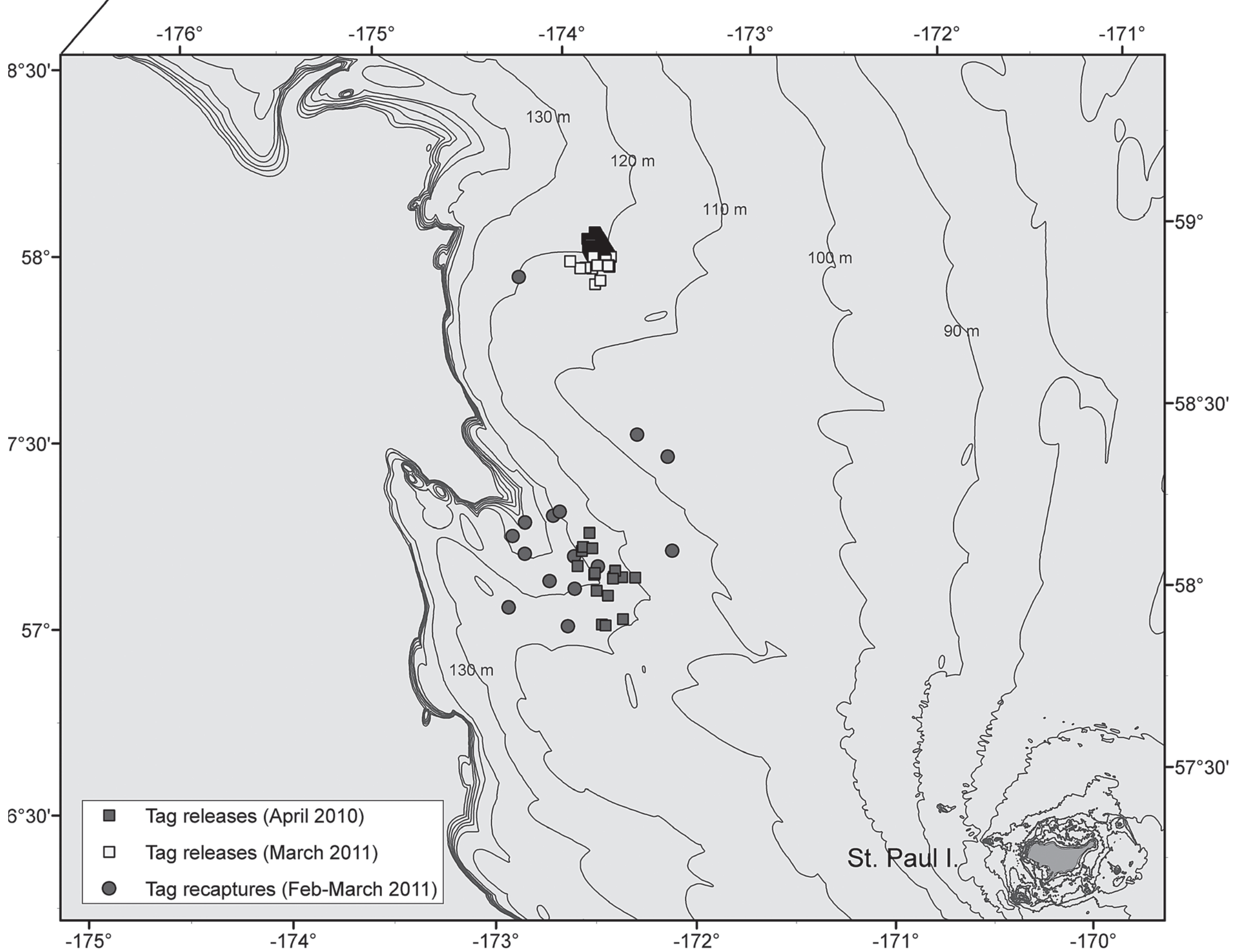


Figure 1. Release and recapture locations of snow crab with attached electronic archival tags.

The archival tags, which record depth at 1-minute intervals and temperature at 30-minute intervals, are attached to crabs that are then released. When the tags are subsequently recovered, migration pathways of the individual crabs can be reconstructed from the stored depth data. Because the depth sensors are sensitive enough to record the change in tide heights (pressure differences produced from the changing water elevations above the crab), the timing and shape of the tidal signature from a tag can be compared to a tidal simulation model using a technique called "tidal pattern matching" to then locate where an individual crab is on any particular day after being released.

In April 2010, a total of 120 male snow crabs were fitted with electronic archival tags aboard the fishing vessel *Kiska Sea* and released. An additional 157 were tagged aboard the fishing vessel *Pacific Sun* and released in March 2011 (Fig. 1). The archival tags are attached to spaghetti tags which are wrapped around the carapace of the crabs between the first and second walking legs (Fig. 2). Because male snow crab do not molt after they reach maturity, there is no concern with molting and the attachment of tags.

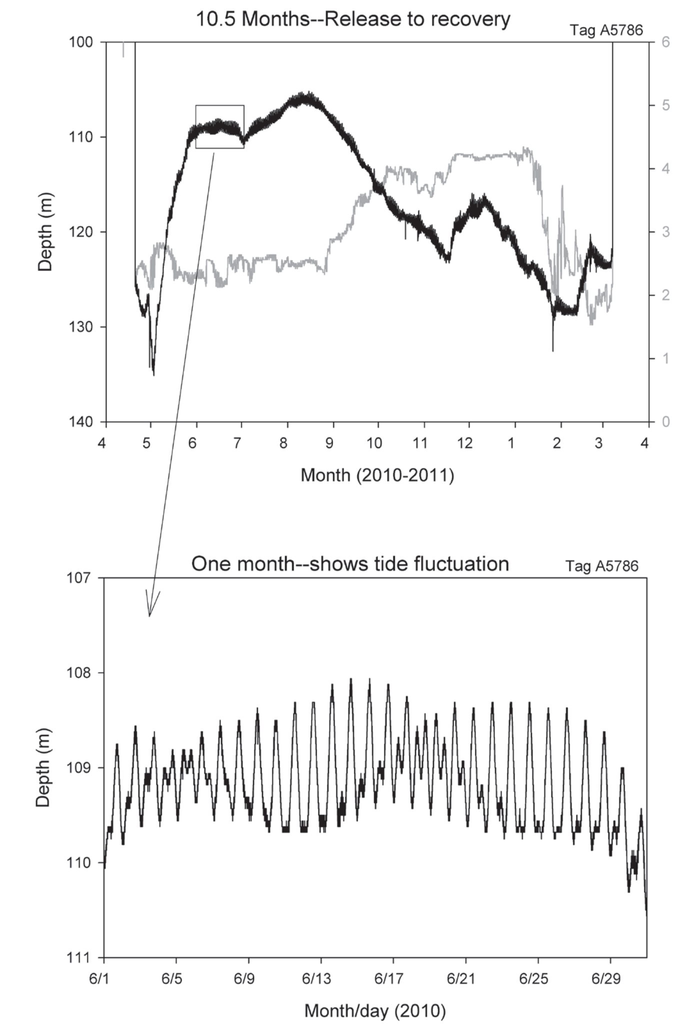


Figure 3. Plot of depth and temperature recordings from an electronic archival tag attached to an adult male snow crab in the eastern Bering Sea (top). The tag depth sensors are sensitive enough to also detect the change in tidal height (bottom), which will be used to help construct a migratory pathway for the crab.

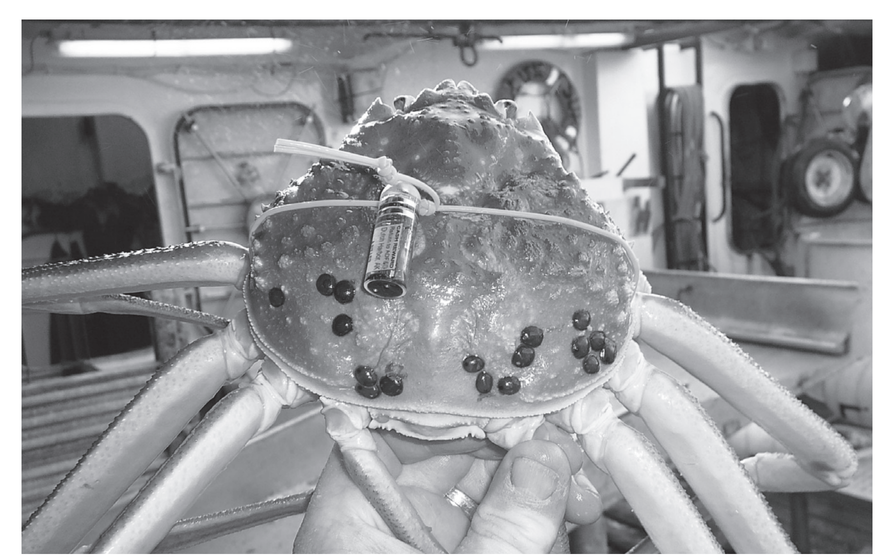


Figure 2. A snow crab tagged with an electronic archival tag, just prior to release.
Photo by Dan Nichol.

To date, 23 tagged snow crabs have been recaptured by the commercial fishery and returned, more than 9 months after their release. These initial tag depth records show that some but not all the crab made an inshore migration and returned offshore (Fig. 3), which could be interpreted as some but not all adult males return for mating every year. We expect to have a better picture of the overall migration patterns of the snow crabs once we get additional returns from the 2012 fishery and once we've applied the tidal pattern matching analysis to examine the specific routes undertaken.

By Dan Nichol and Dave Somerton

Trawl and Setline Survey Workshop Held at the AFSC

Scientists from Canadian and U.S. federal and state fisheries agencies gathered at AFSC Headquarters in Seattle on 22-24 March 2011 for a workshop on trawl and setline groundfish resource surveys. Most attendees were from the Pacific Coast and a few joined us from the Atlantic Coast as well (e.g., NOAA Fisheries Northeast Fisheries Science Center, Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program, and Maine Department of Marine Resources). The workshop was convened by a working group of the Technical Subcommittee (TSC) of the Canada-U.S. Groundfish Committee, a technical working group from Pacific Coast fisheries research and management agencies that has been meeting since 1960 seeking ways to collaborate and leverage each others' programs. The core Trawl Survey Working Group of the TSC, representing NOAA Fisheries' AFSC and Northwest Fisheries Science Center (NWFSC) and Fisheries & Oceans Canada (DFO) Pacific Biological Station (Nanaimo, British Columbia), began meeting regularly in 2002 to share expertise and knowledge of trawl survey methodology. In 2010, the TSC recommended that the group augment and broaden their annual meeting by inviting participants from other Pacific Coast state agencies, as well as researchers using fixed gear methods to survey groundfish resources. The March 2011 workshop, with nearly 60 participants, realized this recommendation.

At the workshop researchers described various trawl and setline surveys conducted by their respective agencies to assess various stocks of groundfishes. A particularly interesting focus session featured representatives from Rapp Hydema US, an international firm that provides trawl winches for research and fishing fleets. They presented a detailed functional description of the automatic tensioning systems ("autotrawl") featured in their winches and discussed with workshop participants the pros and cons of using autotrawl technology during scientific or research trawl survey sampling. More than a dozen presentations were made on a variety of topics including ergonomics and safety, the effects of ambient light levels on catch rates, improvements in methods for data analysis, and how to present results effectively. Lively discussions ensued following nearly every presentation. As wrap up, a general discussion covered a variety of issues relating to groundfish resource topics including peer review of survey methods, challenges of continuing to fund surveys, design problems related to missed station sampling opportunities, ever-increasing data requests and workloads, and the emerging issue of protected species catches on conducting fisheries survey operations.

The workshop offered an opportunity for scientists from a wide range of agencies, each working on similar projects, to gather and share their insights, challenges, and frustrations about this important work they do. Organizers Mark Wilkins (AFSC/RACE Division), Rick Stanley (DFO Pacific Biological Station), and Aimee Keller (NWFSC, FRAM Division) are particularly grateful to Bruce Leaman and the International Pacific Halibut Commission for hosting a convivial dinner on the first evening, which effectively promoted and facilitated communication among participants (as well as being delicious). A link to the proceedings of the workshop can be found on the TSC homepage at www.psmfc.org/tsc2/ where a list of participants, the agenda, slideshows of the survey overviews and special topic presentations, and the minutes are posted.

By Mark Wilkins

Shellfish Assessment – Fisheries Resources Pathobiology

University of Maryland and Living Marine Resources Cooperative Research Center

AFSC scientist Frank Morado was invited to participate in a workshop to provide an opportunity for scientists and students affiliated with the National Science Foundation Centers of Research Excellence in Science & Technology Center at University of Maryland Eastern Shore (UMES) to engage in discussions with key stakeholders, including academics, scientists, and policy makers from federal and state agencies about research that will be conducted in Maryland coastal waters over the next 5 years. A sub-project of the grant is an epizootiological study of a parasitic dinoflagellate, *Hematodinium* sp., in the blue crab, *Callinectes sapidus*. Frank provided an overview on *Hematodinium*-related diseases of crustaceans as an introduction to a presentation by Dr. Joseph Pitula of UMES on continuing collaborative but contrasting *Hematodinium* research.

The UMES is the lead institution in a consortium of six minority-serving institutions that includes Delaware State University, Hampton University, Savannah State University, University of Maryland Biotechnology Institute Center of Marine Biotechnology, and the University of Miami Rosenstiel School of Marine and Atmospheric Science. This consortium, The Living Marine Resources Cooperative Research Center (LMRCRC), was established in 2001 in partnership with NOAA.

By Frank Morado

Recruitment Processes Program (FOCI)

Developing a Rapid, Accurate, DNA-based Identification Technique for Larvae and Dietary Components of Commercially Important Marine Fish Species

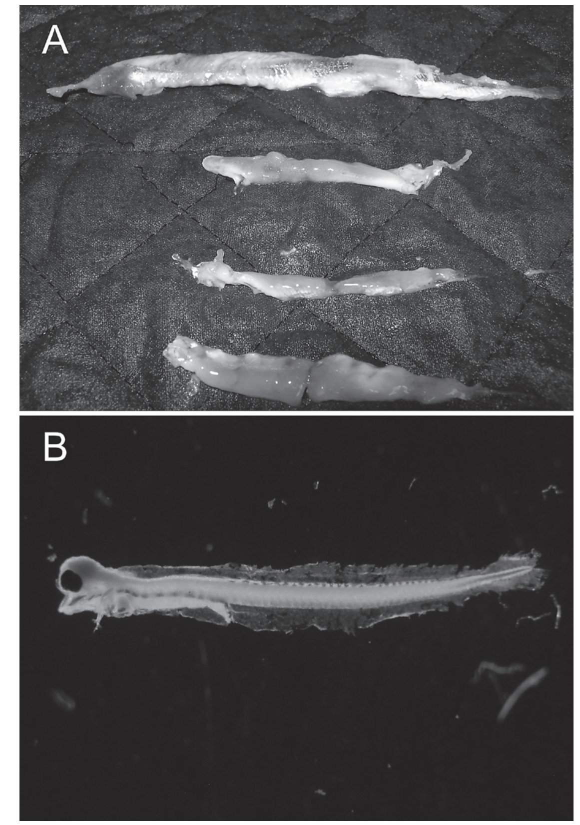


Figure 4. A) Digested forage fish obtained from gut. B) Unidentified *Bathymaster* spp. larva.
Photos by Mei-Sun Yang (top) and Morgan Busby (bottom).

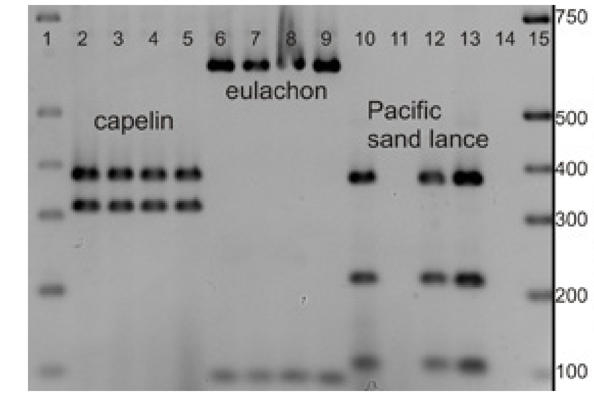


Figure 5. Restriction fragment length polymorphism (RFLP) patterns for three species of forage fish. Lanes 2-5 contain individual capelin, lanes 6-9 contain eulachon and lanes 10, 12 and 13 contain Pacific sand lance. Lanes 1 and 15 contain DNA size standards of known fragment lengths.
Photo by Melanie Paquin.

Correctly identifying 'who eats whom' in the ocean is critical to constructing food webs and understanding how marine ecosystems function. Identification of prey remains in predator stomachs is often inconclusive; for example, prey may be in an advanced state of digestion (Fig. 4A). Members of the Recruitment Processes Program, in collaboration with the Resource Ecology and Fisheries Management (REFM) Division, recently completed a North Pacific Research Board-funded project focused on developing rapid, accurate, DNA-based identification of larvae (Fig. 4B) and dietary components of commercially important species. Mitochondrial DNA restriction fragment length polymorphism (RFLP) protocols were developed for 19 fish species that produced diagnostic banding patterns with gel electrophoresis (Fig. 5). The results indicated that DNA-based methods can provide accurate species identification or verification in food habits studies or for larval fish when traditional morphometric and meristic approaches are uninformative or taxonomic expertise is lacking.

By Mike Canino, Troy Buckley (REFM), Melanie Paquin, and Richard Hibpshman (REFM)

Recruitment Processes Program Contributions to the Lower Trophic Level and Modeling Components of the Gulf of Alaska Integrated Ecosystem Research Program

The lower trophic level (LTL) component of the Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP) is focusing on the investigation of early life history dynamics and recruitment of five target species of groundfish: walleye pollock, Pacific cod, arrowtooth flounder, sablefish, and Pacific ocean perch. Compilation, analysis, and interpretation of ichthyoplankton surveys pertaining to these species from three decades of sampling in the western GOA by the Recruitment Processes and EcoFOCI Programs has commenced as part of the GOA-IERP retrospective analysis of this time series. Annual patterns of abundance and seasonal progression in distribution of eggs (pelagic spawners) and larvae at various ontogenetic stages are being compiled and analyzed (Fig. 6). A time-series of abundance for late spring (1981-2009) is available and will be used to investigate relationships between species larval abundance and environmental variables. Links between the species and the variables will contribute to a mechanistic understanding of environmental forcing on early life history aspects of recruitment processes among these species in the GOA ecosystem. Synthesis of the historical ichthyoplankton data will also provide species-specific life history parameters for egg and larval stages that will be used in the development of individual based models (IBM) for each of the GOA-IERP focal species.

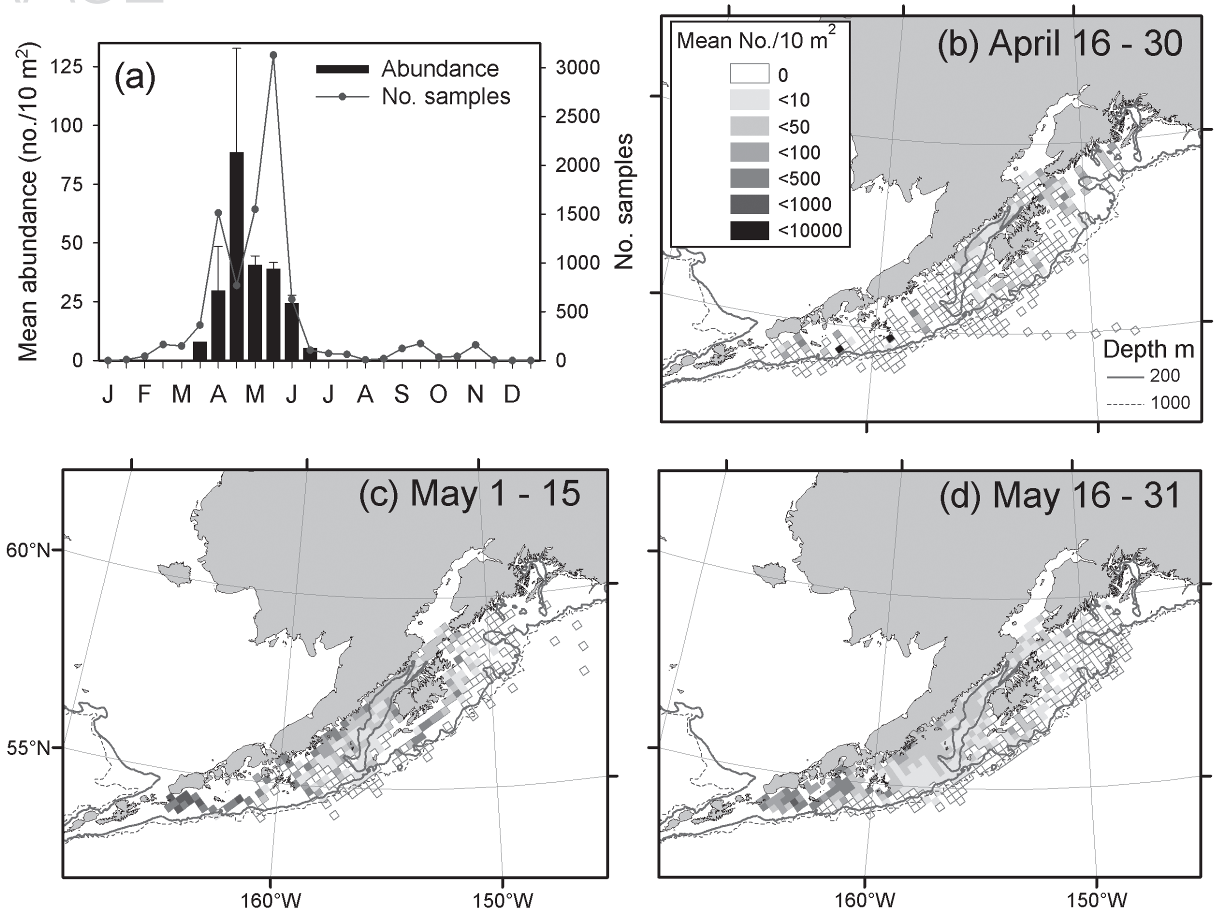


Figure 6. Seasonal variation in abundance and distribution of Pacific cod larvae from ichthyoplankton collections (1971, 1977-2009) by the Recruitment Processes Program in the western Gulf of Alaska; half monthly mean abundance (+standard error) weighted by year in 60-cm Bongo Net samples (a), weighted mean abundance in 20-km² grid squares in the area sampled during the second half of April (b), first half of May (c), and second half of May (d).

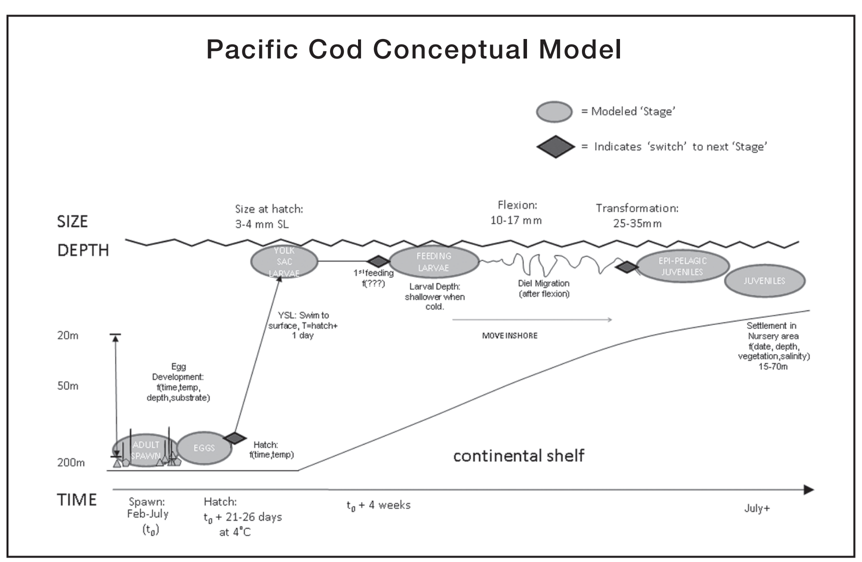


Figure 7. Conceptual model for Pacific cod early life history as it will be represented in the individual based model. Shown are the individual life stages and some of the processes that Pacific cod eggs, larvae and juveniles go through over time and as they change in depth and size. Eggs are spawned between February and July on the bottom in rocky areas with emergent vegetation, and rise to near surface waters as yolk-sac larvae. Feeding larvae begin diel migration after caudal fin development begins at 10-17 mm standard length (SL) and settle into nursery areas characterized by depth and emergent vegetation (kelp, eelgrass).

The modeling component of GOA-IERP includes the development and application of a vertically integrated suite of models from the Regional Ocean Modeling System (ROMS) hydrodynamic model, a Nutrient-Phytoplankton-Zooplankton (NPZ) model, five IBMs, one for each focal species (Fig. 7), and an upper trophic level model. Recruitment Processes personnel are involved in coordinating the modeling work and will have responsibility for construction and integration of several of the IBMs into the GOA Program. This suite of models is intended to integrate information from the historical databases and the field and lab components of GOA-IERP, and to trace the effects of climate and environmental forcing through the ecosystem, from upper ocean and atmospheric physics through plankton to larval and juvenile fish. This knowledge can then be applied to questions about how best to manage our groundfish fisheries under a changing climate scenario.

By Miriam Doyle and Sarah Hinckley

Fisheries Behavorial Ecology Program - Newport Laboratory

Applying Otolith Chemistry To Explore Dispersal and Mixing in Bering Sea Pacific Cod Populations

Population structure of Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea (EBS) remains unresolved, although genetic analyses currently indicate isolation-by-distance (i.e., that the closer two groups of fish are, the more genetically similar they appear). However, genetic-based approaches provide stock structure information on evolutionary timescales (thousands of years) whereas the effects of fishing and other management actions can influence populations on ecological timescales (within a few generations). Therefore, it is important to understand how much mixing and exchange occurs among geographically discrete groups of fish on ecological time frames. In collaboration with Oregon State University, researchers from the AFSC's Newport Laboratory are exploring the variation in otolith chemistry of larval and juvenile Pacific cod in order to evaluate patterns of dispersal and mixing in the EBS. Researchers from Auke Bay Laboratories and the Recruitment Processes Program are also participating in this project supported by a grant from the North Pacific Research Board.

Otoliths are small bony structures composed of calcium carbonate in a gelatin matrix situated in the inner ear and used for fish movement and balance: as the fish moves or the head tilts, the otolith stimulates small hair cells, which send signals down sensory fibers to be interpreted by the brain. While otoliths are used for balance and orientation as well as sound reception, they also provide researchers with a tremendous amount of ecological information. In most fishes, the otolith begins to grow during the egg stage, laying down one distinct increment every day and, eventually, one increment per year. Otoliths deposit layers of calcium carbonate throughout the life of a fish, which are analogous to tree rings. By counting the rings the age of a fish can be estimated in years (or in young fish, days; Fig. 8a). The otolith structure also records aspects of the chemical environment of a fish and, hence, can provide information on the environment in which individual fish lived, i.e., a "geochemical fingerprint."

In one component of the work, laboratory experiments were used to determine the influence of temperature and growth rate on elemental incorporation into larval otoliths. Larval cod were reared at 2°, 5°, and 8°C for up to 51 days, and the otoliths and rearing water were examined for chemical composition using an inductively coupled plasma mass spectrometer at Oregon State University's W.M. Keck Collaboratory for Plasma Spectrometry. The differences in elemental concentration between rearing waters and the fish otolith reflect physiological and chemical partitioning of elements in the deposition of the otolith matrix. The effect of temperature on partition coefficients varied among elements: otolith incorporation of strontium and barium decreased with increased temperature, while incorporation of magnesium was unaffected by temperature. Incorporation of the three elements was not affected by variation in growth rate within temperature treatments. This type of information is important for accurate interpretation of otolith chemical composition of fish collected in the EBS. We now know that it is unlikely that variation in growth will complicate any spatial patterns in otolith composition that we observe in the field.

Two sets of samples were used to evaluate the ability to use variation in otolith chemical composition to correctly identify fish to their collection sites. In one test, the elemental composition of otoliths from cod larvae (4-12 mm) collected on either side of the Alaska Peninsula in 2006 and 2008 were examined for spatial variation. In both years, fish could be classified to their basin of origin with over 70% accuracy based on standardized ratios of Ba, Mn, Mg, Sr, and Zn (referred to as the "elemental signature").

A second test examined spatial variation in elemental signatures of juvenile Pacific cod captured from six sites across the EBS in 2006 and 2008. Here, the chemical composition of a 200µm transect (about 1/50th of an inch) along the otolith edge (corresponding to approximately the last 10 days of life prior to capture) was examined (Fig. 8c). Again, the majority of fish could be correctly assigned to their collection site. These two tests demonstrated that there is sufficient spatial variation in elemental signatures of both larval and juvenile Pacific cod otoliths to apply this technique in studies of population dispersal and movement.

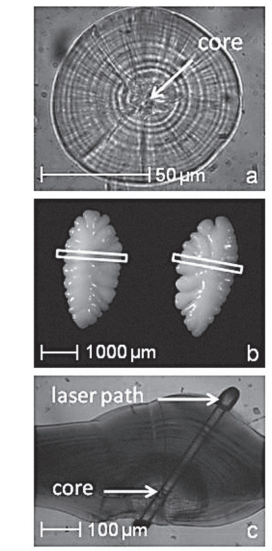


Figure 8. a) Otolith of an 8-mm Pacific cod larva. The otolith was polished with fine-grit sandpaper to reveal daily growth-increment formations that were used to age the fish.
b) A pair of otoliths of a 70-m juvenile Pacific cod. The rectangular box indicates the thin cross-section of the otolith from which the chemical composition was analyzed.
c) Cross-section of a juvenile Pacific cod otolith that has been processed for chemical composition. A laser is used to ablate the otolith to collect material for chemical analysis. The wide line is the path the laser took across the surface of the otolith from one edge, through the core to the opposite edge.

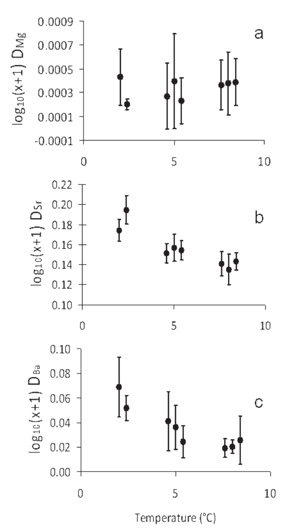


Figure 9. Mean partition coefficients for a) Magnesium (DMg), b) Strontium (DSr), and (c) Barium (DBa). Pacific cod were reared in the laboratory to 51 days of age at three temperatures. Chemical composition of seawater and fish otoliths were measured using mass spectrometry. Partition coefficients represent the relative concentrations of each element (ratioed to Calcuim) in the water and in the otoliths of the fish. Partition coefficients of Sr and Ba (but not Mg) were affected by rearing temperature.

A final component of the project is examining the elemental signatures of the otolith cores, which reflect the environment at the time of hatch of those Bering Sea juveniles (Fig. 9). Because variation in elemental signatures of otoliths appears spatially driven, the elemental signatures in the otolith that were deposited early in life can be used to determine patterns of movement and mixing prior to capture. Through cluster analysis of elemental signatures in the otolith core (deposited during the early larval phase) the researchers hope to determine the number of distinct spawning regions contributing to the juvenile population in the SE Bering Sea. Although they caution that pinpointing the exact locations of the main spawning areas will not likely be possible yet. The degree to which fish with similar elemental signatures in the otolith core (presumed to represent distinct spawning areas) are found together as juveniles will provide evidence of the spatial scale of mixing during early life stages in this valuable resource species.

By Thomas Hurst

Resource Ecology & Ecosystem Modeling Program

Feeding Ecology Among *Myoxocephalus* Sculpins in the Eastern Bering Sea

Three of the largest species of *Myoxocephalus* sculpins are widely distributed across the continental shelf of the eastern Bering Sea: plain sculpin (*M. jaok*), great sculpin (*M. polyacanthocephalus*), and warty sculpin (*M. verrucosus*). Consistent distinction among all three of these species has occurred since about 2000, and diet descriptions for each individual species are sparse. Stomach samples from all three species were collected during AFSC bottom trawl surveys during 2000 and 2006-2008. We divided each species into size categories and calculated the diet overlap among all species-size pairs using both the number and weight composition of the stomach contents (Table 1). The highest diet overlap generally occurred between size categories within each species (in bold face in the table), especially for plain sculpin and great sculpin. The warty sculpin had a high degree of diet overlap with the great sculpin, especially in the 46-55 cm and 36-45 cm size-categories. The plain sculpin had low diet overlap with both warty and great sculpin.

The patterns in diet overlap are generally consistent with the geographic distributions of each species and the prey available to them. The plain sculpin is caught primarily on the inner shelf and has a diet of shrimp, mysids, and other small crustaceans that decrease in importance with increasing body size while flatfishes and other fishes increase in importance with increasing body size. The great sculpin is caught primarily on the middle shelf and consumes *Chionoecetes* crabs at all sizes examined, while eelpouts and smaller fishes decrease in importance with increasing body size and gadids, flatfishes, and scavenged offal increase in importance with increasing body size. The warty sculpin also inhabits the middle shelf but is most abundant in northern areas frequently influenced by the "cold pool." The warty sculpin diet includes less fish than the other two species, with lyre crabs, other crabs, shrimp, and other small crustaceans decreasing in importance with increasing sculpin body size and *Chionoecetes* crabs increasing in importance with increasing body size. Most of the *Chionoecetes* crabs consumed by warty and great sculpins are snow crabs (*C. opilio*), and the size of the snow crab consumed generally increases with the size of the sculpin predator, with great sculpin preying on slightly larger snow crabs relative to their body size than the warty sculpin (Fig. 1).

By Todd TenBrink and Troy Buckley

Fish Stomach Collection and Lab Analysis

During the first quarter of 2011 Resource Ecology and Ecosystem Modeling (REEM) Program staff analyzed the stomach contents of several species from the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska regions. The contents of 2,831 stomach samples from 17 species were analyzed from the Bering Sea, 8 stomach samples from 7 species were analyzed from the Aleutian Islands, and 73 stomach samples from 7 species were analyzed from the Gulf of Alaska. Detailed analysis, with high taxonomic resolution of prey types and enumeration of all prey items, was performed on several flatfish species for an essential fish habitat (EFH) project and on walleye pollock for the Bering Sea Integrated Ecosystem Research Program (BSIERP) project. Both of these projects incorporate independent information on the available prey community. Fisheries observers returned stomach samples from 15 arrowtooth flounder from the eastern Bering Sea. In total, 14,605 records were added to the REEM food habits database.

By Troy Buckley, Geoff Lang, Mei-Sun Yang, and Richard Hibpshman

Table 1. Diet overlap indices among size categories (FL in cm) of three species of *Myoxocephalus* sculpins (great, plain, and warty). Indices above the diagonal were calculated using the numeric composition of the diet and indices below the diagonal were calculated using the gravimetric composition of the diet. **Bold** indices highlight comparisons within a species.

Species FL (cm)	Great 26-35	Great 36-45	Great 46-55	Great 56+	Plain < 26	Plain 26-35	Plain 36-45	Plain 46-55	Plain 56+	Warty 26-35	Warty 36-45	Warty 46-55
Great 26-35		**63.91**	**55.05**	**49.43**	25.77	26.34	35.79	41.56	6.89	47.78	60.05	48.95
Great 36-45	56.33		**83.33**	**75.01**	14.49	17.87	24.89	37.54	19.06	30.90	51.59	67.60
Great 46-55	49.51	77.64		**83.23**	10.57	11.60	17.86	30.52	15.45	23.84	48.42	71.92
Great 56+	47.72	69.32	74.46		8.91	14.53	21.46	29.14	12.90	15.23	38.61	66.10
Plain <26	21.76	13.43	10.38	26.27		**71.69**	**54.32**	**29.75**	**3.29**	37.90	37.03	16.44
Plain 26-35	22.72	14.16	10.47	26.31	**55.04**		**80.83**	**42.69**	**14.80**	40.47	35.24	16.47
Plain 36-45	27.71	25.40	20.24	36.16	**41.68**	**84.95**		**54.36**	**21.77**	48.85	44.12	21.41
Plain 46-55	25.51	28.17	24.63	33.61	**25.93**	**68.48**	**72.74**		**49.25**	41.10	47.45	34.32
Plain 56+	5.05	11.47	4.93	18.75	**17.24**	**58.62**	**61.63**	**57.54**		12.31	24.17	9.90
Warty 26-35	28.78	24.79	21.30	12.84	21.96	19.29	22.17	21.11	3.50		**64.05**	**33.03**
Warty 36-45	47.90	67.22	64.23	53.21	7.43	8.06	12.84	23.30	3.50	**51.53**		55.12
Warty 46-55	35.60	65.09	60.74	49.75	0.95	1.63	6.00	20.76	2.06	**19.77**	**67.32**	

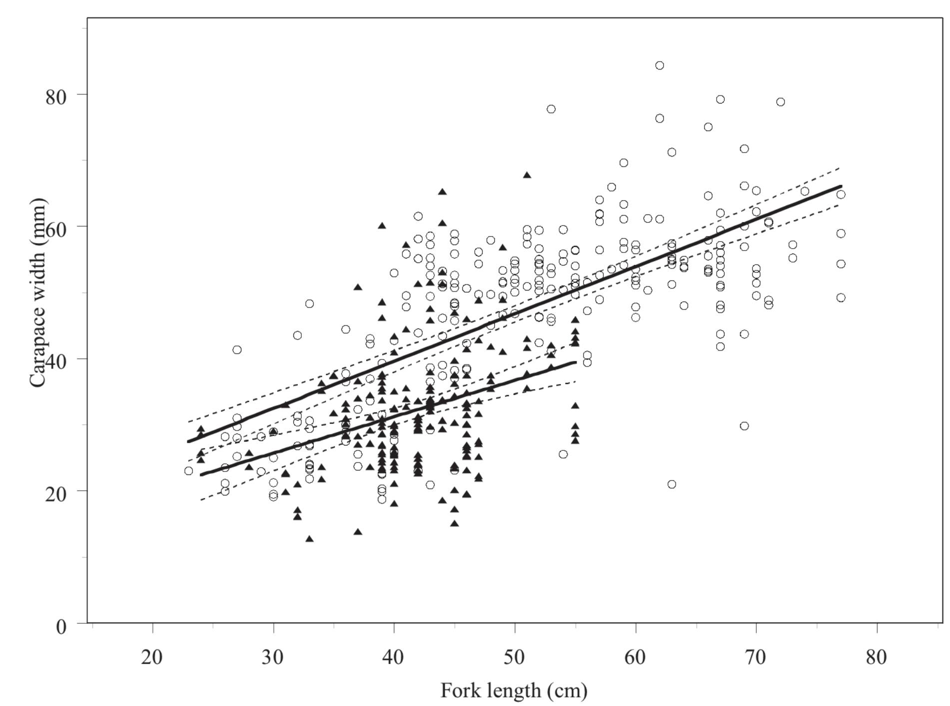


Figure 1. The sizes (carapace width, mm) of *C. opilio* consumed by sizes (fork length, cm) of great sculpin (circles) and warty sculpin (triangles) in the eastern Bering Sea. The regressions with 95% confidence intervals for each sculpin species are shown.

The patterns in diet overlap are generally consistent with the geographic distributions of each species and the prey available to them.

Ecosystem Modeling Meetings

The final meeting of the GLOBEC Pan-regional Synthesis project "End-to-end energy budgets in US-GLOBEC regions" was hosted by REEM Program researchers Sarah Gaichas and Kerim Aydin at the AFSC Headquarters in Seattle, 28 February-4 March 2011. This 3-year collaboration synthesized data and built ecosystem models to compare the characteristics of four regions studied by GLOBEC: the Gulf of Alaska, Georges Bank, the Northern California Current, and the Southern Ocean. AFSC researchers Anne Hollowed and Bob Foy also collaborated with 20 other scientists from the Northwest Fisheries Science Center (Newport); U.S. Geological Survey; Woods Hole Oceanographic Institution; Oregon State University; Western Washington University; Old Dominion University; and the Universities of Massachusetts, Rhode Island, Alaska, South Florida, and Maine. During this project, a new ecosystem model was built for the Southern Ocean, existing models were improved for the Northern California Current and Georges Bank, and a model of the Central Gulf of Alaska was developed based on the existing full Gulf of Alaska ecosystem model. Simple models were derived to address physical drivers and bottom-up forcing in each ecosystem, and more complex models were maintained for implementing dynamic scenarios. At the meeting, the Central Gulf of Alaska model was finalized with all data updates and five dynamic scenarios were presented to collaborators. The scenarios were standardized across all ecosystems and included whale restoration (with and without fishing), no fishing, doubling jellyfish and halving jellyfish, and observing the ecosystem response to each. Model code and software developed at the AFSC will be used for similar dynamic runs incorporating uncertainty using the Southern Ocean and Northern California Current models. Many publications resulting from this collaboration were outlined at the final meeting, with REEM Program scientists sharing primary responsibility for an overall ecosystem metrics comparison paper and a paper comparing ecosystem responses to standardized fishing scenarios.

At this meeting, the Central Gulf of Alaska model was finalized with all data updates, and five dynamic scenarios were presented to collaborators.

REEM Program scientists Kerim Aydin, Troy Buckley, and Ivonne Ortiz presented research results at the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program (BSIERP) Principal Investigators' meeting 21-25 March in Anchorage, Alaska. Results presented included preliminary simulations from the Forage Euphausiid Abundance in Space and Time (FEAST) model and results from diet analyses conducted during the program for determining functional responses for key fish predator/prey pairs.

By Sarah Gaichas and Kerim Aydin

Economics & Social Sciences Research Program

Improving the Usefulness of Logbook Data in the North Pacific Groundfish Fisheries

Economics and Social Sciences Research (ESSR) Program researchers Stephen Kasperski and Alan Haynie are currently conducting research exploring the feasibility of using logbook data to improve fisheries management in Alaska. Logbooks are a major data reporting requirement for fishers in the North Pacific groundfish fisheries, yet the logbooks are not verified for accuracy nor digitized to make them available to fishery managers or analysts. While NMFS has implemented a substantial observer program in the North Pacific to monitor the activities of large vessels, the majority of catcher vessels have only partial observer coverage. As smaller catcher vessels have an observer on board for 0%–30% of their days at sea, it is possible that vessels' harvesting strategies differ depending on whether they are observed. This could include changing fishing locations, altering the species composition harvested, or taking shorter trips when observed.

To explore the potential observer effect and the potential usefulness of logbook data in the North Pacific groundfish fisheries, we have merged data from fish tickets, observer data, and a set of digitized logbooks for all trawl vessels operating in the Gulf of Alaska in the year 2005. Preliminary results suggest that for trips in which there is full coverage (a fish ticket accompanied by a record of observer and logbook hauls), the total harvests by species in the fish tickets are generally close to the totals derived from the logbook records, except for some flatfish species. We are in the process of exploring how total catch of prohibited species such as halibut and Chinook salmon, fishing location choice, species composition, and trip length differ across datasets. We also hope to explore whether there are any quantifiable differences in the characteristics of observed and unobserved trips.

By Stephen Kasperski and Alan Haynie

Optimal Multispecies Harvesting in the Presence of a Nuisance Species

ESSR Program researcher Stephen Kasperski is currently conducting research relating to the multispecies bioeconomic models of groundfish in the Bering Sea. Specifically, he is examining models that account for biological and technological interactions among species to determine the optimal quotas and subsequent stock sizes for each species in the presence of a nuisance species. The nuisance species lowers the value of the fishery by negatively affecting the growth of the other species in the ecosystem and has little harvest value of its own. The model also allows for technological interactions by estimating gear- and class-specific cost functions which allow for bycatch and combined harvesting of multiple species that varies across target species. As approaches for ecosystem-based fisheries management are developed, results demonstrate the importance of focusing not only on the species with harvest value but also on species which may have no harvest value on their own but affect the productivity and availability of higher value species. Ignoring the role of these nuisance species can result in a less productive and lower value fishery if the nuisance species replaces some of the exploited species and its population remains unchecked because it is not economically valuable.

This study uses the arrowtooth flounder, Pacific cod, and walleye pollock fisheries in the Bering Sea/Aleutian Islands region of Alaska as a case study and finds the net present value of the fishery is decreased from $16 billion to $3 billion dollars by ignoring arrowtooth's role as a nuisance species on the growth of Pacific cod and walleye pollock. To account for the negative impact of arrowtooth flounder on the profitable harvesting of cod and pollock, the model solves for an optimal subsidy on the harvest of the nuisance species. Aggregated over all vessels and time periods, the total subsidy on the harvest of arrowtooth is $49 million dollars, which increases the net present value by $111 million dollars after accounting for the subsidy, which results in a 126% rate of return on the subsidy for the nuisance species.

By Stephen Kasperski

Spatial Competition with Changing Market Institutions

Competition across space can be fundamentally altered by changes in market institutions such as the creation of catch shares or individual fishing quotas. In this research, we propose a framework that integrates market-altering policy changes in the spatial analysis of competitive behavior and incorporates endogenous breaks in explanatory variables for spatial panel datasets. This research fills a gap between work focusing on spatial price responsiveness of agents and work on changes in market regulations that affect competition. We apply the framework to an important current fishery managment policy to explore how a change from aggregate to individual fishing quotas affects the spatial price responsiveness of fish processors for the Alaska sablefish fishery. We find that processors are more responsive to each other's prices after rationalization.

What is the policy implication of these findings for fisheries management? The application has important policy ramifications as catch shares represent one of the most important examples of natural resource economics being used in resource management. Better accounting for the distributional impacts of this resource management policy is a valuable contribution that will enable policymakers to better anticipate the distributional impacts of the creation of catch shares in other fisheries that are currently considering this policy change. In some cases, publicly expressed concerns about distribution may be merely an effort to seek rents or quota share, but our results suggest that the concern that catch shares will impact the competitive pressures faced by processors is well-founded. A case-by-case examination is required to determine the degree to which this is likely, but there is certainly the possibility that after catch share implementation, processors in neighboring communities will compete more aggressively. Whether or not additional competition is perceived to be beneficial will largely be based on how equitable the current distribution of rents between the processing and harvesting sectors is perceived to be.

By Harrison Fell and Alan Haynie

As approaches for ecosystem-based fisheries management are developed, results demonstrate the importance of focusing not only on the species with harvest value but also on species which may have no harvest value on their own but affect the productivity and availability of higher value species.

The Economic Value of Marine Recreational Salmon Fishing Trips in Southeast Alaska

Few studies have examined the net economic value of Alaska's salmon sport fisheries. Of the existing studies, most tend to focus on fisheries of Southcentral Alaska rather than Southeast Alaska, and none use recent data on fishing behavior. Moreover, past studies generally used empirical frameworks that are generally considered less flexible compared to recreation demand models used today. To fill this gap, economic values of fishing opportunities and changes in harvest rates are estimated for single-day private boat saltwater fishing trips for king (Chinook) and silver (coho) salmon by Southeast Alaska anglers using a recreation demand model of trip frequency and participation that jointly estimates anglers' opportunity costs of time.

The data used in the analysis are from a national mail survey conducted during 2007 of people who purchased sport fishing licenses in Alaska in 2006. The survey was developed with input collected through several focus groups and cognitive interviews with Alaska anglers, as well as from fishery managers. The survey is described, and the data collected summarized, in Lew, Lee, and Larson (2010), on the AFSC website at www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-214.pdf. The focus in this analysis is on people who took single-day trips using private boats in Southeast Alaska because it is the dominant type of trip taken by residents of that region.

In the model, the decision of where to fish is assumed to depend upon the time and money cost of traveling to the site and the angler's expectation of how many fish will be harvested at each site under consideration. Two formulations of the harvest rate variables are used that differ based upon whether or not information available on the species targeted by the angler is used to define which harvest rates are relevant to trip choices.

Results suggest that the model that includes harvest rates for both king and silver salmon for everyone, regardless of their individual targeting strategies, was preferred on the grounds of goodness of fit statistics. The preferred model leads to mean economic value estimates of approximately $45 for a fishing trip, which translates to $2,250 for a season of salmon fishing. Marginal values associated with changes in harvest rates are also calculated for a variety of harvest changes. For example, the mean (taken across anglers) value for a 50% increase in the king salmon harvest rate alone is $7, and for a 100% increase is $16. For 50% and 100% decreases in king salmon harvest rates, the change in the value of a trip is -$6 and -$11, respectively.

By Dan Lew and Doug Larson

Evaluating the Impact of Buffers to Account for Scientific Uncertainty when Setting TACs: Application to King Crab in Bristol Bay, Alaska

ESSR Program economists Brian Garber-Yonts and Mike Dalton collaborated with AFSC stock assessment scientists and researchers at the University of Washington, the North Pacific Fishery Management Council (NPFMC), and the ADF&G in the development of new methods for evaluating the economic and biological trade-offs associated with the implementation of annual catch limits (ACLs) under an acceptable biological catch (ABC) control rule. Results of this work were presented recently at the NMFS National ACL Workshop in February 2011. The approach was well received by scientists and resource managers as a novel method for incorporating biological and economic uncertainty in management decision making. In addition, the new methods are being documented in a manuscript (Punt et al. 2011) for publication in a peer-reviewed journal.

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the overfishing level (OFL) for a stock is defined as the level of harvest which exceeded would constitute overfishing. In reauthorizing the MSA in 2006, Congress specified the ABC as the level of harvest that accounts for scientific uncertainty in the estimate of the OFL and is hence equal to, or lower, than the OFL. The requirement to adjust OFLs to account for scientific uncertainty has proved challenging for the regional fishery management councils, and each has followed a different course. A new paper by Punt et al. outlines the approach developed for crab fisheries in Bering Sea and Aleutian Islands for the NPFMC.

An approach based on simulation is outlined which can be used to evaluate the trade-offs among performance metrics for fisheries management for different "buffers" (i.e., the differences between the target catch level given perfect information and the set catch limit, when only a fraction of the uncertainty related to estimating the target catch level is quantified through stock assessments). Specifically, the performance of different buffers is evaluated in terms of their impact on short- and long-term catches, expected values of economic earnings, the probability of overfishing (i.e., the catch exceeding the true, but unknown, target catch), and the stock becoming overfished (i.e., in the case of crab mature male biomass, MMB, dropping below half of the MMB corresponding to maximum sustainable yield). The paper presents the approach as applied to the fishery for red king crab, *Paralithodes camtschaticus*, in Bristol Bay, Alaska. The application, which formed the basis for NPFMC decision making for this stock, accounts for the complexities induced by joint state-federal management of the fishery and also for catches in fisheries other than the directed male-only pot fishery. The approach is also unique in the application of forecasting methods to account for uncertainty in future market values for crab products as well as in stock condition.

By Brian Garber-Yonts and Michael Dalton

Developing a Multi-regional Computable General Equilibrium Model for Alaska and West Coast Fisheries

Many of the vessels operating in Alaska fisheries are owned and crewed by residents of West Coast states, especially Washington and Oregon. Some of these vessels also tend to participate in West Coast fisheries during the year. Expenditures made by these vessels generate income in port and may also have multiplier and spillover effects in other regions. Assuming that all expenditures are made locally will significantly overestimate economic impacts in a region. Taking account of the regional distribution of expenditures made by Alaska fishing vessels in Alaska, West Coast states and elsewhere will enhance our ability to model the overall economic impacts of Alaska fisheries and West Coast fisheries. The major task under this project is constructing a multi-regional computable general equilibrium model (MRCGE) of the Alaska and West Coast economies with explicit detail of the two regions' fishery sectors. The investigators are using IMPLAN software and data available from the Alaska Department of Labor and Workforce Development to estimate interregional flows of goods, services, and factors of production.

The core of the MRCGE will consist of a CGE model previously developed by the investigators for the Alaska region. Reports produced under that project provide detailed estimates of the interregional distribution of expenditures for intermediate goods and services made by Alaska vessels. These data are being combined with data developed by the Northwest Fisheries Science Center (NWFSC) for the IO-PAC model of West Coast fishery sectors. IO-PAC is an IMPLAN-based regional input-output model that includes detailed, survey-based estimates of expenditures by West Coast fishing vessels. To date, the following tasks have been completed under the project. First, available regional data associated with the Alaska CGE model was assembled in the Alaska Social Accounting Matrix (SAM) for year 2004. This data includes estimates of costs and interregional expenditures made by Alaska fishing vessels and processors for intermediate inputs and labor, and it forms the core of the Alaska portion of the MRCGE model. Second, the investigators prepared the 2006 West Coast (Washington, Oregon, and California) IO-PAC model from the NWFSC. IO-PAC is an IMPLAN-based IO model of the combined three-state West Coast region. Data from IO-PAC was used to generate West Coast SAM that will be used to implement the West Coast portion of the MRCGE model. Third, using IMPLAN v.3, the investigators have estimated the interregional trade flows among Alaska, West Coast, and the rest of the United States (RUS) for the year 2008. Fourth, the non-2004 information (West Coast data and interregional trade flows) have been deflated to 2004 value. Fifth, the investigators have examined previous MRCGE models which were modified to develop equations and GAMS codes for the present MRCGE project. They have developed a three-region CGE model using some hypothetical data. When the actual three-region SAM data is prepared, the hypothetical data will be replaced with the actual data and the model will be recalibrated.

The next steps include 1) constructing RUS SAM; 2) continuing to estimate interregional flows of goods, services, and factors of production; 3) integrating the three individual SAMs to construct a multiregional SAM; and 4) completing development and refinement of the three-region CGE using actual data. The immediate use of the resulting model from this project will be for estimating the regional and interregional economic impacts of Alaska and West Coast fisheries. The model, if used along with Mike Dalton's global GTAP model, will also be able to calculate the impacts on Alaska, the West Coast, and the rest of the world (ROW) of (for example) 1) change in exports of Alaska seafood to ROW and 2) change in ROW demand for Alaska seafood. In the longer run, the multiregional CGE model from the current project will be fully integrated with Mike Dalton's global GTAP model, resulting in a full multiregional, multicountry CGE model, if funding is available.

By Chang Seung, Edward Waters, Mike Dalton, and Jerry Leonard

Status of Stocks & Multispecies Assessment Program

Award Winning Talk Given at the Alaska Marine Science Symposium

Ingrid Spies, a stock assessment scientist and geneticist in the Status of Stocks and Multispecies Assessment (SSMA) Program, won the "Best Student Paper" award at the 2011 Alaska Marine Science Symposium for the presentation "A Landscape Genetics Approach to Pacific cod (*Gadus macrocephalus*) Population Structure in the Bering Sea and Aleutian Islands Reveals Multiple Distinct Populations."

Landscape genetics of Pacific cod (*Gadus macrocephalus*) within the Bering Sea/Aleutian Islands (BSAI) management area of Alaska was examined at nine spawning locations, with one temporal sample, using 17 microsatellite DNA markers. This fine-scaled study of genetic population structure tested the hypothesis that more than one discrete population of Pacific cod exists within the BSAI and examined oceanographic and landscape features that may act as barriers to migration. Samples were taken from spawning fish collected from the western Aleutian Islands east to Unimak Pass and as far north as the Pribilof Island area. The data provide evidence for limited connectivity among spawning groups; in particular, there is strong evidence that a barrier exists at Samalga pass. There is further evidence that within the Bering Sea, the Unimak and Pribilof spawning groups are distinct from each other, and that samples west of Amchitka Pass in the western Aleutians are distinct from those of the eastern Aleutians. Overall, distance between samples is proportional to genetic differentiation between them, but barriers exist within the system and dispersal is not continuous.

By Ingrid Spies and Julie Pearce

How Can Genetics Be Used in Stock Assessment?

Ingrid Spies, SSMA program, is undertaking a project to simulate the consequences and benefits of incorporating genetics into fisheries management. Although genetic population structure has been documented in marine fish species, no clear method exists to translate this information into a meaningful management strategy. This is particularly true when no distinct boundary is present, as in the case of an isolation-by-distance pattern, or a cline in gene frequencies (Fig. 2). In many cases, it is unclear what effect splitting a management area to match population units would have on the future size of the fish populations or on the value of the catch.

Several simulation studies have emphasized the importance of managing at an appropriate spatial scale. In one study, two populations with limited migration were managed as a single stock for 100 years; fishing was spatially biased, carrying capacity varied between the populations, and population persistence was evaluated. Depletion occurred in one of the two populations, regardless of the rate of dispersal or carrying capacity of the two populations. Another study examined the consequences of management areas that encompass many fish populations with limited mobility, differing growth rates, and localized fishing pressure. They found that managing at a biological scale that matched life history parameters resulted in reductions in the probabilities of overfishing and collapse.

Ingrid's project is a simulation study which extends these ideas to an evaluation of the ability of genetic methods to identify stocks. Genetic data associated with a particular type of population structure are simulated, then standard genetic methods are used to determine where a boundary should be drawn between management areas. Population growth and management of the fishery, both as one management area and with management areas as determined by genetic analysis, are then simulated for 100 years. Performance measures such as total catch and population size will be compared under both management scenarios. This project is a work in progress with results expected in 2012.

By Ingrid Spies

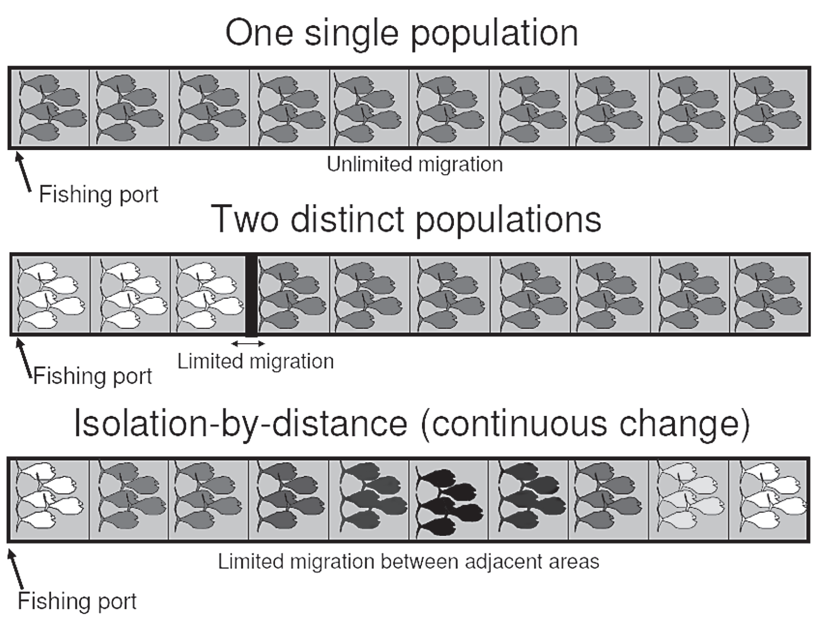


Figure 2. Three types of population structure: one population (upper row), a distinct break resulting in two populations (middle row), and isolation-by-distance/continuous change (lower row). Different shades of grey represent different genetic sub-populations."

Depletion occurred in one of the two populations, regardless of the rate of dispersal or carrying capacity of the two populations.

Rockfish Management and Research Presentation in Dutch Harbor

Paul Spencer gave a public presentation titled "Bering Sea/Aleutian Islands rockfish management and research" at the Forum of Alaska Marine Issues seminar series in Dutch Harbor, Alaska, on 23 February. The presentation covered a variety of topics, including the fundamentals of fishery assessments, unique aspects of rockfish biology including longevity and reproductive biology, historical rockfish management, and current rockfish research projects and management issues. About 20 people attended, including representatives of various community, fishing, and scientific organizations. The presentation was approximately 30 minutes, with a question and answer period of approximately 20 minutes that covered a variety of topics, including rockfish species ranges, habitat use, and management of non-target species.

By Paul Spencer

Chum Salmon Bycatch Analysis

Ecosystem fisheries management, as practiced by the North Pacific Fishery Management Council (NPFMC), involves many facets including measures to avoid exceeding prohibited species catch (PSC) limits. Likewise, another ecosystem principle ensures that catch limits remain below overfishing levels (typically set equal to maximum-sustainable yield levels), based on single-species assessment models for each stock or stock complex. This means that the management system is based explicitly on multispecies considerations. Salmon have been a prohibited species since the days of foreign and joint-venture trawl fishing in the eastern Bering Sea, and management has evolved after two decades of an extensive scientific observer data collection program. These data, supplemented with summer surveys and cooperative research programs, provide unique insights on the temporal and spatial structure of salmon stocks during their oceanic life stage. In particular, patterns of bycatch appear to be affected by season, location, and temperatures. However, year-effects appear to be the largest factor indicating that interannual variability in environmental conditions and run sizes likely play an important role in bycatch. For new, more optimal management measures (such as closure areas), the available data are limited due to the occurrence of past closures.

Presently, NPFMC and AFSC scientists are on track to present management alternatives to reduce chum salmon bycatch. Analyses of these alternatives are being conducted based on a variety of data sources. For example, chum salmon age data (based on examination of growth patterns on their scales), as compiled by colleagues at the Auke Bay Labs (ABL) with funds from the NPFMC, were used to estimate the proportion of bycatch that would have returned in the current or a future year. These estimates can then be combined with genetic analyses to estimate the origins of the chum salmon bycatch. The genetics work was completed by ABL scientists and is being applied to provide a rough idea of the historical impact the pollock groundfish fishery has had on western Alaska salmon returns. Another part of the analysis involves developing time-area closures that can be effective in reducing bycatch. The extensive quantification in space and time of chum salmon bycatch (1991-2010), based on observer data collection programs, provides critical information on the difficulty of the problem. Times and areas vary greatly between years, but they also reveal some consistent patterns that can be applied for management (and to assist industry in ways to avoid bycatch). The analysts note that new regulations designed to reduce bycatch of one species may result in higher bycatch of others. Such complications are highlighted so that the NPFMC will have the information needed to strike an appropriate balance of management measures.

By Jim Ianelli

Age & Growth Program

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 31 March 2011. Total production figures were 5,294 with 1,104 test ages and 92 examined and determined to be unageable.

Species	Specimens Aged
Blackspotted rockfish	23
Great sculpin	149
Greenland turbot	574
Kamchatka flounder	24
Northern rockfish	331
Pacific ocean perch	1,001
Rougheye rockfish	226
Shortraker rockfish	19
Southern rock sole	415
Walleye pollock	2,532

By Jon Short

Otolith Oxygen Isotopes Reveal the Life History of a Yellowfin Sole in the Eastern Bering Sea

Otoliths have been widely used to reconstruct various aspects of fish environmental and biological history in marine and freshwater ecosystems. Specifically, oxygen isotopes ratios ($\delta^{18}O$) in fish otoliths, while dependent on the isotopic composition of the ambient water, are inversely related to seawater temperature and may provide a record of a fish's thermal experience. Yellowfin sole (*Limanda aspera*) is a common flatfish species in the Bering Sea that is known to undertake a gradual offshore ontogenetic migration until maturity, after which it moves seasonally over the continental shelf for the purposes of spawning and feeding. In a feasibility study, otolith oxygen isotope analysis was conducted with an ion microprobe at the University of Wisconsin-Madison's Secondary Ion Mass Spectrometer (WiscSIMS) laboratory to explore the life history of a yellowfin sole in the eastern Bering Sea. The ion microprobe has much finer spatial and temporal sampling resolution than conventional acid digestion/gas-source mass spectrometry, allowing otolith $\delta^{18}O$ measurements to be taken sub-annually.

Values of $\delta^{18}O$ were measured from discrete 10-micron spots along three transects from the otolith core to its edge (Fig. 3). Fish age was estimated by counting growth zones, and calendar year was assigned to each growth zone and all corresponding $\delta^{18}O$ spot analyses. Cyclical variations in $\delta^{18}O$ values in the juvenile portion of the otolith corresponded with the otolith growth-zone banding pattern and were presumably related to seasonal changes in ambient water $\delta^{18}O$ values and temperatures (Fig. 4). The ontogenetic migration from shallow to deeper waters was revealed by increasingly higher $\delta^{18}O$ values from age-0 to approximately age-7, which roughly corresponds to the onset of maturity (Fig. 4). In conclusion, the ion microprobe provided high-resolution (sub-annual) records of relative environmental conditions experienced on an individual level and was consistent with population-level studies of yellowfin sole ontogeny (Fig. 5).

This work was completed in collaboration with Ian Orland, John Valley, and Takayuki Ushikubo (University of Wisconsin-Madison), Bryan Black (Oregon State University), and Thomas Helser (AFSC's Age and Growth (A&G) Program). A future study is being planned to use the ion microprobe as a tool to complement current work by A&G scientist Craig Kastelle on Pacific cod (*Gadus macrocephalus*) age validation. Because of its fine-scale sampling resolution, the microprobe may be able to elucidate seasonal patterns in otolith δ^{18}O better than conventional methods, thereby resolving several currently inconclusive findings.

By Beth Matta

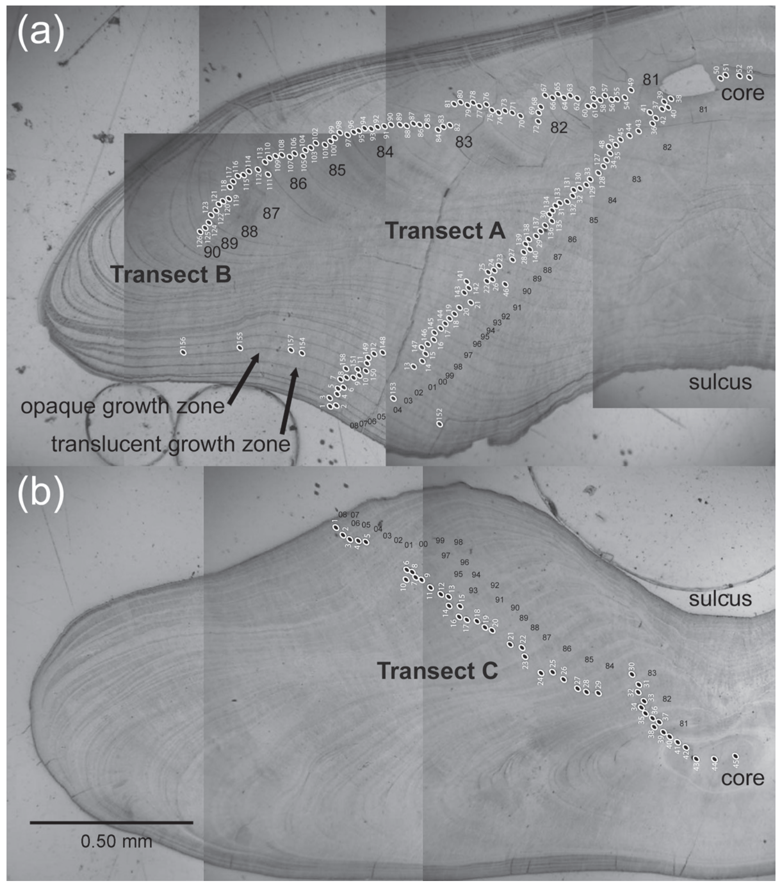


Figure 3. Composite photographs of polished surfaces of (a) roasted and (b) unroasted yellowfin sole otolith cross sections labeled with δ^{18}O spot analysis locations (white numbering) and calendar year assignments (black numbering) for each transect.

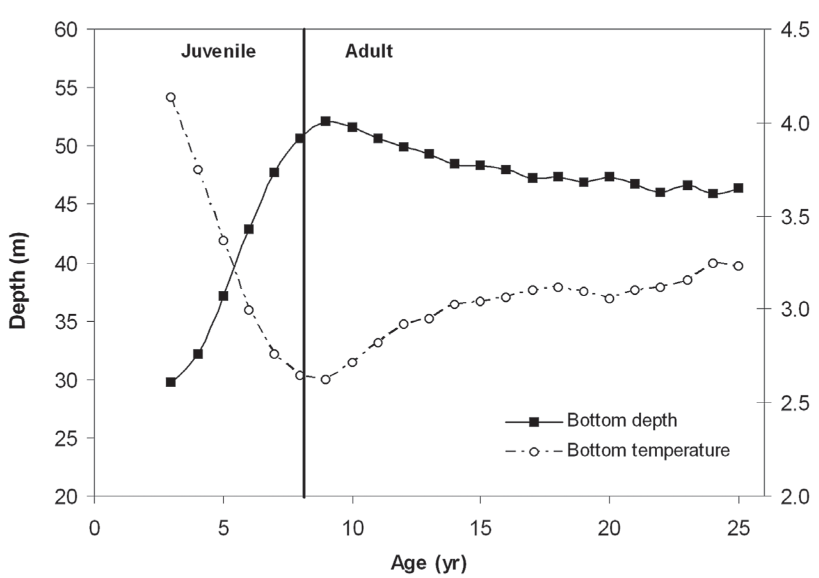


Figure 5. Ontogenetic change in depth and temperature preferences of yellowfin sole. Summer mean bottom depth and bottom temperature (weighted by catch per unit effort, CPUE) occupied by each age class. Data source: National Marine Fisheries Service eastern Bering Sea summer bottom trawl survey, 1982-2008.

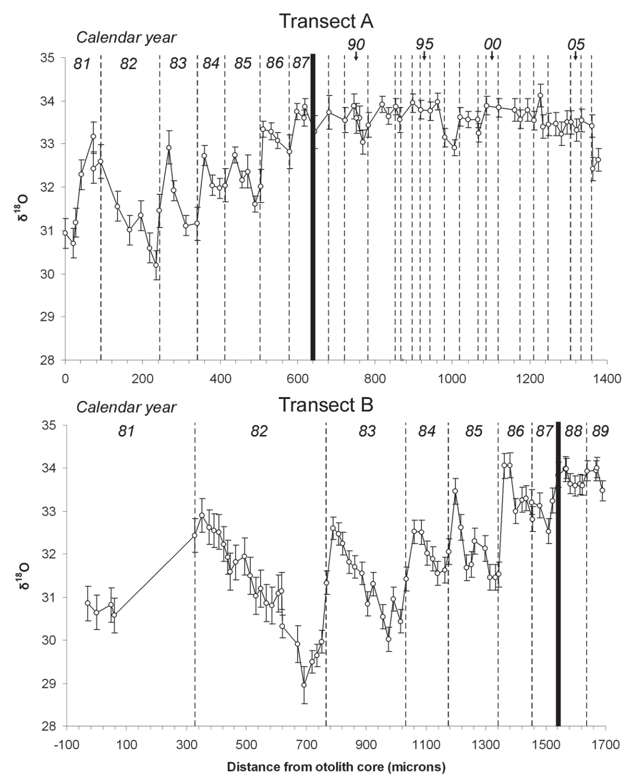


Figure 4. Measurements of δ^{18}O (‰ Vienna Standard Mean Ocean Water, ± 2 standard deviations) made at WiscSIMS from the otolith core to the edge of Transect A (upper panel) and Transect B (lower panel). Solid vertical line indicates approximate transition between juvenile and adult phases (age-7). Dashed vertical lines indicate locations of annual growth zones, with calendar years of formation labeled in italic type (1981-2007).

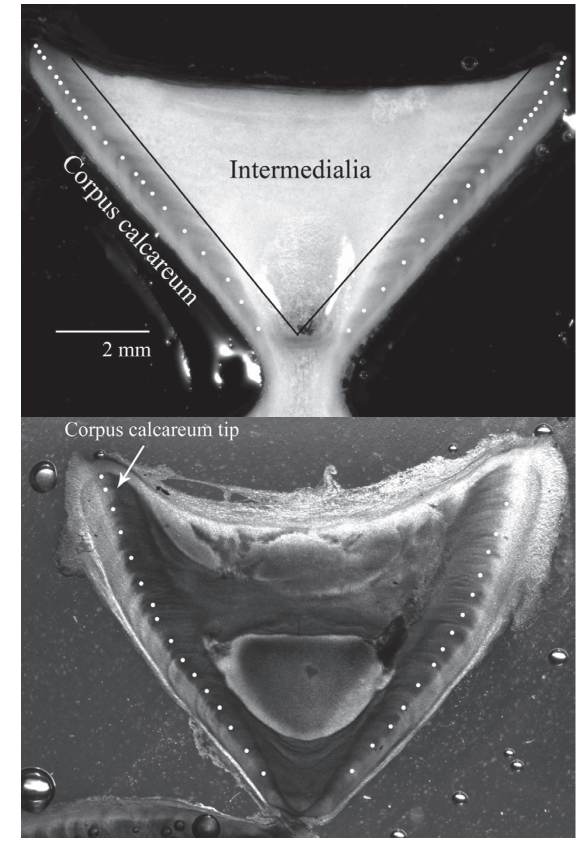


Figure 6. Longnose skate (*Raja rhina*) vertebral thin sections from the same individual prepared using the standard and new method. The unstained specimen (top) was aged at 22 years. The stained specimen (bottom) was aged at 16 years. Increased contrast on corpus calcareum tip of stained specimen may lead to interpretation differences between the two methods.

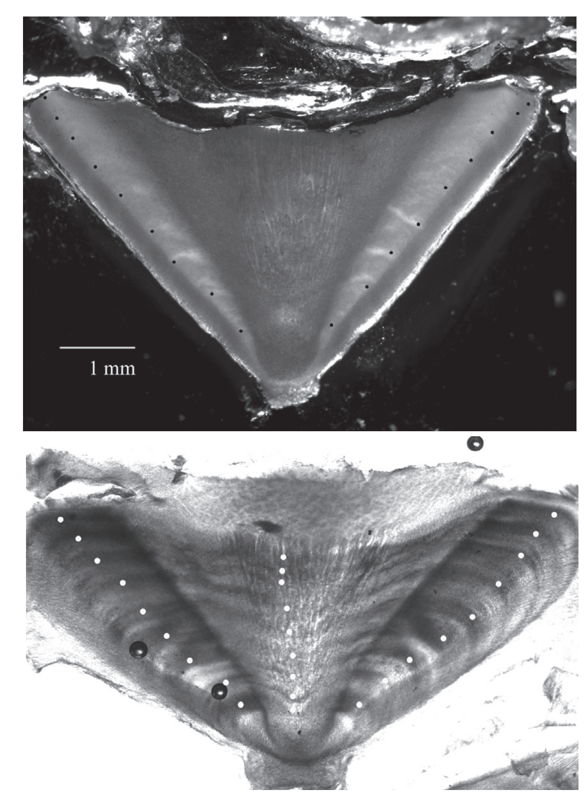


Figure 7. Alaska skate (*Bathyraja parmifera*) vertebral thin sections from the same individual. The unstained specimen (top) was aged at 9 years. The stained specimen (bottom) was aged at 9 years. Contrast has been increased with staining for the entire thin section including the intermedialia and corpus calcarea.

A Pilot Study on the Effectiveness of Hematoxylin Staining for Improved Age Determination of Skate Vertebrae

The A&G Program is currently evaluating a new histological preparation method for age determination using skate vertebrae. The stained-thin-section method was developed and successfully applied to *Malacoraja senta*, an Atlantic skate species, by Lisa Natanson at the Northeast Fisheries Science Center (NEFSC) and later adapted and applied to spiny dogfish (*Squalus acanthias*) by Walter Bubley at the University of New Hampshire (UNH). The A&G Program initiated a pilot study in December 2010 to test this new method on vertebral thin sections from Alaskan skate species (big (*Raja binoculata*), longnose (*R. rhina*), and Alaska (*Bathyraja parmifera*) skates). This study's main objective is to compare ageing interpretations and precision between the unstained (standard) method of thin section preparation and the new method (Figs. 6 and 7).

To date, vertebrae from 33 skates have been prepared using both methods: big (n = 10), longnose (n = 13), and Alaska (n = 10). Two thin sections per individual were removed from vertebrae at a thickness of approximately 0.30 mm using an Isomet™ 5000 linear precision saw. One untreated thin section from each skate was slide-mounted as a control. The other thin section was decalcified with a rapid decalcifier (RDO), stained with Harris hematoxylin, destained with acid-alcohol solution, soaked in glycerin, and slide mounted. Completed thin sections were examined under a dissecting microscope with transmitted light.

A small number of specimens have been aged by two people, a reader and a tester, using both methods. Within a sample of longnose skates collected in 2009 in the Gulf of Alaska, unstained vertebrae (n = 29) yielded a reader-tester percent agreement of 34.5%, with a reader-tester bias of 17:2. A subsample of vertebrae from the 2009 specimens, selected for discrepancies between the reader and tester's age estimates using the standard approach, were stained and evaluated. The stained subsample of longnose skates (n = 13) yielded a reader-tester percent agreement of 23.1%, with a reader-tester bias of 7:3. Observed ages ranged from 1 to 22 years for unstained thin sections and 4 to 17 years for stained thin sections. While bias appears to have improved using the new method, percent agreement decreased; however, due to the small sample size tested thus far, results should not be considered conclusive. Furthermore, the specimens selected for staining already had a high age discrepancy between the reader and tester using the standard approach.

Both reader and tester noted that general specimen clarity and growth-zone contrast improved with staining. Subsequently, this method may improve interpretation while addressing potential inter-reader bias for Alaskan skate species. The staining method may also assist in resolving current ageing criteria differences between North Pacific age determination laboratories. All Alaskan skate species will be further evaluated quantitatively for precision and bias with additional specimens. The development of an active vertebral thin section staining program is ongoing.

By Christopher Gburski