Alaska FISHERIES SCIENCE CENTER

Quarterly Report

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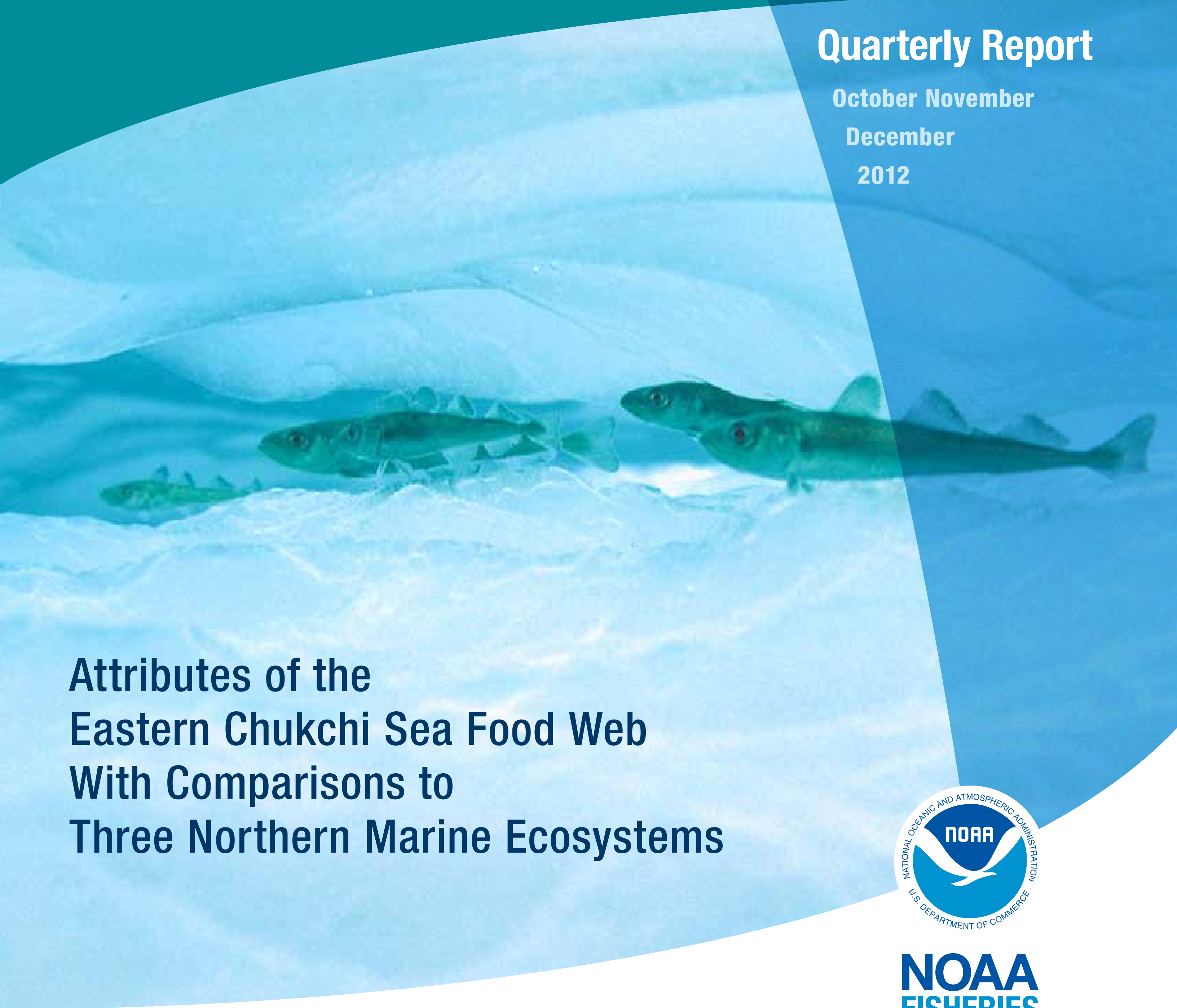

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Cover image Arctic Cod Under Ice

Photo by E. S ddon, UAF, H dden Ocean 2005, NOAA

Attributes of the Eastern Chukchi Sea Food Web With Comparisons to Three Northern Marine Ecosystems

By Andy Whitehouse

There is growing recognition that the Arctic is threatened by multiple human impacts including climate change and increased activities resulting from greater access due to retreating sea ice. Arctic sea ice cover has declined about 3% per decade over the satellite record (1979-present), with the six lowest annual sea ice minima occurring in the last 6 years (2007-12). The Alaska Arctic contains large petroleum reserves, and human activities related to energy extraction are expected to increase in the near future. Further reductions in the extent of Arctic sea ice could improve access for the oil and shipping industries and also has spurred interest in understanding what changes in sea ice coverage could mean for future Arctic fisheries. The Alaska Arctic is presently home to several subsistence fisheries and marine mammal harvests. The development of new commercial fisheries in the Alaska Arctic is currently prohibited by the Arctic Fishery Management Plan until sufficient research has been conducted to allow for adequate evaluation of the ecological impact of commercial fishing. Thus, there is great need for the development of modeling and other decision-support tools that can synthesize existing knowledge of Arctic marine ecosystems and foster an improved understanding of ecosystem structure, function, and sensitivity to human activities.

Food web models describe the organization of a food web and the exchange of material (measured in biomass) between species in a food web through feeding interactions. These models can be used to study the structure and function of ecosystems and produce ecosystem metrics and indicators that can help to identify and clarify ecosystem properties. Scientists with the Alaska Fisheries Science Center's (AFSC) Resource Ecology and Ecosystem Modeling (REEM) program previously developed mass-balance food web models of large marine ecosystems (LME) in Alaska, including the eastern Bering Sea, Gulf of Alaska, and Aleutian Islands. These food web models are updated frequently and are used regularly in fishery management advice in annual Stock Assessment and Fishery Evaluation (SAFE) reports.

Food web models provide a convenient means to evaluate ecosystem structure and function by utilizing existing ecological knowledge to quantify the strength of linkages and interactions between predator and prey groups, including the role of humans in the food web via fisheries and marine mammal harvests. Knowledge of trophic interactions and ecosystem function is an important part of predicting and interpreting an ecosystem's response to expected changes related to climate change, extractive activities such as fishing, or other large mortality events such as an oil spill.

The Chukchi Sea is a seasonally ice-covered, peripheral sea of the western Arctic Ocean. It lies north of the Bering Strait off the northwestern coast of Alaska (Fig. 1). The Chukchi Sea is a broad and shallow continental shelf sea, with most depths less than 60 m and a total area of about 565,000 square kilometers. Ice covers the Chukchi Sea for about 6 to 8 months a year, with ice cover advancing southward beginning in October and retreating northward starting in June. From a management perspective, the Chukchi Sea falls within the territorial waters of the United States and Russia, and is divided approximately in half by the U.S.-Russia maritime boundary.

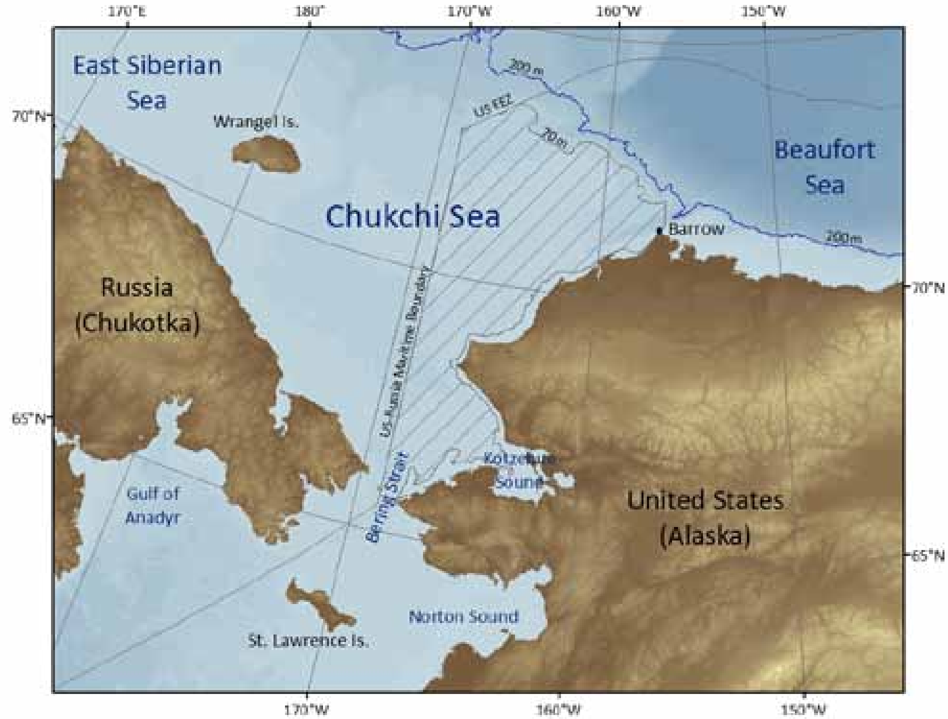

Figure 1. The Chukchi Sea, with the model area filled in with hatched lines. The model area is bounded by the United States-Russia convention line in the west, Pt. Barrow to the east, Bering Strait to the south, and a combination of the 70 m isobath and the U.S. Exclusive Economic Zone (EEZ, 200 mile limit) in the north. Near shore, the model is bounded by the 20 m isobath. The blue contour is the 200 m isobath.

The eastern Chukchi Sea presents a unique opportunity to study the trophic ecology of a large marine ecosystem prior to the development of large-scale commercial fisheries or widespread energy extraction. The purpose of our study was to synthesize available data from published and unpublished sources in the construction of a food web model and to use this model to quantitatively compare the eastern Chukchi Sea to other northern marine ecosystems. The assembly of a preliminary food web model of the eastern Chukchi Sea provides important groundwork for improving our understanding of trophic relationships, produces a baseline for many ecosystem indicators, and provides a means of assessing the ecosystem-wide impacts of the removal of fish species by potential fisheries and possible environmental disturbances related to energy extraction and shipping.

A comparative approach to ecosystem analysis with a common modeling framework has been used previously to highlight similarities and differences in the structure and function of high latitude marine ecosystems. The comparative approach improves our understanding of ecosystem structure and function by revealing a number of contrasts that would otherwise not be apparent when studying a single ecosystem. The use of a common modeling framework improves these comparisons by removing the confounding effects of interpreting different metrics from different models and grants us the ability to make generalizations about ecosystem-scale processes.

In this article we summarize some of the early findings of our mass balance food web model which describes the key attributes of the eastern Chukchi Sea food web. Specifically, we examined the distribution of biomass throughout the food web and sought to identify important prey groups linking production of lower trophic levels to mammals and seabirds. We also evaluated mass flows, which describe the exchange of mass between groups in a food web, mediated by feeding interactions, to describe the relative significance of benthic and pelagic trophic pathways. Using the same food web modeling framework, we then focused on a set of network metrics to draw comparisons with nearby subarctic ecosystems— the eastern Bering Sea and Gulf of Alaska, and a more distant Arctic ecosystem, the Barents Sea.

Methods

Study System

We developed a food web model for the eastern Chukchi Sea continental shelf between the 20- and 70-m isobaths covering approximately 192,000 km^2 (Fig. 1). Waters outside this depth range are beyond the range of existing trawl survey data and may incorporate nearshore or deep-water processes and taxa that are not modeled here. The base time period for the model is the late 1980s and early 1990s, as many of the data needed to parameterize the model were obtained during this time period. Data from other years were included as needed to improve parameter estimates. Temporal and spatial patterns (e.g., migration, primary production) were not explicitly modeled, though where data were available they were taken into consideration when developing model parameters. This is a static mass balance model that presents an annual average snapshot of the food web. The mass-balance assumption is a way of ensuring that the food web model does not represent a configuration where mass loss or mass gains are unaccounted for, such as predator groups with excessively high biomass consuming prey at rates much higher than prey can withstand. The mass-balanced model represents just one of many possible balanced states but the mass-balance assumption assures that the balanced model obeys this basic conservation of mass principle.

Modeling Framework

The eastern Chukchi Sea food web was modeled using Ecopath with Ecosim (EwE) software (www.ecopath.org). Ecopath is a biomass compartment model describing the structure and material flows of a food web. Each compartment represents a model group and is comprised of a single species or suite of species that have similar habitat requirements, diets, and life histories (Fig. 2). Mass balance is achieved by solving a set of linear equations which quantify the exchange of biomass between the compartments in the food web. For each model group the basic model parameters are an estimate of biomass density ($t\ km^{-2}$) in wet weight, the diet composition of predators, fishery removals or subsistence harvests ($t\ km^{-2}$), production rate (yr^{-1}), consumption rate (yr^{-1}), and ecotrophic efficiency. Ecotrophic efficiency is the proportion of a model group's total production that is consumed by predation or removed by fisheries explicitly represented in the model and must have a value less than 1.

Ecopath mass balance is ensured by solving for one unknown parameter for each linear equation. Typically estimates of biomass, production, consumption, diet composition, and any fisheries removals are entered into the model and the equation is solved for ecotrophic efficiency. When reliable input estimates are not available, ecotrophic efficiency can be set equal to an arbitrary value and the equation solved for the missing parameter (usually biomass). Setting ecotrophic efficiency and solving for biomass is referred to as a "top-down balance" because it is estimating prey biomass based on estimated predator demand and fishery removals. Ecotrophic efficiency is difficult to accurately measure in nature, but is generally thought to be close

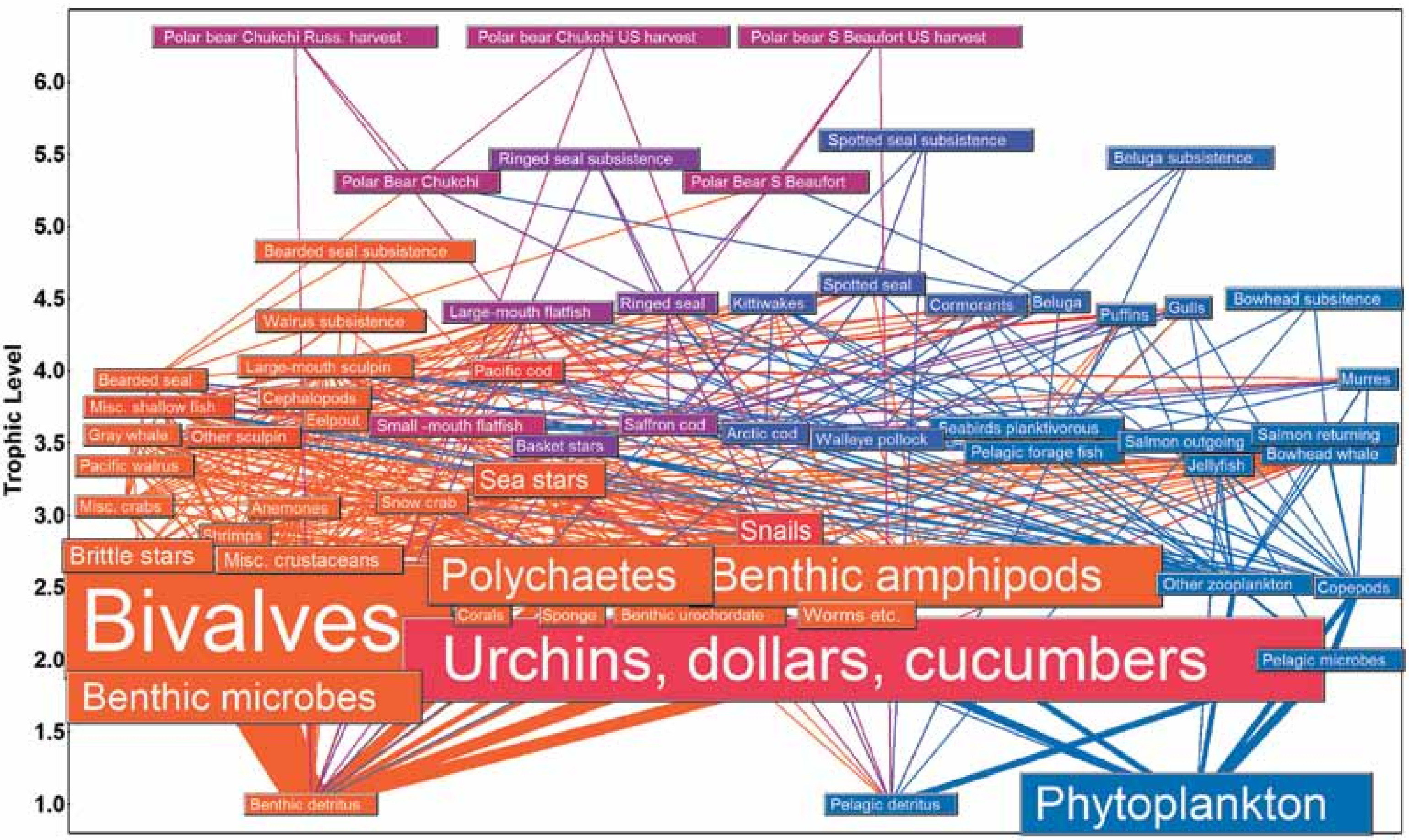

Figure 2. Visualization of the eastern Chukchi Sea food web. Each box represents a functional group and the boxes are arranged vertically by their approximate trophic level. The size of the box is roughly proportional to the biomass of the group and the width of the lines represents the magnitude of flows between the groups. Groups highlighted in blue have a pelagic orientation, while groups highlighted in red have a benthic orientation, with varying shades in between.

to 1 for groups subject to predation and exploitation and closer to 0 for top predators who experience little predation or exploitation.

The development of a mass-balance food web model and the necessary parameters for each functional group requires the synthesis of a large body of literature. Our model includes 54 functional groups consisting of 52 living groups and 2 detrital compartments. Additionally, 9 fishing and subsistence harvest groups were identified and parameterized separately. Many model parameters can be taken directly from the literature, while others require adjustment in order to accommodate the spatial and temporal restrictions of the model. Still other parameters may need to be calculated following empirical relationships. Our preferred method in this study was to obtain parameter estimates directly or calculate them from literature sources and unpublished reports. When parameter estimates were unavailable in the literature, they were obtained from other food web models or were computed following published empirical relationships. The full model and a detailed description of all model parameters can be found in Whitehouse (2011).

The relative strength of benthic and pelagic pathways was evaluated by examining the amount of total system throughput that is attributed to benthic- or pelagic-oriented functional groups. Total system throughput (TST) is a sum of total mass flows within the food web (t km^{-2} yr^{-1}) for consumption, respiration, flow to detritus, and export. Total consumption is the total food intake by a predator. Respiration flow is calculated as the fraction of assimilated food that does not lead to production. The flow to detritus from each group is a combination of the unassimilated portion of food that is egested and the portion of the group that is lost to other sources of mortality outside of the predation and fisheries mortality explicitly included in the model.

Fish occupy a central position in the food web connecting production on lower trophic levels to upper level piscivores and are potentially susceptible to future fishery exploitation. We examined the consumption of fish by mammals and seabirds in an effort to identify key fish prey species/functional groups. The total consumption of each fish group was summed across all piscivorous mammals and seabirds, yielding the total consumption of each prey by this collection of predators.

Table 1. Aggregate functional groups used in the comparative analyses of the four modeled food webs.

Aggregated functional groups
Phytoplankton
Microbes
Zooplankton
Jellyfish
Shrimp
Benthos
Snow crab
Arctic cod or walleye pollock*
Pelagic forage fish
Demersal fish
Seabirds
Baleen whales
Toothed whales
Polar bears and seals
Detritus

*The eastern Chukchi Sea and Barents Sea have an Arctic cod group and no walleye pollock group, while the eastern Bering Sea and Gulf of Alaska both have a walleye pollock group and no Arctic cod group.

Model comparisons

We compared our mass balance trophic model of the eastern Chukchi Sea to existing models of the nearby subarctic eastern Bering Sea, Gulf of Alaska, and to another polar system, the Barents Sea, to highlight similarities and identify differences in ecosystem structure and function. The basic model properties of these additional models are briefly reviewed. Each of the models presents an annual snapshot of its respective system during a similar base time period. For the eastern Bering Sea and Gulf of Alaska models, the base time period is 1990-94 and for the Barents Sea it is 1995. Initially, all the models had different numbers of functional groups, ranging from 149 in the eastern Bering Sea to 47 in the Barents Sea. Because differences in the level of trophic aggregation can make comparisons difficult to interpret and may confound some system indices, we aggregated all models to a common set of 15 functional groups (Table 1).

We computed system level metrics that describe total ecosystem production and biomass, enabling cross-ecosystem comparisons between the eastern Chukchi Sea and the selected ecosystems. Total ecosystem production is the sum of production (t km^{-2} yr^{-1}) from all functional groups, and total biomass density was calculated as the sum of biomass density estimates (t km^{-2}) of all functional groups (excluding detritus). Additionally, we calculated the ratio of total system production to total biomass density (P/B).

Results and Discussion

Model balancing

The primary diagnostic tool used to balance the eastern Chukchi Sea model was to identify groups with ecotrophic efficiency values greater than 1, which implies that the loss rates of these groups exceeded production rates. Eight of the 13 fish functional groups had ecotrophic efficiencies greater than 1 with the initial input parameter estimates. The initial estimates of biomass density for fish groups were calculated from the catch data of a single bottom trawl survey conducted in the northeastern Chukchi Sea during the summer of 1990. After re-examining the model parameters for all the fish groups, we concluded that the primary cause of this misbalance was underestimation of fish biomass in the trawl survey data. We therefore used a top-down balance approach, assuming an ecotrophic efficiency of 0.8 and estimated biomass for these groups. An ecotrophic efficiency of 0.8 implies the model explains 80% of the mortality of these groups via consumption by predators or fishery removals. As there are no large-scale fisheries targeting these fish groups we assume the model captures most of their mortality through consumption by predators. Other sources of mortality not explicitly represented in the model include disease, starvation, senescence, and possible outmigration. This non-predation mortality is not generally measurable; a uniform percentage of 20% for this other "unexplained" mortality allows a standardized analysis and is generally consistent with dynamic fits of unexplained mortality across a range of species. The top-down balance produced estimates of biomass density that were markedly larger than the survey-derived estimates (Fig. 3). The top-down balance results suggest that, based on the consumptive demands of predators, there are more fish present in this system than the survey-derived estimates indicate. The underestimation of the survey estimates may reflect low catchability of some groups to bottom-trawl gear, spatial limitations of survey coverage, patchy fish distribution, and high interannual variation in fish abundance. For example, Arctic cod were likely undersampled by the bottom trawl gear as they may be found in pelagic habitats in ice-free waters and also in association with sea ice in ice covered areas.

Fish have not been abundant in previous demersal trawl surveys of the eastern Chukchi Sea, but when present have been dominated by gadids. In particular, Arctic cod has been consistently identified as the most abundant fish species in the eastern Chukchi Sea, and it is identified as a species of potential commercial importance in the Arctic Fishery Management Plan. Arctic cod primarily prey on zooplankton and represent an important trophic pathway for pelagic predators. They were the primary fish prey of marine mammals and seabirds in the present food web model, accounting for nearly 46% of all consumed fish (Fig. 4). As modeled here, seabirds and marine mammals consume about 75% of total Arctic cod production. Ecological studies of the Beaufort Sea and Canadian High Arctic have indicated Arctic cod are similarly abundant and are of central importance in the transfer of energy from lower trophic levels to top predators including seabirds and marine mammals.

Model outputs

In the eastern Chukchi Sea food web, the total biomass flows (TST) amongst consumer groups (trophic level > 2) were dominated by benthic invertebrates. The dominant mass flows were concentrated near the bottom of the food web and were primarily the result of productive phytoplankton and microbial groups combined with a sizeable detrital pool. Because these mass flows dominate and obscure those occurring at higher trophic levels, we separately assessed the magnitude of trophic flows among consumer groups (trophic level > 2). When phytoplankton, microbes, and detritus are excluded, pelagic groups such as copepods and other zooplankton represent about 3.6% of the total system throughput, while benthic invertebrate groups account for approximately 94.5% (Fig. 5), emphasizing the dominance of the benthic trophic pathway. This is consistent with the distribution of biomass in this ecosystem as well. Benthic invertebrates collectively account for 81% of the total system biomass, while copepods, other zooplankton, and jellyfish together represent 1.1% of total biomass. Fish biomass and throughput was much less than that of benthic invertebrates. All fish groups combined accounted for 0.2% of total system throughput and only 1.1% of total system biomass.

Model comparisons

The system-level metrics revealed differences between the eastern Chukchi Sea and the other selected ecosystems. The eastern Chukchi Sea and eastern Bering Sea were nearly equal in terms of biomass density, while the Barents Sea had only a third of the biomass density of the eastern Chukchi Sea (Table 2). A similar relationship was observed in total production, with the eastern Chukchi Sea again having only half that of the eastern Bering Sea, but the eastern Chukchi Sea having more than 1.5 times the production observed in the Barents Sea. The subarctic Gulf of Alaska had the second highest total production. The production in all four study systems was dominated by production of phytoplankton and microbes, which together accounted for more than 75% of the total production in all systems.

Table 2. Summary of network metrics calculated by EwE along with the ratio of total production to total biomass (ECS=eastern Chukchi Sea, EBS=eastern Bering Sea, GOA=Gulf of Alaska, BAR=Barents Sea). See text for system metric definitions.

System metric	ECS	EBS	GOA	BAR
Sum of all production (t km^{-2} yr^{-1})	3,578.06	7,935.91	5,573.88	1,921.29
Total biomass (excluding detritus) (t km^{-2})	355.43	363.24	214.11	118.95
Total production/total biomass (P/B)	10.07	21.85	26.03	16.15

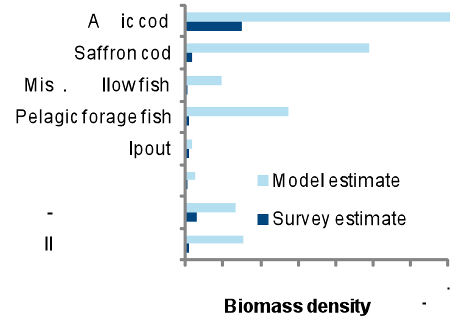

Figure 3. Biomass density estimates (t km^{-2}) of fish from the eastern Chukchi Sea. The survey estimates are derived from a 1990 bottom-trawl survey of the northeastern Chukchi Sea and the top-down estimates are from our Ecopath model, assuming an ecotrophic efficiency of 0.8. The large-mouth flatfish, walleye pollock, Pacific cod, salmon returning, and salmon outgoing groups are not included in this figure as the Ecopath model was not used to estimate their biomass density.

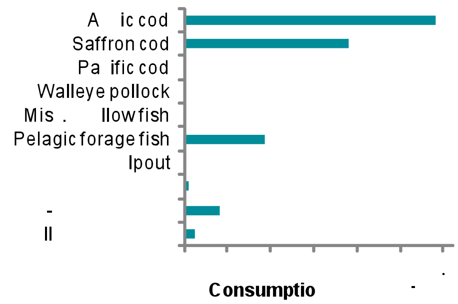

Figure 4. The estimated consumption (t km^{-2} yr^{-1}) of fish functional groups by seabirds and piscivorous mammals in the eastern Chukchi Sea.

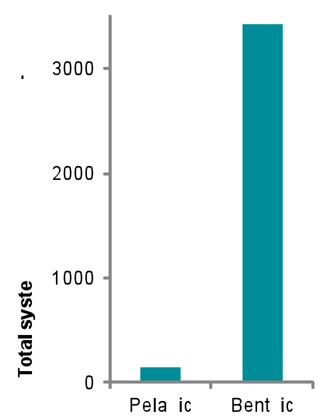

Figure 5. The distribution of total system throughput (t km^{-2} yr^{-1}) between pelagic and benthic oriented consumer groups in the eastern Chukchi Sea. Phytoplankton, microbes, and detritus are excluded from this figure. Total system throughput is a measure of mass flow between groups in a food web.

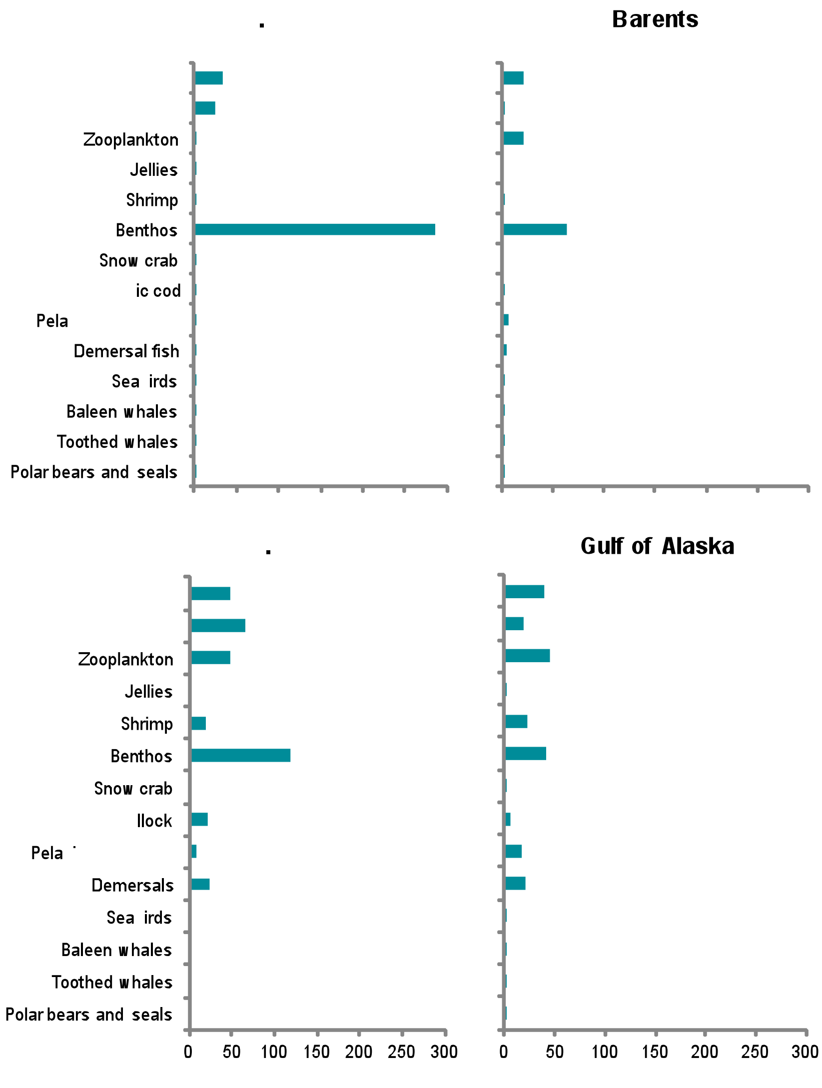

Figure 6. The biomass density of all living functional groups in the four modeled ecosystems.

Using the common set of aggregated functional groups, we examined structural differences among ecosystems in terms of the distribution of biomass density. In both polar systems the benthos comprised the majority of total system biomass (Fig. 6). This was especially pronounced in the eastern Chukchi Sea where the benthos comprised 81% of the total biomass. The benthos accounted for 54% of the Barents Sea total biomass, and only 33% and 19% in the eastern Bering Sea and Gulf of Alaska, respectively. Fish account for the smallest proportion of biomass in the two polar systems, representing only 1.1% of total biomass in the eastern Chukchi Sea and 9% in the Barents Sea, while in the subarctic systems fish comprised 15% of total biomass in the eastern Bering Sea and 20% in the Gulf of Alaska.

These comparisons bring attention to the dominant role of the benthos in food web structure and energy processing in the eastern Chukchi Sea. This is a structural and functional distinction between the Arctic and subarctic systems modeled here. Both subarctic systems have a much more even distribution of biomass between benthos, zooplankton, and fish. In the two Arctic systems, the high benthic component is in part attributed to tight pelagic-benthic coupling, where low grazing rates on phytoplankton by zooplankton, combined with shallow shelves, permit much of the primary production to eventually settle to the seafloor where it becomes available to support the benthos. Numerous ecological studies conducted over the last 50 years in the eastern Chukchi Sea have documented a diverse and abundant community of benthic invertebrates. The abundant benthos is an important prey resource for benthic-foraging marine mammals, such as bearded seals, Pacific walrus, gray whales, and for seabirds.

Future food web modeling studies could also help address questions about the fragility and resilience of the eastern Chukchi Sea food web and its sensitivity to human activities.

Comparison of the network metrics highlights distinctions that lead to the eastern Chukchi Sea having the lowest total production/biomass (P/B) ratio of the systems examined (Table 2). Both Arctic systems had lower P/B ratios than the subarctic systems. This is largely due to much higher levels of primary production in the subarctic systems, but is also augmented by higher production from zooplankton, fish, and shrimp groups. Total production in the eastern Chukchi Sea is diminished by the less productive benthos. In contrast to the eastern Chukchi Sea, the P/B of the nearby eastern Bering Sea was about double that of the eastern Chukchi Sea. In practical terms, this characteristic implies that the eastern Chukchi Sea is fundamentally different from the adjacent eastern Bering Sea – they have roughly comparable total biomass density but the total production of the Chukchi Sea is 45% that of the eastern Bering Sea. Thus, the standing biomass in the Chukchi Sea is not expected to be highly resilient to commercial fishing or other high-mortality events such as that which might be expected following a large-scale oil spill. Further research into the production of species/functional groups and their response to extraction or disturbance could be useful for evaluating the impact of future fisheries on the food web and predicting response to potential environmental disturbances related to energy extraction.

Future work

Our mass balance food web model of the eastern Chukchi Sea provides a general description of food web structure and function. Future updates to model parameters would not only improve its accuracy but would also affect the system metrics as well. Recently, the AFSC partnered with other federal and state agencies to conduct an integrated ecosystem assessment of the northern Bering and Chukchi Seas. As this assessment progresses and new data on the abundance, distribution, diet, and life histories of marine organisms becomes available, we intend to produce an updated version of our model, detailing the current state of the eastern Chukchi Sea food web. Future food web modeling studies could also help address questions about the fragility and resilience of the eastern Chukchi Sea food web and its sensitivity to human activities. Future food web studies employing dynamic simulations, can examine potential stressors, such as fishing and energy extraction, individually to explore the possible range of food web responses, and they can be modeled simultaneously to identify any interactive effects of multiple stressors occurring simultaneously. The present model represents just one of many possible mass balanced states and could be improved with updated parameters and more precise data specific to the study area. A number of assumptions and parameter adjustments were required to achieve mass balance, but despite these limitations this model provides an instructive broad-scale view of the structure and function of the eastern Chukchi Sea ecosystem.

Looking southward from high over the Arctic Ocean, NASA's Aqua satellite reveals coastal phytoplankton blooms in the Chukchi Sea along northern Alaska (foreground) stretching into the Bering Strait in September 2006. Credit: NASA

Additional Reading

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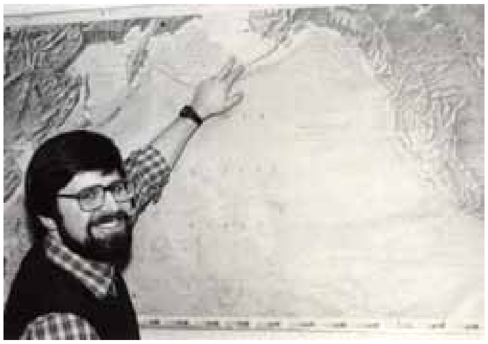


Top. Russ Nelson......
Bottom. Chuck Fowler and NMML Deputy Director Robyn Angliss.
Right. AFSC Retirees on 31 December 2012 in front of Favorite Channel, Juneau, Alaska. Left to right: Scott Johnson, Bill Heard, Pat Harris, Dave Clausen, Frank Thrower, John Thedinga.

More Than 500 Years of Federal Service!

Sixteen staff from the Alaska Fisheries Science Center (AFSC) retired between August 2012 and January 2013. The group includes program and division directors, research fishery biologists, IT specialists, a zoologist, and a program analyst, who together have contributed to the NOAA mission, and the Center's mission particularly, for more than 500 years. Their individual contributions have made, in part, the Center what it is today – one of the most productive and most respected marine research institutions in the world. Each has worked for the federal government for at least 20 years – and one for 52! Those years in public service reflect well on the Center workplace and are a testimony to the dedication of our staff.

On behalf of the AFSC Directorate and all Center staff, I wish each of our recent retirees well on their next phase of life. It has been a privilege to work with you. As a team we have accomplished much, put up with a great deal, and worked hard towards contributing to science, service, and stewardship within the NOAA Fisheries family.

Doug DeMaster
Science and Research Director
Alaska Region, NOAA Fisheries

Bill Heard

Supervisory Research Fishery Biologist, (ABL)
52 years of federal service

Bill Heard ended his remarkable career at Auke Bay Laboratories on 31 December 2012 with 52 years of federal service. Bill's career is remarkable not only for its longevity but also for its many positive impacts on fisheries in Alaska. In fact, almost no scientific career so fully mirrors the evolution of U.S. federal fisheries research as Bill's, beginning with his broad assortment of basic biological field studies in the freshwaters of Alaska under the Bureau of Commercial Fisheries to the NOAA Fisheries' management-focused ecosystem-level studies in the international waters of the North Pacific.

Over the span of more than five decades in fishery science, Bill played a pre-eminent role in developing our understandings of salmon biology, aquaculture, and ocean ecology in Alaska and the North Pacific Ocean. His sustained excellence in scientific achievement is illustrated by his contributions over four periods: the founding of the Alaskan salmon aquaculture industry (1961– 73); the ratification of the Pacific Salmon Treaty (1973– 85); the publication of the definitive work on life history of pink salmon (1991); and the series of annual pink salmon harvest forecasts in Southeast Alaska (1999 – 2012).

Founding of the Alaskan salmon aquaculture industry (1961–74)

Bill recognized early in his career that not all Pacific salmon species are abundant in all areas of Alaska and that annual abundances fluctuated widely. While Southeast Alaska (an area the size of California) often has an abundance of the relatively low-priced pink salmon, it has few sources of the more highly-valued coho and Chinook salmon, which are so prized by commercial and sports fishers. The pioneering aquaculture research conducted by Bill and his associates at NOAA's Little Port Walter (LPW) research facility was so successful that it resulted in the production of commercial quantities of coho salmon and was a key factor in the 1974 decision of the Alaska State Legislature to authorize the private nonprofit (PNP) aquaculture industry to conduct ocean ranching of salmon. The enormous positive economic impact of the PNP industries in Alaska today is exemplified by the year 2008 when PNP operations in Southeast Alaska generated a total economic output of $233 million, including 821 jobs with a $39 million payroll.

Ratification of the Pacific Salmon Treaty (1974 – 85)

Negotiations for the international treaty between the United States and Canada on the conservation, equitable harvest sharing, and enhancement of Pacific salmon were stymied for years not only by U.S.-Canadian differences, but also by opposing interests of Alaska and those of the rest of the salmon-producing United States. Because relatively few Chinook salmon were locally produced in southeastern Alaska, Bill and state scientists conducted research at LPW on the feasibility of using aquaculture to increase Alaskan Chinook salmon production. The success of the LPW research in developing brood lines based on Alaska stocks allowed negotiators to seal a deal in which reductions in Alaska's harvest of migratory Chinook would be substantially offset by increases in production of Alaskan Chinook, thereby removing one of the major road blocks to ratification. The Pacific Salmon Treaty was ratified in 1985, and it continues to be the ultimate management forum for preventing overharvest of North American Chinook salmon.

Life history of pink salmon (1991)

In another honor, Bill was selected by his colleagues to write the chapter on pink salmon in the definitive 1991 book Pacific Salmon Life Histories, published by University of British Columbia Press.

Annual forecast of pink salmon harvest (1999 – 2012)

Bill's understanding of pink salmon biology led to a breakthrough in forecasting annual harvests to the benefit of the salmon fishing industries in Alaska. Prior to 2004, forecasts of annual harvest were made by a standard stock-recruitment model that relied on knowledge of abundance of spawners. That model lacked the level of precision desired by industry and fishery managers for pre-season planning because early marine survival normally controls year-class strength in pink salmon, independent of spawning stock size. Bill and his team launched an investigation in 1999 into the relation between early marine pink salmon stock size and subsequent harvest. From 2004 to 2012 Auke Bay Lab's forecast estimates deviated from the actual harvests by an average of 7% with only one exception. The 2006 forecast was more than twice the actual harvest, serving as a reminder that later marine survival can sometimes determine year-class strength.

The staff at the Center and Auke Bay Labs wish Bill the very best in his retirement.

By Phil Mundy

Jeep Rice

Research Fishery Biologist, (ABL)
41 years of federal service

Dr. Stanley Rice, known to all as "Jeep," retired as Program Manager of Habitat and Marine Chemistry at the Center's Auke Bay Laboratories on 5 November 2012. During a federal career spanning more than 40 years, Jeep's tireless efforts to understand the long-term fate and biological effects of oil in the marine environment led the way in positioning NOAA as the premier scientific voice in habitat impacts of oil.

Jeep's many publications (more than150) have greatly added to our understanding of the long-term ecological implications of both oil spills and chronic oil pollution. The discovery of the extent to which very low concentrations (ppb) of oil in the environment could damage the productivity of marine organisms and compromise their habitats culminated, after a decade of further research, in a paradigm-shifting publication in *Science* (2003).

For 5 years following the 1989 *Exxon Valdez* oil spill, Jeep's team traced persistent oil to the sediments of river mouths, shorelines, and estuaries. Using a combination of field work, hydrocarbon finger printing, and painstaking laboratory and field experiments, Jeep's work established that concentrations of oil an order of magnitude below the then existing EPA standards had the ability to compromise survival, growth, and reproductive capacity in pink salmon. These findings published in the scientific literature were built upon by other scientists to extend to seabirds, marine mammals, and the intertidal biota, resulting in a major paradigm shift in the scientific view of oil spills and chronic pollution, disrupting the previous understanding that chronic low-level oil contamination following a spill posed no biological threats.

The finding that oil (once allowed to make landfall) could persist and cause environmental damage for decades was applied to minimize environmental damages during the 2010 Deepwater Horizon oil spill. Jeep was among the first scientists to be consulted by command after that spill. His advice to focus efforts on preventing landfall helped command to decide to launch efforts on dispersants and booms, significantly limiting damage to the U.S. Gulf of Mexico coastline.

Beyond the arena of catastrophic oil spills, Jeep's findings have been applied by scientists in the management of very low levels of hydrocarbon pollution and the protection of ecosystems in urban estuaries. For example, Jeep's team's findings led to more stringent water quality standards for hydrocarbons in fish spawning habitats. His findings also led NMFS investigators to focus on hydrocarbons as causative agents for declines in fish populations in Puget Sound, Washington, where prior investigations had discounted the possibility of hydrocarbons as causative agents. This work resulted in changing the basic EPA methods for establishing maximum permissible loading of hydrocarbons in the aquatic environment. The findings also had an impact on oil spill contingency planning where proactive measures such as double-hulled tankers and altered shipping routes have appeared in plans that once focused solely on cleanup technologies.

Jeep's leadership and his habit of "speaking truth to power" will be missed, but he leaves behind a team of scientists who are capable of picking up where he left off. His retirement leaves the AFSC and ABL with a legacy of science and administration of science of which anyone would be proud.

By Phil Mundy

Brenda Shiraki, center right, with her OFIS colleagues .

Brenda Shiraki

Information Technology Specialist, (OFIS)
38 years of federal service

Brenda Shiraki retired from the Office of Fisheries Information Systems (OFIS) at the Alaska Fisheries Science Center in August 2012 with 38 years of federal service.

Brenda was hired as a Computer Specialist with the Center by the then OFIS Director, Ted Rodgers, in August 1992 and saw many technological changes and advances during her career—from mainframe computing to server/client architecture, distributed computing, and to today's cloud computing technologies. She joined the OFIS staff just as the computer mainframe (Burroughs B7800)/terminal environment was coming to an end at the Center and the Unix-server/client (SGI IRIX server/desktop PC) environment had just begun. In her early years with OFIS, Brenda spent time troubleshooting and resolving PC hardware problems. At the close of her career Brenda managed the AFSC Help Desk and supported the LANDesk PC management software.

Prior to joining the AFSC, Brenda was in the Air Force and a Lieutenant Colonel in the Air Force Reserves. She worked as a Computer Specialist at the Information Center, Fort Shaftner, Hawaii, and as a lab manager for the Department of Pathology, Tripler Army Medical Center, Hawaii. Her colleagues at the Center wish her all the best in retirement.

By Frank Kikuchi.

RACE Division Director Russ Nelson (right) with Center Deputy Director Steve Ignell.

Russ Nelson

Supervisory Research Fishery Biologist, (RACE)
36 years of federal service

Russ Nelson, Director of the Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division, retired in January 2013 with 36 years of federal service. For the many of us who have worked with Russ during the course of those years, three words come to mind when reflecting upon his rich and lasting legacy at the Center.

The first word is *generosity*. Russ's door was always open to all of us despite our position or concern. He was generous with his time and counsel and gracious in his relationships, displaying the rare ability to empathize with the needs and perspective of all parts and people that make up the Center. The second word is *excellence*— excellence in all things administrative, scientific, and managerial. (We've coined a term "WWRD" (what would Russ do?) that we have applied throughout the years and will continue to do so in his absence.) The third is *teamwork*. Russ has been the consummate team player on the Center leadership team, with the unusual ability to represent the RACE Division, yet keep an eye towards the larger picture of the Center as a whole. To borrow a basketball concept, Russ has been in many ways like the most valuable player, adding to his own excellence with the ability to make everyone better around him.

Russ began his career with the National Marine Fisheries Service as a fishery research biologist with the Northwest and Alaska Fisheries Center's Foreign Fishery Observer Program after completing a graduate degree in fisheries at the University of Washington in 1977. In 1982 he was appointed program manager of the Observer Program. In that position he led the implementation of 100% observer coverage of the foreign fishing fleet beginning in 1983, observer coverage of high-seas driftnet fisheries, and worked with the North Pacific Fishery Management Council and the fishing industry on the development and implementation of the current North Pacific Domestic Observer Program for Alaska groundfish fisheries.

Russ was appointed Division Deputy Director of the RACE Division in 1993 where he worked closely with other offices within NOAA, the fishing industry, academic institutions, and state fishery agencies towards establishing and advancing a broad array of research and survey efforts on Alaskan groundfish and crab. Under his leadership, the RACE Division has conducted a multitude of stock assessment surveys and research cruises on both NOAA ships and chartered commercial fishing vessels. Russ worked closely with the Alaskan fishing industry in the chartering of vessels and on cooperative research projects with industry and with NOAA's Marine and Aviation Operations to schedule cruise time on NOAA ships.

Russ took over as RACE Division Director in 2006, directing a program of over 120 staff that comprised fishery and oceanography research scientists, geneticists, pathobiologists, technicians, IT specialists, fishery equipment specialists, administrative support staff, and contract research associates located in Seattle, Washington, Kodiak, Alaska, and in Newport, Oregon. Under Russ' oversight, this diverse group conducted world-class quantitative fishery surveys and related ecological and oceanographic research directed at commercially and ecologically important fish and crab stocks in the eastern Bering Sea, Aleutian Islands, Gulf of Alaska, and more recently the Arctic, and cooperative research efforts to investigate technologies and techniques to reduce bycatch, bycatch mortality and the effects of fishing on habitat.

Throughout this impressive career, Russ has served as a superb mentor, showing us the way not only in the excellence of scientific leadership and management, but also in the more fundamental aspects of being a genuinely "good person." While a new term is evolving here—-"WWWDWR" (what will we do without Russ?)—we are comforted that his legacy will remain in the Center workplace for many years to come.

By Steve Ignell, Guy Fleisher, and Susan Calderón.

Chuck Fowler

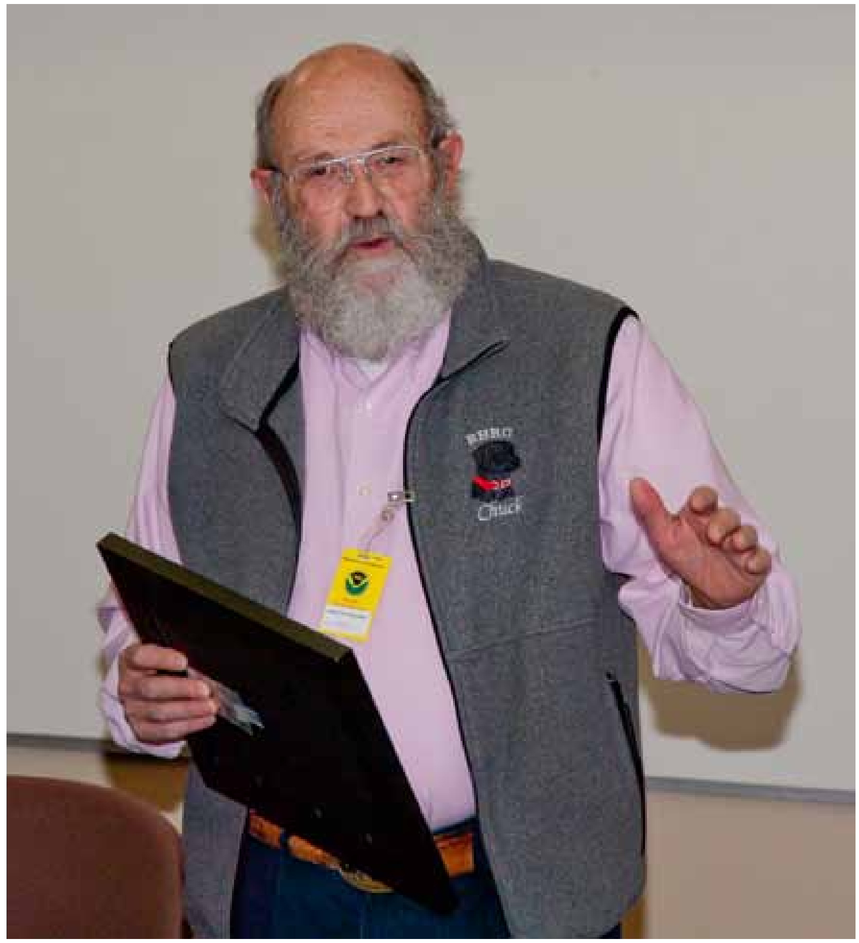
Research Fishery Biologist, (NMML)
35 years of federal service

Chuck Fowler retired in December 2012 after 35 years of federal service. Chuck has made substantial contributions to science during his career, including more than 140 scientific publications. After spending much of his career studying ecosystems, he began challenging conventional ecosystem management and proposed systemic management as a holistic, consistent, and objective means of finding sustainability.

Chuck earned his Ph.D. at the University of Washington in the Center for Quantitative Science in Forestry, Fisheries and Wildlife and spent 6 years on the faculty at Utah State University in the Department of Wildlife Sciences studying population dynamics and stream ecosystems. He began his career with the National Marine Fisheries Service (NMFS) as a population dynamics expert at the Northwest and Alaska Fisheries Center's National Marine Mammal Laboratory (NMML) in 1979 and was hired to conduct research on northern fur seals on the Pribilof Islands, Alaska. In 1980, he was appointed manager of the Fur Seal Research Program and in 1981 began serving as the chief U.S. scientific representative to the North Pacific Fur Seal Commission. On numerous occasions he also participated in the International Whaling Commission's scientific committee. He became manager of the Ecosystem Ecology and Assessment Program in 1988 and led this program until 1999. During this time, Chuck promoted awareness of marine pollution and spearheaded efforts to study the effects of marine debris and entanglement on northern fur seals. Chuck continued field studies of northern fur seal population dynamics on the Pribilof Islands through 2006.

Much of Chuck's early research centered on large mammal population dynamics, with a particular focus on density-dependent regulation. His 1981 book, co-edited with Tim Smith, *Dynamics of Large Mammal Populations*, was the first to synthesize the state of knowledge on the subject and has since become a classic. Chuck has always been a big-scale thinker, so even while focused on population level dynamics and ecology, he discerned higher-level patterns. One of these, related to life history and published in the journal *Evolutionary Ecology* in 1988, became known as Fowler's rule. His seminal 1982 paper in *American Naturalist*, co-authored with Jim McMahon ("Selective extinction and speciation: their influence on the structure and functioning of communities and ecosystems") was an early expression of ideas that would ultimately become the focus of Chuck's latter years with NMFS.

In 1999, Chuck began to focus specifically on providing empirical information on the limits to natural



variation for use in guiding management by defining and finding a niche for humans through sustainable interactions with other species, species groups, ecosystems, and the biosphere. Such tenets are of special importance in management to allocate harvests over time, space, and alternative species while accounting for numerous factors of varying importance; such factors include population dynamics, genetic effects of harvesting, evolutionary and coevolutionary interactions, predator/prey relationships, competition, and nutrient flow all accounted for in proportion to their relative importance. Systemic management requires synthesis of integrative information to include not only single-species approaches, but also management that applies at the level of ecosystems and entire ocean basins. Chuck focused on this approach in his two most recent books which serve as capstones for his federal career: *Systemic Management: Sustainable Human Interactions With Ecosystems and the Biosphere* and *Ecosystem-based Management for Marine Fisheries: An Evolving Perspective*.

Chuck has been committed to teaching and mentoring multiple generations of new scientists throughout his career. He taught courses at San Jose State College and during his years in the Peace Corps in Columbia. He served on the faculty at Utah State University from 1975-79, became an affiliate professor at the University of Washington, and taught courses at the University of Washington and Seattle University. Over his career, he has mentored numerous young researchers, students, and volunteers through both formal and informal internship programs.

Chuck's continuous scientific contributions, his mentoring of young researchers, and development of new ideas about management will be sorely missed, but provide an outstanding legacy of a long and fulfilling career.

By Robyn Angliss, Rolf Ream and Jason Baker

The "A Team" Retires with 92 Years of Federal Service!

Scott Johnson, John Thedinga, and Pat Harris of Auke Bay Labs' Nearshore Habitat Project worked as a team. Affectionately known as the "A-team" with a combined total of 92 years of federal service, Scott, JT, and Pat each retired 31 December 2012.

Scott, JT, and Pat spent their careers in this nearshore zone despite the fierce insect infestations, rogue waves, uncharted rocks, inclement weather, sink holes, and other massive logistical difficulties. They manually hauled in over a thousand beach seines: identifying and measuring tiny immature fish without killing them, assessing eelgrass beds in unforgiving rising tides, and dealing with skiffs determined to go high and dry.

Their passion for knowledge in Alaska's shallow nearshore has resulted in several key manuscripts detailing essential fish habitat where virtually no information previously existed. They even went one step further by developing an online database known as the Alaska Nearshore Fish Atlas available to the public, researchers, resource managers, and educators for which they received a NOAA Bronze award. Their body of work will be the number one "go-to resource" for future nearshore studies of essential fish habitat in Alaska.

We wish them each the very best in retirement.

Scott Johnson

Research Fishery Biologist, (ABL)
33 years of federal service

Scott Johnson, Team Lead for the Auke Bay Laboratory's Nearshore Habitat Project, retired 31 December 2012 with 33 years of federal service.

Scott began his career at Auke Bay Laboratories in June 1982 as a fisheries biologist in the Habitat Investigations Program studying the impact of logging on salmon. This research firmly established the critical importance of buffer strips around salmon streams. In subsequent years Scott was often the first choice to lead any new Habitat survey, always bringing a "can-do" attitude, dogged persistence, and a dedication to publishing the results to each new endeavor. Scott led the marine debris program to enumerate fishing gear washed up on Alaskan beaches.

Since 2000, Scott led research on forage fish habitat utilization of the coastal nearshore throughout Alaska including the Aleutians and Arctic. His 50 publications spanned such diverse subjects as the effects of logging, marine debris, mine tailings, Pacific herring and salmonid ecology, rockfish behavior, forage fish distribution, and eelgrass habitat.

Scott was born in Prescott, Arizona, obtaining his B.S. in zoology in 1974 from San Diego State University. Upon graduation he worked as a medical research technician at Scripps in La Jolla, California, for several years. He took his first job with NOAA in 1977 as a fisheries biological technician in the Tuna-Porpoise program at the Southwest Fisheries Center in Sand Diego and spent almost an entire year at sea. In 1979 he began his graduate research in Arcata, at the Salmonid Wastewater Aquaculture Facility. In 1981 he received his M.S. degree in Natural Resources from Humboldt State University. The title of his master's thesis was "Length frequency, relative abundance, and catch-age analysis of sablefish in the Gulf of Alaska."

During his 30 years at the lab, Scott's skills in the outdoors, his witty banter and wacky nicknames for colleagues made him a warm personality to work with in the field. In his retirement, Scott will have more time to enjoy his hobbies, including snowshoeing, traveling, hiking, hunting and fishing, and enjoying a good brandy ice.

Pat Harris

Zoologist, (ABL)
25 years of federal service

Pat Harris retired on 31 December 2012 after 25 years of federal service.

Pat Harris grew up in Fairbanks, Alaska, then lived in Whitehorse, obtained a degree in zoology, and eventually migrated to the coast where she discovered marine habitats. Pat began work at Auke Bay Labs as a parasitologist in May 1987, inventorying the distribution of brain myxosporidians in salmon watersheds. Following the 1989 *Exxon Valdez* Oil Spill in Prince William Sound, Pat's study focus changed to the effects of oil in the nearshore environment. In a fish-centric environment, Pat became an expert in marine vegetation and invertebrates. Her expertise with eelgrass beds has taken her all over Alaska, including Izenbek Lagoon in the Aleutian Islands, which is the largest eelgrass bed in the world.

Pat has a comprehensive knowledge of the distribution of eelgrass beds throughout the City and Borough of Juneau, much of the rest of Southeast Alaska, and Prince William Sound. The importance of this critical habitat as nursery areas for juvenile fishes is only now being fully appreciated. Most recently, Pat worked on baseline monitoring associated with the development of the Kensington Gold Mine near Juneau, Alaska.

Pat's giving nature and ability to communicate complicated science into easily-understood concepts for the public has made her a wonderful mentor for many students. She has been a huge proponent of ABL's recycling program. In her spare time, she is an avid gardener and volunteer extraordinaire.

John Thedinga

Research Fishery Biologist, (ABL)
34 years of federal service

John Thedinga retired on 31 December 2012 with 37 years as a fishery biologist (34 with the AFSC) and 45 publications. His combination of unfailing good humor, clever solutions to thorny logistic problems, and physical agility meant that JT, as he was affectionately known, was the researcher everyone wanted on their team.

JT was born in Menomonie, Wisconsin. He studied Fish and Wildlife Management at the University of North Dakota, during which time he spent his summers assisting in stream and lake surveys in Wisconsin and North Dakota. In 1975 he received his B.S. from Univeristy of North Dakota.

JT began work at Auke Bay Labs in December 1978 as a fishery biologist studying the effects of timber harvest on salmonids, after assisting with research and management of Cook Inlet sockeye salmon from 1976 to 1977. While working at ABL, JT went on to obtain his M.S. in Fisheries at the University of Alaska, Juneau in 1985. His M.S. thesis was titled "Smolt scale characteristics and yield of coho salmon Oncorhynchus kisutch, smolts and adults from Procupine Creek, southeastern Alaska." In addition to his extensive work on the utilization of nearshore habitat by fishes, JT worked on the effects of mechanical shock on incubating salmon eggs, salmonid ecology (notably homing and habitat use), the impact of glacial flooding, kelp and eelgrass distribution, and salinity tolerance of salmon smolts.

JT is an avid and skilled gardener, likes to fish and hunt, and has completed more laps around the cross-country track than most of us in Juneau.

By Mandy Lindeberg

Frank Thrower

Research Fishery Biologist, (ABL)
35 years of federal service

Frank Thrower retired from the federal government with 35 years of federal service. Frank joined Auke Bay Laboratories (ABL) in 1983 working at the Little Port Walter (LPW) Marine Station, where he quickly played a key role in ongoing cooperative Chinook salmon research with the Alaska Department of Fish and Game. This was just prior to final agreement between the United States and Canada over a Pacific Salmon Treaty, with Chinook salmon allocation the most contentious issue to reaching a treaty agreement. Based on his research at LPW, Frank played a major role in helping to formulate an enhancement strategy that has significantly helped Southeast Alaska hatcheries produce more Alaska-origin Chinook salmon for Southeast Alaska fisheries.

Frank has served in a number of capacities at ABL and LPW. He was the NMFS-Alaska Mark/Tag Coordinator involved with the use of Coded-Wire Tags (CWTs) in salmon enhancement research. Additionally, Frank pioneered the use of half-length CWTs on emergent pink salmon fry. In 1997 he became the LPW Station Manager, managing and allocating staff and facility resources in coordinating various research projects at this remote field station.

In 1996 Frank was responsible for establishing ABL's commitment to protected species research on the unique circumstances associated with Sashin Creek steelhead. His numerous publications and presentations of research on genetic architecture and biology of anadromous steelhead and their sympatrically-sequestered counterparts, isolated in Sashin Lake for over 80 years, have made Sashin Creek steelhead internationally famous. Working with scientists from several universities, state, and other federal agencies, Frank has authored or co-authored more than 40 publications and reports during his career at ABL on the biology and enhancement technology of pink, chum, and Chinook salmon and steelhead trout.

After receiving his undergraduate degree in fisheries at the University of Washington in 1973, Frank spent 3 years in the Peace Corps managing rainbow trout hatcheries in Columbia, South America, and then serving as technical advisor to a carp farming complex in Nepal. He returned to the United States, and in 1977 signed on with the National Marine Fisheries Service at the Northwest and Alaska Fisheries Center, working on a myriad of salmon issues on the Columbia River. In 1980 he moved to Juneau to become a University of Alaska School of Fisheries and Ocean Science research assistant and completed his M.S. in fisheries with a focus on adult pink salmon migration behavior in the Juneau area.

We wish Frank the very best in his retirement.

By Adrian Celewycz

Dave Clausen

Research Fishery Biologist, (ABL)
34 years of federal service

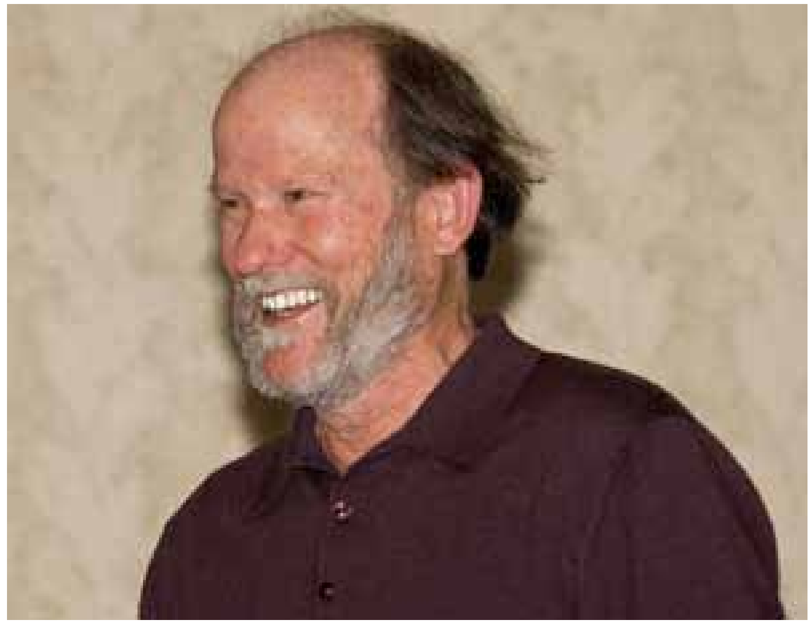
Dave Clausen retired from the Center with 34 years of federal service. Dave began working with Auke Bay Labs' Marine Fish Investigations Program (currently Marine Ecology & Stock Assessment) in 1978. He was one of ABL's most field-experienced biologists, having spent countless days on the high-seas as a chief scientist on various projects. Early in his career he was the U.S. representative aboard a Korean research vessel conducting a 30-day survey between Hawaii and Japan focusing on neon flying squid. In 1982, Dave was one of the first U.S. scientists to participate in the Japan – U.S. Cooperative Longline Survey, which eventually evolved into the Domestic Longline Survey – one of the longest running surveys conducted by the Center. Ironically, Dave's final field trip was aboard the 2012 longline survey, 30 years after his first trip.

Dave's retirement brings a huge loss of corporate memory. Dave's biological expertise and his talents as a mentor, writer, and organizer of field research and lab social events will be truly missed. His knowledge of life history, feeding habits, and ecology of a wide range of groundfish species, from grenadiers to rockfish and sablefish, was exemplified by more than 30 peer-reviewed articles he authored. His technical expertise with the deployment and configuration of longline and trawl gear contributed to the success of a large number of research projects. His ability to organize diverse groups of scientists was highlighted by his chairmanship of the Technical Subcommittee of the Canada-U.S. Groundfish Committee.

Dave was a leader also of ABL social events, such as the annual holiday eggnog gathering where his subtle but infectious sense of humor was always a highlight of the festivities. For these gatherings, Dave made sure the entire ABL family celebrated together by personally inviting retirees through phone calls.

We wish Dave the best in retirement. His travels will surely take him to exotic places where he can don his snorkel gear and populate his Flickr page.

By Jon Heifetz, Chris Lunsford, and Phil Rigby



Kevin Bailey

Research Fishery Biologist, (RACE), 32 years of federal service

Dr. Kevin Bailey, Senior Scientist of the RACE Division's Recruitment Processes Program, retired from the Alaska Fisheries Science Center on 4 January 2013 after 32 years of federal service. Kevin was a leader in the field of fisheries biology and fisheries oceanography with an emphasis in early life history studies. His scientific productivity, the importance of his research, his strong scientific leadership, and his mentoring of young scientists will continue to be a standard of excellence for the field.

Kevin began his federal service in 1974 as a biological technician while pursuing an M.S. degree in fisheries at the University of Washington (UW). His first assignment was on a Japanese crab vessel in the eastern Bering Sea for 4 months taking biological measurements on the catch, and then on a Japanese walleye pollock factory trawler. In 1977 he worked as a Fisheries Research Biologist for a small early life-history team emerging at the Northwest and Alaska Fisheries Center. In 1978, he returned to the UW to pursue studies centering on the recruitment and early life history of Pacific hake and completed his Ph.D. in 1981. His strong academic background as well as his practical experience, both in the laboratory and the field, resulted in early career recognition as a leader in recruitment research. Kevin's scientific leadership in NOAA's Fisheries Oceanography Coordinated Investigations (FOCI) Program was instrumental in getting this program firmly established, nationally and internationally recognized, and into the transition from a single species focus to ecosystem encompassing studies.

During his career Kevin showed exceptional skill, imagination, and creativity in his applied research. He produced over 100 refereed publications in journals, books, and symposia providing the field of marine fisheries with the best possible advice on how to understand and predict variability in survival of fishes to the age of recruitment. He worked and published on species as diverse as: walleye pollock, Pacific cod, arrowtooth flounder, Pacific halibut, capelin and Alaska plaice. Throughout his career he developed, improved and adopted new methods that increased our insight into how and what was causing variation in larval fish survival in Alaska Large Marine Ecosystems. His research includes seminal articles on: life history and ecology of fish larvae and juveniles; fisheries oceanography and larval transport, complexity, landscape ecology and ecosystem dynamics; age and growth; trophic interactions; recruitment and population dynamics; effects of periodic environmental signals such as El Niño; and fish population genetics. He advanced the field through his critical application of new techniques such as RNA/DNA condition indices, otolith microchemistry, and molecular genetics. He was given the American Fisheries Society prestigious Oscar Sette Award in 2008 for his outstanding lifetime achievement in marine fisheries.

In addition to his own scientific achievements, Kevin worked tirelessly to promote the education and careers of young scientists. Over the years he served on numerous graduate committees, gave many lectures, and personally encouraged many students. He spent considerable personal effort to create opportunities for young investigators. His efforts included forging relationships between established researchers and new talent, finding funding opportunities for burgeoning scientists, and fostering collaboration and dialogue between new researchers and their international counterparts.

By Jeffrey Napp and Ann Matarese

Sarah Hinckley

Research Fishery Biologist, (RACE)
31 years of federal service

Dr. Sarah Hinckley of the RACE Division's Recruitment Processes Program retired from the Alaska Fisheries Science on 4 January 2013 after 31 years of federal service.

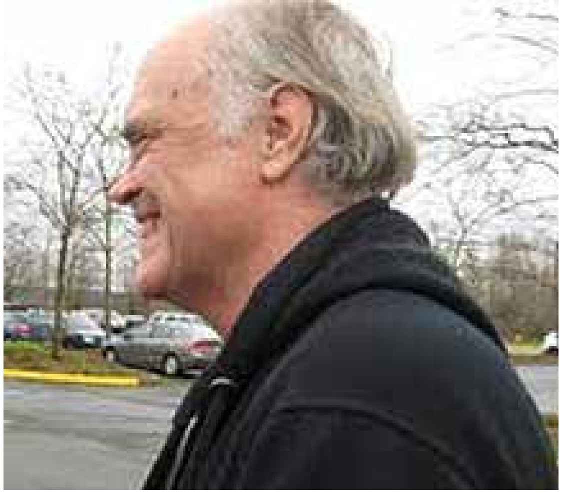
Sarah began her federal service in 1980 as a data analyst and field scientist at the Northwest and Alaska Fisheries Center. As part of her Master's graduate research (1984-86), she was responsible for designing and conducting a study of the fecundity and spawning dynamics of walleye pollock in the eastern Bering Sea. Sarah soon became interested in ecological and ecosystem modeling and returned to the University of Washington School of Fisheries and Aquatic Science for her doctorate. She received her Ph.D. in 1999 and since then has been active in the scientific modeling community. Her early work focused on biophysical models of walleye pollock recruitment in the Gulf of Alaska.

Sarah Hinckley receives her retirement certifcate from Recruitment Processes Program manager Jeff Napp.

Sarah was a pioneer in implementing individual-based modeling (IBM) in Alaskan waters. She developed one of the first complex biophysical models which coupled three separate models together to examine walleye pollock recruitment: a hydrodynamic model of ocean circulation; a Nutrient-Phytoplankton-Zooplankton model describing lower trophic level production; a complex IBM model that described larval fish biology. The IBM model was an innovation itself because it explicitly simulated important life processes such as: egg development, growth, mortality, bioenergetics and movement for eggs, larvae, and early juvenile walleye pollock. Simulations from the model improved our understanding of biophysical processes that determine fisheries recruitment. Her methodologies formed the basis of future modeling work in the Recruitment Processes Program and in other research groups around the world because her methods could be applied to other economically important species in other large marine ecosystems.

In recent years, Sarah led a large study to model transport and survival of larval snow crab in the eastern Bering Sea using IBM models. This work resulted in significant advances in explaining life history patterns of snow crab and variability in recruitment as it relates to climate variability and change. In addition, she was an important member of the modeling teams for large multi-institutional programs such as the NE Pacific GLOBEC (Global Ocean Ecosystem Dynamics), and the Gulf of Alaska IERP (Integrated Ecosystem Research Program). The latter program is attempting to build coupled models for four new species: Pacific cod, arrowtooth flounder, sablefish, and Pacific Ocean perch.

By Ann Matarese, Carolina Parada, and Jeff Napp.



Ed Dunn

Information Technology Specialist, (FMA)
28 years of federal service

Ed Dunn retired from the Center's Fisheries Management and Analysis (FMA) Division, with over 28 years of federal service. As an invaluable Information Technology Specialist, Ed's tenure is characterized by gentle self deprecating humor, dedication to a job well done, and courtesy to everyone. It was a privilege to work with him, to enjoy his creativity, and reap the benefits of his talents in building software that supports the AFSC Observer Program.

Ed is a tenacious problem solver who as a member of the FMA Division was unafraid to try multiple approaches regardless of the complexity or technology until a business issue was ultimately resolved. The Center has greatly benefited from both Ed's curiosity needed to maintain a positive attitude in taking on new challenges and from his perseverance in solving problems.

Ed was last seen driving off in his much abused van, a couple of homemade solar panels strapped to the roof, solar panels that Ed asserted would enable him to power his laptop (and possibly his home espresso machine?) from any place in the United States. His heart remains youthful; his outlook adventurous; he will surely enjoy travel and art around the globe. We, who have benefited from his friendship and joie de vivre, wish him the very best in retirement.

By Doug Turnbull

Jan Haaga

Research Fishery Biologist, (RACE)
22 years of federal service

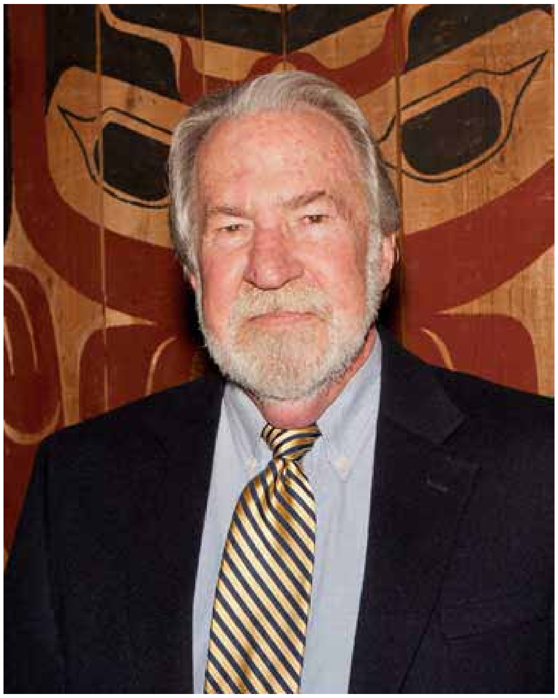
Jan Haaga began working as a research fisheries biologist for the Alaska Fisheries Science Center in 1990 as part of the Shellfish Assessment Program at the Kodiak Laboratory. Her early career involved work on the deep sea submersible *Delta*and a variety of other remote-operated vehicles used to conduct detailed studies of Tanner crab reproductive behavior in Chiniak Bay off Kodiak Island. She also was the "go-to" person for all of the Kodiak Lab's graphics needs.

During her career, Jan was an integral part of the eastern Bering Sea bottom trawl survey team and led the organization and logistics for the crab portion of the survey. As many at the Center know, preparing for the 65-day survey and tracking the special projects for the survey are not small tasks. For many years, Jan ensured that everyone got on the right boat and that the data were properly collected and stored.

In recent years Jan has focused many of her talents as the Kodiak Laboratory outreach coordinator while working on research projects in the Kodiak Seawater Laboratory. She spent countless hours representing the Center at the Kodiak Comfish and Whale Festival events. These events attract thousands of visitors to Kodiak, and Jan ensured that the Center was represented well with science exhibits, live animal tanks, videos highlighting AFSC surveys, and NOAA brochures. Jan also assisted with numerous projects in the seawater laboratory including research on the effects of ocean acidification on crab survival.

Jan will be missed by all who worked with her. We congratulate her on her retirement.

By Bob Foy



Jay Kennedy

Management & Program Analyst, (OCD)
23 years of federal service

Jay Kennedy served as the AFSC's Safety and Environmental Compliance Officer for nearly 15 years until his retirement on 31 December 2012, leaving a legacy transformational to AFSC processes, people, and culture.

Jay served as the Center's first Safety and Environmental Compliance Officer (SECO) beginning in 1998. As such, he was instrumental in developing a program which increased employee safety training and awareness and policies and procedures for hazardous materials storage, handling, and disposal. As a certified aviation safety instructor, Jay served as the National Marine Fisheries Service (NMFS) representative on the NOAA Aviation Safety Council for many years, making substantial contributions to the development of NOAA aviation safety policies and standards. Jay helped develop safety procedures for small boat handling and diving operations. In collaboration with AFSC safety committees, he worked on projects and initiatives to address safety issues and concerns including a major revision to the At-Sea Safety Manual. He was a key member of an AFSC team that evaluated the ergonomics of deck work aboard vessels which led to a decrease in injuries. Jay has been a leader representing the AFSC on the NMFS Safety Council and NMFS Facilities Council for many years. In fact, he was asked to serve as the Acting NMFS SECO, spending almost a year at NMFS Headquarters in Silver Spring, Maryland, and served as the NMFS lead for development of an agency Operational Risk Management Program.

Facilities projects have also been a major part of Jay's career with the Center. He was a certified Contracting Officer's Technical Representative (COTR) for many years, serving as project manager for numerous facility projects. His knowledge and expertise has contributed to the successful award of contracts and completion of projects critical to the AFSC's infrastructure and operations. One of these, the specimen storage facility in Juneau, was a complex and specialized facility with sophisticated electrical and mechanical systems. His successful management of that construction testified to the breadth of Jay's competence and his ability to bring excellence to whatever he did. In 2009 when the Center assumed responsibility for management of the NMFS Pribilof Island facilities, Jay's duties increased significantly. He has been involved with several major projects at that location including a serious hazardous material removal and remediation.

Prior to his employment with the Center, Jay served a United States Air Force (USAF) Officer serving for eight years as a Flight Examiner and Instructor Pilot. After an honorable discharge from the USAF, Jay worked in the mortgage and banking industries for several years before pursuing training in occupational health and safety. He became a successful entrepreneur, managing his own safety and environmental compliance consulting company, where he provided investigative services, performed safety surveys and audits, provided training, managed projects and developed policies for a wide variety of industrial and government clients.

Jay's legacy is his investment in each of us, by developing a safer environment at the AFSC, serving with excellence in all things safety, environmental compliance, and facilities, and by always being available to individual needs and finding solutions to everyday problems. His door was always open. He has helped to improve the AFSC work environment and operations in countless ways – from working with individuals on a specific need to writing national level policies with far reaching impacts. Moreover, we have a fabulous library of Monthly Safety Briefs filled with important safety reminders and tips and unique photos presented with Jay's wit and wisdom.

We know there will be some golfing, art, travel and family time in Jay's future, and we wish him every happiness in retirement!

By Lori Budbill and Steve Ignell.

Mike Guttormsen

Research Fishery Biologist, (RACE)
22 years of federal service

Michael Guttormsen retired from the Midwater Assessment and Conservation Engineering (MACE) Program of the RACE Division on 29 November 2012.

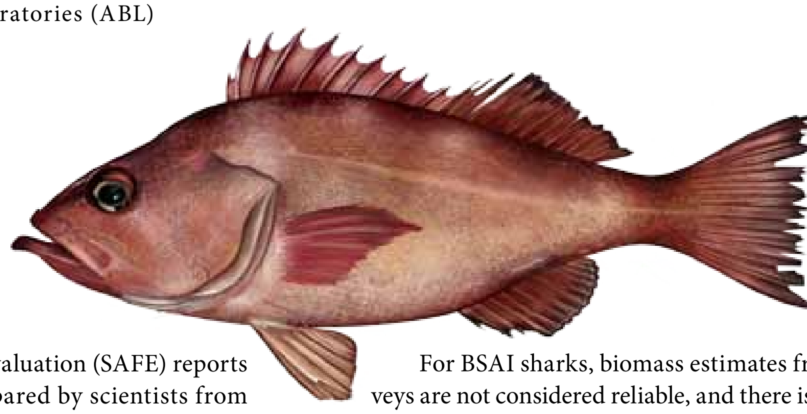
After receiving his Bachelor of Science degree in Fisheries from the University of Washington (UW) in 1980, Mike took to the open sea as a fisheries observer in 1980 and 1983. He began his career with the National Marine Fisheries Service in 1986 as a member of what was then the Northwest and Alaska Fisheries Center's North Pacific Fisheries Observer Program.

Mike assumed roles of increasing responsibility with the Observer Program including completion of a Master's degree in Fisheries from the UW in 1995, which addressed bycatch reduction techniques for juvenile walleye pollock. Later that same year, he joined the MACE Program. He sailed on his first acoustic-trawl survey in Shelikof Strait during March 1995 and logged a truly impressive amount of survey time both during the summers and winters over the course of his career, participating in 16 consecutive Shelikof Strait winter survey). Mike became the MACE go-to expert for "all things pollock" in the Gulf of Alaska. Among his many accomplishments, was his skill at planning and conducting acoustic- trawl surveys aboard the NOAA ships *Miller Freeman* and *Oscar Dyson*. Mike was especially valued for his efforts in mentoring junior staff in the different aspects of acoustic-trawl survey methods. He also made substantial contributions to many important survey-related research projects conducted within the MACE Program; one of Mike's most significant efforts was the work he conducted to estimate capelin *in situ* target strength for this species in Alaskan waters.

Throughout his career, Mike was recognized by his colleagues as a highly capable co-worker and great shipmate. He will be missed … and envied … for Mike has retired to the sunny climes of New Mexico – about as far away as one can get from the 50 knot gusts of freezing spray in Shelikof Strait during the MACE winter field season.

Mike — All the best to you, from your NOAA Fisheries friends and colleagues.

By Neal Williamson and Chris Wilson



Marine Ecology and Stock Assessment Program

Groundfish Stock Assessments

This quarter three full Stock Assessment and Fishery Evaluation (SAFE) reports and eight executive summary SAFE reports were prepared by scientists from ABL's Marine Ecology and Stock Assessment (MESA) program. For each assessment, the results were presented to the North Pacific Fishery Management Council's Groundfish Plan Teams in November and also reviewed by the Council's Scientific and Statistical Committee in December. The Council used these assessments as the primary source for determining levels of Total Allowable Catch (TAC) in 2013. Full assessments were prepared for Alaska sablefish, Bering Sea/Aleutian Islands (BSAI) sharks, and Alaska grenadiers. Executive summaries were prepared for species in the Gulf of Alaska (GOA): Pacific ocean perch, thornyheads, northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "other rockfish," and sharks.

The sablefish longline survey abundance index decreased 21% from 2011 to 2012 following an 18% increase from 2008 to 2011. The fishery abundance index was stable from 2010 to 2011 (the 2012 data are not available yet) following a decrease of 9% from 2009 to 2010. There are signs of a strong incoming 2008 year class based on longline survey data. Spawning biomass is projected to decrease from 2013 to 2017 and then stabilize. The strong 2000 year class is the largest contributor, comprising 20% of the spawning biomass in 2013. The Alaska sablefish stock assessment model was unchanged from 2011 and showed a 6% decrease in TAC recommendations as a result of the decrease in the 2012 longline survey index that is somewhat offset by the relatively high survey years in 2010 and 2011.

Research on depredation effects on the sablefish survey index from both killer whales and sperm whales continues. Thus far there has been success in determining the effects of whale depredation on the index. Sperm whale effects may be useful to incorporate as a correction factor in the index, but killer whale effects may be too variable to use.

A detailed analysis of sablefish fishery catch rate data is being conducted in collaboration with a postdoctoral researcher to better capture abundance trends from fishery data. A "core fleet" that has fished for at least 15 years has been identified. The effects of spatial and depth distributions of the fishery and other species (Greenland turbot, Pacific halibut, Pacific cod, and grenadiers) catch rates on the index are being explored.

Although there are seven species of grenadiers in Alaska, the giant grenadier is the most abundant species and is by far the most common grenadier caught in commercial fisheries and surveys. Thus, stock assessments focus on giant grenadier. A new method of estimating giant grenadier biomass in the Aleutian Island (AI) was used. This method incorporated both longline and trawl survey data to extrapolate trawl survey biomass estimates to deep water (500 – 1,000 m). The new method provided lower estimates of biomass than previously reported, but trends are similar between the old and new method. Presently, grenadiers are not included in the Fishery Management Plans (FMPs). ABL scientists continue to recommend that the Council include grenadiers in both the BSAI and GOA FMPs so that annual catch limits can be established.

For BSAI sharks, biomass estimates from surveys are not considered reliable, and there is limited biological information. Thus, TAC recommendations are determined based on a calculation that uses historical catch history. A comparison of potential catch quotas was made between two different methods of estimating shark catch. The first method used official catch estimates as provided by the Catch Accounting System, and the second method used catches that incorporated the Halibut Fishery Incidental Catch Estimates (HFICE) that attempt to account for unobserved shark bycatch in the halibut fishery. ABL scientists recommended that catch quotas continue to be determined using the first method primarily because of uncertainties associated with the HFICE.

A stock structure analysis was completed for sharks in the GOA and BSAI. The shark complex has a mix of three main species (spiny dogfish, Pacific sleeper shark, and salmon shark), each with different life histories. There is considerable difficulty in evaluating whether there is a need for additional spatial or species-specific management of sharks because data are limited. A stock structure analysis was also completed for Pacific ocean perch in the GOA. Given the available evidence on stock structure, the current resolution of spatial TACs could potentially be increased to smaller areas (five areas instead of three), without imposing quotas that are onerously small for management.

For more information about these assessments, see the Status of Stocks & Multispecies Assessment Program's article "Groundfish Stock Assessment for 2013: Fishery Quota Recommendations" in the Resource Ecology and Fishery Management (REFM) Division section of this issue or the stock assessment reports on the AFSC website.

By Jon Heifetz.

FMA Observer Program Activities in 2012

For the 2012 fishing year, 760 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 264 fixed gear and trawl vessels and at 22 processing facilities for a total of 44,710 observer days. This is slight decrease from our record high of 45,188 observer days in 2011.

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 2012, the Fisheries Monitoring and Analysis (FMA) Division provided training for 168 new observers compared to 225 new observers in 2011.

Returning observers are required to attend an annual 4-day briefing class prior to their first deployment each calendar year. These briefings provide observers with updates regarding their responsibilities in the new fishing year. Each deployment can last up to 90 days. Prior to subsequent deployments within the year, returning observers attend a refresher briefing; the length of the briefing is dependent on that individual's training needs. In 2012, FMA staff provided briefings for 549 observers.

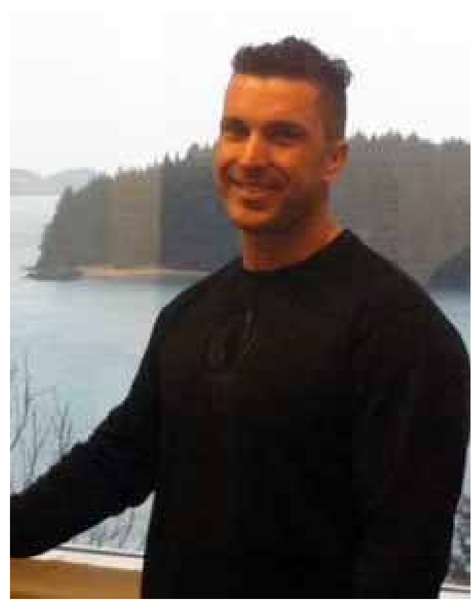
After each deployment, observers meet with a FMA staff member for debriefing to review the observer's work and finalize the data collected. There were 56 debriefings in Anchorage completed by 4 FMA staff and 480 debriefings in Seattle completed by 15 FMA staff. Many observers deploy multiple times throughout the year and, as a result, debrief after each contract followed by a briefing for redeployment. Thus, the total number of briefings and debriefings for 2012 does not represent a count of individual observers.

Each new year brings some degree of change to observer data collections as part of our efforts to meet the various needs of the end data users. In preparation for this year's fishing season the 2013 Observer Sampling Manual was updated to reflect changes of how data will be collected, as well as including sampling protocol for new data collection projects. The manual is available on the FMA website.

One of the highlights of 2012 was filling vacant staff positions at our field offices in Dutch Harbor and Kodiak, Alaska. Pearl Rojas and Sam Zmolek began working at our Dutch Harbor field office in August, providing support 7 days a week to observers deployed during the pollock and Pacific cod fishing season last fall and winter. Rob Barnett began working at our Kodiak field office at the end of December, providing full-time staff support for observers who began to deploy in the 2013 fishing season. All three of our new FMA field staff have had extensive experience as observers deployed on fixed-gear and trawl vessels as well as sampling at processing plants. Our Dutch Harbor and Kodiak field staff will be a valuable resource for current observers deploying in 2013 and future years.

By Allison Barns and Ren Narita





From left to right: Pearl Rojas, Sam Zmolek, and Rob Barnett of the FMA Division..

Alaska Ecosystems Program

Satellite Tracking of Adult Female Steller Sea Lions in the Western-Central Aleutian Islands Reveals Diverse Foraging Behaviors

Very little is understood about adult female Steller sea lion (*Eumetopias jubatus*) foraging behavior in the Aleutian Islands, particularly during winter for the western and central Aleutian Islands area. Understanding where marine mammals forage to obtain energy needed for growth and reproduction is necessary to evaluate the potential for competition with other predators (including humans) for resources, and gathering this information is especially crucial in the western and central Aleutian Islands where controversial large-scale commercial fisheries restrictions were enacted (see 2010 NOAA News Release). However, attaching satellite-telemetry instruments capable of recording diving behavior and tracking locations requires the safe capture and restraint of sea lions that may weigh more than 350 kilograms. Thus, to develop suitable techniques, a team from the National Marine Mammal Laboratory's (NMML) Alaska Ecosystems Program (AEP), Alaska Department of Fish and Game Steller Sea Lion Program, and Vancouver Aquarium conducted a pilot project to test capture and handling methods in the more logistically tractable area of Southeast Alaska in November 2010. As reported in a previous AFSC Quarterly Report, October-December 2010, that effort resulted in three successful captures and the subsequent tracking of Steller sea lion movements for up to 253 days, longer than any previous satellite-telemetry instrument deployments on adult females. Based on that success, captures were next attempted in the western and central Aleutian Islands in November 2011, but the effort was confounded by weather and ocean conditions. The successful capture of one adult female (identified as "=24") on Ulak Island in the central Aleutian Islands resulted in the subsequent tracking of her movements for a period of 175 days. During this time, "=24" spent most of her time foraging north of Semisopochnoi Island over the southern portion of Petrel Bank, where the potential prey field was described by a concurrent AFSC Fisheries Interaction Team Atka mackerel study (see AFSC Quarterly Report April-June 2012).

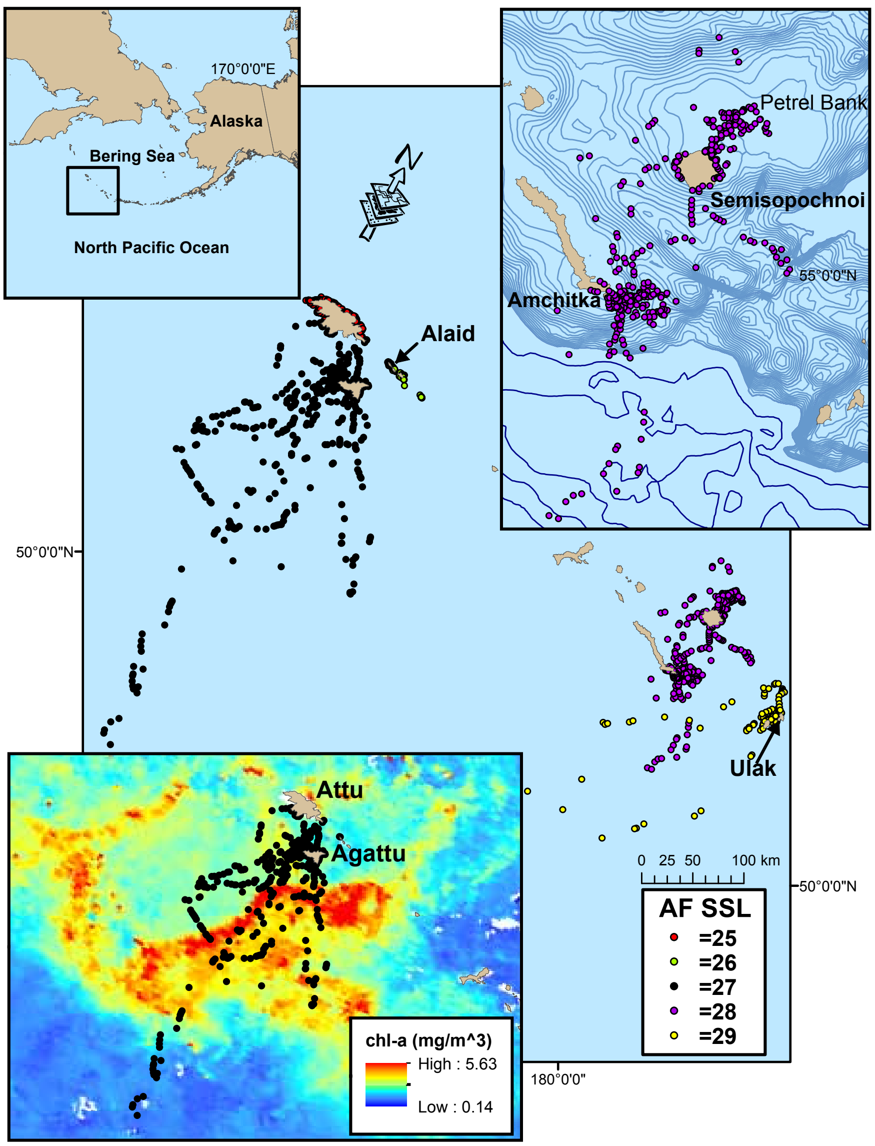


Figure 1. GPS location data for five adult female Steller sea lions (*Eumetopias jubatus*) captured in the western and central Aleutian Islands during October 2012. Top left insert: study area; top right insert: movements of sea lion "=28" relative to ETOPO 2-ft gridded elevation data; bottom left insert: movements of sea lion "=27" relative to a mean composite of chlorophyll-*a* (mg/m3; Aqua MODIS, oceancolor.gsfc.nasa.gov) for the month of October. GPS data range through 2 January 2013.

During October 2012, the Steller sea lion team returned to the western and central Aleutian Islands, where adult females with dependent pups were captured successfully at Attu, Agattu, and Alaid Islands in the western Aleutian Islands and at Amchitka and Ulak Islands in the central Aleutian Islands (Fig. 1). Satellite telemetry revealed these animals displayed an intriguing variety of foraging strategies within and among individuals. The sea lion captured at Cape Wrangell, Attu Island (identified as "=25" in Fig. 1), traveled among haulouts across the northern side of the island, and all of her foraging trips have been nearshore. In contrast, sea lion "=26," captured at Alaid Island, moved around the Semichi Islands before making trips up to 48 km away to the Ingenstrem Rock area, where transmissions stopped after 19 days. Sea lion "=27," captured at Cape Sabak on Agattu Island, has traveled among the Near Islands but mostly undertakes pelagic foraging trips lasting as long as 6 days and extending as far as 420 km south of Agattu Island. While at sea, this sea lion appeared to target areas associated with a mesoscale anti-cyclonic eddy south of the Near Islands (Fig. 1, inset). The last adult female

Figure 2. Adult female Steller sea lion "=28" returning to the sea upon release after being captured on Amchitka Island, 25 October 2012. In view on the top of her head is the satellite-telemetry instrument, attached to track movements and record dive behavior. Photo by Dr. Vladimir Burkanov (NMFS MMPA research permit 14326).

captured in the western Aleutian Island area, "=28" captured on Amchitka Island (Fig. 2), spent 3 weeks post-release in areas within 31 km of the East Cape capture site but then made a 2-day trip off the western side of Semisopochnoi Island and, after returning to Amchitka, another 2-day trip south of Amchitka Pass. After a couple more trips to Semisopochnoi Island and Amchitka Pass, sea lion "=28" returned to Semisopochnoi Island, where she made trips over the southern portion of Petrel Bank, displaying movements similar to those of "=24" from the previous year, until transmissions ceased on 10 December. The adult female "=29," captured on Ulak Island in the central Aleutian Islands, spent most of her time among the Delarof Islands (Ulak, Amatignak, and Unalga Islands) undertaking nearshore foraging trips until late December and, as of this writing, is taking long, looping trips south of Amchitka Pass, encircling the area previously visited by sea lion "=28" in November.

Findings from tracking these six adult female Steller sea lions in the western and central Aleutian Islands will greatly improve our understanding of their foraging behavior and at-sea habitat use. Formal analysis of these data is forthcoming, but it is clear that adult female Steller sea lions in the western Aleutian Islands utilize pelagic (offshore) and benthic (on-shelf areas) habitats with foraging strategies that may key on definable habitat features both offshore (mesoscale eddies) and over shelf areas (e.g., Petrel Bank near Semisopochnoi Island). To date, none of these tracked adult females have relocated to regions away from their general area of capture.

By Brian Fadely and Michelle Lander

Cetacean Assessment and Ecology Program

Soviet Illegal Whaling in the North Pacific: Reconstructing the True Catches

Figure 3. Processing sperm whales on the deck of a Soviet factory ship. Photos by Nikolai Doroshenko.

For the past several years, National Marine Mammal Laboratory (NMML) staff have been involved in investigations of the huge campaign of illegal whaling conducted by the U.S.S.R. from 1947 to the end of the 1970s. In the Southern Hemisphere (primarily the Antarctic), the U.S.S.R. killed an estimated 338,336 whales, of which only 185,778 were officially reported to the International Whaling Commission (IWC)—a difference of more than 150,000 whales. Through the efforts of several former Soviet whale biologists, working with Dr. Bob Brownell at the Southwest Fisheries Science Center, the Southern Hemisphere catch record has been largely corrected with "true" data. However, large gaps remained for Soviet whaling in the North Pacific Ocean, a gap that we have recently been able to fill because of the discovery in Russian public archives of numerous formerly secret reports from the Soviet whaling industry.

With occasional exceptions, our problem in pursuing this research has not been the lack of records, but rather the opposite: the relevant records in this formerly classified material include scientific reports, whaling production reports, and whaling inspectors' reports—but these are filed (not always logically) with endless financial reports, labor reports, Communist Party activity reports, and innumerable other outputs from the prodigious Soviet bureaucracy.

First, some background. Whaling has a long history in the North Pacific: aboriginal subsistence whaling existed in different areas around this ocean for centuries, and commercial whaling began at the end of the 1700s, with a major expansion in the 19th century; this was sail-based whaling, which concentrated on slower species such as humpback, gray, right, bowhead, and sperm whales. Later, as innovations such as steam catcher boats and explosive harpoons were introduced, faster species such as blue, sei, and fin whales were taken, and by the early 20th century, most baleen whales were being regularly hunted in this region.

A number of nationalities were involved in North Pacific whaling, primarily American, Canadian, British, and Norwegian. Russian whaling, however, had been virtually nonexistent with the exception of a successful operation conducted by Otto V. Lindholm (a Finn, but a Russian subject) in the Okhotsk Sea from 1864 to 1884 and a brief operation using modern methods operating from Gaydamak near Vladivostok during 1889.

In 1932, the U.S.S.R. began a commercial whaling operation in the North Pacific with a converted factory ship named *Aleut*, which for 16 years was the only Soviet whaling operation in this ocean. Soviet whaling expanded after World War II with the restoration, in 1948, of formerly Japanese land stations in the Kuril Islands. The *Aleut* fleetand catchers from the Kuril stations were operating in the western North Pacific exclusively until 1959; by that time, the whale resources in this part of the North Pacific had been heavily depleted, and the focus of the Soviet operations moved east, first to waters around the eastern Aleutian Islands and then into the Gulf of Alaska, eastern Bering Sea, and areas off the western coast of North America.

In the space of just 2 years, 1962-63, three new, large whaling factory ships were added to the Soviet North Pacific whaling operation, with the main focus remaining in the eastern North Pacific. As a result of this expansion, catches—many of them illegal—dramatically increased from 3,970 whales in 1961 to 12,945 in 1964 and continued to increase in subsequent years. Catches of sperm whales (the primary target of Soviet whalers in the North Pacific) increased five-fold from 1962 (3,035) to 1966 (15,205). Such intensive whaling continued in the North Pacific until 1969, with up to four Soviet whaling fleets working in the area simultaneously.

The high catches, both in the North Pacific and elsewhere in the world, were driven by very specific requirements of the Soviet economic system to meet or exceed

Figure 4. Objects found by Soviet whalers in the stomach of a sperm whale killed in the North Pacific. Photo by Nikolai Doroshenko.

annual production targets (see details in Ivashchenko et. al. 2011, *Marine Fisheries Review*). Because the U.S.S.R. was a signatory to the International Convention for the Regulation of Whaling (1946), it was required to follow catch restrictions defined in the Schedule of the IWC. Such restrictions typically included areas in which hunting was prohibited, as well as various mandates regarding protected species and the minimum allowable length for catches of “legal” species. This created an obvious conflict with the requirements for increasing catches and production. Accordingly, the reports submitted to the Bureau of International Whaling Statistics from each Soviet whaling fleet were sanitized, with almost all illegally caught whales removed or (in some cases) replaced by falsified numbers for legal species.

So how many whales did the U.S.S.R. kill in the North Pacific? After sifting through a truly huge volume of formerly secret material, we can now reconstruct most of the catch record, which is summarized in Table 1. During 1948-79, a minimum of 190,183 whales were killed by the U.S.S.R. in the North Pacific (195,783 if one includes an estimate for sperm whales taken in years for which there are no true data); of these, only 169,638 were reported to the IWC, a difference of 20,568 whales (26,168 including the sperm whale estimate). Figures were falsified for 8 of 12 hunted species, with some catches over-reported to camouflage takes of illegal species.

Table 1. Total catches of whales in the North Pacific by the U.S.S.R., 1948-1979, by species.

Species	Actual catch	Reported catch	Difference
Blue whale	1,621	858	+763 (189%)
Fin whale	14,167	15,445	-1,278 (92%)
Humpback whale	7,334	4,680	+2,654 (157%)
Sperm whale	153,686*	132,505	+21,181 (116%)
Sei whale	7,698	11,363	-3,665 (68%)
Gray whale	149	1	+148 (-)
North Pacific right whale	681	11	+670 (6,191%)
Bowhead whale	145	0	+145 (-)
Baird’s beaked whale	146	148	-2 (99%)
Killer whale	401	401	0 (100%)
Bryde’s whale	3,466	3,517	-51 (99%)
Minke whale	689	686	+3 (101%)
Total	190,183*	169,615	+20,568 (112%)

***If one includes an estimate for catches in years for which no data exist, the total sperm whale catch is estimated at 159,286, and the overall total for Soviet catches in the North Pacific would be 195,783 whales.**

In terms of sheer numbers, sperm whales were the major target of Soviet whalers and were pursued relentlessly throughout this ocean (Figs. 3-4). The U.S.S.R. not only under-reported total catches for this species but also falsified data on sex and length, taking huge numbers of females but reporting that they had taken large catches of males. A further tragedy was that the IWC, seeing the fake male catch numbers, lowered the minimum size limit for catches to take pressure off males by allowing more females to be taken—yet, in reality, females had already borne the brunt of the whaling.

As reported in a previous AFSC Quarterly Report, April-June 2011, another species that was extensively damaged by Soviet whaling was the North Pacific right whale, which had been theoretically protected by international agreement since 1935. It is likely that the U.S.S.R. wiped out most of the remaining right whale population in the eastern North Pacific, which today NMML estimates at only 30 animals. Most of the right whales in the Soviet catch were large, mature animals, which means that much of the prime reproductive portion of the population was destroyed. In the Sea of Okhotsk, the Soviets killed large numbers of right and bowhead whales, although the status of those populations today appears to be somewhat better. One bright spot is that humpback whales, of which the U.S.S.R. killed more than 7,000, are doing well in most parts of the North Pacific: a large international study, of which NMML was a part, recently estimated the population at more than 20,000.

Our next project, funded by the North Pacific Research Board, is to reconstruct the details of sperm whale catches in the North Pacific. This study will look at such factors in the Soviet catch as sex, length, and spatio-temporal distribution in an effort to better understand the status and population structure of this largest and most heavily exploited of the toothed whales.

Yulia Ivashchenko is an Associate Scientist at NMML and is currently finishing a Ph.D. at Southern Cross University. Phil Clapham leads NMML’s Cetacean Assessment and Ecology Program (and, more importantly, is Yulia’s husband). The North Pacific Soviet whaling catch study summarized here was recently accepted for publication by the *Journal of Cetacean Research and Management*.

By Yulia Ivashchenko and Phil Clapham

Polar Ecosystems Program

Accounting for Species Identification Errors from Aerial Surveys of Ice-associated Seals

Figure 5. The characteristic bands on the coats of ribbon seals are not necessarily clearly visible in an aerial image. The images on the top right and bottom right were taken with a Canon 1DS Mark III digital camera fitted with a Zeiss 100-mm lens from 1,000 ft during a 2012 line-transect survey in the Bering Sea. In the top right image, a species identification expert would likely rely on the clearly visible bands to conclude that the seal is certainly a ribbon seal. In the bottom right image, a species identification expert would likely rely on a combination of body shape, head size, flipper size and shape, and what could be one or more bands to conclude that the seal is probably a ribbon seal.

In April-May 2012, researchers from the National Marine Mammal Laboratory's (NMML) Polar Ecosystems Program (PEP) conducted abundance and distribution surveys for the four species of ice-associated seals (bearded, spotted, ribbon, and ringed seals) that occur and breed in the Bering Sea. Advanced thermal-imaging technology was used to detect the warm bodies of seals against the background of the cold sea ice, and high-resolution digital images will be used to identify the species of seals detected by the thermal imagers. Ultimately, this project—which is partly funded by the Bureau of Ocean Energy Management and includes a collaboration with Russian colleagues—will provide the first comprehensive estimates of abundance for the four species of ice-associated seals found in the Bering and Okhotsk Seas.

The different characteristics that distinguish these ice-associated seal species can sometimes be difficult to discern from imagery taken at the survey altitude of 1,000 feet. For example, the characteristic bands on the coats of ribbon seals (Fig. 5) or the "red face" of bearded seals (Fig. 6) will not always be visible in a photo, depending on the orientation of the seal and angle of the image. The identifying characteristics of spotted and ringed seals can be even more difficult to discern from aerial photos. Although typically ignored in population estimates, errors can therefore be common when attempting to identify similar-looking seal species from aerial photographs.

We are accounting for species misidentification in our abundance model by estimating misclassification probabilities for species identified in the images. Several PEP seal experts are identifying the species of each seal in each image. To learn more about the factors driving the species identification process, our experts are also recording the specific morphological characteristics that are visible in each image. In addition, experts rank their confidence in each species identification as "positive," "likely," or "guess," where it is assumed that a positive species identification is the correct species.

Figure 6. A red face, which is one of the characteristics associated mostly with bearded seals, is not always present, nor is it necessarily visible in an aerial image. The image on the right was taken with a Canon 1DS Mark III digital camera fitted with a Zeiss 100-mm lens from 1,000 ft during a 2012 line-transect survey in the Bering Sea. In this image, a species identification expert would likely rely on the combination of body shape, head size, front-flipper size and shape, and position on the floe to conclude that the seal is probably or certainly a bearded seal.

Replicating the species identification process with multiple observers for each seal allows the probabilities of correct (and incorrect) species identification to be estimated and accounted for in our final estimates of population abundance for each species.

Our expert observer trials are illustrated in Table 2, where the true species identity is only assumed to be known with certainty when at least one expert ranks the species identification as positive. By "anchoring" on these positive identifications (e.g., seals 1, 2, and 3 in Table 2), statistical models may then be used to estimate the different species misclassification probabilities and assign species identities to images that are not known with certainty (e.g., seals 4 and 5 in Table 2).

Table 2. Example of species identification trials for three expert observers and four species of ice-associated seals (SD = spotted, RN = ribbon, BD = bearded, RD = ringed, UK = unknown). Observers rank their confidence in a species identification as "positive" (red), "likely" (green), or "guess" (purple).

Seal ID	Observer 1	Observer 2	Observer 3	True Species ID
1	RN	RN	RN	RN
2	SD	SD	RD	SD
3	BD	BD	RN	BD
4	SD	SD	SD	?
5	RN	UK	UK	?

Our expert observers are currently conducting species identification trials for more than 600 seals detected by our thermal imagers. Once these trials are completed, not only will we have a better understanding of the frequency of errors when identifying ice-associated seal species from aerial photos, but we also will be able to properly adjust our population estimates for each species accordingly. In addition, we will gain a better understanding of the specific morphological characteristics most commonly used to identify each species from aerial transect surveys.

By Brett McClintock, Erin Moreland, and Peter Boveng

Newport Laboratory:
Fisheries Behavioral Ecology Program

Field Validation of RAMP Approach for Determining Bycatch Mortality

The Alaska Fisheries Science Center (AFSC) has a long history of research designed to assess and reduce bycatch mortality of both fish and crabs, with regular funding from the North Pacific Research Board, NOAA's Bycatch Reduction Engineering Program, and other sources. Experiments related to discard practices, bycatch reduction, and fishing gear design have included many collaborative efforts between AFSC biologists in Seattle, Washington; Kodiak, Alaska; and Newport, Oregon; their graduate students; and commercial fishers in Alaska.

The AFSC's Fisheries Behavioral Ecology Program based at Oregon State University's Hatfield Marine Science Center has focused substantial effort on developing ways to assess the likelihood of fish or crab mortality resulting from the various stressors associated with fishing gear encounters and/or animal discard. Reflex Action Mortality Predictors (RAMP), pioneered by AFSC researchers at the Newport lab, have become relatively common tools for estimating likely mortality in North American fisheries. In brief, clear relationships occur between the presence or absence of reflexes, (usually between five and seven different tests) and subsequent delayed mortality of an individual. The relationship is typically described by a sigmoid curve, whereby the probability of mortality increases with the number of lost reflexes, and the species-specific RAMP curves appear to be universal such that there is little variation of effect related to animal gender, size, or type of stress.

Figure 1. Retrieving crab pots in the commercial ocean fishery off Oregon (above) and recreational fishing in Yaquina Bay (below). Only legal sized males are retained while undersize males and all females are discarded.

To date, RAMP curves have been developed by tracking the fates of fishes or crabs held in laboratory or shipboard tanks. Although some laboratory holdings have spanned several months, shipboard holding is necessarily short, and these experiments do not account for some types of mortality that can occur in the natural environment, especially predation on injured individuals. Consequently, the best test of a RAMP curve is a field tag-recovery experiment.

The first RAMP experiments with Dungeness crab were initiated in 2012, with funding from the Oregon Dungeness Crab Commission (ODCC), NOAA's Bycatch Reduction Engineering Program, and an Oregon State University Markham Fellowship to Ph.D. student Noëlle Yochum. In fact, the Oregon Dungeness crab fishery is ideal for a field validation of RAMP, primarily because the likelihood of getting tag returns is high. The Oregon shelf, where the commercial pot fishery is concentrated, is narrow, and the fishing effort during winter and spring months is very high. The inshore recreational fishery is also intensive, and past tag-recovery experiments have yielded returns greater than 30%. In the Dungeness crab fishery all female crabs and all undersized males are returned to the water. The ODCC is required to determine discard mortality associated with the different crab fishing sectors as part of maintaining Marine Stewardship Council certification for their products. Field validation of the RAMP approach with Dungeness crab is perceived as a valid model system for investigations ultimately aimed at the Alaskan crab species.

Figure 2. Undersize Dungeness crab marked with a green T-bar spaghetti tag and released as part of the RAMP field validation experiment. The tag is inserted through the suture at the back of the carapace so that it can be retained through a molt.

During 2012, more than 600 crabs were assessed, tagged, and monitored in the Newport seawater laboratories for survival; this yielded the first RAMP data for Dungeness crab. Most of these crabs were collected from commercial pot-fishing operations (nine trips, February through July), and others were gathered from recreational fishers and experimental pot-capture effort in Yaquina Bay, Oregon (Fig. 1). In total, nearly 6,000 crabs intended for discard from the different fishing sectors were assessed for reflex actions. These observations provide the basic information needed to estimate discard mortality, but field validation of the RAMP approach for discard estimation is required.

RAMP validation depends upon a robust tag-recovery experiment, to provide actual survival data for different RAMP scores. Tag methods have been perfected for Dungeness crab (Fig. 2), and 270 individuals were tagged and released in Yaquina Bay during inshore crabbing trips with recreational gear during fall 2012, and additional crabs will be tagged each month until September 2013. However, the primary tagging effort shifted to the Oregon shelf with the start of the commercial ocean crabbing season at the end of December 2012. Four trips on commercial pot-fishing boats have already been made as of this writing. Crabs will continue to be tagged and released each month during commercial crabbing trips; tag returns already are being recorded with rewards paid to the fishers. Bycatch mortality rates that are generated from the mark-recapture study will be compared to those estimated using the traditional RAMP approach. Tag recoveries also will provide new information on crab movements and insights into ways that fishing practices can be altered to reduce mortality rates of discarded crabs.

By Allan Stoner and Noëlle Yochum
(Oregon State University)

Resource Ecology & Ecosystem Modeling Program

Fish Stomach Collection and Lab Analysis

During the fourth quarter of 2012, Resource Ecology and Ecosystem Modeling (REEM) program staff analyzed the contents of 4,869 groundfish stomachs. The majority of these samples were from 11 species sampled in the eastern Bering Sea, 1 species from the Aleutian Islands, and 2 species from the Gulf of Alaska. In total, 23,537 records were added to the REEM food habits database. In preparation for stable isotope analysis, 319 muscle and liver tissue samples from Alaskan groundfish were ground, and 673 tissue samples were tinned in preparation for gas isotope-ratio mass spectroscopy. This ongoing project provides additional information on long-term integration of energy transfer in Alaska's marine food webs.

Analysis of the stomach contents of predators sampled this summer from the Chuckchi Sea has begun. Procedures for laboratory analysis of these samples have been developed to support the dietary descriptions, food web analyses, and project-integration. The detailed identification standards, the regional species assemblages, and the small size of the predators require modifications from the REEM standard procedures for stomach content analysis. Species lists, descriptions, reference materials, and identification techniques are being compiled to achieve the desired level of detail. In addition, fish specimens are being shared among Chukchi Sea investigations, which is requiring additional handling and processing time in the laboratory.

Groundfish stomach samples were collected during the Alaska Department of Fish & Game (ADF&G) surveys and by fishery observers during commercial fishing operations. During the fourth quarter, 820 stomach samples were collected from seven predator species from Pavlov and Marmot Bays in the Gulf of Alaska during ADF&G surveys. Fisheries observers returned 182 stomach samples from three species collected in the eastern Bering Sea, from 44 arrowtooth flounder collected in the Gulf of Alaska, and from 43 arrowtooth flounder collected in Aleutian Islands waters. In preparation for future observer collections, REEM staff assembled 15 stomach collection kits and sent them to Fisheries Monitoring and Analysis Division personnel in Dutch Harbor, Alaska, for deployment on fishing vessels not available to REEM personnel in the Seattle area. REEM staff trained new observers on stomach sampling procedures and instructed them on how the samples are analyzed and how the data is used.

By Troy Buckley, Geoff Lang, Mei-Sun Yang, Richard Hibpshman, Kimberly Sawyer, Caroline Robinson and Sean Rohan

Diet Composition of Walleye Pollock in the Eastern Bering Sea, 1987-2011, and Predator-Prey Relationships with Copepods and Euphausiids

Walleye pollock (*Theragra chalcogramma*) has a central role in the eastern Bering Sea (EBS) food web. It is a key forage species for many intermediate and upper trophic level predators and is the dominant consumer within the EBS food web. Pollock diet composition is known to differ with pollock size and location in the EBS, the geographic distribution and size composition of the EBS pollock stock changes over time, and the sampling of pollock stomachs varies among years in intensity and geographic distribution. Weighting diet information by stomach fullness and biomass for six size-categories (0-19, 20-29, 30-39, 40-49, 50-59, and > 60 cm fork length, (FL)) was used to provide a consistent average diet description of walleye pollock in the bottom trawl survey from 1987 through 2011. An index of partial fullness was also calculated for major prey over this time-period.

Partial fullness is an indicator of the average relative consumption of each prey type in each year (Fig. 1). The average index was calculated and plotted for euphausiids and copepods for three time periods – 1987-92, 1993-2004 and 2005-11, with the middle period being 12 years of continuous below average (0.22) partial fullness values for copepods. Partial fullness values for euphausiids were found to be serially random ($P > 0.5$), the probability that the partial fullness values for copepods were serially random was lower ($P = 0.10$), and the difference between the partial fullness values of euphausiids and copepods were found to be serially non-random ($P = 0.02$).

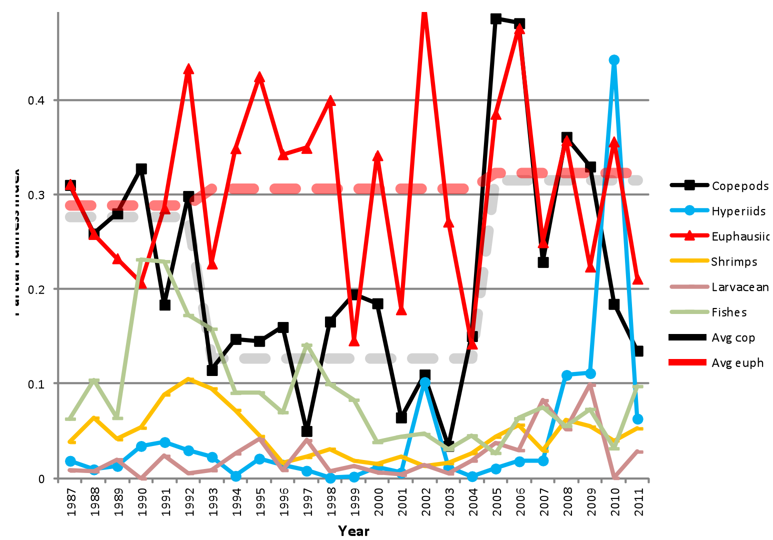


Figure 1. An index of partial fullness of major components in the diet of EBS pollock from 1987 through 2011. The average index for copepods (Avg cop) and euphausiids (Avg euph) are indicated for 3 periods; 1987-92, 1993-2004 and 2005-11.

Hyperiid amphipods were not important in the diet of EBS pollock in most years, but in 2010 they were the dominant prey type (Fig. 1). The majority of these amphipods were likely *Themisto libellula* based on the locations and water temperatures where they were consumed. *Themisto libellula* is associated with Arctic water masses, and in the Barents Sea the highest concentrations are found near the Polar Front where the majority of reproduction and production of this species likely occurs due to the greater amount of food available to them compared to the Arctic Ocean. We speculate that recent conditions of cold water temperatures over the EBS shelf coupled with early ice-melt in the Arctic or more extensive ice-free zones in the Arctic may contribute to conditions that have favored the reproduction and survival of *T. libellula*. This may provide a vector for the enhanced retention of primary production in the pelagic zone in the northern Bering Sea and could have an effect on benthic-feeding invertebrates, fishes, and marine mammals.

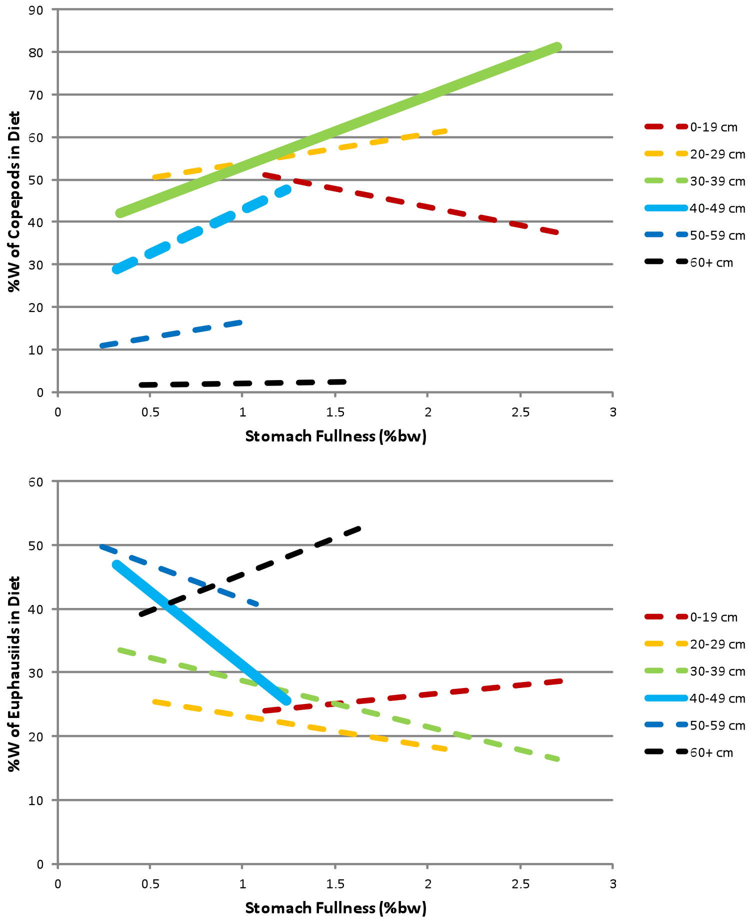


Figure 2. The trend in the average annual weight composition (%W) of copepods (upper panel) and euphausiids (lower panel) relative to the average annual stomach fullness (%bw) of each size category of pollock sampled by AFSC's EBS bottom trawl survey, 1987-2011. Correlations are significantly ($P < 0.05$, thick solid line), almost significantly ($0.10 > P > 0.05$, thick dashed line), or not significantly ($P > 0.10$, thin dashed line) different from zero.

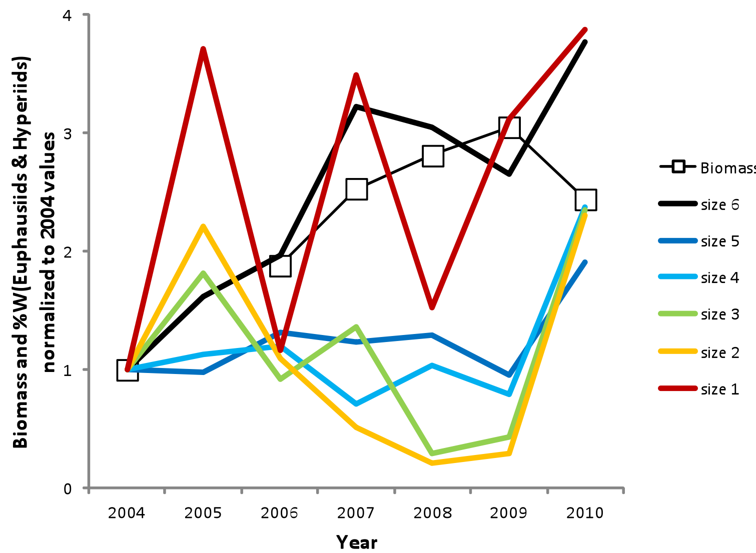


Figure 3. Time series of euphausiid biomass from the hydroacoustic survey and the combined %W of euphausiids and hyperiid amphipods in the diets ofsix sizes of pollock from the Bottom Trawl Survey. The seven time series are normalized to their 2004 value to indicate the relative change over time. Euphausiid biomass data courtesy of P.H. Ressler.

The relationship between average annual weight composition (%W) of copepods and euphausiids to the average annual stomach fullness (%bw) varies by pollock size (Fig. 2). Each trend-line extends over the range of %bw values observed over the 25 years for each size category. The correlation between %bw and (arcsin transformed) %W of copepods in the diet was generally positive, especially for 30-39 cm pollock ($r^2 = 0.20$, $P < 0.05$) and 40-49 cm pollock ($r<2 = 0.15$, $0.10 > P > 0.05$). The correlation between %bw and %W of euphausiids in the diet was positive for the largest and smallest size groups of pollock ($r^2 = 0.05$, $0.20 > P > 0.10$; $r^2 = 0.01$, $P > 0.50$; respectively), but negative for other size groups, especially 40-49 cm pollock ($r^2 = 0.20$, $P < 0.05$). For 40-49 cm pollock, euphausiids became more important in the annual average diet when the annual average stomach fullness was lowest. Euphausiids may provide a more consistent food source from year to year than other potential prey of intermediate sizes of pollock. This may be similar to the role of euphausiids as a more consistent, baseline food source in seasons when other prey becomes less available.

Euphausiid biomass estimates have recently become available for 2004 and 2006-10 in the EBS (and include some hyperiid amphipod biomass). The increase in euphausiid biomass over this period was reflected in the %W of euphausiids in the diets of pollock ≥ 60 cm FL and possibly pollock < 20 cm FL (Fig. 3). Although correlations were not significant, the positive correlation between euphausiid biomass and %W of euphausiids in the diets of the smallest and largest size groups in the EBS, had r^2 values of 0.41 and 0.61, respectively.

The strongest trophic link between pollock and euphausiids appears to be limited to the smallest and largest pollock while intermediate sizes of pollock appear to have a closer link to copepods in the summer. Size-specific relationships between pollock and specific subsets of the zooplankton community should improve the interpretation of patterns in pollock abundance and distribution whether due to interannual changes in physical conditions or longer-term climate change.

By Troy Buckley and Kerim Aydin

Seabird Bycatch Estimates for Alaskan Federal Groundfish Fisheries

The AFSC released the most recent estimates of seabirds caught as bycatch in commercial groundfish fisheries in Alaska operating in federal waters of the U.S. Exclusive Economic Zone for the years 2007–11. The report can be found in the 2012 Ecosystem Considerations report, available at http://access.afsc.noaa.gov/reem/ecoweb/index.cfm.

The gear types represented are demersal longline, pot, pelagic trawl, and non-pelagic trawl. The bycatch estimates do not apply to gill-net, seine, troll, or halibut longline fisheries. Seabird bycatch in pot fisheries is minimal. These estimates are based on two sources of information: 1) data provided by NMFS-certified fishery observers deployed to vessels and floating or shoreside processing plants, and 2) catch estimates provided by the NMFS Alaska Regional Office Catch Accounting System.

The 2007-11 bycatch estimates are produced from the NMFS Alaska Regional Office Catch Accounting System. Total estimated seabird bycatch in all Alaskan groundfish fisheries is shown in Table 1. Northern fulmars (*Fulmaris glacialis*) are the most commonly caught seabird in each year. Gulls and shearwaters, both of which are combined species groups, were typically the second and third most commonly caught, although shearwater bycatch was much reduced in 2011. Albatross bycatch varied annually. The greatest numbers of albatross were caught in 2008. In 2011, 87.0% of albatross bycatch occurred in the GOA which accounts for only 18.5% of overall seabird bycatch. Of special interest is the endangered short-tailed albatross. Since 2003, bycatch estimates were above zero only in 2010 and 2011, when two birds and one bird were incidentally hooked respectively. This incidental take occurred in the Bering Sea area.

In the longline fishery, the 2011 numbers are 30.5% above the 2007-10 average of 7,249 (Fig. 1). Bycatch in the longline fishery showed a marked decline beginning in 2002 due to the deployment of streamer lines as bird deterrents. Since then, annual bycatch has remained below 10,000 birds. The 2010 bycatch (3,704 birds) was the lowest estimated in this fishery overall, but the numbers increased to 8,914 in 2011, the second highest in the streamer line era. The increased numbers in 2011 are due to a doubling of the gull numbers (1,084 to 2,206) and a 3-fold increase in northern fulmar bycatch from 1,782 to 5,848.

There are many factors that may influence annual variation in bycatch rates, including seabird distribution, population trends, prey supply, and fisheries activities. The longline fleet has traditionally been responsible for about 91% of the overall seabird bycatch in Alaska, as determined from the data sources noted above. However, standard observer sampling methods on trawl vessels do not account for additional mortalities from net entanglements, cable strikes, and other sources. Thus, the trawl estimates are biased low. A project is underway that addresses this issue.

Seabird mitigation gear used on longline vessels can substantially reduce bycatch (Fig. 1). Individual vessel performance varies, and further reduction of overall fleet averages may depend on targeted improved performance for a handful of vessels within the fleet. Additional methods, such as integrated weight longline gear, have been researched and shown to be effective (Washington Sea Grant Program). Continued collaboration with the longline industry will be important. Albatross bycatch in the Gulf of Alaska is generally higher than in other regions. With observer program restructuring and the deployment plan recommended by NMFS and approved by the North Pacific Fisheries Management Council, we will have a better sense of albatross bycatch issues within GOA-fisheries.

By Shannon Fitzgerald and Stephani Zador

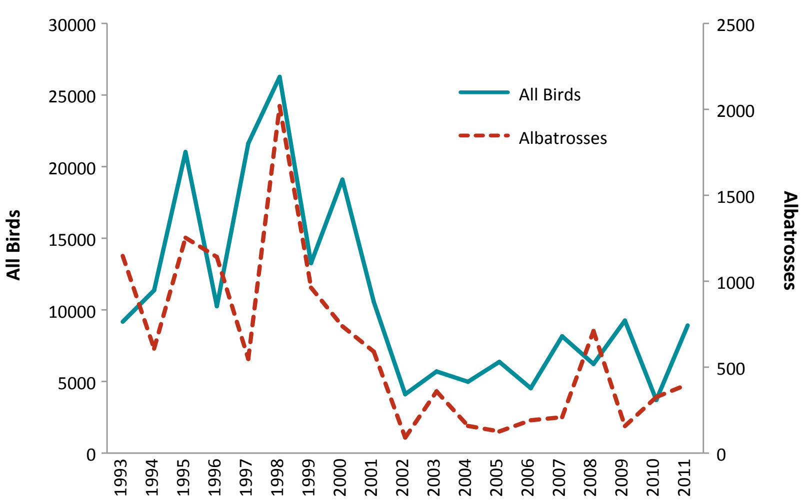


Figure 1. Estimated seabird bycatch by year in the Alaskan demersal groundfish longline fishery, 1993 through 2011, for all birds (left axis) and all albatross (right axis). The deployment of streamer lines as bird deterrents began in 2002.

Table 1. Total estimated seabird bycatch in Alaskan groundfish fisheries, all gear types and Fishery Management Plan areas combined, 2007 through 2011. Note: estimations extrapolate observed bycatch to unobserved portions of the fisheries fleets and thus are greater than actually observed bycatch.

Species/Species Group	2007	2008	2009	2010	2011
Unidentified Albatross	16	0	0	0	0
Short-tailed Albatross	0	0	0	15	5
Laysan Albatross	17	420	114	267	189
Black-footed Albatross	176	290	52	44	206
Northern Fulmar	4,581	3,426	7,921	2,357	6,214
Shearwater	3,602	1,214	622	647	199
Storm Petrel	1	44	0	0	0
Gull	1,309	1,472	1,296	1,141	2,208
Kittiwake	10	0	16	0	6
Murre	7	5	13	102	14
Puffin	0	0	0	5	0
Auklet	0	3	0	0	0
Other Alcid	0	0	105	0	0
Other Bird	0	0	136	0	0
Unidentified	509	40	166	18	259
Total	10,228	6,914	10,441	4,596	9,298

Alaska Marine Ecosystem Considerations: 2012 Report Completed and Posted Online

The Ecosystem Considerations report is produced annually for the North Pacific Fishery Management Council as part of the Stock Assessment and Fishery Evaluation (SAFE) report. The goal of the Ecosystem Considerations report is to provide the Council and other readers with an overview of marine ecosystems in Alaska through ecosystem assessments and by tracking time series of ecosystem indicators. The ecosystems under consideration include the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska. New this year, the report includes a preliminary Arctic ecosystem assessment.

The intent of adding the Alaskan Arctic to the Ecosystem Considerations report was to provide an overview of general ecosystem information that may form the basis for more comprehensive future Arctic assessments that would be useful for fishery managers making decisions on the authorization of new fisheries. Consistent with ecosystem assessments of the eastern Bering Sea, Gulf of Alaska, and Aleutian Islands, we intend for the future Arctic assessments to include a list of indicators that directly address ecosystem-level processes and attributes that can inform fishery management advice by communicating indicator history, current status, and possible future directions.

The hot topic for the Gulf of Alaska includes a report on the apparent poor foraging conditions for upper trophic predators in 2011 that may indicate that this particular year-class of fishes may be poor.

The report includes additional new and updated sections, including the 2012 eastern Bering Sea and Aleutian Islands report cards and ecosystem assessments. This year, the hot topics section includes topics from each ecosystem. For the Arctic, these include a description of the record sea ice minimum that was reached in mid-September and a review of the apparent waning of the Unusual Mortality Event for ice seals and walrus noted in 2011. The hot topic for the eastern Bering Sea was the fisheries failure that was declared for the commercial king salmon fisheries. The two leading hypotheses for the reduced runs are climate change and fishing. The hot topic for the Aleutian Islands focused on the recent spatial analysis of Blackspotted/Rougheye Rockfish which indicates that local exploitation rates may be higher than previously thought. The hot topic for the Gulf of Alaska includes a report on the apparent poor foraging conditions for upper trophic predators in 2011 that may indicate that this particular year-class of fishes may be poor. The section in the report that describes ecosystem and management indicators includes updates to 44 individual contributions and presents 5 new contributions. These include contributions on trends in surface carbon uptake by phytoplankton and forage fish catch rates during late summer to early fall in the eastern Bering Sea; Gulf of Alaska ichthyoplankton abundance indices and regional distribution of juvenile salmon and age-0 marine fish; and an analysis of spatial variability of catches in Bering Sea and Gulf of Alaska crab fisheries.

Additional regional 2012 ecosystem highlights include the extensive sea ice and cold pool in the eastern Bering Sea and record cold water temperatures during the summer in the Aleutian Islands, which may have influenced the observed decreases in pelagic foragers and apex fish predator biomass estimates relative to the last survey in 2010. NMFS surveys are conducted in the Aleutian Islands and Gulf of Alaska in alternate years, so no surveys were available in 2012.

The final draft was presented to the Council's Groundfish Plan Teams in November, and the final report was presented to the Science and Statistical Committee and Council Advisory Board in December when the 2013 groundfish quotas were set. The report is now available online at the AFSC's Ecosystem Considerations website.

By Stephani Zador

Economics & Social Sciences Research Program

Using Vulnerability Indicators to Aid in the Assessment of Vulnerability and Resiliency in Alaskan Communities

The purpose of our project is to develop a framework for assessing the vulnerability and resiliency of Alaskan fishing communities to a wide variety of risk factors such as the implementation of catch shares programs, stock collapse, natural or man-made disasters, or other factors affecting Alaskan communities. Creating vulnerability indicators for fishing communities provides a pragmatic approach toward standardization of data and analysis for assessment of some of the long-term effects of management actions. Historically, the ability to conduct such analysis has been due to the lack of quantitative social data. The use of indicators to monitor sustainability and other measures of well-being within marine fisheries has been promoted within international fisheries management and there have been some cases of its use within U.S. fisheries, mainly in the Southeast. These social indices are intended to improve the analytical rigor of fisheries Social Impact Assessments, through analysis of adherence to National Standard 8 of the Manguson-Stevens Reauthorization Act and Executive Order 12898 on Environmental Justice in components of Environmental Impact Statements . Given the short time frame in which such analyses are often conducted, an advantage to this approach is that the majority of the data used to construct these indices are readily accessible secondary data and can be compiled quickly to create measures of social vulnerability and to update community profiles.

Modifications to the current methodology and vulnerability indicators will be made based on community feedback.

We have adopted a methodology and data management protocols consistent with other regions of the country to create a standardized nationwide suite of vulnerability indicators to provide for a comparison of community resilience and vulnerability between Alaska and other regions. This will also facilitate more objective inter- and intra-regional analysis of social impacts of fisheries management decisions. However, unlike many other regions, communities in the North Pacific region are not well represented in many census surveys (i.e., they are not big enough to be adequately captured by the American Community Survey), which has required us to develop novel approaches for our region. The vulnerability indicators we have developed to date are population composition, labor force structure, poverty, housing characteristics, fishing labor force, commercial fishing reliance, commercial fishing engagement, recreational fishing engagement, recreational fishing reliance, commercial fisheries diversification, occupational diversification, subsistence fishing reliance, and subsistence marine mammal hunting reliance. These indicators have been computed for approximately 300 communities in Alaska using average values from 2000 to 2010.

We are now in the process of conducting three additional aspects of this project. First, we will incorporate community stakeholder feedback through a groundtruthing exercise to assess the appropriateness and adequacy of the current set of vulnerability indicators for communities in Alaska and test the validity of the results through in-community education and outreach. Modifications to the current methodology and vulnerability indicators will be made based on community feedback. Second, we will create a time series dataset that will allow us to assess community vulnerability each year and track changes over time. Third, we will explore how these vulnerability indicators, which incorporate important economic and social variables over time, can be used to assess a community's vulnerability or resilience to a wide variety of risk factors, such as the implementation of catch shares programs, stock collapse, natural or man-made disaster, or other factors affecting the community. Given the variety of types of risks a community faces, it is important to understand how the different types of risk will likely impact the resilience and vulnerability of a community. Similarly, across communities, it is important to understand which indicators best predict resilience or vulnerability of a community to each type of risk, and how these vulnerability indicators can be used to predict the changes in resilience and vulnerability of a community before and after the community experienced a significant risk event. We will apply the proposed vulnerability and resilience indicators to a selection of case studies known to have had significant impacts on Alaskan communities. The hypothesis is that some indicators will be good for analyzing certain types of risks (e.g., biophysical risks compared to fisheries management driven risks), but all indicators will not be useful for analyzing community vulnerability to all risks. In addition, this component of the project will use historical data to test the reliability of our indicators and better forecast which communities will be vulnerable to certain types of events in the future.

By Amber Himes-Cornell and Stephen Kasperski

Two-stock Bioeconomic Model for Estimating Joint Economic Yield of Bristol Bay Red King Crab and Eastern Bering Sea Snow Crab

Maximum sustainable yield (MSY) is the default reference point in U.S. fisheries management. However, optimum yield is the amount of fish that provides the greatest overall benefit to the nation, which could be lower than MSY because of economic or other factors. To analyze relationships between MSY and maximum economic yield (MEY), the stock assessment methods used to provide management advice for Bristol Bay red king crab (*Paralithodes camtschaticus*) and eastern Being Sea snow crab (*Chionoecetes opilio*) were linked with an economics module. This two-stock bioeconomic model relates fishing mortality in each directed pot fishery to days fishing and variable costs related to fuel, food, and bait (the latter by relating days fishing to the number of potlifts). This bioeconomic model was used to estimate fishing effort corresponding to MSY and MEY, as well as the sensitivity of fishing effort at these reference points to uncertainty in prices, costs, and crab population dynamics. Catch, abundance and size-composition data were also modeled using simplified (i.e., 5-size-class) population dynamics, and these simplified population dynamics were used as the basis for a two-stock bioeconomic model. The full and simplified bioeconomic models were used to evaluate the sensitivity of the estimates of management reference points to the structure of the assessment model and to explore the impact of constraints on total effort on the joint yield and profit for these two fisheries. The bioeconomic models were also used to assess the optimal split of total effort between the Bristol Bay red king crab and eastern Bering Sea snow crab fisheries given different levels of total effort and three alternative management objectives: 1) maximizing long-term catch, 2) maximizing long-term profit, and 3) maximizing net present value. Finally, the bioeconomic models were used as an operating model in a management strategy evaluation to illustrate how control rules, including rules with an economic foundation, can be tested for multi-stock crab fisheries.

By Mike Dalton

Advances in the Stock Assessment and Fisheries Evaluation – Economic Status Report

Each year the Economic and Social Sciences Research (ESSR) program documents and reports the economic status of the North Pacific Groundfish and Crab fisheries. The results of this analysis are compiled into an economic chapter of the Stock Assessment and Fisheries Evaluation Report. The Economic SAFE reports and evaluates the economic status of the fisheries for managers and stakeholders by providing recent estimates of economic variables in the fisheries. These data are compiled and distributed not only to inform management decisions but to provide stakeholders and the public access to data on North Pacific fisheries. As the needs of management and stakeholders evolve, so should the Economic SAFE evolve to meet these changing demands. Here we update the ESSR program's progress planned for the Economic SAFE and described in last year's report.

The 2012 Economic SAFE was transitioned into a new document production routine that improves accessibility of the content and simplifies the future production of the report. Information is presented using modern formatting standards making the document more readable, cleaner and more navigable. In addition, compilation of the Economic SAFE has been automated making the production of the report and its data more efficient. Scripts used to extract the raw collected data and calculate the data reported have been rewritten and migrated to the native database and are more easily accessible by researchers. These tasks have improved transparency of the process from data to document and made production of the report more efficient.

This year's Economic SAFE reports the economic data of wholesale and ex-vessel value, production and price; discards and prohibited species catch; and changes in the composition of the fleet. The data are printed in tables that stratify the data along different dimensions. In addition, data are available as excel files on the Socioeconomics web page which also provide longer time series of the data when available. Following up on last year, economic indices are presented that evaluate the economic performance through value, price, and quantity, across species, product and gear types. These are plotted to allow for a concise visual display of relative performance, and economic trends are discussed. Another component of this report is a set of market profiles for pollock, Pacific cod, sablefish, and flatfish (yellowfin and rock sole, and arrowtooth flounder). The goal of these profiles is to discuss and, where possible, explain the market trends observed in pricing, volume, and supply and demand for each of these groundfish species. Finally, new and ongoing research and data collection programs by AFSC social scientists are summarized and recent scientific publications are listed.

Following up on last year, economic indices are presented that evaluate the economic performance through value, price, and quantity, across species, product and gear types.

The Economic SAFE report will continue to evolve to meet the needs of management, stakeholders, and others who use the information it contains. We will continue to improve the structure and format of the document to make the information and data more accessible. We will continue to expand the Economic SAFE by including analyses which evaluate the status of the fishery by including reports on Alaska communities' catch share program. Furthermore, we will continue our outreach efforts by attempting to engage users of the Economic SAFE so that we can improve future reports. Readers of this quarterly report can contribute to our efforts to improve the Economic SAFE by completing the online survey accompanying the Groundfish SAFE Economic Status Report, by attending the feedback session at the NPFMC meeting in Seattle, February 2013, or by contacting us at Ben.Fissel@noaa.gov.

By Ben Fissel

Status of Stocks & Multispecies Assessment Program

Update on Groundfish Stock Assessments for the 2013 Fishery

Many of the flatfish stocks (e.g., rock sole, Alaska plaice, and arrowtooth flounder) remain at high levels but catches are relatively low.

The stock assessment and fishery evaluation (SAFE) reports compiled again this year included 50 sections for individual species groups or stocks (split evenly between the Bering Sea and Aleutian Islands (BSAI) and the Gulf of Alaska (GOA)). These reports provided the scientific basis for groundfish acceptable biological catch (ABC) and total catch recommendations. These reports present analyses of the extensive data collected by NMFS-trained observers and AFSC scientists aboard dedicated research surveys. Observer data are used to estimate catch of target and prohibited species (e.g., salmon, crab, herring, and Pacific halibut) to ensure that fisheries do not exceed annually specified total allowable catches (TACs) or violate other fishery restrictions (like time-area closures). Results from the AFSC surveys, combined with observer data, are critical for conditioning statistical stock assessment models. Results from these models (and their estimates of uncertainty) are used to determine the status of individual species and make recommendations for future catch levels. This TAC-setting process involves annual presentations of these reports at a series of public meetings coordinated by the North Pacific Fishery Management Council's (NPFMC) staff.

The reports present analyses on individual stocks and/or species groups and provide targets and limits—acceptable biological catches (ABC) and overfishing levels (OFL), respectively. The NPFMC Groundfish Plan Teams review drafts of these reports during September and November meetings and make recommendations for ABC and OFL levels (one each for the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) regions) for review by the NPFMC Scientific and Statistical Committee (SSC). The SSC then makes the final ABC recommendation to the Council and the Council's Advisory Panel of industry representatives makes TAC recommendations during the December NPFMC meeting. Finally, the recommended TAC levels are adjusted (for some species) by the Council to ensure that other constraints (e.g., limiting the sum of all TACs in the BSAI regions to be less than 2 million tons) are met.

Importantly, the following rule applies for each federally managed groundfish stock (or stock complex) in a given year:

Catch < TAC < ABC < OFL

In practice, catch is often less than TAC and TAC is often less than ABC. The multispecies management system is therefore based on the premise that individual components are fished at safe, sustainable levels and that overfishing is avoided.

The Midwater Assessment Conservation Engineering (MACE) Program of the Center's RACE Division conducted a survey in summer of 2012 covering the main area of the eastern Bering Sea (EBS) and extended into the Russian zone as part of a cooperative agreement. The AFSC's Auke Bay Laboratory's (ABL) Marine Ecology and Stock Assessment scientists again conducted the annual longline survey which is designed primarily for sablefish but also produces data used in Greenland turbot and some rockfish assessments. This survey covers the slope regions of the GOA along with segments of the BSAI region. The groundfish assessment group also conducted bottom-trawl surveys that covered three areas during the summer of 2012: the EBS shelf area, the EBS slope (down to 1,000 m), and the Aleutian Islands.

The ecosystem considerations chapter reports on 74 ecosystem status and management indicators of which 6 were new contributions and 47 others were updated. These are presented for Council consideration in setting catch limits and other recommendations for management. Fisheries for these groundfish species during 2011 landed 1.99 million metric tons valued at approximately $2.52 billion after primary processing (Economic Chapter). This represents nearly half of the weight of all commercial fish species landed in the United States. The bulk of the landings are from EBS pollock (landings of about 1.2 million t). Many of the flatfish stocks (e.g., rock sole, Alaska plaice, and arrowtooth flounder) remain at high levels but catches are relatively low. Yellowfin sole abundance is high but a larger fraction of the ABC is caught compared to other flatfish stocks in the EBS. Atka mackerel biomass abundance is variable and the 2012 survey estimates indicate a relatively sharp decline from recent above-average biomass levels. Rockfish species comprise 5%-8% of the groundfish complex biomass and have generally increasing based on recent surveys. Presently, projections of 2012 spawning biomass for the main groundfish stocks are estimated to be near or above their target stock size (B_{msy}) for both the BSAI and GOA regions. The following presents some assessment highlights by area and for selected species.

Gulf of Alaska (GOA)

In the GOA, the main species trends were mixed. The ABC for pollock increased by 4% relative to 2012; whereas, the Pacific cod and sablefish ABCs declined by 8% and 3%, respectively. The sum of the recommended ABCs for 2013 is 595,920 t which represents a 2% decrease from the 2012 total. New fishery-independent data was available from the winter acoustic-trawl survey for pollock and the summer longline survey for sablefish. Additional model developments were presented for Pacific cod and some flatfish stocks. These changes are highlighted below.

GOA Pollock: In July 2012 the Center for Independent Experts (CIE) conducted a review of the GOA pollock assessment and a number of their recommendations were included (and future assessments are likely to include more). Three alternative models were presented and performance evaluated. The survey time series in recent years are consistent and show generally increasing trends since about 2007, even though the 2012 Shelikof Strait acoustic survey biomass estimate declined 22% from the 2010 estimate. In contrast, the ADF&G crab/groundfish survey biomass estimate increased by 71% from the 2011 estimate. The estimated abundance of mature fish in 2013 is projected to be nearly the same as in 2012 and is projected to decrease gradually over the next 5 years. The model estimate of spawning biomass in 2013 is 259,843 t, which is 35.1% of unfished spawning biomass (based on average post-1977 recruitment).

GOA Pacific Cod: The 2012 GOA Pacific cod assessment author presented an evaluation of ten alternative models which focused on exploring the effects of different combinations of tuning to survey pre-recruits and larger Pacific cod (>27 cm), separately. Additional issues were related to how the model was fitted to available survey mean length-at-age data. Estimated age-0 recruitment has been relatively strong since 2005, and stock abundance is expected to be stable in the near term. With projected female spawning biomass in 2013 estimated at 111,000 t, the stock is above the Bmsy proxy of 82,100 t.

GOA/BSAI Sablefish: The longline survey abundance index decreased 21% from 2011 to 2012 following an 18% increase from 2008 to 2011. The assessment model indicates somewhat lower incoming recruitment compared to 2011 estimates and that spawning biomass is projected to decrease from 2013 to 2017, and then stabilize. The estimated spawning biomass in 2013 is about 6% above the *Bmsy* proxy.

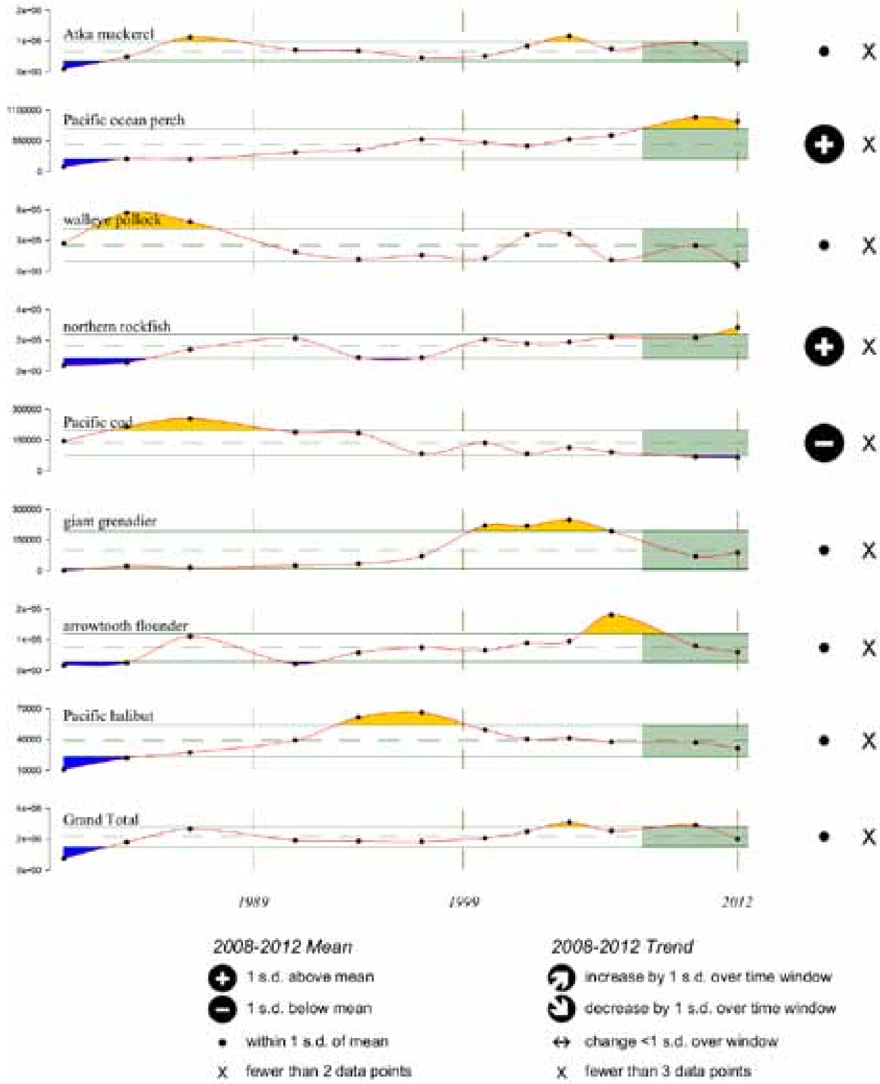


Figure 1. NMFS survey biomass trends (in t) for the main groundfish species observed in the Aleutian Islands region, 1980-2012. Click to enlarge.

Bering Sea/Aleutian Islands (BSAI)

In the BSAI region, full assessments for 24 stocks or stock groups were completed. Since new primary groundfish survey data were available for the Aleutian Islands, full assessments for the rockfish stocks were presented to the Council (in years where no survey occurs, a summary update is conducted for long-lived species). For the region, the sum of the ABCs for 2013 is about 2.64 million t, up slightly from the 2012 totals (2.51 million t). The largest component is the EBS pollock ABC (1.375 million t for 2013 compared to 1.22 million t in 2012). The EBS 2013 pollock TAC increased by 4% to 1.247 million t from the 2012 TAC of 1.2 million t. The 2013 Pacific cod TAC increased by about 18% to 307,000 t from 261,000 t in 2012.

A synopsis of the Aleutian Islands survey trends by main groundfish stock groups indicates a mixture of declines and increases between species with the overall total being about average in 2012 (Fig. 1). Examining just the main rockfish stocks indicates mostly above-average stock sizes, particularly for Pacific ocean perch and northern rockfish (Fig. 2).

Most of the BSAI groundfish stocks continue to be above target spawning biomass levels. Two stocks are projected to be below Bmsy in 2013: Aleutian Islands pollock (by about 2%) and Greenland turbot (by about 44%). Age 3+ pollock biomass estimates are projected to be 8.14 million t in 2013 whereas Pacific cod projections are for about

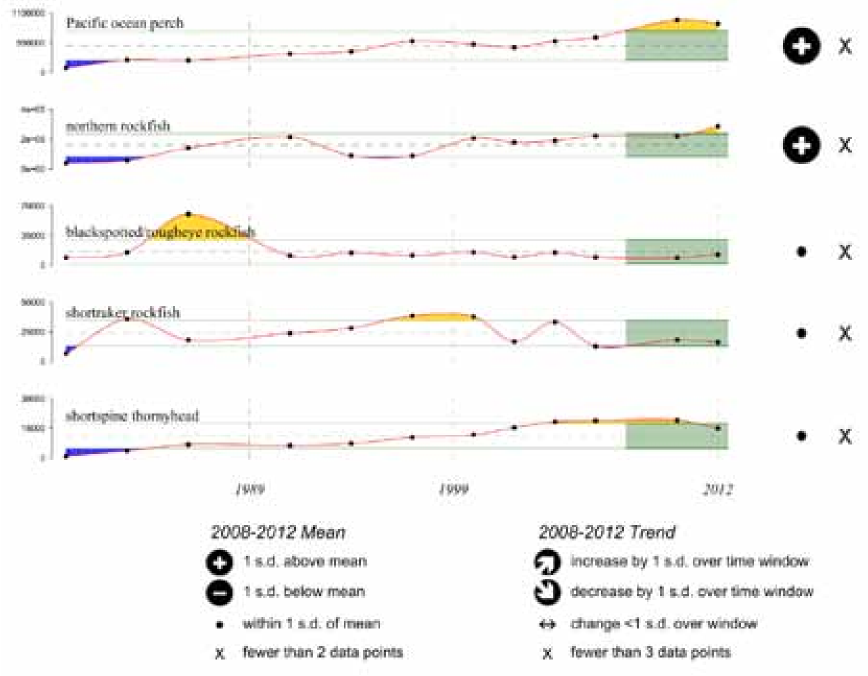


Figure 2. NMFS survey biomass trends (in metric tons) for the main rockfish species groups in the Aleutian Islands. Click to enlarge.

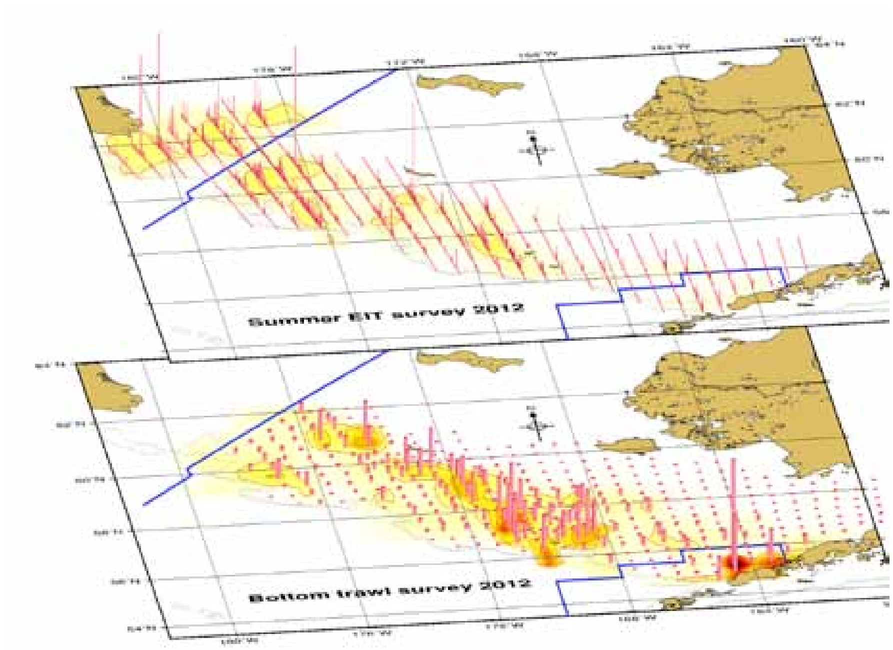


Figure 3. NMFS acoustic-trawl and bottom trawl survey results for 2012. Vertical lines and contours represent relative biomass of pollock as observed in the different surveys. Click to enlarge.

1.51 million t. The flatfish show generally increasing trends and due to recent high recruitments, Greenland turbot is projected to increase by about 17% in the coming year. The biomass of Atka mackerel for 2013 is estimated at 289,000 t, down 29% from the 2012 level.

EBS Pollock: As noted above, the MACE group within the RACE Division completed an extensive acoustic-trawl survey in summer 2012 that indicated about 22% of the mid-water pollock biomass (~500,000 t) they observed occurred within the Russian zone. The abundances in mid-water (being comprised mainly of pollock aged 1-4 years) were considerably shifted to the northwest portion of the survey compared to the generally older pollock (ages 4-15+) observed in the bottom trawl survey (Fig.3). The occurrence of mid-water pollock in the Russian zone was also considered unusual because the bottom temperatures were very cold with a very extensive "cold pool." Even within the U.S. zone, concentrations of pollock extended well into the cold pool which, when compared to other years, they tended to avoid (Fig. 4).

The new data on age composition from the fishery and the surveys resulted in estimates for the 2008 year class that were considerably higher than last year (and well above average) and that the next most recent strong year class (2006) was estimated to be of lower strength than estimated in 2011. In response to requests from the Council, a new form of decision table for considering future pollock fishing levels was presented which considered factors affecting fishing conditions (i.e., CPUE (catch per unit effort)), proximity of stock status to threshold levels, and indicators on the diversity of ages within the spawning population. This work generated some lively discussion and provided direction for more management-strategy evaluation studies.

BSAI Pacific Cod: The EBS shelf survey biomass estimate was nearly the same (less than 1% change) in 2011 and 2012 and 15% above the 1982-2012 mean value. The stock is increasing due to the fact that the six most recent year classes include four of the top nine year classes of all time (2006, 2008, 2010, and 2011). The female spawning biomass is estimated to be above Bmsy levels (about 47% of unfished) and the projected near-term outlook is for further increases. The Council also discussed the presentation of splitting the AI region from the EBS (a preliminary analysis was presented) and the expectation (if the Council proceeds) is that the TAC would be split in 2014 (to allow for further developments of the assessment approach).

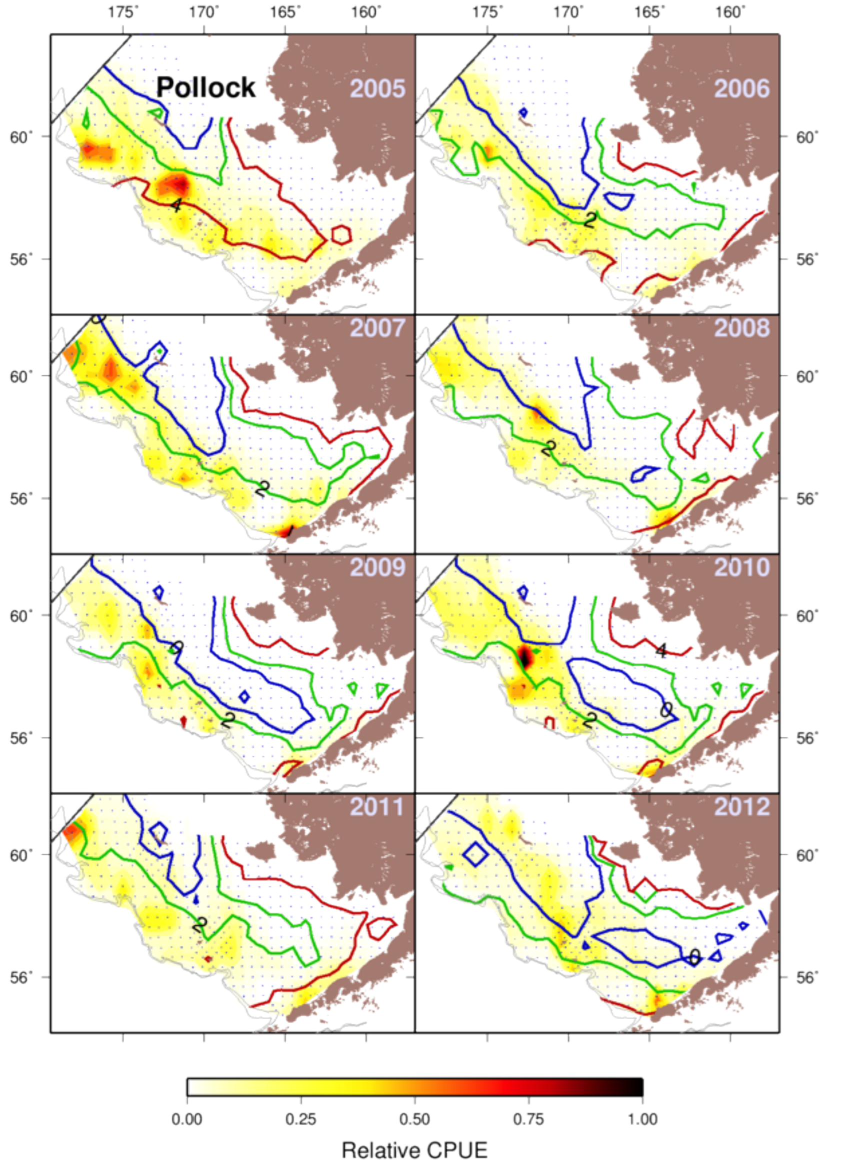


Figure 4. EBS pollock CPUE (shades = relative kg/hectare) and bottom temperature isotherms of 0°, 2°, and 4° Celsius from NMFS summer bottom-trawl surveys, 2005-2012. Click to enlarge.

BSAI Flatfish: Yellowfin sole is one of the most abundant flatfish species in the EBS and the projected female spawning biomass estimate for 2013 is 582,000 t (well above the Bmsy value of 353,000 t) with a stable trend which may increase due to an above-average 2003 year class. The northern rock sole model indicates a 2013 age-6+ biomass estimate of just under 1.5 million t, and the relatively low harvest rates suggest further increases for the next few years. Alaska plaice and flathead sole models indicate that the 2013 spawning biomass estimates are well above Bmsy levels and that exploitation rates remain relatively low (catches are about one-third of ABCs). Arrowtooth flounder and Kamchatka flounder stocks commenced being treated separately in 2011. Presently, the models for both of these assessments are in the process of being refined for application in 2013. The catches have remained well below the ABC limits.

BSAI Greenland Turbot:Recent trawl surveys of the EBS shelf trawl survey indicate positive signs of recruitment to the population. The assessment model and data for Greenland turbot was completely revised in 2012. This included updated weights-at-age and selectivities and a correct to the projection model inputs. This affected the stock status determination (estimated to be at about 21% of "unfished" in 2013) and subsequently reduced the recommended ABC to about 26% of last year's estimate. Fortunately, there appears to be strong 2008 and 2009 year classes based on both the survey and fisheries size composition data. These two year classes are expected to be larger than any other recruitment event since the 1970s and will begin to have an increasing influence on spawning stock biomass starting in about 2014.

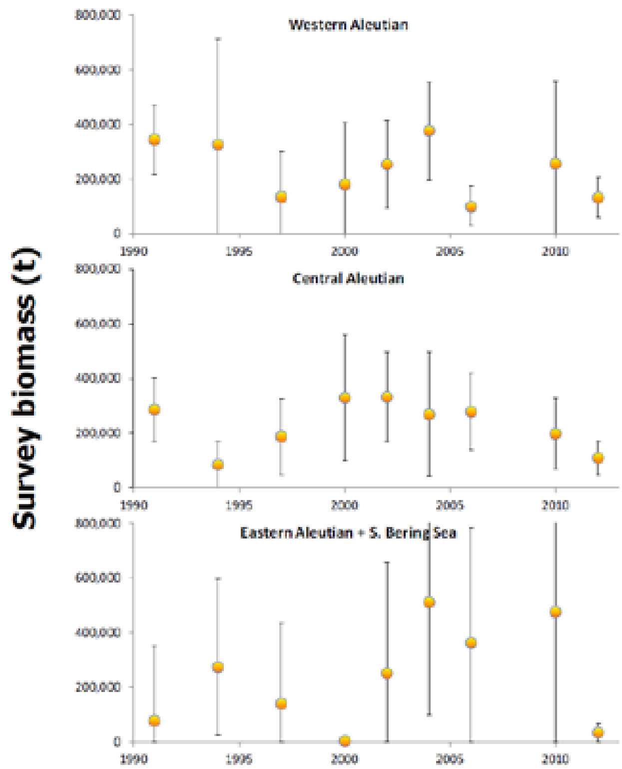


Figure 5. Atka mackerel Aleutian Islands survey biomass estimates by area and survey year. Bars represent 95% confidence intervals based on sampling error. Click to enlarge.

BSAI Atka Mackerel: Due to a very low survey estimate in 2012 the catch projections for Atka mackerel have been revised downwards from previous estimates. Survey estimates in all areas declined from the 2010 values, especially for the eastern Aleutian Islands area (including the southern Bering Sea segment of the survey; Fig. 5). This assessment is characterized by having considerable uncertainty in the survey biomass index but fairly consistent age composition information over time from both surveys and the fishery. Model results indicate that the abundance of Atka mackerel has decreased after a peak in 2005 due to four back-to-back strong year classes (1998-2001). The projected female spawning biomass for 2013 is 103,000 t, which is 37% of unfished levels. Atka mackerel is thought to be the most common prey item of the endangered western Steller sea lions within the AI region. NMFS has closed Atka mackerel fishing in areas around Steller sea lion haulouts and rookeries and also has used fine-scale time-area ABC allocations in attempts to maintain sufficient prey for Steller sea lions. Other regional closure measures have reduced the amount of allowable catch, which should promote future increases in the stock.

By Jim Ianelli

SSMA Staff Participate in the PICES 2012 Annual Meeting

Status of Stocks and Multispecies Assessment (SSMA) program staff Anne Hollowed, Steve Barbeaux, and Libby Logerwell participated in the PICES 2012 Annual Meeting, held October 12-21 in Hiroshima, Japan, with the theme "Effects of natural and anthropogenic stressors in the North Pacific ecosystems: Scientific challenges and possible solutions." The North Pacific Marine Science Organization (PICES) is an intergovernmental scientific organization established in 1992, which promotes and coordinates marine research in the North Pacific Ocean and adjacent seas. Currently, PICES members include Canada, Japan, Peoples' Republic of China, Republic of Korea, the Russian Federation, and the United States.

Shrinking governmental budgets are making it difficult to develop or expand ocean monitoring systems.

Anne Hollowed co-chaired a meeting of the Section on Climate Change Effects on Marine Ecosystems (S-CCME). S-CCME is a joint expert group with the ICES (International Council for the Exploration of the Sea) Strategic Initiative on Climate Change Effects on Marine Ecosystems. The goals of S-CCME are to define, coordinate and integrate the research activities needed to understand, assess and project climate change impacts on marine ecosystems; plan strategies for sustaining the delivery of ecosystem goods and services, and when possible, predictions should include quantifying estimations of uncertainty; define and quantify the vulnerability and sustainability of marine ecosystems to climate change, including the cumulative impacts and synergetic effects of climate and marine resource use; and build global ocean prediction frameworks, through international collaborations and research, building on ICES and PICES monitoring programs. Anne also gave an oral presentation in the Science Board Symposium on "Projecting future status and trends of commercial fish and fisheries under shifting management strategies and climate change."

Steve Barbeaux co-convened a Topic Session on "Monitoring on a small budget: Cooperative research and the use of commercial and recreational vessels as sampling platforms for biological and oceanographic monitoring." This session was intended to explore the ways in which cooperative research with other seagoing stakeholders and the use of commercial and recreational vessels as sampling platforms for biological and oceanographic monitoring can be integrated into ocean monitoring systems. Although cooperative monitoring has long been part of our scientific tool box, this session (S4) was the first time ICES or PICES has offered a session aimed specifically at highlighting cooperative monitoring projects. Shrinking governmental budgets are making it difficult to develop or expand ocean monitoring systems. Cooperative monitoring provides a means to leverage scarce government funding and has the added benefit of involving other stakeholders in the scientific process. Working together with fishers and other stakeholders in cooperative projects allows scientists not only to collect data cost effectively, but also to collect data over temporal and spatial ranges and at times of the year that would not be feasible using research vessels or fixed moorings. In this session there were ten papers presented and two posters displayed which covered a diverse array of cooperative projects from around the Pacific. The projects ranged from opportunistic data collections where data are collected while vessels and crew go about their everyday activities, to directed cooperative survey efforts where vessels and crew are contracted or volunteer to collect data in a systematic manner. A summary of the presentations will be available on the PICES website. Although Steve was not able to attend the meeting in person due to NOAA travel restrictions, he did make two oral presentations via WebEx, one in session S4 on "Cooperative monitoring in the Alaska walleye pollock (*Theragra chalcogramma*) fishery" and one in the FIS Contributed Paper session (described below) on "A novel approach for estimating location and scale-specific fishing exploitation rates of eastern Bering Sea walleye pollock (*Theragra chalcogramma*)."

Libby Logerwell served as chair of the Fishery Science Committee (FIS). The FIS's area of responsibility is to promote and coordinate fisheries science and interdisciplinary research in the northern North Pacific Ocean. This would include biology and ecology of living resources, particularly those that are subject to harvest or have the potential to be harvested. Topics could include taxonomy, genetics, behavior, trophic relationships, habitat, distribution, abundance, population dynamics, and methods for stock assessment. Focus is on the relationship between human factors and climate on the fluctuations of these resources. Libby also convened the FIS Contributed Paper Session. This session invited papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by FIS. The session consisted of 13 oral presentations and 15 posters that covered a wide variety of species and topics from all six PICES member countries. A summary of the presentations given will be available on the PICES website. She also gave an oral presentation in the Topic Session on "Monitoring on a small budget…" chaired by Steve Barbeaux (described above) on "Using walleye pollock acoustic survey data and Steller sea lion foraging information to manage fisheries – sea lion interactions in the Aleutian Islands."

By Libby Logerwell and Steve Barbeaux

Recent Advances in Otolith Geochemistry as a Tool for Understanding Fish Biogeography and Age Validation

Figure 1. The University of Wisconsin-Madison Secondary Ion Mass Spectrometer (WiscSIMS) IMS-1280 ion microprobe. Dr. Thomas Helser, Age and Growth Program Manager, is at the helm.

The increased spatial resolution allows for finer temporal resolution of measurements while maintaining high accuracy and precision.

The Age and Growth (A&G) Program is collaborating with colleagues at the University of Wisconsin, Department of Geosciences Secondary Ion Mass Spectrometer (WiscSIMS laboratory) to analyze otoliths for stable oxygen isotopes. The WiscSIMS IMS-1280 ion microprobe, funded by the National Science Foundation, is being used to explore new applications of in situ analysis of stable isotope geochemistry (Fig. 1). The advantage offered by the IMS-1280 ion microprobe over conventional isotope mass spectrometry is the dramatic reduction in analysis spot sizes.

Recent developments in the analytical capabilities of the IMS-1280 have allowed in situ analysis of otoliths on sub-annual, even daily, timescales. The ion microprobe can analyze discrete samples (~ 2 ng) that are thousands of times smaller than those required by conventional acid digestion/gas-source mass spectrometry (10-100 μg). The increased spatial resolution (sample diameter = 10 μm with depth of ~1 µm) allows for finer temporal resolution of measurements while maintaining high accuracy and precision.

Researchers in the A&G laboratory are currently using the IMS-1280 to study the detailed signatures of otolith $\delta^{18}O$ measurements from Bering Sea yellowfin sole and Pacific cod as a tool to understanding environmental history and age validation.

In one study, we conducted high-precision otolith $\delta^{18}O$ analysis using the IMS-1280 ion microprobe to investigate the life history of a yellowfin sole (Limanda aspera), a Bering Sea species known to exhibit age related migratory behavior. The oxygen isotope ratio ($\delta^{18}O$) of aragonite fish otoliths is dependent on the temperature and $\delta^{18}O$ of ambient water and can thus reflect a fish's environmental history. The IMS-1280 offers a spatial-resolution advantage over conventional acid-digestion techniques for stable isotope analysis of otoliths, which is especially given their compact nature (Fig. 2).

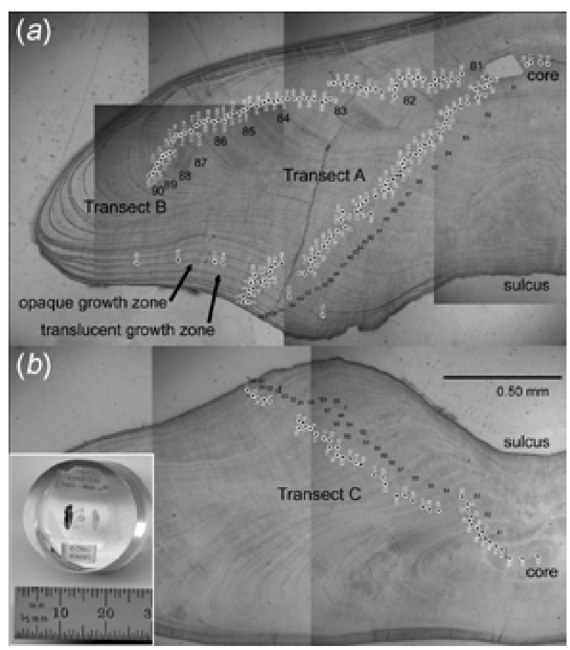


Figure 2. Composite photographs of polished surfaces of matching (a) roasted and (b) unroasted yellowfin sole otolith cross sections labeled with $\delta^{18}O$ spot analysis locations (white numbering) and calendar year assignments (black numbering) for each transect. Inset: Roasted (darker) and unroasted otolith halves embedded in epoxy mount.

The yellowfin sole otolith was cut transversely through its core and one half was roasted to eliminate organic contaminants. Values of $\delta^{18}O$ were measured in 10-µm spots along three transects (two in roasted half, one in unroasted half) from the core toward the edge (Fig. 2). Otolith annual growth zones were dated using the dendrochronology technique of crossdating to accurately assign fish age and calendar year for each growth zone.

The results of this analysis yielded a total of 73 spot analyses of $\delta^{18}O$ over Transect A, which spanned the years 1981 through 2007 (Fig. 3). No analyses were attempted in the growth band for 2008 as it was too narrow and close to the edge of the otolith.

The number of 10-µm-diameter spot samples per annulus within Transect A ranged from 1 to 7. Transect B spanned the years 1981 through 1989, and the number of spot samples per annulus ranged from 3 to 23 (total n = 78; Fig. 3). The linear sampling density of both Transects A and B was approximately 50 spot analyses per mm. Measured values of $\delta^{18}O$ ranged from 29.0-34.1‰ (relative to Vienna Standard Mean Ocean Water).

Ontogenetic migration from shallow to deeper waters was reflected in generally increasing

$\delta^{18}O$ values from age-0 to approximately age-7 and subsequent stabilization after the expected onset of maturity at age-7. Cyclical variations of $\delta^{18}O$ within juvenile otolith growth zones, up to 3.9‰ in magnitude, were caused by a combination of seasonal changes in the temperature and $\delta^{18}O$ of ambient water. The IMS-1280 ion microprobe at WiscSIMS obtained a high-precision and high-resolution record of relative environmental conditions experienced by a yellowfin sole that is consistent with population-level studies of ontogeny.

In a second related study using the IMS-1280 ion microprobe, we conducted a high resolution $\delta^{18}O$ spot sample analysis of otoliths from seven Pacific cod from which bi-hourly temperature and depth records were stored from electronic archived tags. These Pacific cod were also analyzed for $\delta^{18}O$ from micromilling and conventional continuous flow isotope ratio mass spectrometry techniques as part of

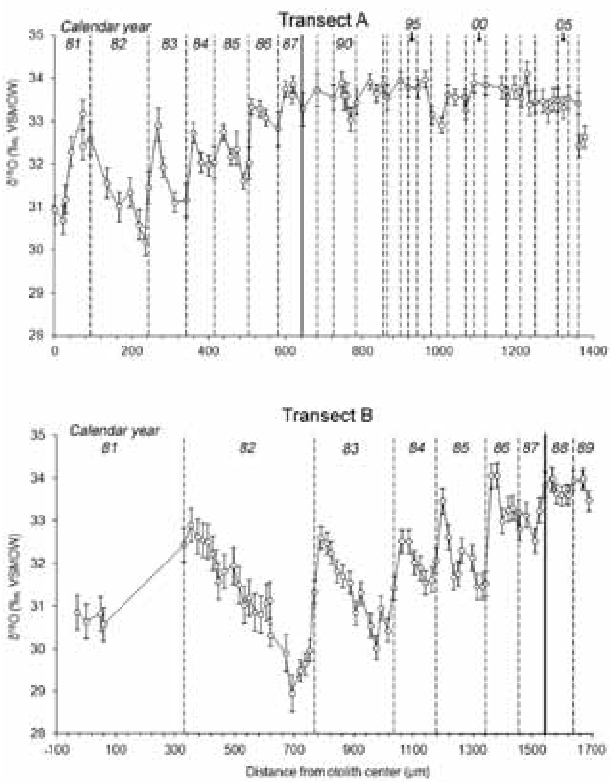


Figure 3. Measurements of $\delta^{18}O$ (‰ VSMOW, ±2 S.D.) made at WiscSIMS from the otolith center to the edge of Transect A (upper panel) and Transect B (middle panel) of the roasted otolith half. Solid vertical lines indicate estimated transition between juvenile and adult phases (age-7). Dashed vertical lines indicate locations of translucent growth zones, with calendar years of formation labeled at top of each panel in italic type (1981-2007)

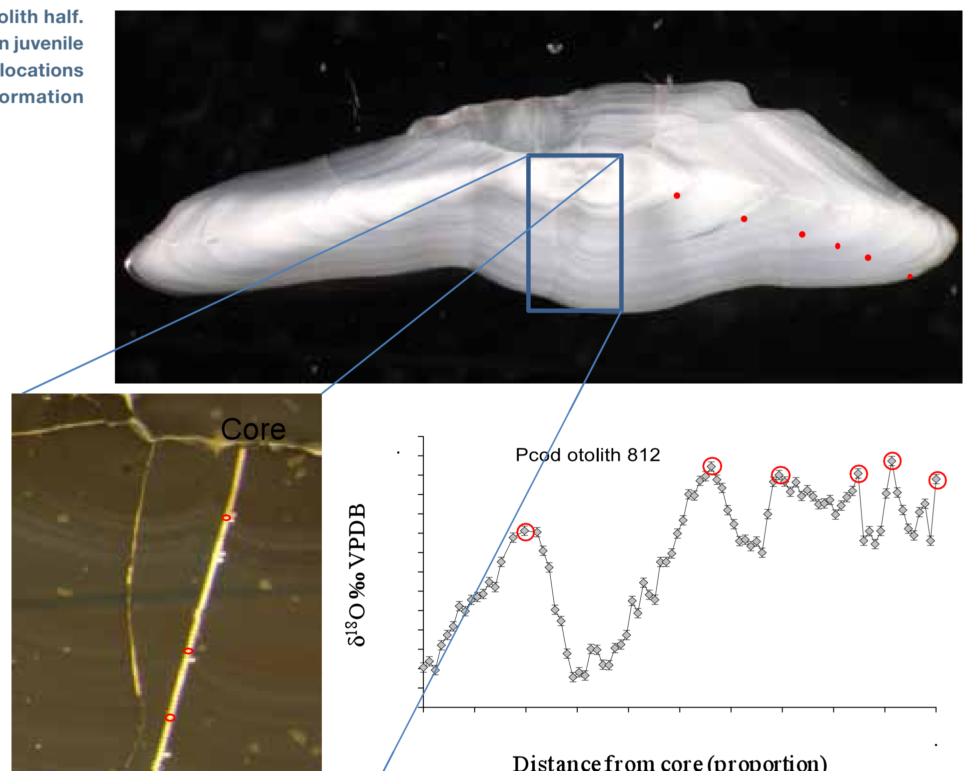
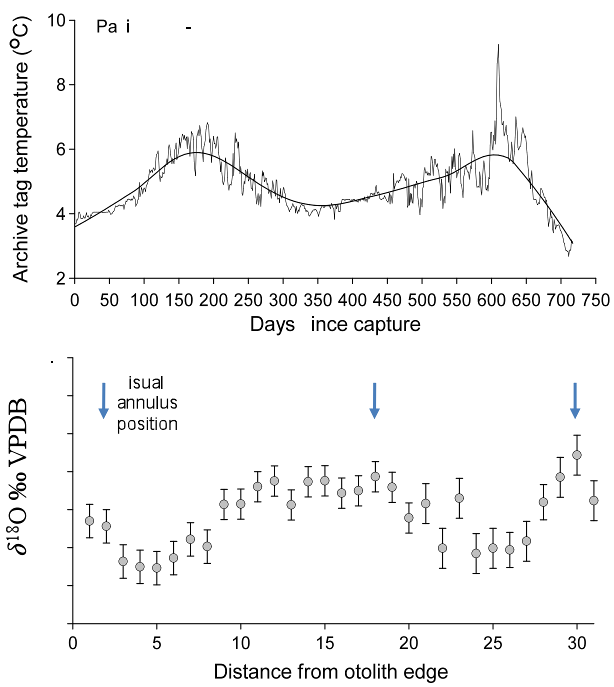


Figure 4. Ion microprobe spot samples and measured sequence of secondary ion mass spectrometry stable oxygen isotopes $\delta^{18}O$ (‰ VPDB, ±2 S.D.) made at WiscSIMS in a traverse section of a 6-year-old Pacific cod. Measured peaks in the oxygen isotope signature correspond to seasonal temperature lows in the Bering Sea and help researchers elucidate the age of fish (oxygen isotopes and temperature are inversely related-below).



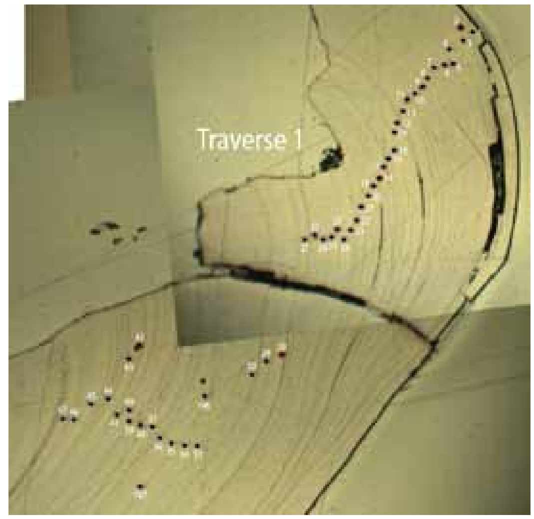


Figure 5. Sequence of ion microprobe spot samples measuring stable oxygen isotopes $\delta^{18}O$ (‰ VPDB, ±2 S.D.) made at WiscSIMS from a traverse sectioned Pacific cod tagged with an electronic data logger (temperature and depth) and at liberty for 716 days. Spot samples 1-31 were sampled near the outer edge of the otolith and represented the aragonite material accreted during the period at liberty, and illustrates the strong inverse relationship between $\delta^{18}O$ and in situ temperatures.

another study to validate ageing using $\delta^{18}O$ signatures in otoliths. In this analysis our goal was to 1) compare IMS-1280 mass spectrometry and micromilling/conventional ratio mass spectrometry for intra-otolith $\delta^{18}O$ signatures; 2) confirm that otolith $\delta^{18}O$ signatures can be used as a tool to validate ageing; and 3) calibrate the $\delta^{18}O$ – temperature (in situ from electronic archive tags) relationship from all seven fish and develop a fractionation equation for aragonite in the Bering Sea. For example, Figure 4 shows sequence of $\delta^{18}O$ measurements obtained using SIMS in a traverse section of a 6-year-old Pacific cod (ID 812, tagged and recaptured near Amak, Alaska). We obtained 87 spot samples of $\delta^{18}O$ with very high analytical precision from the otolith core to the edge, which represents a sampling density approximately 2 to 3 times

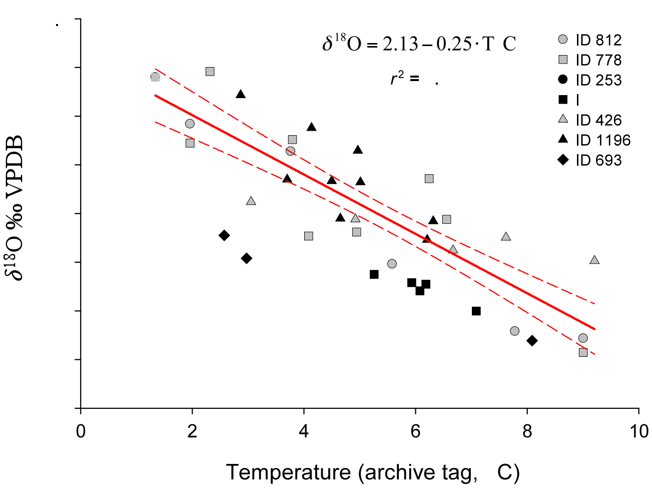


Figure 6. Estimated fractionation equation from otoliths (aragonite) extracted from 7 Pacific cod tagged with electronic data recorders (in situ temperature data). As expected, relationship between Pacific cod otolith aragonite ($\delta^{18}O$) and bottom temperature showed an inverse, statistically significant linear relationship (Fig.6; r=0.75, p<0.001).

greater than micromilling/conventional mass spectrometry techniques. Measured peaks in the $\delta^{18}O$ signature in this otolith, which corresponds to six seasonal temperature lows in the Bering Sea (assuming oxygen isotopes and temperature are inversely related), confirming the years of life for this Pacific cod.

The otoliths from archival-tagged Pacific cod afforded a rare opportunity to relate the $\delta^{18}O$ measurements to in situ instrumental temperatures recorded during the time the animal was at liberty, and hence estimate the fractionation equation for Bering Sea aragonite. More importantly, it allows the equation to be estimated individually for each archival-tagged Pacific cod that was SIMS analyzed and lends insight to the degree to which such curves vary among individuals of the same species.

To achieve this goal, we identified the spot samples of measured $\delta^{18}O$ values that were sampled near the outer edge of the otolith and represented the aragonite material accreted during the period at liberty. In the case of Pacific cod 1169, which was at liberty for 716 days and captured during late winter 2004, we isolated 31 spot samples between the outer edge and the last two annual growth zones. The $\delta^{18}O$ samples measured from the edge of the otolith show a highly coherent relationship with archival tag temperatures since capture (Fig. 5), illustrating their inverse relationship and the fact that $\delta^{18}O$ may be used as a proxy for temperature reconstruction. We then estimated the fractionation equation from all seven Pacific cod using a linear mixed effects model.

As expected, the relationship between Pacific cod otolith aragonite ($\delta^{18}O$) and bottom temperature showed an inverse, statistically significant linear relationship (Fig.6; r=0.75, p<0.001). Mean $\delta^{18}O$ declined with temperature at a rate of about 0.25‰/°C, which is approximately consistent with the expected temperature-driven variation in δ18O of aragonite of 0.2‰/ °C from North Atlantic waters. Here, as in the North Atlantic, a 5°C variation should produce a ~1o/oo change in the otolith's $\delta^{18}O$ composition based on the equilibrium fractionation curves calculated for biogenic aragonite. We are not aware of fractionation curves for the North Pacific, so the reported fractionation relationship here is the first for aragonite $\delta^{18}O$ of Pacific cod otoliths vs. temperature and shows the oxygen isotopic equilibrium with ambient sea water for different temperatures.

By Thomas Helser, Craig Kastelle and Beth Matta

Otolith Microchemical Fingerprinting: Assessing Juvenile Pacific Cod Habitat Utilization in the Gulf of Alaska

Otoliths act as data recorders of the environment a fish is exposed to during its lifetime. Chemical signatures within otoliths are often unique to a specific geographical area and period of time and may be used as natural tags to classify adult fish to their natal origins. The Gulf of Alaska (GOA) is a complex marine ecosystem that is spatially and temporally variable in its oceanography, physiochemistry, and primary production. It also provides critical nursery habitat for commercially important species of fish such as Pacific cod (Gadus macrocephalus). The National Oceanic and Atmospheric Administration (NOAA) has in recent years supported a breath of habitat related studies as part of the Alaska Essential Fish Habitat Research Plan.

The Age and Growth program recently received NOAA Essential Fish Habitat funding for a multi-year research project to conduct research to assess juvenile Pacific cod habitat utilization in the GOA. More specifically, otolith trace element composition may reflect differences in the environmental chemistry of nursery areas in the GOA, allowing discrimination of juvenile Pacific cod from different nearshore habitats. Age-0 fish were collected during the 2011 Middle Trophic Level component of the North Pacific Research Board GOA Integrated Ecosystem Research Project (Fig. 7).

In summer 2013, fish from the same cohort (age-2) will be collected during the RACE GOA bottom trawl survey. Using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), we will determine whether otoliths can be used to distinguish among age-0 fish from different nearshore nursery areas in the GOA and whether older individuals from the same cohort can be retrospectively linked to these nursery areas based on unique combinations of trace elements in their cores. Thus far, boron, strontium, magnesium, and barium have all displayed strong signals (Fig. 8) and may prove useful in discriminating between otoliths collected at different nursery sites. In particular, a large peak in 138Ba noted in some specimens may correspond to upwelling events or freshwater run-off into nursery bays. Analyzing the elemental signatures of the surviving 2011 cohort as they move from the nursery to offshore waters is the critical key to identifying and understanding the connectivity of habitat and recruitment to the offshore population.

By Beth Matta, Thomas Helser, and Craig Kastelle

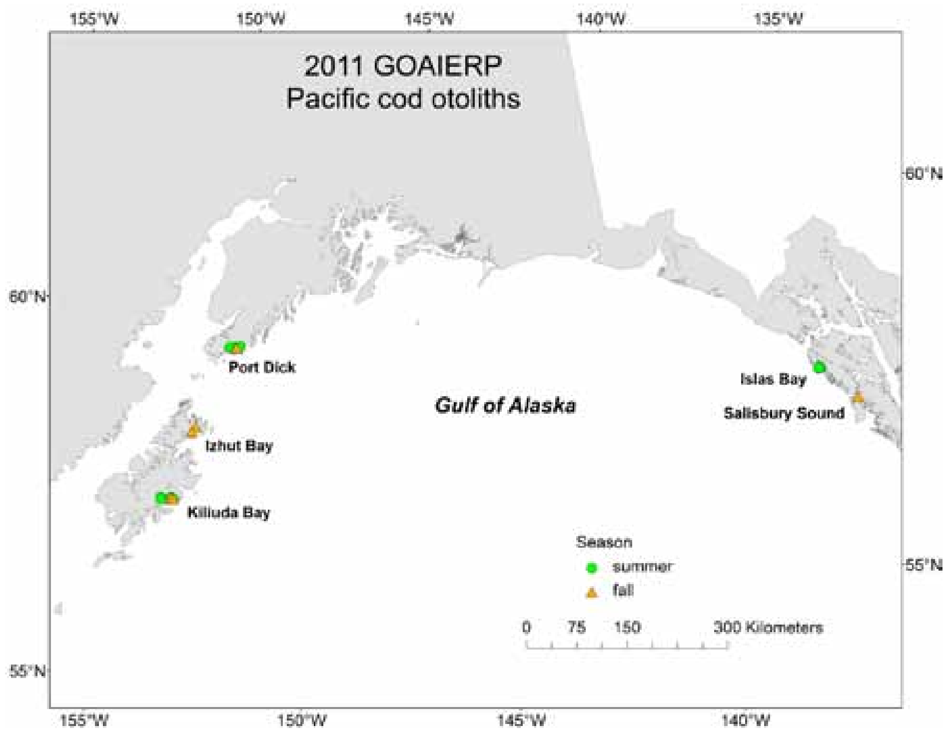


Figure 7. Otolith collection sites in the eastern and Central Gulf of Alaska from the NPRB GOA-IERP project. Otoliths were collected during summer (July-August) and fall (September-October) 2011. Each site shown represents a nearshore bay (site) with replicate hauls performed in three site subareas.

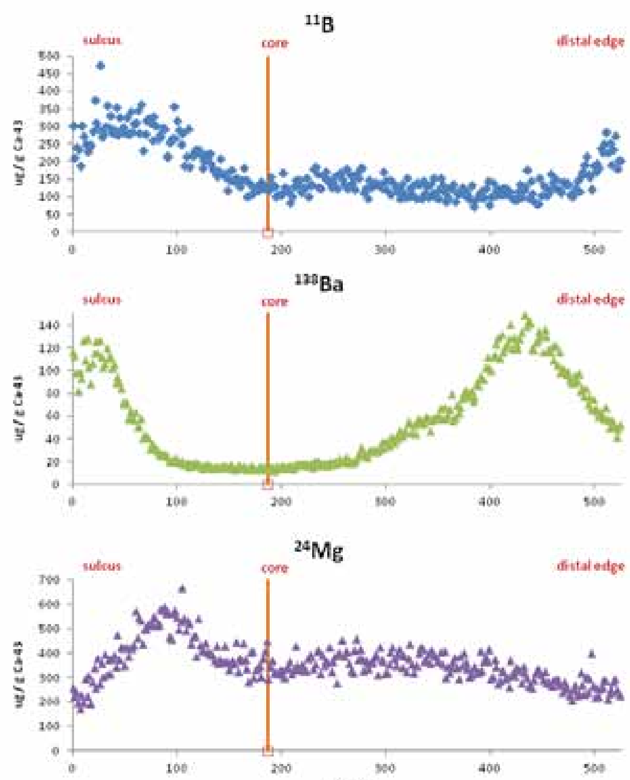


Figure 8. Trace element signatures of boron, barium, and magnesium in an age-0 Pacific cod otolith.

Preliminary Age Validation of Pacific Cod Using Stable Oxygen Isotope ($\delta^{18}O$) Signatures in Otoliths

Pacific cod (Gadus macrocephalus) is the second most important groundfish managed by the North Pacific Fishery Management Council, with harvests totaling more than 250,000 metric tons (t) annually and recent ex-vessel values of more than $250 million. Pacific cod are assessed using age-structured models where age data are key to estimating mortality, recruitment, and harvest. Because the age data for Pacific cod are so controversial, the stock assessments for each of the last several years have included, as an alternative, at least one model with the age data excluded. Over the five most recent assessments, the model with age data excluded has always resulted in a higher estimate of the acceptable biological catch (ABC), ranging from 2% to 13% (6,000-30,000 t) above the ABC estimated by the preferred model with age data included.

Needless to say, Pacific cod age determination is one of the most difficult of the over 30 species aged each year by the Age and Growth program. Historically, uncertainty has existed in interpretation of otolith growth zones during the process of age determination. Because Pacific cod are relatively short lived, proven age validation techniques using bomb radiocarbon are at present not possible. However, we initiated an alternative strategy to estimate Pacific cod age accuracy with new geochemical techniques such as stable oxygen isotope (δ18O) signatures in otoliths. This approach is based upon the well-established principle that variability in marine carbonate δ18O is inversely related to water temperature. Therefore, the δ18O signature in an otolith, determined with high-resolution sequential microsampling of otoliths and mass spectrometry, inversely mirrors annual seasonal temperature cycles, and can be used as a tool for age validation. This project is utilizing forty specimens collected from the eastern Bering Sea (Fig. 9). To date we have analyzed nearly half of the samples.

Members of the Age and Growth program have also developed the capability to precisely sample otoliths, producing calcium carbonate samples as small as 25 µg with a computer controlled Carpenter CM-2 micromilling system (Fig. 10). We sampled Pacific cod otoliths from specimens estimated by growth zone counts to be 2 to 5 years old.

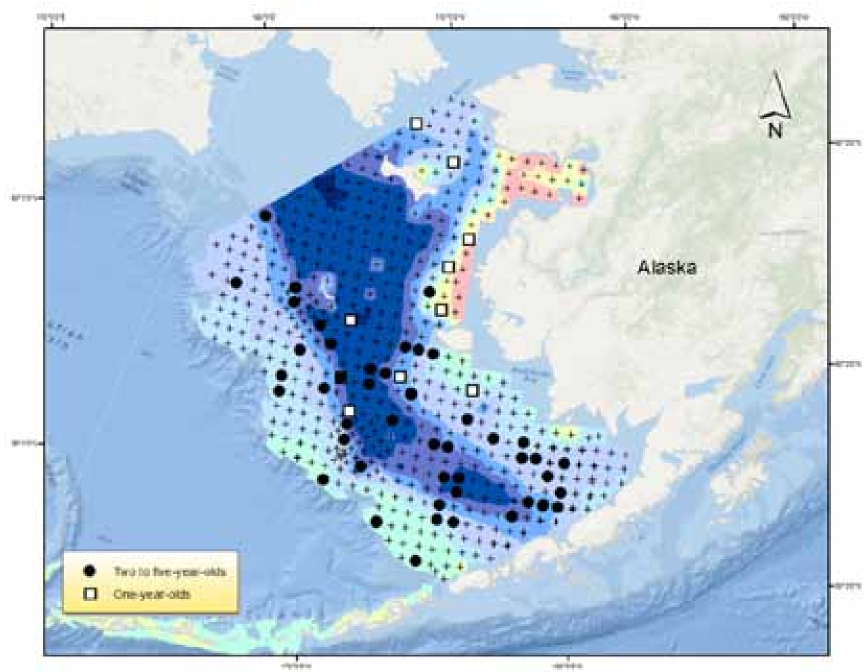


Figure 9. Map of collection locations for each Pacific cod otolith specimen in the eastern Bering Sea.

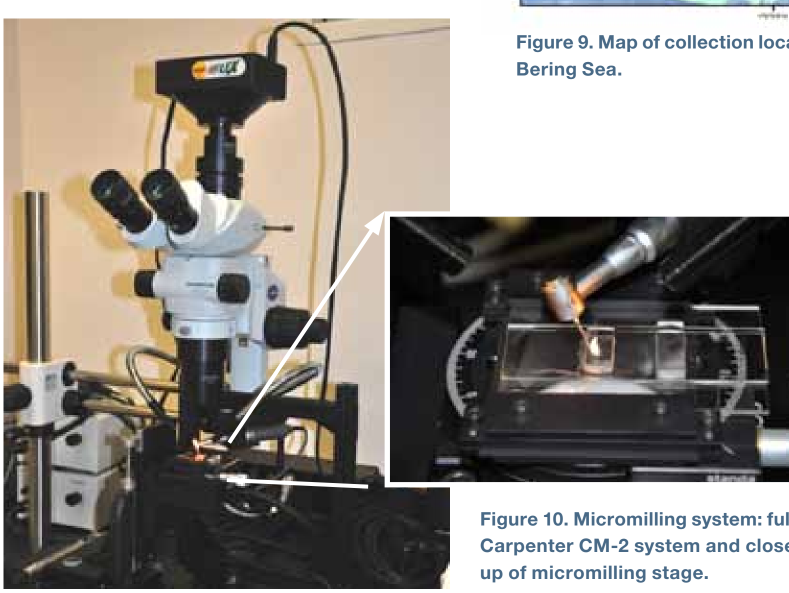


Figure 10. Micromilling system: full Carpenter CM-2 system and close up of micromilling stage.

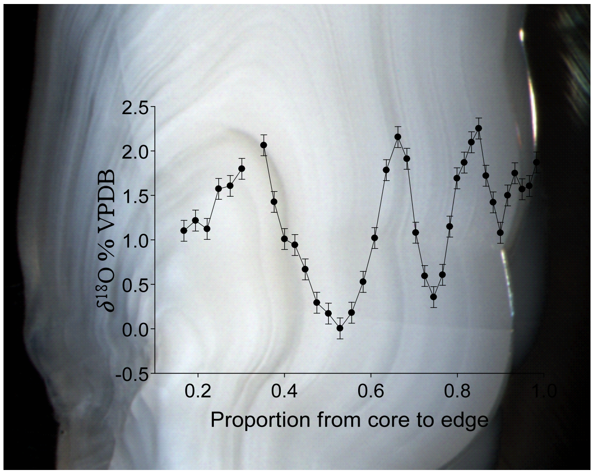


Figure 11. Pacific cod otolith estimated to be 5 years old by age readers in the Age and Growth Laboratory. The sequence of δ^{18}O values show the "signature" revealing five distinct peaks which represent annual lows in bottom temperature. The plotted data represents a "life history transect" sampling in the otolith from birth to capture.

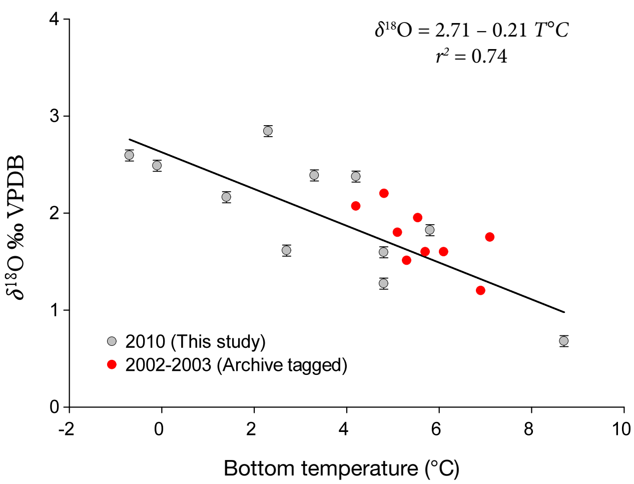


Figure 12. Plot of relationship between temperature and δ^{18}O. The δ^{18}O in the most recently deposited material at the edges of juvenile otoliths is related to a broad range of bottom temperatures measured at capture.

High-resolution micromilling provided up to ten samples (data points) per posited annual growth zone; which in some cases approached 50 sequential samples per specimen. The sequential sampling represented each specimen's full life history, birth to capture. Collaborating with staff at Oregon Status University, we then analyzed each sample using flow ratio isotope mass spectrometry for δ18O. The δ18O life history profile revealed annual seasonal information for age validation and life history information such as possible migration (Fig. 11). We also sampled the most recently deposited material at the edges of juvenile otoliths (n=10) and related this to a broad range of bottom temperatures measured at capture (Fig. 12), demonstrating the strength of the relationship between δ18O in otoliths and water temperature (r2 = 0.74).

Craig R. Kastelle, Thomas E. Helser, Jennifer McKay, Delsa M. Anderl

Preliminary Results on the Age Validation of Big Skate (*Beringraja binoculata*) and Longnose Skate (*Raja rhina*) using Bomb-Derived Radiocarbon

Age estimation of Alaskan skates, big skate (*Beringraja binoculata* (formerly *Raja bioculata*)) and longnose skate (*Raja rhina*), is currently performed by interpreting the accretion of growth bands from vertebrae with the assumption that each band pair is counted as one year. Age and growth curve estimates are available from the GOA, British Columbia and U.S. West Coast; however, ageing precision across agencies, AFSC and the Pacific Biological Station (PBS), is dissimilar (Fig. 15).

With these inter-agency differences, an age determination study was initiated. The objectives are 1) use bomb radiocarbon dating techniques to validate ages of big and longnose skates, and develop age determination criteria; 2) conduct an inter-agency comparison of new age determination methods using a histological method (hematoxylin stained-thin-sections) versus the standard technique (unstained-thin-sections) to assess bias, precision and develop a standardized protocol of age assignment across their geographical range.

Big and longnose skates were collected off Monterey, California. in 1980-81 and were considered alive during the rapid increase in (14C) oceanic radiocarbon during the atmospheric atomic bomb testing from 1967 to 1969. Each vertebra was thin sectioned (≈1 mm thick), microscope slide mounted and aged. At the AFSC, the Carpenter Microsystems™ CM-2 milling system was used to remove the first three inner band pairs and the last three outer band pairs along the corpus calcarea from each vertebra while acquiring a minimum of 5.0 mg of sample material (Fig. 16). For this preliminary study, inner growth bands from 11 milled samples—big (n = 3) and longnose (n = 8)—were assayed for (14C) at Beta Analytic (a carbon dating laboratory in Miami, FL) using accelerator mass spectrometry.

For big skate, the eight samples assayed appear to be consistent while comparing the Δ14C values to the GOA Pacific halibut otolith reference curve for the years 1965-70. The estimated ages are unlikely to be underestimated, although relatively uninformative since they occur late in the bomb-derived radiocarbon signal (Fig.17). The three samples of longnose skate are consistent with Δ14C values that are reasonably close, albeit 1-2 years older, to the true age based on the reference curve chronology for the years 1961-1963 (Fig. 17).

This collaborative study was conducted with this NPRB project lead principal investigators Jacquelynne King (Fisheries and Oceans Canada, Pacific Biological Station) and Thomas Helser (AFSC's Age and Growth (A&G) Program) with collaborators David Ebert (Pacific Shark Research Center, Moss Landing Marine Laboratories) and Romney McPhie (Fisheries and Oceans Canada, Pacific Biological Station). Milling and assaying the remaining vertebrae, applying histological methods (staining) and comparing inter-lab ageing results from unstained/stained thin sections to big and longnose (14C) validated ages are ongoing. Ultimately, a standardized protocol for age assignment and criteria will be developed for all agencies to ensue, leading to age determination for big and longnose skates in the North Pacific.

By Chris Gburski and Thomas Helser

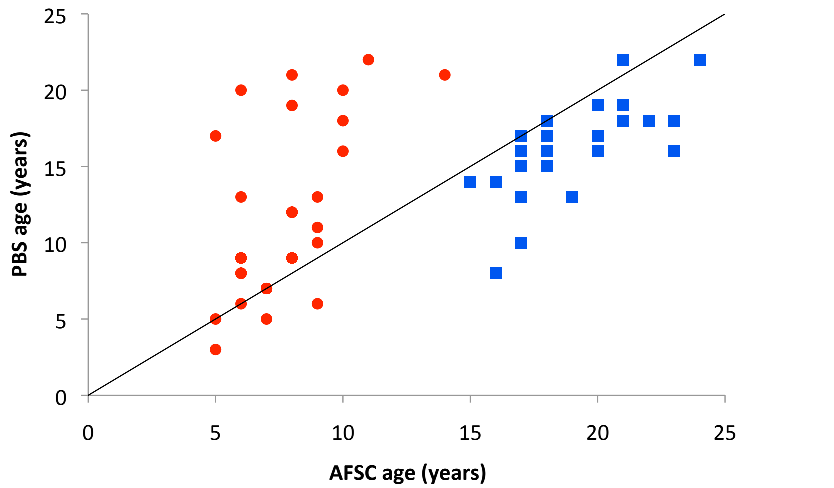


Figure 15. Age bias graph for female big skate (red dots, n = 29) and female longnose skate (blue squares, n = 27) vertebral band counts from unstained thin sections by AFSC and PBS. The diagonal line represents the one-to-one equivalence line.

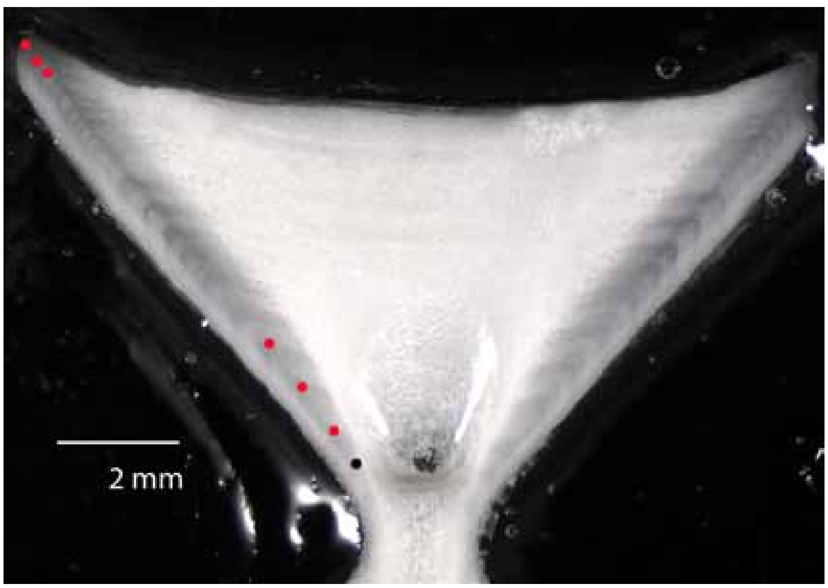


Figure 16. Longnose skate unstained thin section. On the corpus calcareum, the birth year (0) is indicated with a black dot; inner and outer three growth band pairs are indicated with red dots where sample material is milled.

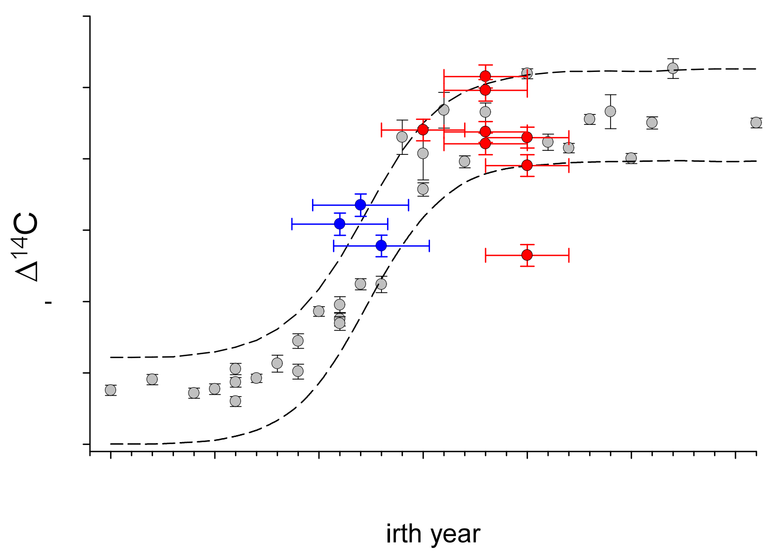


Figure 17. Birth year and Δ14C (‰) for big skate (red dots, n = 8) and longnose skate (blue dots, n = 3) from the inner three growth bands with error bars associated with 14C measurements and ageing imprecision; compared to the GOA Pacific halibut reference curve (gray dots) with Bayesian credible intervals.

Age and Growth Program Production Numbers

Table 1. Estimated production figures for 1 January – 31 December 2012.

Species	Specimens Aged
Alaska plaice	565
Atka mackerel	2,134
Bering flounder	864
Big skate	113
Blackspotted rockfish	789
Dover sole	459
Dusky rockfish	47
Flathead sole	3,496
Great sculpin	51
Kamchatka flounder	1,058
Longnose skate	216
Northern rock sole	1,319
Northern rockfish	1,006
Pacific cod	2,848
Pacific ocean perch	2,299
Rougheye rockfish	482
Sablefish (black cod)	2,394
Southern rock sole	384
Walleye pollock	12,104
Yellowfin sole	2,040

By Jon Short

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[1] The NOAA Technical Memorandum series NMFS AFSC (formerly F/NWC) is a Center publication which has a high level of peer review and editing. The Technical Memorandum series reflects sound professional work and may be cited as publications. Copies may be ordered from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161 or at *www.ntis.gov*.

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National Oceanic and Atmospheric Administration (NOAA)
of the U.S. Department of Commerce

The mission of the NOAA Fisheries Service is to provide stewardship of the nation's living marine resources through science-based conservation and management and promotion of healthy ecosystems

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