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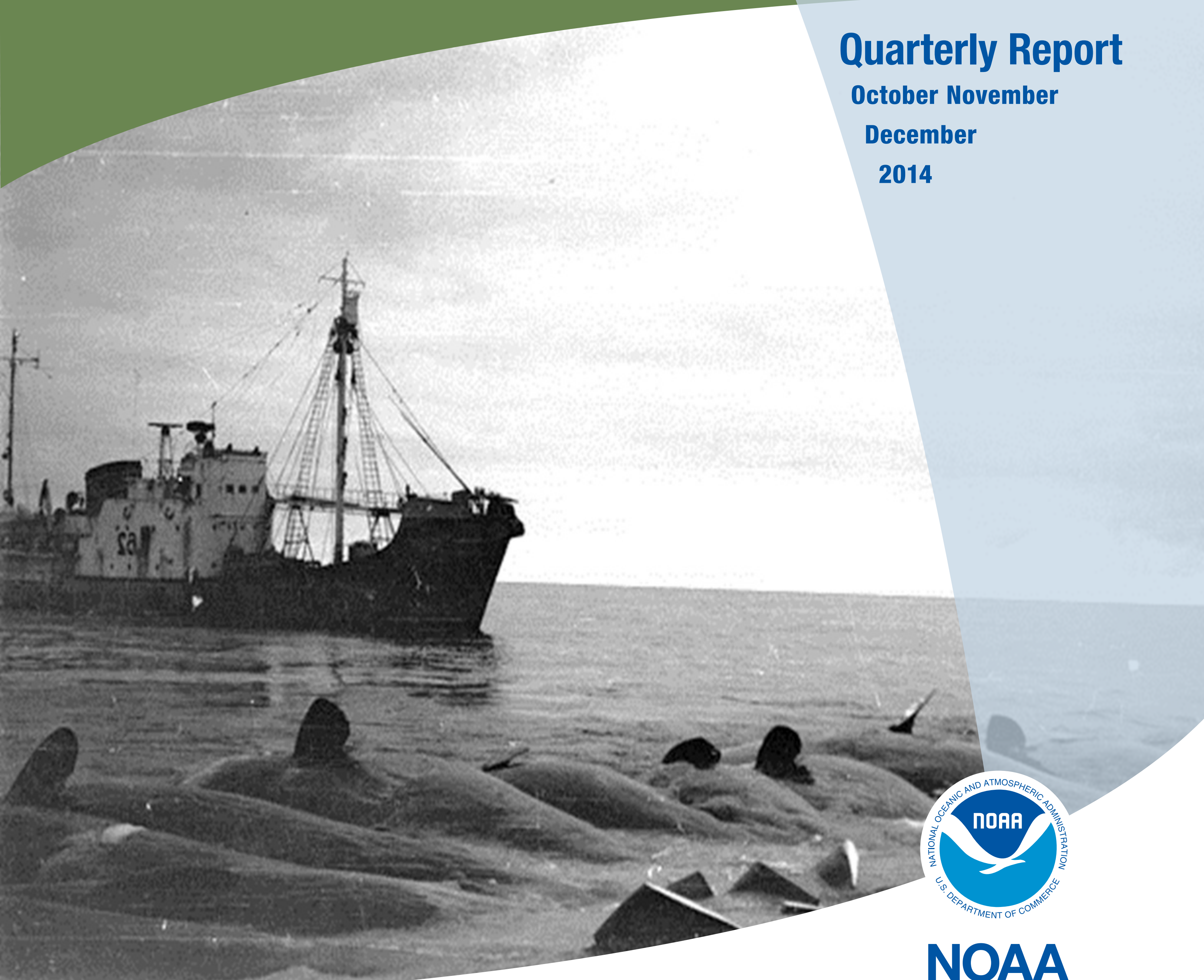

Quarterly Report
October November December 2014

NOAA FISHERIES

Resurrecting Leviathan: Reconstructing sperm whale catches in the North Pacific

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

Alaska FISHERIES SCIENCE CENTER

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NOAA FISHERIES

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Resurrecting Leviathan: Reconstructing sperm whale catches in the North Pacific

Phillip J. Clapham and Yulia V. Ivashchenko

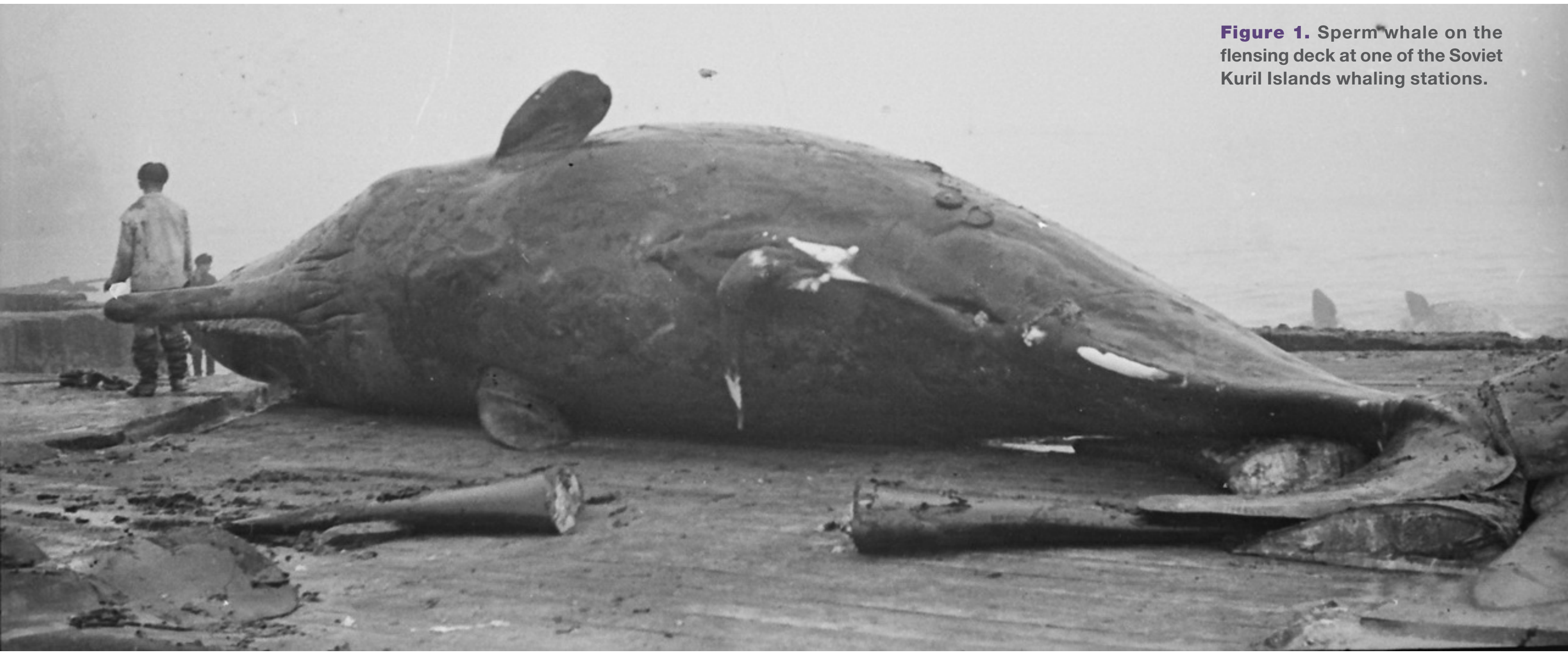


Figure 1. Sperm whale on the flensing deck at one of the Soviet Kuril Islands whaling stations.

To anyone who has ever seen one, the sperm whale (*Physeter macrocephalus*) is among the more bizarre-looking animals on our planet. With its wrinkled skin, giant head, and large teeth arrayed in an oddly underslung jaw, it looks less like a creation of Planet Earth than something put into the world's oceans as a prank by extraterrestrials. Yet this remarkable animal has probably been around for longer than any other living cetacean–perhaps as long as 25 million years–and it is superbly adapted to the pelagic ocean environment in which it expends its long life span. Sperm whales may well be the deepest-diving of all mammals: they can hold their breath for more than 2 hours in extreme cases, and there is good evidence that they can dive to depths of around 10,000 feet. They are a highly socially evolved species, with strong familial bonds evident in groups that travel, forage, and foster their young together. They are found in all the world's oceans and travel thousands of miles on their wanderings.

A long history of exploitation

None of these characteristics, however, saved sperm whales from human greed. Although sperm whale meat is definitely not good to eat–it is so highly oxygenated that it is truly black rather than dark red–the whale's oil is of extraordinary quality, and for many years whale oil quite literally lit the streets of the industrialized Victorian world. Sperm whale oil maintains its lubricative powers at extremes of temperature, and as a result it was much sought-after for use in everything from watches to heavy machinery. Beginning in the late 18th century, American whalers began seeking out sperm whales farther and farther afield from their home bases in New Bedford, Nantucket, and other New England ports. They were joined in these predatory explorations by vessels from other nations, and sperm whalers were often the first westerners to discover new areas of ocean (and sometimes even new lands). So valuable was sperm whale oil that voyages of 4 or even 5 years, taken to the other side of the world, became common during the height of historical whaling in the 19th century.

Through examination of old whaling logs and other historical records, retired NMFS biologist Tim Smith and colleagues estimated that, between 1712 and 1899, some 300,000 sperm whales were killed worldwide, most by sail-based whalers who chased whales from small open boats and used hand-held harpoons and lances to kill them. Occasionally a sperm whale had the upper hand: the most famous case is that of the Nantucket whaler *Essex*, which was stove and sunk by an angry male sperm whale in the Pacific Ocean in 1820; the crew were subsequently forced to endure months in an open boat and eventually resorted to cannibalism before finally being rescued. But although this incident was dramatic (it inspired Herman Melville's classic novel *Moby Dick*) it was an exceptional event even then; and when the invention in the late 1800s of steam-powered catchers and explosive harpoons ushered whaling into a modern, industrialized era, no whale anywhere was safe.

In collaboration with our colleague Robert Rocha from the New Bedford Whaling Museum, we recently estimated that in the 20th century the global catch of sperm whales was more than 760,000. Just over 400,000 of these animals were taken in the Southern Hemisphere, but the total catch for the North Pacific was almost 315,000.

The great majority of the North Pacific catches were made by two nations: Japan and the former U.S.S.R. Both nations greatly intensified their whaling after the Second World War, with large factory ships plying the waters between Japan and the western coast of North America.. The Soviets took about 159,000 sperm whales in the years between 1948 and 1979, of which some 23,000 were killed from shore whaling stations in the Kuril Islands (these formerly Japanese islands and whaling operations had been taken over by the U.S.S.R. as reparations following World War II; Fig. 1). This, and Japan's own large catches from land stations–86,379 sperm whales–is testament to the extraordinary productivity of the marine environment in this region.

A Convention, regulations, and violations thereof...

In 1946, both Japan and the U.S.S.R. signed the International Convention for the Regulation of Whaling, which created the International Whaling Commission (IWC) to manage whale stocks, set catch limits based upon scientific advice, and oversee a wide variety of regulations pertaining to the killing and processing of whales. The IWC was, virtually from the outset, a failure: science was ignored and uncertainty exploited in favor of continued profits; major flaws in the Convention allowed member states to delay, obstruct, or ignore measures intended to make catches sustainable and whaling operations transparent.

However, it was not until the 1990s that the extent of this failure became apparent, with revelations from former Soviet scientists that the U.S.S.R. had conducted a global campaign of illegal whaling which began in 1948 and lasted for three decades. The whaling was conducted secretly and on a massive scale, with size limits, protected species, and other regulations largely ignored; recently, we estimated that the Soviets killed 534,119 whales of all species, of which 178,726 were not reported to the IWC despite the whaling regulations requirements. The catches were driven by a relentless industrial system which demanded that ever-higher production targets be met, regardless of the state of the resource being exploited; success meant bonuses and awards, while failure to hit or exceed targets often brought negative consequences for workers and managers.

For North Pacific sperm whales, this huge deception involved not only nations lying about the number of animals taken, but also falsifying the sex and length data for the catches. This was because the IWC had established a minimum legal length for catches of this species at 11.6 m, and many females were smaller than this (in sperm whales, males are much larger than females). Because most of the females killed by the U.S.S.R. were under this length and thus illegally caught, many catches were "transformed" from females to males, and the length adjusted, in official reports to the IWC. For example, in 1970–71 (the year before the IWC finally agreed to place international observers on factory ships) Soviet fleets caught more than 9,000 female sperm whales in the North Pacific, but officially reported fewer than 1,800; in contrast, they killed 5,700 males but reported 12,300.

This gross misrepresentation of the sex ratio of catches led to one of the greater tragedies of this era. Because of the fake catch statistics, the IWC was so concerned that males were under heavy hunting pressure that in 1972 they lowered the minimum size limit from 11.6 m to 9.2 m. The idea was to take pressure off males by allowing more females to be hunted. But in fact it was females that had borne much of the brunt of the catch already, and by lowering the size limit they were now subject to even greater, "legal" hunting pressure.

Reconstructing the true catch

Since the truth about Soviet whaling was revealed, we and our colleague Robert Brownell (Southwest Fisheries Science Center) have worked with former Soviet biologists to reconstruct the true catch of sperm whales and baleen whales. This exercise is essential, because assessments of current whale populations relative to historical abundance levels depend upon possession of an accurate catch series. The Southern Hemisphere catches were corrected in the 1990s, but there remained major gaps in the North Pacific record.

Then, in 2009, one of us (Yulia Ivashchenko) began a doctoral study on this topic and discovered that — contrary to what we had expected — most of the formerly secret Soviet whaling industry reports had not been destroyed but were gathering dust in Russian public archives. These contained the true catch data, unlike the falsified records that were submitted to the IWC. It took many months of sifting through the numerous reports and other materials - Soviet bureaucracy was very good at creating paperwork, much of it irrelevant to our objectives - but with the help of some Russian former whalers it eventually became possible to reconstruct the true catches for most species in the North Pacific (Table 1).

Of the 159,000 sperm whales killed by Soviet whalers after World War II, 25,000 were not reported to the IWC. However, this figure is very misleading because there were also major falsifications of sex and length. In some years and areas, legal-sized females made up less than 2% of the Soviet catch. Catches rose in the 1960s with the introduction of large new factory ships, some of which had more than 20 fast catcher boats. The peak period was between 1963 and 1971 (the last year before an international inspection scheme was introduced by the IWC), when 58,000 sperm whales were killed (Fig. 2). Some 32,000 of these were females, most of them under the legal size limit.

Meanwhile, Japan was also killing large numbers of sperm whales, and we now know that data falsifications were not limited to the U.S.S.R. In 1999 the Japanese scientist Toshio Kasuya published a paper reporting that Japanese shore whaling stations had routinely falsified catch data for sperm whales and other species. The faked data was very similar to those submitted to the IWC by the Soviets, with length and sex misreported for sperm whales. Further details of this were subsequently provided by a retired manager who had worked at the Japanese land stations. Currently, we do not know if these data falsifications extended to the Japanese pelagic (factory fleet) catches, although an analysis in 1983 by British biologist and statistician Justin Cooke suggested that the reported data were suspicious in terms of the length frequencies involved. It may well be that, despite our efforts to correct the Soviet catch, North Pacific whaling data remain compromised.

Table 1. Total catches of whales in the North Pacific by the U.S.S.R., 1948-1979, by species. Note that some catches were over-reported to the IWC to hide illegal whaling or to make catches consistent with reported production data.

Species	actual catch	reported catch
Sperm whale	159,286	132,505
Blue whale	1,621	858
Fin whale	14,167	15,445
Humpback whale	7,334	4,680
Sei whale	7,698	11,363
Gray whale	149	1
North Pacific right whale	681	11
Bowhead whale	145	0
Baird's beaked whale	146	148
Killer whale	401	401
Bryde's whale	3,466	3,517
Minke whale	689	686
Total	**195,783**	**169,615**

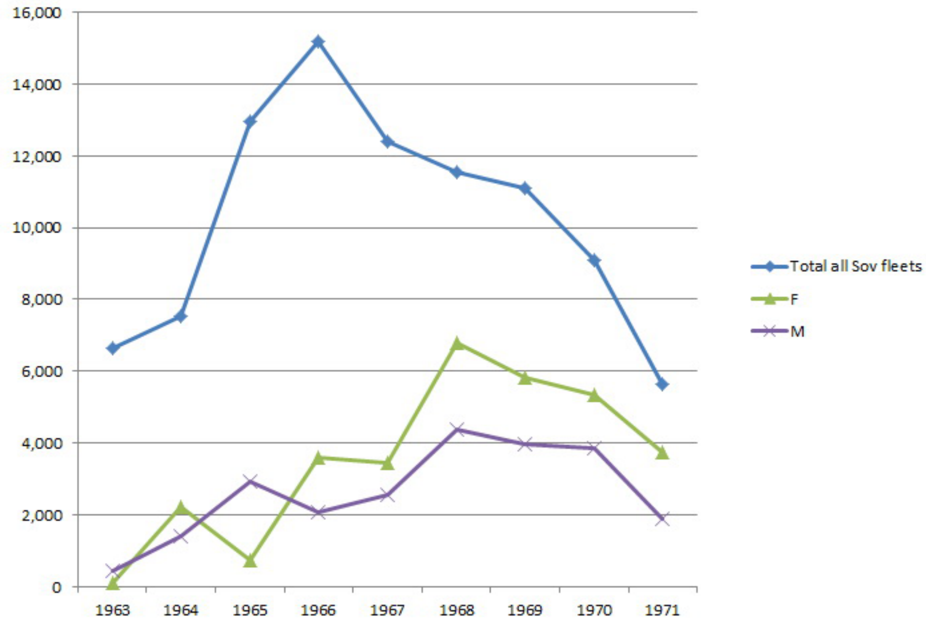


Figure 2. Soviet sperm whale catches (total and by sex, where known) during the peak period of whaling, 1963-1971.

Learning from the past

The only good thing that can be said to have come out of the Soviet illegal catches of sperm whales is the large amount of data now available with which to learn more about the distribution of this mysterious species in the North Pacific. Because the Soviets were taking everything, regardless of size, age, or protected status (Fig. 3), the catch series constitutes a remarkably representative data set. This inevitably conceals a tragic truth: the Soviet accounting, manifest in page after page of endless columns and figures, encompasses many entire families of sperm whales, including countless young calves.

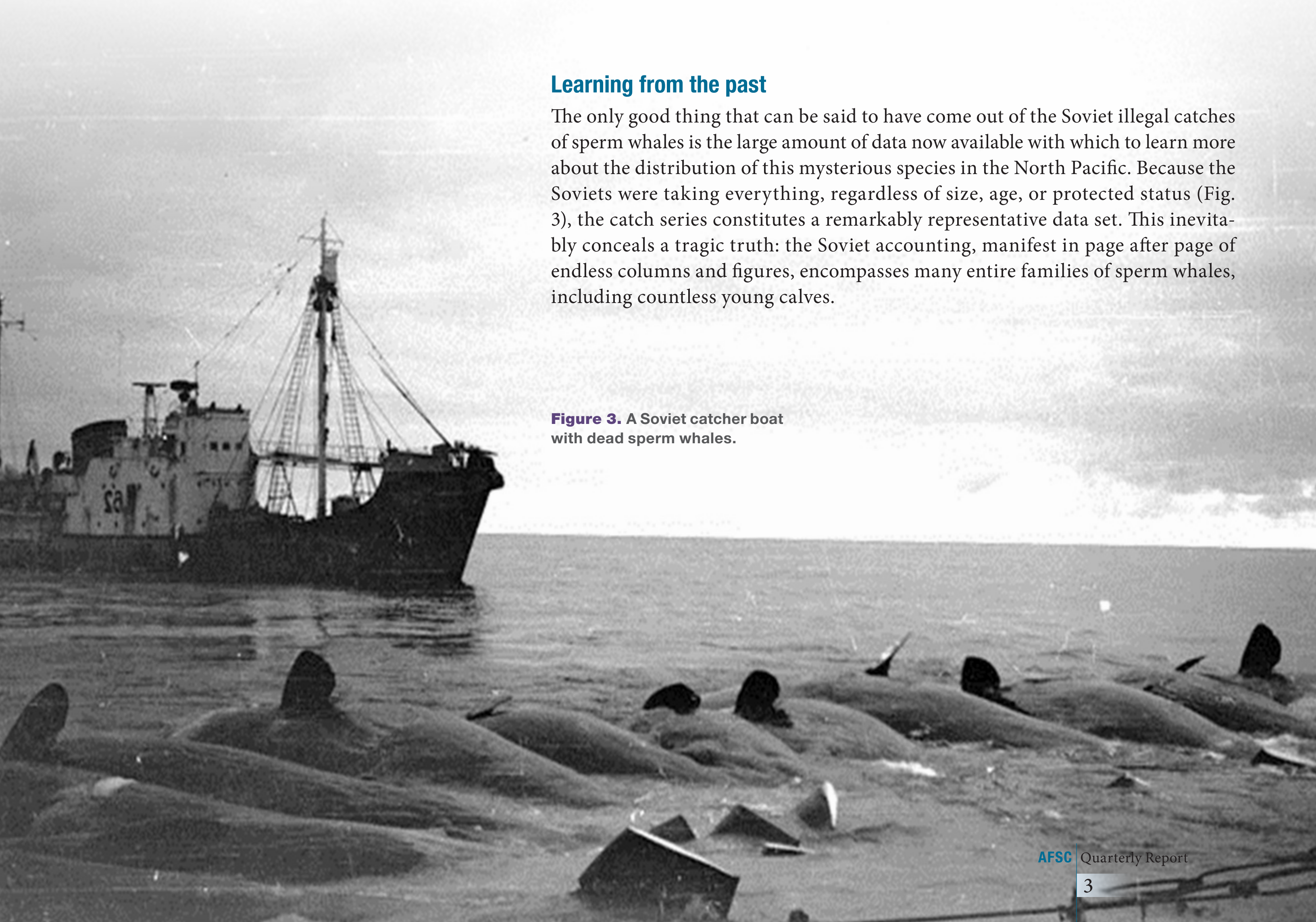


Figure 3. A Soviet catcher boat with dead sperm whales.

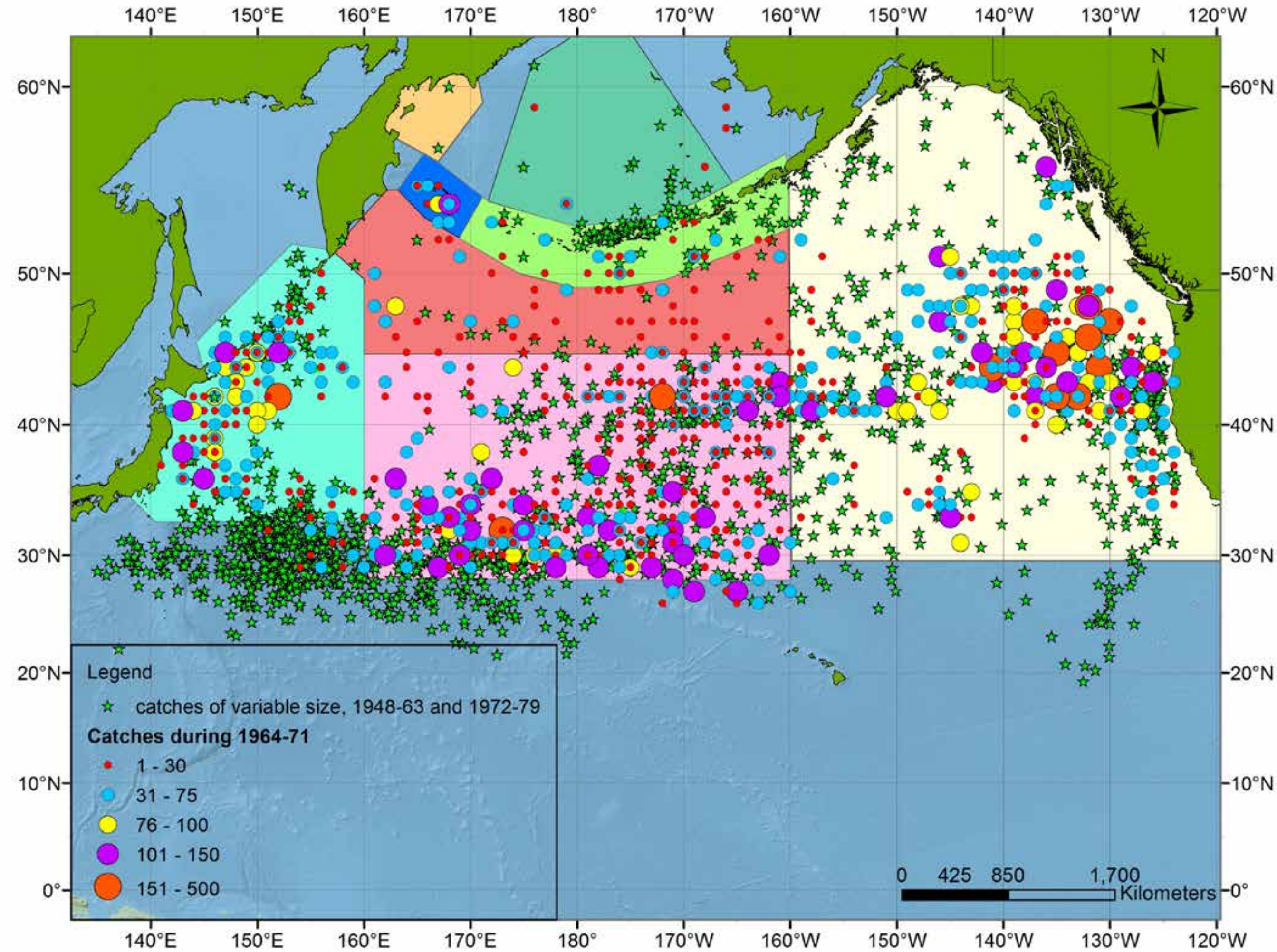


Figure 4. Distribution, where known, of Soviet pelagic sperm whale catches in the North Pacific (*n* = 81,035). Green stars represent catches which are known to be of variable size, but for which numbers often could not be determined; the catch size could be anywhere from one to more than a hundred whales (e.g., the two stars to the west of Kamchatka in the Okhotsk Sea are known to represent more than 200 whales). Catches made by the Kuril Island land stations (*n* = 23,090) are not included.

A look at the catch data shows the breadth of the Soviet whaling effort, which swept most of the North Pacific (Fig. 4). Because sex data are available for many of the catches, we can also examine the distribution of males and females (Fig. 5). By and large, this is as one would expect based upon previous studies: sperm whales are known to be strongly segregated by sex, with mature males foraging in high latitudes and family groups of females and juveniles inhabiting tropical or sub-tropical waters.

However, there are some surprises in the data. Oleutorskiy Bay (which lies at roughly lat. 55°–60°N on the western side of the Bering Sea) seemed to be have been occupied by mixed groups that contained a surprisingly high proportion of females. This, and similar catches of family groups from the Commander Islands, contradict traditional assumptions that female sperm whales are largely confined to lower latitudes and adds to recent discussion of similar catches and sightings. It seems that females at least occasionally travel to higher-latitude habitats, presumably in response to favorable oceanographic conditions and the occurrence of prey.

Of further interest is an apparent division of catch composition in the central Aleutians around long. 180° in the vicinity of Amchitka Pass, with family groups to the west and mature males to the east. This division somewhat parallels the situation with present-day transient-type (mammal-eating) killer whale (*Orcinus orca*) populations: a recent study conducted at the Alaska Fisheries Science Center's National Marine Mammal Lab and led by zoologist Kim Parsons has shown a sharp division in the genetic structure of this species across Amchitka Pass. The reason for this rather pronounced division in sperm and killer whale populations is not clear.

We also compared the Soviet data to positions of 19th century American catches plotted from whaling logbooks by renowned zoologist Charles Haskins Townsend. The Soviets covered a much larger proportion of the North Pacific than Yankee whalers could; nonetheless, some of the sperm whale distribution was very similar to the historical catches, notably in the "Japan Ground" (in the pelagic western Pacific, associated with the Kuroshiro Extension Current) and the "Coast of Japan Ground." The habitats that were important to sperm whales 150 years ago remain so today.

The status of sperm whales today is largely a mystery in most places. Unlike some baleen whales, sperm whales are extraordinarily challenging to study: their offshore distribution and lengthy dive times make them very difficult to access and investigate. There is little doubt that the huge Soviet and Japanese catches of this species wrought considerable damage to the sperm whale populations of the North Pacific. That these catches included so many mature females, of a species that has a reproductive rate that is generally lower than that of many baleen whales, undoubtedly exacerbated the situation and inhibited the chances of a swift recovery.

The habitats that were important to sperm whales 150 years ago remain so today.

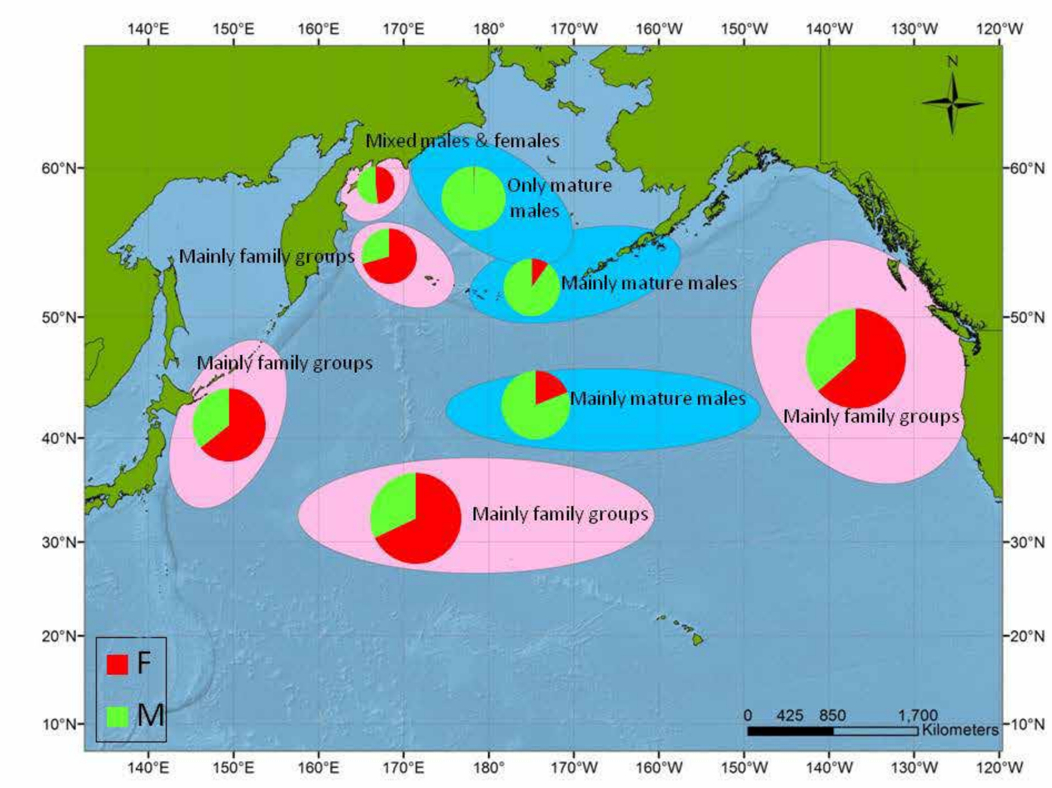


Figure 5. Composition of Soviet catches of sperm whales (F = female, M = male), by area. The size and shape of the ellipses are not intended to represent exact regions but rather to highlight general areas of concentration.

Today, we are attempting to wring as much information as possible from the illegal whaling data. It is our hope that the Soviet bureaucrats' obsession with detail can now be put to use in the service of a better understanding of how to conserve this remarkable species.

For North Pacific sperm whales, this huge deception involved not only nations lying about the number of animals taken, but also falsifying the sex and length data for the catches.

Further reading

Berzin, A.A. 2008. The Truth About Soviet Whaling. [Ivashchenko, Y.V., Clapham, P.J. & Brownell, R.L. Jr. (eds.) Translation: Y.V. Ivashchenko]. *Marine Fisheries Review* 70: 1-59.

Homans, C. 2013. The Vanishing. *Pacific Standard* magazine, Nov/Dec 2013: 56-64.

Ivashchenko, Y.V., Brownell, R.L. Jr. & Clapham, P.J. 2014. Distribution of Soviet catches of sperm whales (*Physeter macrocephalus*) in the North Pacific. *Endangered Species Research* 25: 249-263.

Ivashchenko, Y.V., Brownell, R.L. Jr. and Clapham, P.J. 2013. Soviet catches of whales in the North Pacific: revised totals. *Journal of Cetacean Research and Management* 13: 59-71.

Ivashchenko, Y.V. and Clapham, P.J. 2014. Too much is never enough: the cautionary tale of Soviet illegal whaling. *Marine Fisheries Review* 76: 1-21.

Kasuya, T. 1999. Examination of the reliability of catch statistics in the Japanese coastal sperm whale fishery. *Journal of Cetacean Research and Management* 1: 109-22.

Smith, T. D., R. R. Reeves, E. A. Josephson, J. N. Lund, and H. Whitehead. 2008. Sperm whale catches and encounter rates in the 19th and 20th centuries: an apparent paradox. D. J. Starkey, P. Holm, and M. Barnard (Editors), Oceans past: management insights from the history of marine animal populations, p.149-173. Earthscan, London.

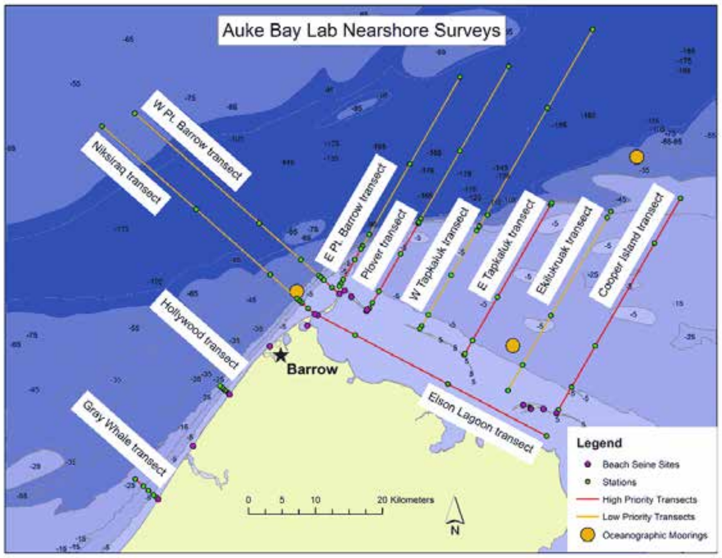


Figure 1. Arctic Coastal Ecosystem Survey sampling efforts near Barrow, Alaska. Click map to enlarge.

Figure 2. Arctic cod, Boreogadus saida.

Recruitment, Energetics, and Coastal Assessment Program

Year 3 of The Arctic Coastal Ecosystem Survey

Summer 2014 marked the third year of the Arctic Coastal Ecosystem Survey (ACES), a study of the fish assemblages in the shallow waters near Barrow, Alaska (Fig. 1). The objective of the study is to understand the importance of shallow waters (< 20 m) as rearing habitats for forage fish species in the high Arctic. This is a collaborative effort involving the Alaska Fisheries Science Center, Florida International University, the University of Alaska Fairbanks, Louisiana State University, the North Slope Borough , Oregon State University, the North Pacific Research Board and the Bureau of Ocean Energy Management. Summer field work involved beach seining at fixed shore stations throughout the ice-free period, trawling at offshore stations, deployment of oceanographic moorings and ADCPs (acoustic Dopplar current profilers), habitat mapping using DIDSON sonar, and collection of zooplankton prey. Laboratory work includes evaluation of the nutritional condition of fish, their diets, and isotopic analysis of fish and zooplankton.

Preliminary results reveal interannual variation in the nearshore arctic fish assemblages, with Arctic cod (*Boreogadus saida*) more abundant during cold years and capelin (*Mallotus villosus*) more abundant during warm years. Shallow-water fish communities are highly variable during the short summer season, with weekly changes in species composition and abundance of beach seine catches. Sculpin (Cottidae) tend to be most abundant early in the summer, with capelin and Pacific sand lance (Ammodytes hexapterus) becoming more common as summer progresses.

Wind-driven changes in the location of various water masses and ontogeny may play a role in these changes. Dominant fish species in beach seine catches in the Chukchi and Beaufort Seas were sculpin, Pacific sand lance, and to a lesser-degree capelin, while catches in Elson lagoon were dominated by capelin, sculpin, pricklebacks (Stichaeidae) and ciscoes (Coregoninae).

Zooplankton density was significantly greater in freshwater plumes in the lagoon. Further from shore, age-0 Arctic cod were found in pelagic layers, while age-1+ Arctic cod formed patchy, dense schools (Fig. 2). Several large Arctic cod with mature gametes were caught in the lagoon, which may provide insight to Arctic cod spawning locations which are largely unknown.

We look forward to another field year in 2015, chemical analysis of the catch in 2016, and closing the studies in 2017.

By Ron Heintz and Johanna Vollenweider

Forage Fish Distribution and Diet in the Eastern Bering Sea

Climate warming has impacted the southern extent of sea ice leading to many changes in ocean conditions and food webs in the eastern Bering Sea (EBS). We explore how these changes have affected two key forage fish species, capelin (Mallotus villosus) and Pacific herring (Clupea pallasii), examining the effects of climate change on this commercially important ecosystem in the EBS.

Catch per unit effort (CPUE) data from surface trawls, size, and diet of capelin and Pacific herring were collected during a series of warm and cold years during fisheries oceanographic surveys conducted in the EBS from mid-August to early October 2003 through 2011 (Fig. 1). Overall, catches for both species were higher in the northeastern Bering Sea (NEBS) relative to the southeastern Bering Sea (SEBS), irrespective of temperature conditions. Capelin catches were lower during warm years than during cold years; Pacific herring catches were less variable between warm and cold years (Fig. 2) . Capelin and herring lengths remained relatively constant between years. Capelin lengths were similar among oceanographic domains, while herring were larger in domains further offshore.

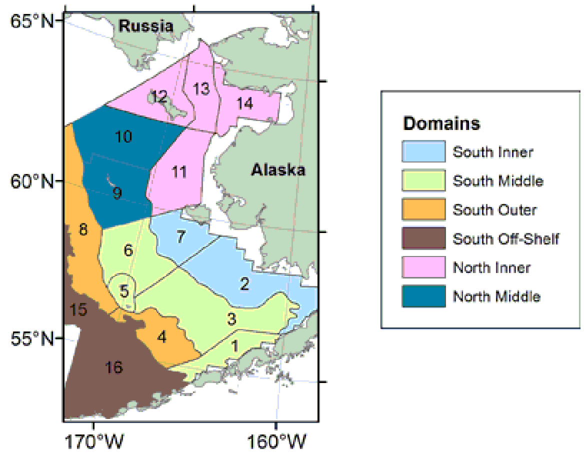


Figure 1. Map of eastern Bering Sea study area with individual Bering Sea Project (BSP) regions (numbered) consolidated into domains (shaded) for this study. Dashed line represents delineation between northeastern Bering Sea (NEBS) and southeastern Bering Sea (SEBS).

Diets for both species were significantly different between climate regimes (Fig. 3). Large crustacean prey comprised a higher proportion of the diets in most regions during cold years. Walleye pollock (Gadus chalcogrammus) contributed more than 60% to the diets of Pacific herring in the southern Middle Domain and more than 30% in the northern Middle domain during warm years. A switch to less energetic prey for these forage fishes during warm years may have implications for fitness and future recruitment. The shifts in the distribution and lower biomass of capelin in the EBS could lead to disruptions in food webs and energy pathways in this complex marine ecosystem.

By Alex Andrews, Wes Strasburger, Ed Farley, and Jim Murphy

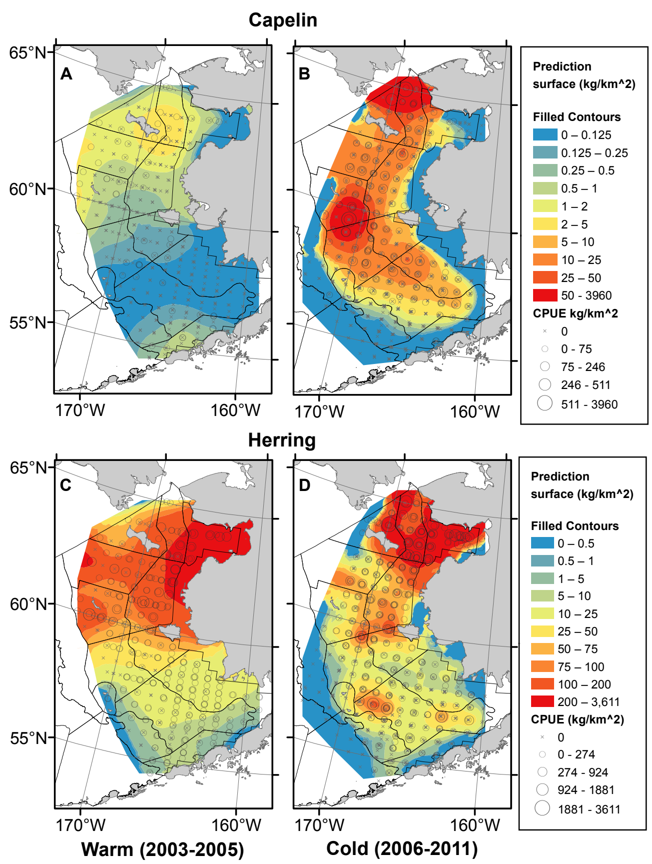


Figure 2. Distribution plots of capelin and herring catch per unit effort (CPUE; kg/km2) during Warm (2003-2005) and Cold (2006-2011) climate periods. Local polynomial interpolation was used to generate shaded contours for visualization. Circles represent magnitude of CPUE at each station that were trawled. (A) Capelin during warm climate period, (B) Capelin during cold climate period, (C) Herring during warm climate period, and (D) Herring during cold climate period.

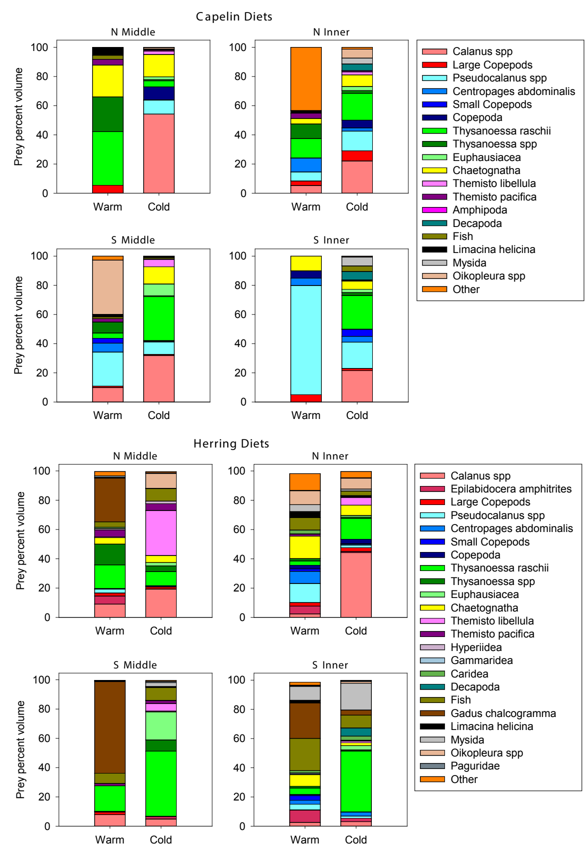


Figure 3. Prey percent volume for prey categories in the diet of capelin (top four bar plots) and herring (bottom four bar plots) within each domain, and during both warm (2003-2005) and cold (2006-2011) climate periods.

Education and Outreach

Pacific Sleeper Sharks in the Gulf of Alaska: Studying an Elusive Species

The tubby shape of the Pacific sleeper shark has lead scientists to think they are slow-moving scavengers that feed on whatever falls to the bottom of the sea. But recent tagging and diet studies by NOAA scientists at the Alaska Fisheries Science Center (AFSC), have found that sleeper sharks actually are active, opportunistic feeders that swim throughout the water column eating a variety of fast-moving species like salmon and squid.

Seeing any species of shark on the back deck of a fishing boat is exciting, but when I saw a flabby, dark brown, sausage with rounded fins and a mouth full of razor-sharp teeth in a catch of Pacific ocean perch I was sampling, I knew I was looking at the elusive Pacific sleeper shark (*Somniosus pacificus*). At 6 feet in length, the shark was lifted out of the fish hold by crane to prevent it from clogging access to the ship's factory where the fish were processed. As a fisheries observer aboard a commercial fishing vessel, my primary goal was to gather data on the target species and as many incidentally-caught species (known as bycatch) as part of the National Oceanic and Atmospheric Administration's (NOAA) mission to monitor and manage U.S. fisheries. Because many sharks are long-lived, have slow growth rates, and reach their age of sexual maturity late in life, the life-history traits make sharks vulnerable to commercial fishing operations that use bottom trawl or long-line gear and therefore, are a concern to fishery managers.

What do scientists know about Pacific sleeper sharks?

The tubby shape of the Pacific sleeper shark has lead scientists to think they are slow-moving scavengers that feed on whatever falls to the bottom of the sea. But recent tagging and diet studies by NOAA scientists at the Alaska Fisheries Science Center (AFSC), have found that sleeper sharks actually are active, opportunistic feeders that swim throughout the water column eating a variety of fast-moving species like salmon and squid. Diet data from juvenile sleeper sharks (averaging 5.5 feet in length) in the Gulf of Alaska suggest the sharks eat low on the food chain, but there is speculation that larger sleeper sharks may consume marine mammals such as the Steller sea lion.

The age of Pacific sleeper sharks caught by fisheries could provide a clue on how old they get. Unfortunately, current ageing techniques don't work for sleeper sharks. The age of sharks is typically assessed by counting band pairs laid down in vertebrae or dorsal spines. "We tried a number of methods to age the vertebrae, including several different staining and microscopy techniques, and when that didn't work we tried other hard structures including neural arches and jaws, all to no avail," said researcher Beth Matta with the AFSC's Age and Growth program of the work she and her coworker Chris Gburski have done trying to age sharks.

Sleeper sharks, like several other deep-sea species, do not lay down any discernable bands in their vertebrae and have no dorsal spines. The vertebral column is unlike any that Dr. Ken Goldman, a colleague at the Alaska Department of Fish and Game, has examined. "It resembles a weird corrogated hose-like structure and all of my attempts over the past 14 years to assess age through vertebrae have failed," he said. AFSC scientists have tried different microscopy techniques, slicing thin sections of the different structures to try to clearly identify any banding patterns; all attempts have yielded no clues on how old these animals get.

To date, no reproductively mature Pacific sleeper shark has been caught in Alaska. Sleeper sharks approaching 25 feet in length have been captured in areas outside of Alaska, and information suggests that both sexes mature at around 14 feet in length, but scientists have no idea about their growth rates. However, incidentally captured Pacific sleeper sharks in Alaska's commercial groundfish fisheries are seldom longer than 7-8 feet. This has left the scientists wondering if Alaskan waters are the preferred habitat for juvenile sleeper sharks. Whatever the reason, it raises another question: Are the commerical fisheries' bycatch of juvenile sleeper sharks impacting future population levels?

A sleeper shark photographed on deck during a NOAA Fisheries research cruise. Photo credit: NOAA.

NOAA Fisheries scientists during tagging operations of a sleeper shark. Photo credit: NOAA.

How do Scientists Estimate Population Size of Sleeper Sharks?

Annual catch limits are required for all federally managed fisheries, including non-target species such as sharks. Scientists at the AFSC have found that fishery catch data are the best data to monitor the Pacific sleeper shark populations in Alaska. When scientists present the trend of Pacific sleeper shark bycatch in all fisheries in the Gulf of Alaska to fishery managers, they can determine if the trend is a concern. A downward trend raises a red flag for both scientists and managers to then investigate if the trend is due to a change in fishing behavior, changes in the environment, or if it may be a real reflection of the Pacific sleeper shark's population size. Currently, the average yearly incidental catch of the Pacific sleeper shark in the Gulf of Alaska has been in a sharp decline since 2005, but scientists are not certain what the cause may be; earlier tagging studies of sleeper sharks did not produce a clear understanding of any migratory or movement patterns that may explain any changes in the fishery catch data.

New data may provide insight in areas where Pacific sleeper sharks have been historically caught. In 2013, fishery observer coverage increased in some small boat fisheries, such as in the Pacific halibut longline fishery in the Gulf of Alaska. These data plus future research will bring much needed information to help scientists better understand the elusive Pacific sleeper shark and help fishery managers make informed decisions.

By Rebecca F Reuter

FMA Director Martin Loefflad Retires from the Alaska Fisheries Science Center

Martin Loefflad, Director of the AFSC's Fisheries Monitoring and Analysis (FMA) Division and the North Pacific Groundfish and Halibut Observer Program, retired 9 January 2015 after a robust history with Alaskan fisheries.

Martin left rural, eastern Pennsylvania at the age of 19 to test his skills in the Pacific Northwest, eventually landing in Alaska. There he worked onboard Russian trawlers in the Foreign Fisheries Observer Program. In 1990 he found himself in Kodiak helping establish the Observer Program's Kodiak Field office where he worked tirelessly with industry to support the newly implemented Domestic Fishery Observer Program. He then moved to a post working in the NMFS Alaska Regional Office on in-season management issues, particularly developing with many others the monitoring systems used for the community development quota (CDQ) fisheries. He returned to the Alaska Fisheries Science Center's Observer Program in Seattle in 1995 where he has been responsible for many of the innovations in the program. While with the Center, Martin continued his education and completed a Master of Public Administration degree from Seattle University in 2006.

Martin has been an integral component of the North Pacific Groundfish and Halibut Observer program through its history. Of particular note, on two separate occasions, he was part of a team that was awarded the Bronze Medal, most recently in 2014 for the design and implementation of a restructured, industry-funded observer program to promote effective management of North Pacific marine fisheries.

Martin's guidance and wisdom will be missed. We can take away a lot from his closing remarks to his colleagues: "As you move forward, please keep safety in mind as we have many people who work with us as observers deployed at sea. During our busy seasons, we have upwards of 230 people on the ocean working in a challenging environment. Most of them are very good and are dedicated to our mission. They depend on us, and on the USCG (U.S. Coast Guard) when things sometimes go wrong. We depend on them for objective data from the fleet. Please do your best for them. I will miss working with each of you. It is the people aspect of working with NMFS, the industry, and in the Council process that have made my years rewarding. One of the greatest rewards to me personally has been in hiring, promoting and helping good people grow and develop in their careers."

As Martin stated at the most recent North Pacific Fisheries Management Council Meeting, "Don't ever forget that this work is really very important… and please keep carrying on the good work."

The best to Martin and his wife, Cheryl, and bounties of Matsutakes and adventures in the years ahead.

By Gwynne Schnaittacher

Ocean Acidification Funding FY2015

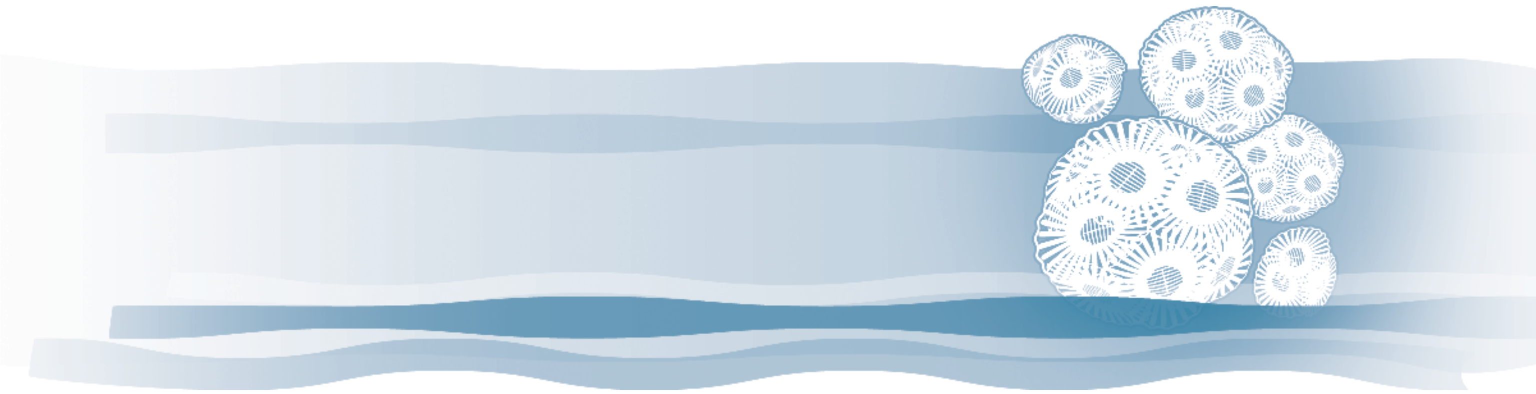
The AFSC will receive about $370,000 to continue existing ocean acidification research projects in FY 2015. These funds primarily will be used to conduct species-specific physiological research. The species-specific physiological response to ocean acidification is unknown for most marine species. Lacking basic knowledge, research will be directed toward several crab and fish taxa. The research will be conducted at the AFSC's Kodiak and Newport Laboratories. The results will be incorporated into bio-economic models; this work will be completed by the AFSC's Socioeconomics Assessment Program in Seattle. In addition, NOAA's Pacific Marine Environmental Laboratory (PMEL) will receive an additional $200,000 in FY15 to support the Alaska observing activities directed by PMEL scientist Jeremy Mathis which will be used to transition support for at least two of the four Alaska moorings and to support the FY15 Alaska coastal cruise.

The titles of the funded projects are "Effects of ocean acidification on Alaskan gadids: sensitivity to variation in prey quality and behavioral responses"; "Forecast effects of ocean acidification on Alaska crabs and pollock abundance"; "Physiological response of commercially important crab species to predicted increases in pCO2"; and "Alaska Ocean Acidification Research: Autonomous Observations of Ocean Acidification in Alaska Coastal Seas." The principal investigators for these studies are Tom Hurst, Bob Foy, Mike Dalton and Jeremy Mathis, respectively.

New research projects also are being considered for funding in FY 2015 (e.g., coral physiological response with PIs Bob Stone and Foy); a decision is anticipated by late spring.

By Mike Sigler

The species-specific physiological response to ocean acidification is unknown for most marine species. Lacking basic knowledge, research will be directed toward several crab and fish taxa.



Alaska Ecosystems Program

Stella, an unmanned aircraft system, during summer 2014 field investigations of the endangered Steller sea lion in western Alaska. Video credit NOAA Fisheries.

Steller sea lion terrestrial haul-out sites successfully surveyed in the Aleutian Islands and western Gulf of Alaska during June and July 2014 by biologists from the ground, hexacopter, and occupied aircraft.

Flying Beneath the Clouds at the Edge of the World: the Use of an Unmanned Aircraft System to Survey the Endangered Steller Sea Lion in Western Alaska

The National Marine Fisheries Service (NMFS) has used occupied aircraft since the 1970s to obtain aerial images of Steller sea lions hauled out throughout coastal Alaska. The subsequent counts of animals captured within those images form the basis for annual population estimates which are used by NMFS for management purposes. The agency listed the Steller sea lion as threatened range-wide under the Endangered Species Act in 1990. Seven years later NMFS identified two stocks in the United States and elevated the listing of the western population to endangered due to persistent drops in abundance. Continued assessment surveys indicate that the portion of this population in the western Aleutian Islands has continued to decline.

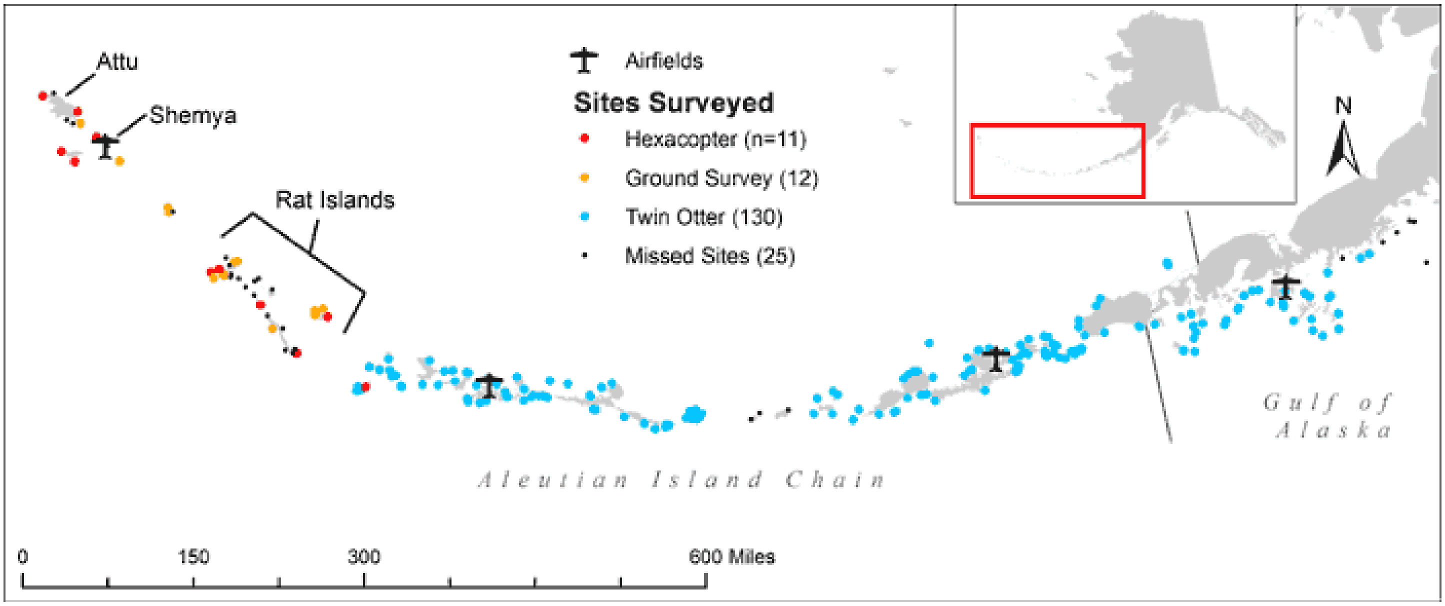
The Alaska Ecosystem Program (AEP) at the Alaska Fisheries Science Center coordinates Steller sea lion surveys to estimate abundance during the same summer time period when sea lions are hauled out at their greatest densities. Flying surveys in Alaska is not without its challenges, especially along the 1,200 miles of the Aleutian Island chain, which is serviced by only three airfields. Inclement weather such as low ceilings, fog, and high winds coupled with remote and scarce airfields have impeded the success of aerial surveys in the Aleutians both temporally and spatially. This is especially true for the westernmost part of the Aleutians, where timely surveys are critical for assessing changes in a relatively small, declining, subpopulation. During the summer of 2012, the AEP survey crew made it to the farthest west airfield on Shemya Island but was able to conduct survey flights only 1 of the 18 days stationed on the island due to fog and low ceilings. Similar restrictions have prohibited surveys in the Rat Island group, just east of Shemya, since 2008-09 (see map for island locations).

Such continual impediments to successful survey efforts prompted the AEP to look into the feasibility of unmanned aircraft systems (UAS) to survey hard-to-reach areas in the western Aleutians. The result is an APH-22 hexacopter (Aerial Imaging Solutions), an insect-like UAS that measures 32 inches in width, 12 inches in height, weighs only 4.5 pounds, with a high resolution digital camera mounted underneath the domed body. Biologists depend on the camera to capture high-resolution images for analysis after survey flights.

The aircraft may be tiny but it requires two skilled pilots certified by the Federal Aviation Administration to fly it: LT. Van Helker (NOAA Corps) and AEP biologist Kathryn Sweeney. While one pilot flies the aircraft using a remote radio controller, the other constantly monitors the skies for other aircraft or obstacles that could pose risks. The ground station mounted on a tripod includes a color screen streaming a live view of what the downward facing camera 'sees,' with the camera engaged to photograph when triggered by the pilot. Another screen provides data on battery level, altitude, distance from take-off location, and time in the air. Nicknamed "Stella" by AEP staff, the craft can stay airborne for as long as 23 minutes and sustain flight in winds as high as 20 knots (typical for the region). Unlike the occupied survey aircraft which flies at about 750 ft and requires access to airfields, Stella flies as low as 150 ft and is portable to survey areas by vessel.

During the 2014 Steller sea lion survey, NMFS biologists stationed on board the U.S. Fish and Wildlife Service research vessel Tiĝlâx focused efforts in the western Aleutian Islands. Simultaneously, a twin Otter aircraft (operated by NOAA Aircraft Operations Center) surveyed eastward along the Aleutian Islands. The overall objective was to obtain visual counts from land and aerial images from both aircraft types to complete a survey throughout the entire Aleutian Island chain during late June to early July. Biologists on the Tiĝlâx also conducted visual surveys of permanently marked sea lions branded as pups or adults and serviced and download images from remote cameras stationed at various sea lion sites in the area.

Of the 178 sites in the Aleutian Islands, 153 were successfully surveyed, making the 2014 survey the most successful survey of Steller sea lion pups and



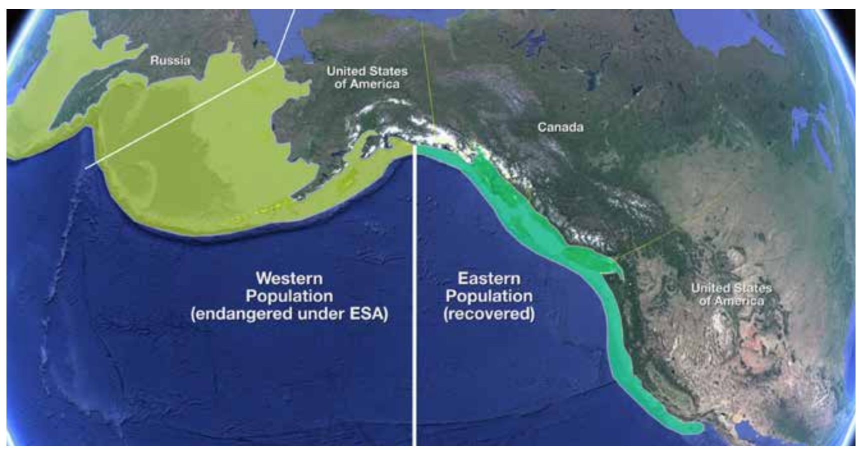
Aerial image captured by the APH-22 hexacopter of Steller sea lion site Cape Wrangell on Attu Island from 200 feet above the animals. Inset: juvenile with a permanent brand, ~100, indicating that this male was branded in 2013 as a pup on the site, Cape Sabak on Agattu Island.

non-pups since the 1970s. The research vessel visited 23 sites in the remote western Aleutians from Attu Island to the Rat Islands where pilots flew Stella over 11 of the most populated sites, capturing more than 1,500 images. The twin Otter crew surveyed east of the Rat Islands along the Aleutians (130 sites) and well into the western Gulf of Alaska (42 sites).

Using the hexacopter to survey the 11 sites required a total of 17 flights adding up to approximately 4 hours of total flight time. This is a testament to the swift efficiency UAS technology brings to abundance surveys, especially in this area of concern which has proven so difficult to survey over the past 45 years. Stella flew over 1,589 sea lions with only one instance of disturbing just 5 animals into the water. This low (0.3%) disturbance rate is significantly less than the 5% disturbance caused by occupied aircraft, adding even greater value to the stealth that Stella provides. Biologists also examined the images captured by the UAS to identify branded animals that were missed by visual observers on the ground. This adds yet another tool to the increasing utility of UAS technology in future NMFS surveys.

Counts from the 2014 Steller sea lion survey have not yet been finalized; however, preliminary counts from the 23 remote sites surveyed by the research vessel or UAS confirm a continued decline of Steller sea lions in the western Aleutian Islands. The 2014 Steller sea lion survey report will report updated counts and abundance trends and should be available on the AFSC website in winter 2015 .

By Kathryn Sweeney



To learn more about our Steller sea lion research in Alaska, please watch the video on the NOAA Fisheries YouTube channel.

All images and fieldwork were conducted under NMFS ESA/MMPA Permit 18528

Resource Ecology and Ecosystem Modeling Program

Fish Stomach Collection and Analysis

During the fourth quarter of 2014, the stomach contents of 3,024 groundfish were analyzed in the Food Habits Laboratory. Data were error-checked and loaded into the AFSC Groundfish Food Habits database resulting in 23,842 added records. Stomach samples were analyzed from a wide range of species from the Chukchi Sea (21 species), the Gulf of Alaska (3 species), and the eastern and northern Bering Sea (21 species). The Chukchi Sea samples were collected during the SHELFZ survey, examining oceanographic processes and biological distributions of invertebrates, fishes, and zooplankton from the shoreline near Barrow (the northernmost point of Alaska) out into the deep waters of Barrow Canyon.

In addition to stomach samples from groundfish, we analyzed bill-load samples from 129 tufted puffins and 28 horned puffins collected from breeding colonies on Buldir and Aitak Islands for the Alaska Department of Fish and Game. Resource Ecology and Ecosystem Modeling (REEM) personnel participated in the Atka mackerel tag recovery cruise in the central and western Aleutian Islands where stomach samples were collected from 940 Atka mackerel and from 542 other fish (mostly rockfish). Fisheries Observers also collected 81 stomach samples from arrowtooth flounder during fishing operations in the Gulf of Alaska and the eastern Bering Sea.

REEM outreach activities included presentations of the REEM educational display and the fish food habits hands-on research activities to the OMI Budget staff visiting from NMFS Headquarters and field offices, and to a marine ecology class visiting from Nathan Hale High School. Presentations were also given during the December 6th scientist spotlight event at the Pacific Science Center.

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

Alaska Marine Ecosystem Considerations 2014 Report

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 Arctic, the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska.

The report includes additional new and updated sections, including the 2014 Eastern Bering Sea and Aleutian Islands Report Cards and ecosystem assessments. This year the "Hot Topics" section includes topics from most ecosystems. In the Arctic, a large phytoplankton bloom observed beneath the sea ice suggests that primary production pathways may be changing in the Chukchi Sea. The hot topic for the eastern Bering Sea was the observed mortalities of two endangered short-tailed albatross in association with a longline fishing vessel. The hot topics for the Gulf of Alaska include the "warm blob" of record high sea-surface temperatures that developed in early 2014 and persisted through the end of summer and the exceptionally high reproductive success across several seabird species in the western Gulf. The section in the report that describes ecosystem and management indicators includes updates to 44 individual contributions and presents 6 new contributions. These include contributions on temporal trends in Pacific sand lance as revealed by puffins; using ecosystem indicators to develop a Chinook salmon abundance index for southeast Alaska; an eastern Bering Sea pollock recruitment index that incorporates sea temperature and salmon; occurrence of mushy halibut syndrome; and two updates on groundfish condition in the Aleutian Islands and Gulf of Alaska.

Additional regional 2014 ecosystem highlights include the warm summer conditions in the eastern Bering Sea, including the early break up of sea ice, a reduced cold pool of bottom water, and warm surface air conditions. This was the first warm year following a sequence of seven cold years in the eastern Bering Sea. The Aleutian Islands also experienced warm temperatures; survey biomasses of most fish species increased compared with the last survey in 2012. In addition, a review of Gulf of Alaska indicators suggests that there was a shift in ecosystem state in 2006.

Presentations on ecosystem status and report contents were given to the Council's Groundfish Bering Sea/Aleutian Islands and the Gulf of Alaska Plan Teams in November and to the Scientific and Statistical Committee in December, when the 2015 groundfish quotas were set. The report is now available online at the *Ecosystem Considerations website*.

By Stephani Zador

Food Web Modeling

Kerim Aydin attended *Ecopath 30 Years* conference in Barcelona, Spain, 10-13 November 2014, where he presented an invited lecture entitled "Notes from 30 years on the front lines of food web modeling in fisheries management" and discussed the methods through which food web models have been used in management scenarios in the Alaska region.

By Kerim Aydin

Seabird Bycatch Estimates for the Alaska Groundfish and Halibut Fisheries

In 2013 the restructured observer program expanded coverage by including vessels less than 60 feet overall and vessels in the halibut fleet. Despite this expansion, the total seabird mortality associated with the fleet was the lowest we have recorded, at 4,730 birds overall (Table 1, Fig. 1). As was expected, however, the bycatch of albatross did increase, to 438, the second highest recorded number since 2007 and well above the average of 347.6 throughout this time period. Overall bycatch remains low when compared to the years prior to 2002 (Fig 1), when the cod freezer longline fleet and other longline vessels began extensive use of paired streamer lines. These numbers include all gear types, but do not include mortality from the trawl fleet where mortality occurs due to warp, net wing, or third wire interactions. Current estimates, beginning in 2007, are produced from the Alaska Regional Office Catch Accounting System.

A report of seabird bycatch, 2007-13 with more detailed information, including information by fishery, can be found on the *AFSC website's seabird page*.

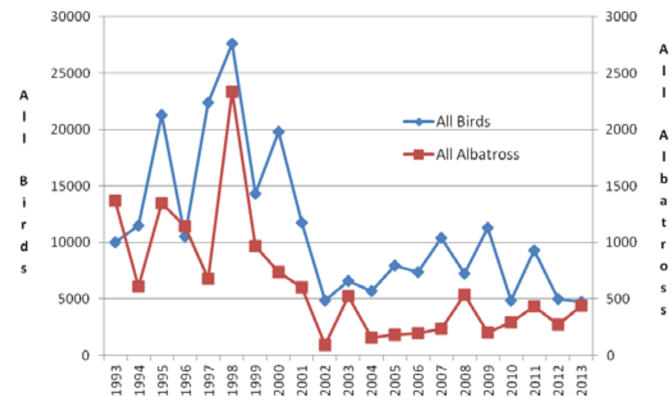


Figure 1. Total estimated bycatch of all seabirds and all albatross in Alaskan Groundfish fisheries, all gears combined — 1993 to 2013.

Table 1. Total estimated seabird bycatch in Alaskan federal groundfish fisheries, all gear types and Fishery Management Plan areas combined, 2007 through 2013.

Species/ Species Group	Year						
	2007	2008	2009	2010	2011	2012	2013
Unidentified Albatross	23	0	0	0	0	0	0
Short-tailed Albatross	0	0	0	15	5	0	0
Laysan Albatross	17	226	148	233	205	135	189
Black-footed Albatross	208	314	56	48	221	141	249
Northern Fulmar	4,806	3,334	8,200	2,452	6,214	3,022	3,268
Shearwater	3,587	1,224	622	653	195	514	191
Storm Petrel	1	44	0	0	0	0	0
Gull	1,360	1,551	1,335	1,145	2,158	890	556
Kittiwake	10	0	16	0	6	5	3
Murre	6	6	13	102	14	6	3
Puffin	0	0	0	5	0	0	0
Auklet	0	3	0	0	0	7	4
Other Alcid	0	0	105	0	0	0	0
Other Bird	0	0	136	0	0	0	0
Unidentified	522	541	696	240	306	285	267
Total	10,540	7,243	11,325	4,894	9,324	5,005	4,730

By Shannon Fitzgerald

Economic & Social Sciences Research Program

Identifying Channels of Economic Impacts: An Inter-regional Structural Path Analysis for Alaska Fisheries

Much of the labor income generated in many Alaska industries flows out of the state because a large share of workers in many Alaska industries, including fishing, are nonresidents. Additionally, a large amount of capital used in Alaska seafood industries is owned by nonresidents, and much of the capital income from these industries leaks to other states. Many of the goods and services used by consumers and seafood and nonseafood industries in Alaska are imported from other states. Therefore, there are additional impacts from exogenous shocks to fisheries or other industries in Alaska affecting those other states that are not captured in a single-region economic impact model.

Several previous studies have used an interregional or multi-regional economic impact model such as a social accounting matrix (SAM) model to capture these additional impacts of Alaska fisheries and calculated the inter- or multi-regional multipliers. However, the multipliers from this model measure only total economic impacts, failing to provide fishery managers with the information on how and along what channels these total economic impacts are generated and transmitted throughout the regions. A structural path analysis (SPA) is a useful tool to investigate the channels through which the initial policy shocks or exogenous shocks to a sector (origin) are transmitted to, and generate effects on, other sectors (destination sectors) of an economy.

Our present study extends a previous study where an SPA was conducted for a single region of Alaska and conducts an inter-regional structural path analysis (IRSPA) for Alaska and the rest of United States within an inter-regional SAM framework. Results from the IRSPA will provide fishery managers with detailed information on the channels of economic impacts generated between the two regions.

By Chang Seung

Perceptions of Measures to Affect Active Participation, Lease Rates and Crew Compensation in the Bering Sea/Aleutian Islands Crab Fisheries

In 2010 the North Pacific Fishery Management Council completed a 5-year review of the Bering Sea and Aleutian Islands Crab Rationalization program. The review identified unintended social issues that have emerged in the fishery as a result of the management program. The central issues noted were the impacts of high quota share lease rates on crew pay, difficulty for skippers and crew to purchase quota shares, and concerns about absentee quota ownership. The Council initiated discussion and analyses on these issues; however, it decided instead to encourage the crab fleet to address the issues through voluntary measures. The crab cooperatives developed measures to address the Council's concerns, which were put in place in 2013. The measures include the Right of First Offer program that gives skippers and crew an initial opportunity to purchase quota shares and a voluntary lease rate cap for two of the crab fisheries.

The Alaska Fisheries Science Center developed a study to gather perspectives on the voluntary cooperative measures. Semi-structured interviews were conducted with participants in the fishery, including quota shareholders, vessel owners, skippers, crew, cooperative representatives, Community Development Quota groups, and expert respondents involved in the financial and brokerage aspects of the fishery. Interview respondents were asked to speak to six main topic areas:

1) Access to purchasing quota shares
2) Experience with the Right of First Offer program
3) Perspectives on quota share lease rate caps
4) Crew compensation in the crab fisheries
5) Access to financing for quota share purchases
6) The future of the crab fisheries

Ownership records and contact information from the 2012-13 season were requested through the Alaska Fisheries Information Network. Contact information was obtained for hired skippers and crew license holders from the crab fisheries' yearly Economic Data Report (EDR). The Commercial Fishery Entry Commission (CFEC) issues gear operator permits and the Alaska Department of Fish and Game (ADF&G) issues crew licenses, either of which is required to crew aboard a vessel. Vessel owners report the CFEC and ADF&G operator and license data through their annual EDRs and contact information for vessel owners, and quota share holders were sourced from the NMFS Alaska Regional Office.

Participants were contacted via phone, mail, and/or email. Between February 2014 and September 2014 a total of 220 industry participants were interviewed. This included 43% of all quota shareholders, 71% of vessel owners, 47% of skippers, and 13% of crewmembers in the fleet. The interviews will be coded using inductive coding methodology and an analysis of code frequency will be completed to determine perspectives on these issues by respondent type. A preliminary report is expected to be released in spring 2015.

By Keeley Kent and Amber Himes-Cornell

Developing Comparable Socio-economic Indices of Fishing Community Vulnerability and Resilience for the Contiguous United States and Alaska

The ability to understand the vulnerability of fishing communities is critical to understanding how regulatory change will be absorbed into multifaceted communities that exist within a larger coastal economy. Creating social indices of vulnerability for fishing communities provides a pragmatic approach toward standardizing data and analysis to assess some of the long-term effects of management actions. Over the past 3 years, social scientists working in NOAA Fisheries' Regional Offices and Science Centers have been developing indices for evaluating aspects of fishing community vulnerability and resilience to be used in the assessment of the social impacts of proposed fishery management plans and actions. These indices are standardized across geographies, and quantify conditions which contribute to, or detract from, the ability of a community to react positively towards change.

The AFSC has developed indices for more than 300 communities in Alaska. We compiled socio-economic and fisheries data from a number of sources to conduct an analysis using the same methodology used by Colburn and Jepson (2012) and Jepson and Colburn (2013). To the extent feasible, the same sources of data are being used in order to allow comparability between regions. However, comparisons indicated that resource, structural, and infrastructural differences between NE and SE Alaska require modifications of each of the indices to make them strictly comparable. The analysis used for Alaska was modified to reflect these changes. The data are being analyzed using principal components analysis (PCA), which allows us to separate out the most important socio-economic and fisheries related factors associated with community vulnerability and resilience in Alaska within a statistical framework.

These indices are intended to improve the analytical rigor of fisheries Social Impact Assessments, through adherence to National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act, and Executive Order 12898 on Environmental Justice in components of Environmental Impact Statements. Given the often short time frame in which such analyses are conducted, an advantage to the approach taken to date by the Principal Investigators 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.

Although the indices are useful in providing an inexpensive, quick, and reliable way of assessing potential vulnerabilities, they often lack external reliability. Establishing validity on a community level is required to ensure indices are grounded in reality and not merely products of the data used to create them. However, achieving this requires an unrealistic amount of ethnographic fieldwork once time and budget constraints are considered. To address this, a rapid and streamlined groundtruthing methodology was developed to confirm external validity from a set of 13 sample communities selected, which were based on shared characteristics and logistic feasibility. The goal of this research methodology is to confirm external validity of the well-being indices through measuring how well quantitative index constructs overlap with qualitative constructs developed from ethnographic fieldwork. Several inter-rater agreement tests, including a Cohen's Kappa and Spearman's rho, were used in assessing construct overlap by measuring how well ethnographic data is in agreement with the indices.

A K-means cluster analysis was used in determining community groupings based on similarities in the secondary data used in creating the indices. Once communities were grouped, 13 sample communities were selected based on the cluster characteristics and logistical constraints. An iterative, mixed-methods grounded approach was used in developing protocols for ethnographic fieldwork. Key-informant categories were identified based on the index-derived constructs, and interview protocols were developed to target specific themes thought relevant to those constructs. Interviews were open-ended to allow for emergent constructs to present themselves during the interview process. Finally, to supplement interview data, physical field assessments of community character, environment, and condition were conducted by researchers.

Once fieldwork was complete, summaries were drawn from researcher experiences and their interview interpretations, which will be used to create a qualitative ranking system. The next step for the groundtruthing exercise is to compare the qualitative fieldwork data to the quantitative indices. As a first step, a rapid assessment will be done in fall 2014. For each quantitative component, a ranking of "high," "medium," or "low" will be given according to the score created from the PCA. Members of the research team then will provide subjective rankings for each component based on ethnographic data, and the two ranking schemes will be tested for inter-rater agreement. Cohen's Kappa will be used to test for perfect matches of rankings, which is the more conservative of two tests. The second test, Spearman's rho, will provide a coefficient of "agreement," and will not omit instances where there was not a perfect match. Together, these tests will provide a well-rounded picture of agreement between the qualitative and quantitative sets of ranks, and thus a general assessment of construct overlap. Reports documenting this phase of the project will be released in 2015.

Groundtruthing the results will facilitate use of the indices by the AFSC, NOAA's Alaska Regional Office, and the North Pacific Fishery Management Council staff to analyze the comparative vulnerability of fishing communities across Alaska to proposed fisheries management regulations, in accordance with NS8. This research will provide policymakers with an objective and data-driven approach to support effective management of North Pacific fisheries.

By Amber Himes-Cornell, Conor Maguire and Stephen Kasperski

Baseline Economic Information about the Alaska Saltwater Sport Fishing Charter Sector, 2011-2013

As discussed in the *Oct-Dec 2013 AFSC Quarterly Report* , AFSC researchers developed and implemented an economic survey that collected information on costs, revenues, employment, and services offered from saltwater sport fishing charter businesses in Alaska. The Alaska Saltwater Sport Fishing Charter Business Survey was conducted jointly with the Pacific States Marine Fisheries Commission (PSMFC) for three consecutive years—2012, 2013, and 2014—to collect data for the previous year's activities. A NOAA Technical Memorandum (Lew et al. 2015) that describes the data collection efforts, summarizes the data, and estimates population-level estimates is currently underway, but some of the principal results are reported here.

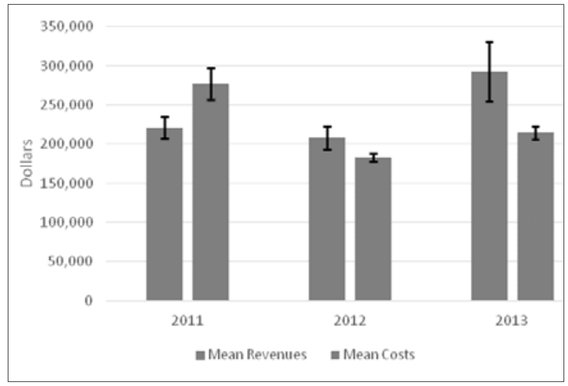


Figure 1. Mean Total Revenues and Total Expenditures by Year for Alaska Saltwater Sport Fishing Charter Sector, 2011-2013

Since overall response rates were lower than expected in each of the 3 years of the survey[1], several adjustments were made to the sample data to generate reliable population-level estimates of costs, revenues, and employment. These adjustments were made using well-established statistical techniques, namely, sample weighting and data imputation methods. In this work, auxiliary information on species targeted, fishing effort, location and timing of fishing, and other information collected from the population of charter businesses as part of the mandatory Alaska charter halibut permit (CHP) logbook program were used to adjust the sample data to better reflect the population (sample weighting). In addition, missing data were replaced with responses from individuals identified as similar according to their fishing activity profiles using the same data (data imputation). Details about the specific methods used are described in detail in Lew, Himes-Cornell, and Lee (2015).

In the forthcoming NOAA Technical Memorandum, descriptive statistics of the samples of respondents of key variables are presented. However, comparisons of sample totals and means (averages) across years have limited value due to the different sample sizes each year (174 in 2012, 141 in 2013, and 125 in 2014)[2], the low overall response rates, and missing data, making it difficult to draw conclusions regarding year-to-year changes in the charter fishery overall looking solely at sample statistics.

Thus, the analysis focused on generating estimates of the population totals and means for variables related to annual revenues, expenditures, and employment. To this end, sample weighting and data imputation were applied to associated variables to adjust the sample for population representativeness. This analysis, which looked at sector-level trends, is a first attempt to provide a basic understanding of the economic conditions in the charter sector leading up to the implementation of the Alaska Halibut Catch Sharing Plan (CSP) implemented in 2014.

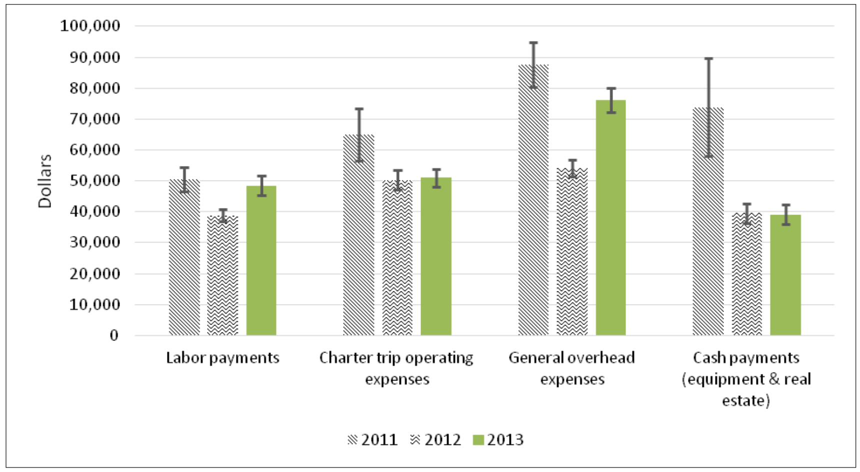


Figure 2. Mean Expenditures on Labor Expenses, Charter Trip-Related Expenses, General Overhead Expenses, and Cash Payments by Year

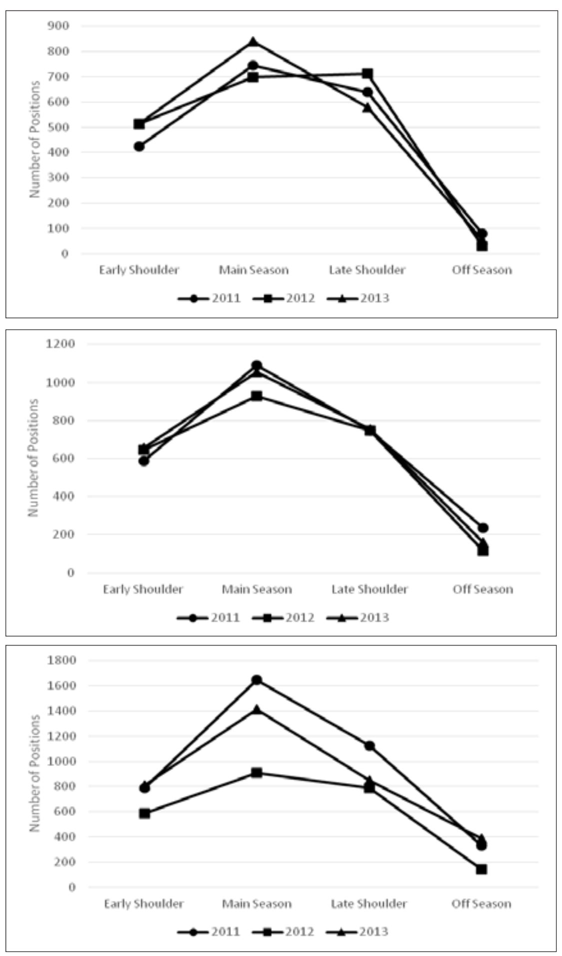


Figure 3. Estimated Number of Total Employee Positions (Full and Part-Time) Hired by Season.

1 Between 22% and 27% of active charter businesses completed the survey each year.

2 The charter sector decreased in size between the 2012 and 2014 surveys. In 2011, the population of charter businesses was 650. In 2012, it declined to 592, and in 2013 further decreased to 572.

Results:

The adjusted population-level results suggest that in 2011 the Alaska saltwater sport fishing charter sector as a whole operated at a loss, but in 2012 and 2013, as the population of charter businesses shrank, the sector yielded an overall profit. The 3-year period leading up to the CSP implementation saw slight changes in employment and spending patterns by charter businesses that remained in the fishery. This includes a shift to using proportionately more part-time employees for on-shore work and decreasing the amount spent on charter trip expenses and cash investments in vehicles, machinery, equipment, buildings and real estate. At the same time, average revenues increased.

Revenue and Cost: Total estimated revenues for the population of charter businesses ranged from a low of $125 million in 2012 to a high of $172 million in 2013. It is estimated that the charter fishing sector, as a whole, operated at a loss during the 2011 fishing year. During the 2012 and 2013 fishing years, however, estimates suggest the charter fishing sector operated profitably in aggregate as well as on an average basis. Statistically speaking, there is no significant difference between 2011 and 2012 mean revenues. However, there was a large and statistically significant increase in total revenues for the 2013 fishing year relative to 2011 and 2012. Mean estimated revenues ranged from a low of $208,321 in 2011 to a high of $292,535 in 2013 (see Fig. 1). For 2013, mean estimated revenues were statistically higher than both 2011 and 2012. Moreover, mean costs per business during the 2012 fishing year were statistically lower than the 2011 fishing year. Mean costs rebounded in 2013, but remained lower than they were in 2011. For both 2012 and 2013, mean revenues per business statistically exceeded mean costs per business, further supporting the notion that the charter business sector operated profitably during those years. Estimated overhead expenses were generally the largest category of expenditures for the charter business population and ranged from approximately $32 million in 2012 to $57 million in 2011, while estimated labor costs were generally the lowest expenditure category. Capital expenditures were also relatively small with the exception of 2011. Mean overhead expenditures ranged from $54,000 in 2012 to over $87,000 in 2011 (Fig. 2). Total labor expenditures, charter trip expenses, and capital expenses (e.g., loan payments) were estimated to generally range between $20 million and $30 million per year across the sector. Mean values for these expenditures generally ranged between $35,000 and $85,000 per year per business.

Note: all captions need to be complete and stand alone and note that shading in figure 1 for mean revenues and mean costs is virtually indistinguishable and thus provides no meaning.

Employment: The fishing year is divided into four seasons: the early shoulder season (April 1 to mid-June); the main season (mid-June to mid-August); the late shoulder season (mid-August to the end of September); and the off season (October through March). Total employment estimates were highest across all personnel categories (guides and operators, crew, and on-shore workers) during the main season (Fig. 3), and as expected, employment estimates were lowest in the off-season.

The population-level estimates generated from these surveys provide baseline information about the economic conditions of the charter boat sector and provide the data necessary to analyze the economic contribution of the charter boat sector to the economy. The survey data also provide insights about trends in charter trip prices, off-season activities by charter business operators, and types of clientele that are summarized in Lew et al. (2015).

By Dan Lew, Amber Himes-Cornell, Jean Lee, and Brian Garber-Yonts

Optimal Growth with Population Dynamics

Maximum Economic Yield (MEY) is used in fisheries economics to evaluate efficiency of outcomes. The definition of MEY is based on a bioeconomic model. Rosenman (1986) presented conditions for MEY under uncertainty that compared outcomes to a bioeconomic competitive equilibrium. In this project, these conditions were generalized to incorporate population dynamics and were then applied using dynamic game theory to analyze outcomes of a rationalized fishery that includes a quota market. Multi-stage population dynamics are a crucial feature of this bioeconomic model because these provide an internal representation of MSY which is used as a reference point and assumed steady-state of a dynamic game. Rosenman's MEY applies to yields with an incomplete (i.e., partially optimizing) feedback between abundance and costs which is not the same as optimal growth of a fish stock. However the biggest disadvantage of Rosenman's bioeconomic model is that it requires stringent restrictions on population dynamics. In particular, it rules out Beverton-Holt type population dynamics which is not a tenable assumption for this project; recent work in this project analyzed conditions for optimal growth in a family of bioeconomic models with population dynamics that include competition for resources by juveniles and adults, and Beverton-Holt population dynamics arise with juvenile predation. Many models in this family have degenerate, or unnecessarily complex, dynamics and were excluded from consideration as an optimal growth model for a fish stock. One class of models met the conditions for optimal growth and these dynamics are equivalent to Lucas and Prescott's (1971) model of investment under uncertainty, and interestingly, to von Bertalanffy growth.

By Michael Dalton

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

Each year the Economic and Social Sciences Research Program (ESSRP) documents and evaluates the economic status of the North Pacific groundfish fisheries. The results of this analysis are compiled into an economic chapter of the *Stock Assessment and Fisheries Evaluation Report*. The Economic SAFE gives managers and stakeholders recent estimates of economic variables in the fisheries. These data are compiled and distributed not only to inform management decisions but also 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.

This year's 2014 Economic SAFE provides summaries of the economic status of North Pacific groundfish fisheries and an annual update to the economic data tables, economic indices, and figures in the market profiles. The economic data tables report ex-vessel and wholesale value; production and price; discards and prohibited species catch; and the composition of the fleet. These variables stratified along different dimensions such as species, region, sector, gear type and product type. This year's economic data tables were expanded to include detailed information on economic aspects of the halibut fishery in Alaska. Furthermore, the small entity ex-vessel data tables 36-39b have been revised to reflect changes to the Small Business Administration's definition of a small business. In addition to the report tables, *excel files are available on the ESSRP website* which provide longer time series of the data when available. Economic indices are presented that evaluate the economic performance through value, price, and quantity, across species, product, and gear types. The "Market Profiles" section has been abridged from previous years as work is underway to revise this section of the Economic SAFE for next year. This year's Market Profiles section provides some historical context and displays trends in prices, volume, and supply for select products of pollock, Pacific cod, sablefish, and yellowfin sole. Finally, new and ongoing research and data collection programs by AFSC social scientists are summarized, and recent scientific publications are listed.

Last year the analytic content of the Economic SAFE was expanded to include new information on the performance and importance of specific aspects of North Pacific groundfish fisheries. These sections were updated where data for 2013 were available. The section Economic Performance Metrics for North Pacific Groundfish Catch Share Programs presents a set of indicators to assess the economic performance of the six catch-share programs currently in operation throughout the U.S. North Pacific. The section Community Participation in North Pacific Groundfish Fisheries characterizes the importance of fishery-related activity to the economy of Alaska and Alaskan communities. The section"BSAI non-Pollock Trawl Catcher-Processor Groundfish Cooperatives (Amendment 80) Program: Summary of Economic Status of the Fishery" summarizes the economic data collected for the fleet defined under Amendment 80 of the Fishery Management Plan.

New analytic content has been added this year to provide more timely information on the state of the fisheries. The section Alaska Groundfish First-Wholesale Price Projections estimates 2014 prices for select first-wholesale products using available data from related markets. Furthermore, first-wholesale prices are projected out over the next 4 years (2015-18), giving a probabilistic characterization of the range of future prices.

An appendix contains additional tables with secondary or ancillary economic data. Tables 16.B-24.B provide secondary information on ex-vessel prices and value which is derived from ADF&G fish tickets priced by the Alaska Commercial Fisheries Entry Commission (CFEC). This alternative method of ex-vessel prices is being analyzed in an ongoing project which compares it to the historical methods used to assemble ex-vessel prices and value Commercial Operator Annual Report (COAR) purchasing data (Tables 16-24). Tables R.1-R.4 present ex-vessel economic data for specific rockfish species which are presented only as an aggregate rockfish complex in the primary tables. Ancillary economic data that was collected externally is provided in Tables E.1-E.4: Table E.1 shows Global whitefish production and value; Table E.2 shows the U.S. export quantity and value of seafood products by destination country; Tables E.3-E.4 provide employment data of seafood workers in Alaska.

The Economic SAFE will continue to evolve to meet the needs of management and stakeholders. We will continue to improve the structure and format of the document to make the information and data contained within the report more accessible. 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* or by contacting *Ben.Fissel@noaa.gov*.

By Ben Fissel

Status of Stocks & Multispecies Assessment Program

Groundfish Stock Assessments

The AFSC completed the set of stock assessments for the Gulf of Alaska (GOA) and Bering Sea and Aleutian Islands (BSAI) Stock Assessment and Fishery Evaluation (SAFE) reports for 2015. These reports present analysis 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 in 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. These assessments were reviewed, compiled, and summarized by the Plan Teams for Council consideration in developing their recommended catch specifications for the 2015 and 2016 Alaska groundfish fisheries.

Research and data collection activities are fundamental to all the assessments and advice used by the Council. The Midwater Assessment Conservation Engineering (*MACE*) Program of the Center's RACE Division conducted a survey in the GOA in the winter and in the summer covered the main area of the Bering Sea shelf. This survey covers the slope regions of the GOA along with segments of the Bering Sea and Aleutian Islands regions. During the summer of 2014 the *groundfish assessment group* conducted bottom-trawl surveys in the eastern Bering Sea (EBS) shelf area (376 stations) and the Aleutian Islands (410 stations). Additionally, this group continued collecting acoustic data when transiting between EBS trawl stations. The change in survey abundance estimates by species for the EBS and the Aleutian Islands indicate mostly increases relative to the previous survey estimates (Figs. 1 and 2). The AFSC's *Marine Ecology and Stock Assessment program* runs the annual longline survey which is designed primarily for sablefish but also produces data used in Greenland turbot and some rockfish assessments (e.g., for the rougheye-blackspotted rockfish complex in the GOA; Fig. 3).

In the GOA, the projected 2015 spawning biomass estimates were estimated to be at or above the level expected to provide maximum sustained yield (*MSY*) in the long term (Fig. 4). This figure also indicates that the catches in 2014 were below levels associated with

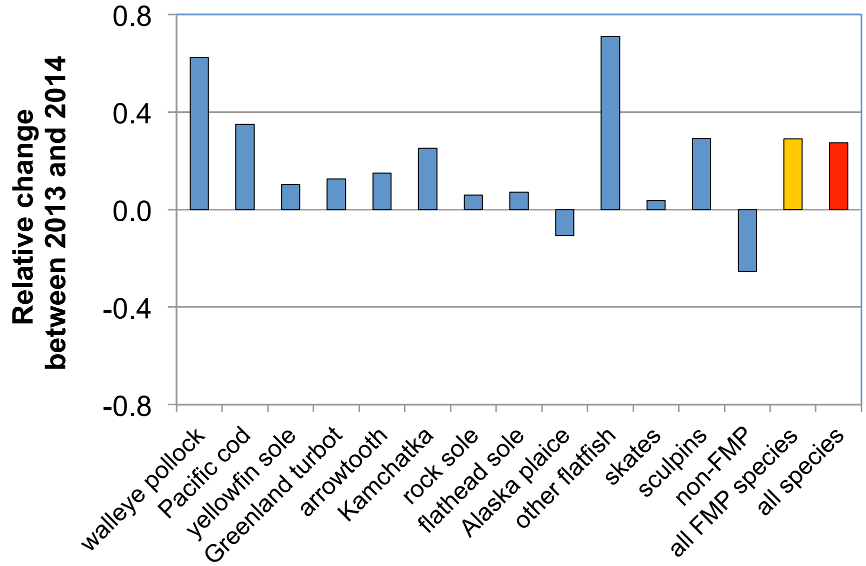


Figure 1.Relative change in the biomass estimates derived from eastern Bering Sea shelf trawl survey data between 2013 and 2014."Additional" strata 82 and 90 included (not used in all assessments). Invertebrates are excluded and sablefish, rockfish, Atka mackerel, and sharks included in total but omitted individually. FMP = Fishery Management Plan (species which are considered "in the fishery").

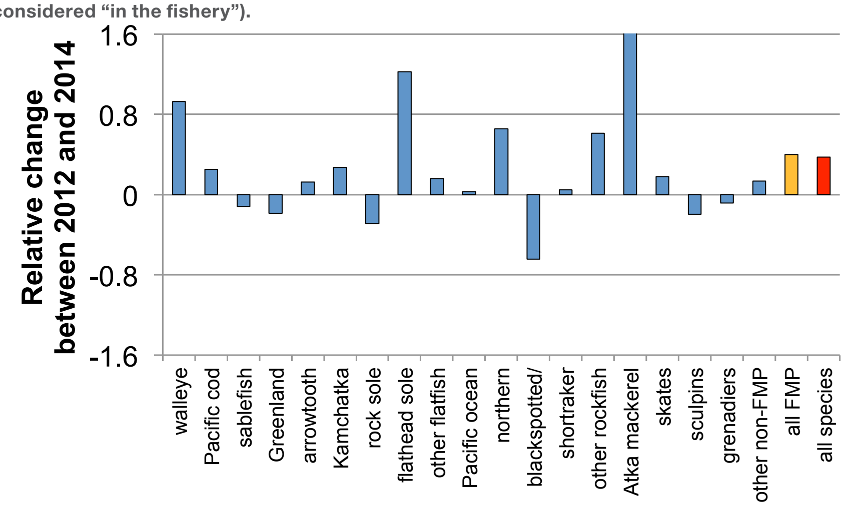


Figure 2. Relative change in the biomass estimates derived from Aleutian Islands trawl survey data between 2012 and 2014. NOTE: Southern Bering Sea excluded and yellowfin sole, sharks, squids, and octopus included in total but not shown.

overfishing. For a number of the GOA stocks, e.g., rex sole, shortraker rockfish, other rockfish, demersal shelf rockfish, thornyhead rockfish, Atka mackerel, skates, sculpins, squid, octopus, and sharks, B_{MSY} estimates are unavailable. Overall, the trends resulted in increase in acceptable biological catch (ABC) by 7% compared to last year. This was due to projected increases in pollock (+17%), Pacific cod (+16 %), Pacific ocean perch (+9%), and shallow water flatfish (+8%). Notable declines were projected in demersal shelf rockfish (-18%), big skate (13%), rougheye and blackspotted rockfish (-10%), dusky rockfish (-7%), and northern rockfish (-6%).

In the BSAI, the sum of the recommended ABCs for 2015 is 2.843 million metric tons (t), a 10% increase over the 2014 value. Most of the BSAI groundfish stocks continue to be above target spawning biomass levels and below fishing mortality rates that are estimated to achieve maximum sustainable yield. Presently four stocks are projected to be below B_{MSY} in 2015: Aleutian Islands pollock, Greenland turbot, the rougheye and blackspotted rockfish (REBS) complex, and sablefish (Fig. 5).

The *ecosystem considerations chapter* (264 pages) of the SAFE report responded to 18 Scientific and Statistical Committee (SSC) comments and had over 100 contributions. In the Bering Sea, conditions warmed considerably relative to recent

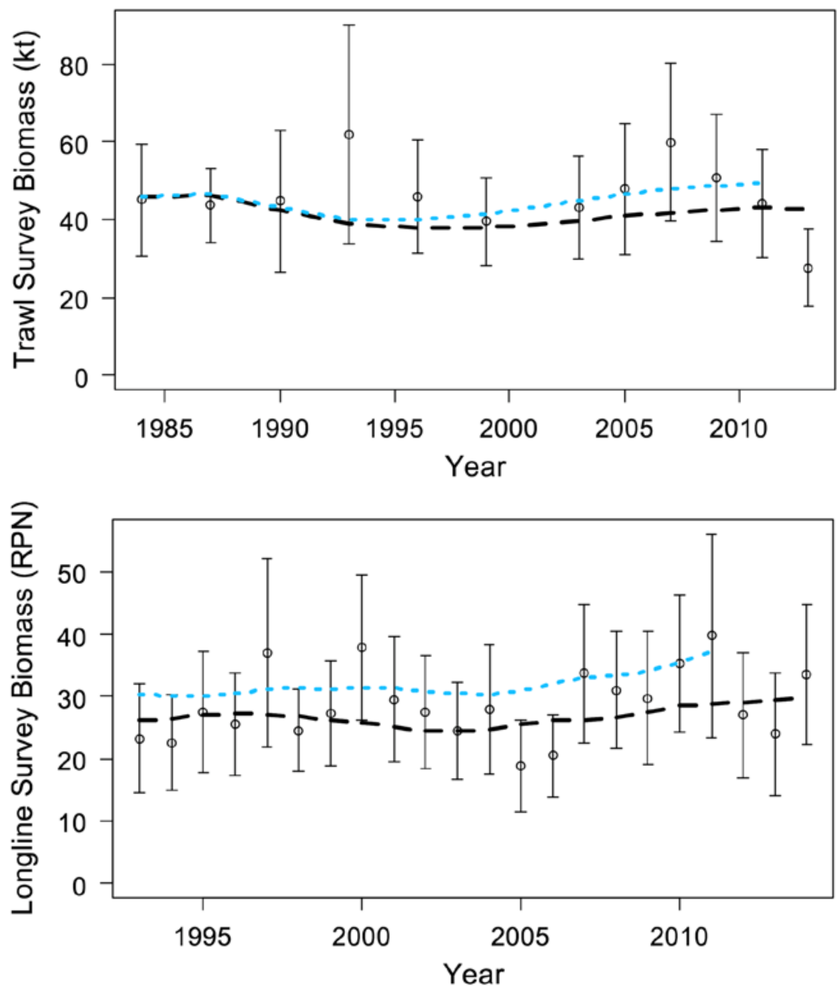


Figure 3. AFSC bottom trawl survey (top) and longline survey (bottom) with survey-derived estimates (open circles) with 95% sampling error confidence intervals for GOA RE/BS rockfish. Predicted estimates from the 2014 model results (dashed line) are compared with the 2011 model estimates (dotted blue line).

years. The summer acoustically-determined time series of euphausiids continues to decrease from its peak in 2009. Survey biomass of pelagic foragers has increased steadily since 2009 and is currently above its 30-year mean. While this is primarily driven by the increase in walleye pollock from its historical low in the survey in 2009, it is also a result of increases in capelin from 2009-13, perhaps due to cold conditions prevalent in recent years. This report also details observations by Aleutian Islands ecoregions (Eastern, Central, and Western).

Fisheries for these groundfish species during 2013 landed 2.2 million t valued at approximately $1.9 billion after primary processing (*Economic Chapter*; 411 pages). This represents about 48% of the weight of all commercial fish species landed in the United States. The bulk of the landings are from eastern Bering Sea pollock (landings of about 1.3 million t). Many of the flatfish stocks (e.g., rock sole, Alaska plaice, and arrowtooth flounder) remain at high abundance 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 eastern Bering Sea. Rockfish species comprise 5%-8% of the groundfish complex biomass and have generally been increasing based on recent surveys. The subsequent sections summarize groundfish conditions in each management area based on the SAFE report.

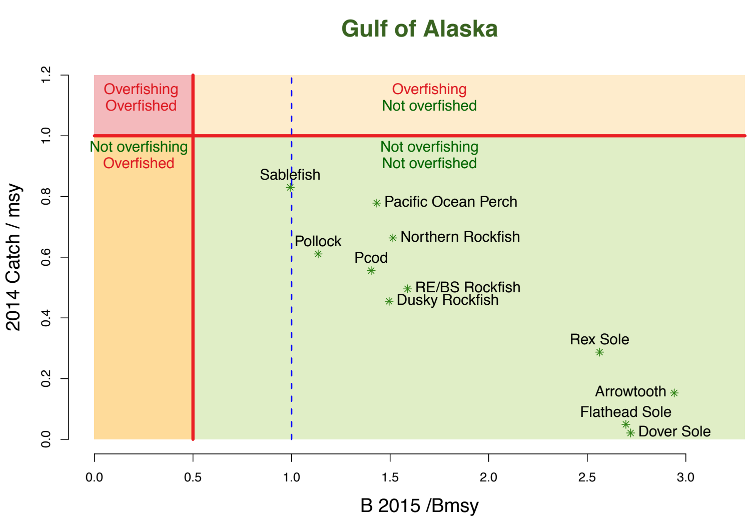


Figure 4. Catch relative to the catch at F_{MSY} relative to the projected stock status (horizontal axis) of groundfish in the GOA.

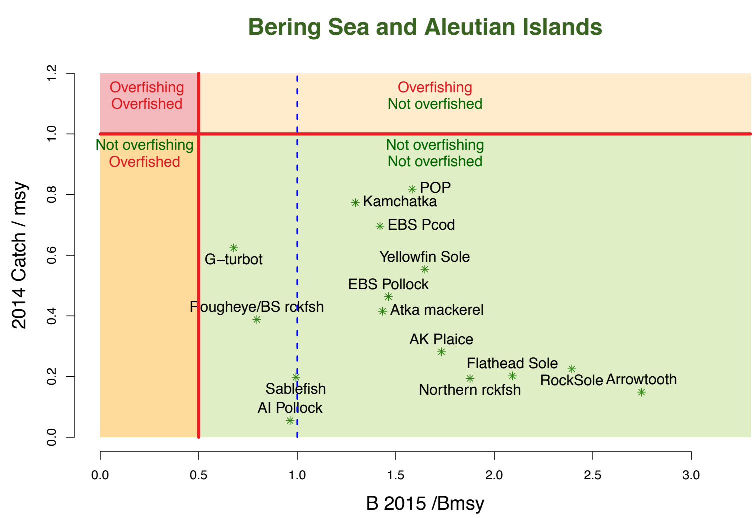


Figure 5. Catch relative to the catch at F_{MSY} relative to the projected stock status (horizontal axis) of groundfish in the Bering Sea and Aleutian Islands.

Other highlights from the individual assessments include:

EBS pollock:

- Acoustic trawl survey data collected over the shelf indicated a return of smaller (~age 2) pollock in the southeast region. This survey also extended into the Russian zone but found proportionally low levels of biomass there relative to the 2012 survey.
- Bottom trawl survey data indicated high abundances of 6-year old Pollock, providing added confirmation that the 2008 year class is well above average
- The mean weight at age of the 2008 year class continues to be below-average (based on fishery and survey data).

GOA pollock:

- The 2014 biomass estimate for Shelikof Strait is 840,000 t, a 6% decrease from 2013, but is still larger than any other biomass estimate in Shelik of Strait since 1985 (excluding 2013???).
- Changes to the assessment model included starting the model in 1970 rather than 1964, removing some earlier less well documented survey data, estimating summer bottom trawl catchability. These were based on recommendations from outside reviews and comments from the SSC and Plan Teams.
- BSAI Pacific cod:
- Survey biomass was higher again in 2014, continuing an upward trend that began around 2006 and has been sustained by several good year classes. Spawning stock biomass is now estimated to be in the vicinity of $B_{40\%}$
- The assessment model was configured the same as in 2011-13 but issues related to survey catchability assumptions continue to be a concern.

Sablefish:

- The longline survey abundance index increased 15% from 2013 to 2014 following a 25% decrease from 2011 to 2013.
- The 2008 year class showed potential to be above average in previous assessments based on patterns in the age and length compositions.
- Spawning biomass has increased from a low of 32% of unfished biomass in 2002 to 35% of unfished biomass projected for 2015, but is trending downward in projections for the near future.
- The retrospective pattern has improved relative to past years.

Flatfish:

- BSAI Yellowfin sole, the largest component of the flatfish biomass, is estimated to be more than 1.5 times above B_{MSY}. The projected female spawning biomass estimate for 2015 is 644,200 t, which is an 8% increase from the 2014 estimate (594,800 t). The total stock biomass has been quite stable throughout the 2000s.
- BSAI Greenland turbot data showed stable trend based on longline surveys but stock remains below B_{MSY} (~$B_{20\%}$).

Rockfish:

- The BSAI blackspotted and rougheye complex stock is below the $B_{40\%}$ estimate; concerns over disproportionate area-specific harvest rates have raised awareness, and the complex is being closely monitored.
- In the GOA, the Pacific ocean perch assessment included a new approach that incorporates new and historical maturity data within the model.
- A consistent approach to survey-averaging for catch-apportionments by area (random-effects time series modeling) was applied to a number of GOA rockfish stocks.

By Jim Ianelli

Developing Maturity Schedules to Improve Stock Assessments for Data-Poor Commercially Important Flatfishes in the Gulf of Alaska

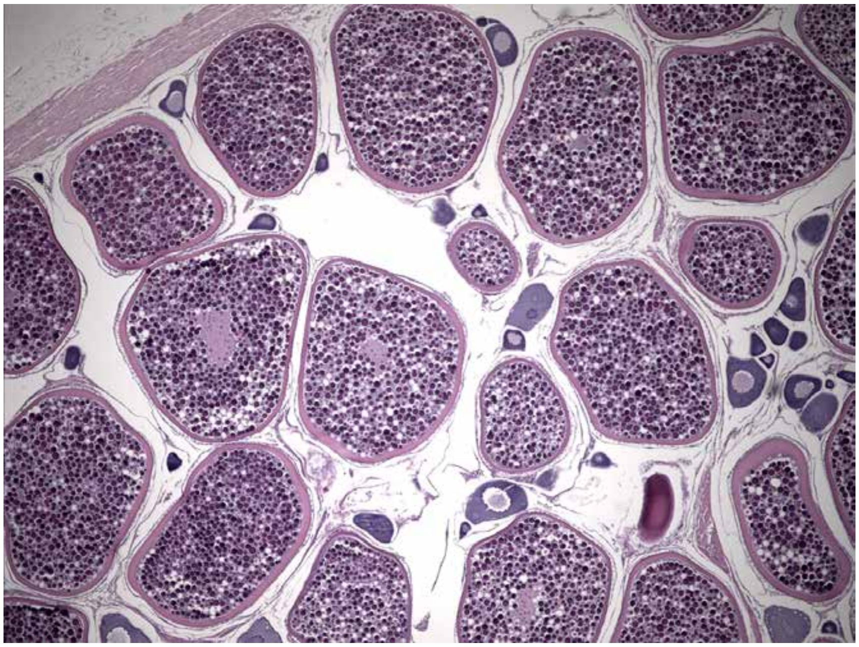


Figure 1. Histological image of an ovarian cross section from a female southern rock sole showing advanced stages of vitellogenic oocytes as the predominant development stage immediately prior to spawning. Photo credit????????

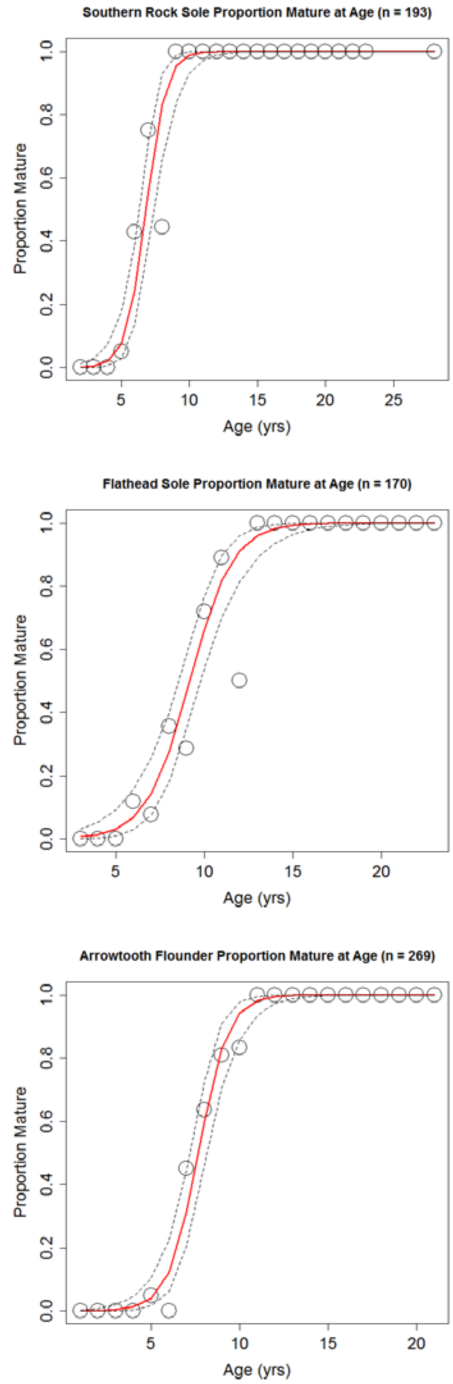


Figure 2. Maturity-at-age ogives for three of the four flatfish species in this study.

The goal of this project was to update historical estimates of length and age at maturity for commercially important flatfish species in the Gulf of Alaska (GOA). In order to achieve our objectives, samples were collected at fishery processing plants in Kodiak, Alaska, in 2012 and 2013 through a partnership with the industry group Alaska Groundfish Data Bank (AGDB). Otolith (age structures) and ovary samples were collected from four commercially important flatfish species for the purposes of updating maturity estimates (arrowtooth flounder, *Atheresthes stomias;* southern rock sole, *Lepidopsetta bilineata;* northern rock sole, *Lepidopsetta polyxystra;*, flathead sole, *Hippoglossoides elassodon*). New data on maturity-at-age can result in changes in the values of the fishing mortality reference points, acceptable biological catch (ABC) and overfishing level (OFL), and the estimate of spawning stock biomass (SSB). Determination of maturity-at-age is crucial in determining the biological productivity of these stocks and the target fishing mortality rate necessary to maintain a healthy reservoir of SSB. These new data will directly enhance stock assessments and fisheries management. Updated maturity estimates are also important to industry to maintain Marine Stewardship Council (MSC) certification of some commercially important flatfish species.

Spawning individuals were defined by those with ovaries containing either hydrated oocytes or ova, with or without post-ovulatory follicles. Reproductive characteristics (notably atresia, or oocyte absorption) were recorded. The break-and-burn method was used for ageing otoliths of each species. Standard quality control methods were used to age specimens, including precision statistics based on testing from a secondary age reader. Data were fitted to a logistic equation to estimate length and age at 50% maturity using generalized linear modeling based on binomial data under the statistical package R. Akaike's information criterion (AIC) was used as the goodness-of-fit index.

Southern rock sole collections were made during the months of April, October, and November (Table 1). Ovaries appeared to be maturing during the spring as evidenced by a relatively large number in later stages of vitellogenesis (Fig. 1). In the fall, spawning was observed in a small percentage of females (hydrated oocytes observed). Of note, our estimate of southern rock sole mature proportion at age was lower than a previous estimate; our estimate was 6.8 years at 50% maturity

(Fig. 2), compared to an average age of 9.0 years at 50% maturity from a study conducted from 1996 to 1999 (Stark 2002). Our length at 50% maturity estimate of 35.7 cm was similar to Stark's (2002) estimate of 34.7 cm (Table 2).

Flathead sole females were collected during the months from February to April. Collections were conducted during a near-spawning to spawning period for this species. During the months of February and March ovaries from mature females exhibited advanced vitellogenesis. Spawning individuals were observed in April. Our estimates of length and age at 50% maturity were 36.7 cm and 9.2 years, respectively (Fig. 2), respectively. These estimates are slightly larger than Stark's (2004), whose estimates for 50% of the population were 33.3 cm and 8.7 years.

Arrowtooth flounder were collected over two seasonal periods, in July and during the fall. Based on the histological characteristics, ovaries were primarily developing in July with many females exhibiting some vitellogenesis, and in the fall months, showing more advanced vitellogenesis with a few observed in spawning mode. The maturity estimates for arrowtooth flounder were similar to previous estimates. The length and age at 50% maturity from our study were 48.3 cm and 7.7 years (Fig. 2), respectively. This is in close agreement to Stark's (2008) study based on GOA collections in 2002 and 2003 that resulted in estimates of length and age at 50% maturity of 46.3 cm and 7.0 years.

The main objective for this cooperative research project was to update estimates of length and age at maturity for four commercially important flatfish species in the GOA. These new estimates will provide updated and critical information for the formulation of reference fishing mortality rates and catch levels (ABCs and OFLs), substantially improving stock assessments for the respective species. The following conclusions can be made from this study:

Collections for three species in this study (southern rock sole, flathead sole, and arrowtooth flounder) were successful for updating estimates of age- and length-specific maturity schedules and providing the best estimates of SSB. This was due to such factors as seasonal timing in sampling, a broad size range of specimens representing both immature and mature fish, and confidence in ageing interpretation. These estimates are considered reliable. The maturity-at-age estimates calculated for these species are now available to update their respective 2015 GOA age-structured stock assessments.

The fourth species, northern rock sole, was not successful due to a relatively low sample size resulting in maturity estimates that were inconclusive. More data needs to be collected for this species in the future for more reliable estimates.

By Todd TenBrink, Tom Wilderbuer, Ingrid Spies, and Teresa A'mar

Table 1. Number of samples by month by species collected in the Gulf of Alaska (GOA) in 2012 and 2013.

Species/Month	*n*	Length range (cm)	Mean size (cm)
Southern rock sole			
October 2012	78	23–50	38.7
November 2012	12	25–42	30.5
April 2013	84	19–60	41.2
May 2013	21	20–48	30.2
Northern rock sole			
February 2013	15	28–50	40.9
April 2013	26	24–56	42.4
May 2013	21	21–36	27.5
Flathead sole			
February 2013	74	23–49	38.8
March 2013	29	31–53	41.3
April 2013	69	21–49	35.1
Arrowtooth flounder			
July 2012	52	28–65	47.5
October 2012	124	21–66	42.7
November 2012	104	22–80	45.9

Table 2. Estimates of length and age at 50% maturity (L_{50} or A_{50}) and logistic parameter estimates for flathead sole, arrowtooth flounder and southern rock sole.

Species	Variable	Coefficients (α, β)		L_{50} or A_{50}	SE
Southern Rock sole	Length (cm)	-26.165	0.732	35.73	0.146
	Age	-9.427	1.379	6.83	1.631
Flathead sole	Length (cm)	-22.216	0.606	36.67	0.098
	Age	-7.539	0.822	9.18	0.127
Arrowtooth flounder	Length (cm)	-34.574	0.716	48.32	0.128
	Age	-9.102	1.188	7.66	0.170

FIT Staff Conducts Successful Atka Mackerel Tag Recovery Cruise in the Aleutian Islands

The goal of our ongoing tag-release-recovery studies is to determine the efficacy of trawl exclusion zones (TEZs) as a management tool to protect critical habitat. TEZs have been established around Steller sea lion rookeries to protect sea lion habitat and prey resources, including local populations of prey such as Atka mackerel. Localized fishing may affect Atka mackerel abundance and distribution near sea lion rookeries. Our tagging experiments estimate local abundance and movement between areas open and closed to the Atka mackerel fishery. From 1999 through 2014, a total of approximately 130,000 tagged Atka mackerel have been released in the Aleutian Islands. To date, over 3,000 tagged Atka mackerel have been recovered. These data have contributed greatly to our understanding of small-scale movements and distributions of Atka mackerel around sea lion rookeries.

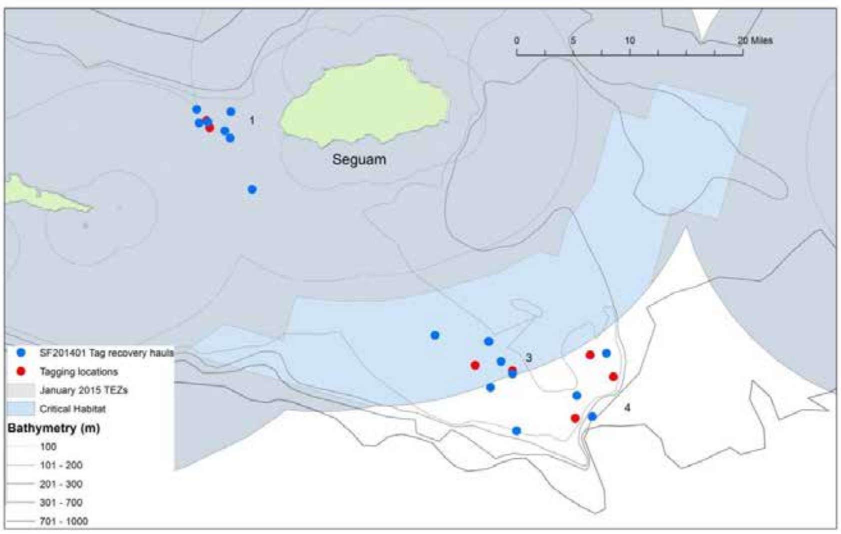


Figure 1. Location of tag recovery hauls (blue) and tag release locations (red) near Seguam Pass (Area 541). Numbers on map indicate research strata.

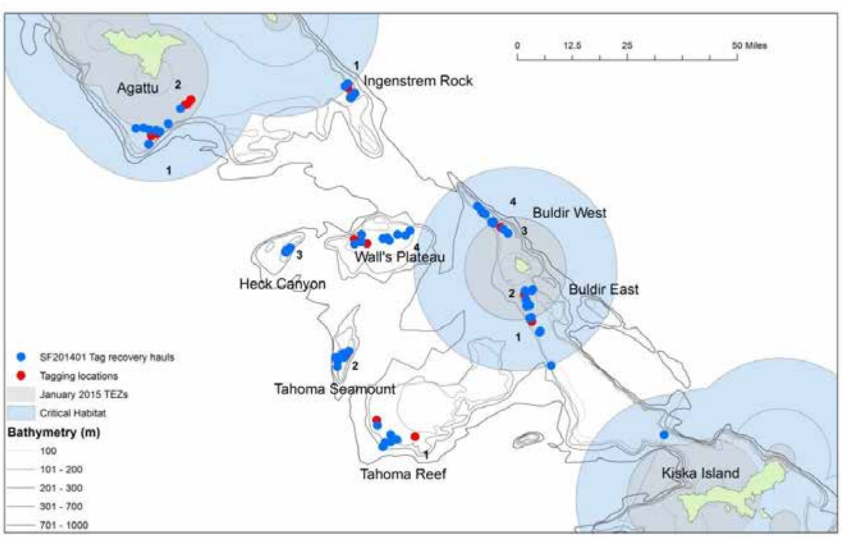


Figure 2. Location of tag recovery hauls (blue) and tag release locations (red) in the Western Aleutian Islands (area 543). Numbers on map indicate research strata.

In May and June 2014, a cooperative venture between the North Pacific Fisheries Foundation and NMFS tagged and released approximately 21,000 fish in the western Aleutian Islands (Buldir Island, WAI Seamounts, Agattu Island, and Ingenstrem Rock) as well as Seguam Pass in the Central Aleutian Islands (Figs. 1-2). The primary objective of the factory trawler *Seafisher* Atka mackerel tag recovery cruise was to recover these tagged fish both in areas open to the Atka mackerel fishery and within trawl exclusion zones that are closed to the fishery. Recovery of tagged fish is also being augmented by the fishery outside of trawl exclusion zones.

Secondary objectives included conducting undersea camera tows near fishing locations. These tows aided in the development of cameras as a tool for identifying fish habit as well as estimating fish species composition, density, and size. In addition, Atka mackerel biological data including stomach samples, gonad samples, and age structures were collected during nearly every haul.

During this cruise we conducted 94 hauls and examined 1,934 t of Atka mackerel for tags (approximately 3.2 million individual fish). We recovered 54 wild tags: 6 at Seguam pass and 48 in the Western Aleutian Islands. All of these tags were released during the 2014 tag release charter and all hauls were sampled for species composition. In addition, we collected 737 Atka mackerel biological samples including stomach, gonad, and age structures, and we obtained sexed length frequencies from 8,776 individual fish. Length distribution of Atka mackerel differed by area, with the small-sized fish found at the Western Aleutian sea mounts, medium-sized fish found at Buildir, Ingenstrem rock and Agattu, and the largest fish found at Seguam Pass (Fig. 2).

In order to examine the habitat and develop indices of abundance, we conducted 22 underwater tows with a portable underwater camera (Figs. 4 and 5) using a stereo camera system developed at the AFSC by the *Midwater Assessment and Conservation Engineering group*.

The data we collected on this cruise will be used to estimate population sizes of Atka mackerel in the study areas, as well as to understand relative abundance of other SSL prey species and invertebrates and the habitat types associated with those populations.

Finally, we conducted four special projects at the request of other researchers: stomach collections from the predominant fish species encountered, stable isotope samples from a range of fish species for Steller Sea lion dietary and mercury content analysis, rockfish maturity samples, and Pacific cod maturity samples. We collected an additional 752 specimens for these projects.

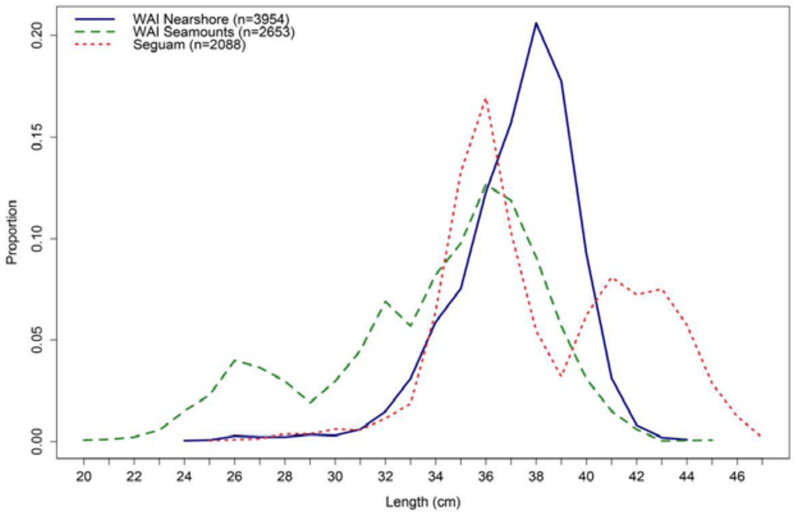


Figure 3: **Length Frequency distribution in each study area. "WAI Nearshore" includes Buldir, Ingenstrem rock, and Aggatu; "WAI Seamounts" includes Tahoma Reef, Tahoma Seamount, Heck Canyon, and Walls Plateau.**

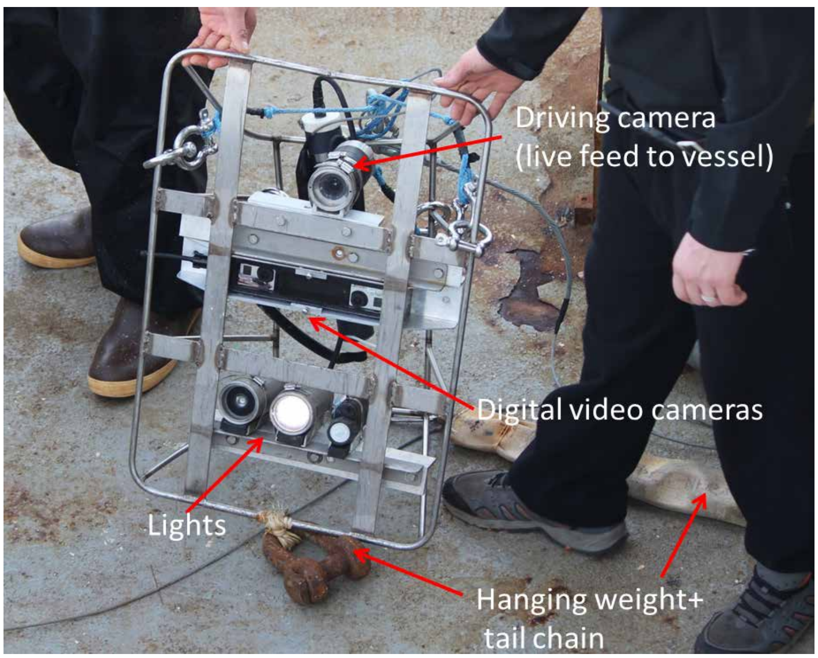


Figure 4. Underwater stereo drop- camera system. Photo credit: Susanne McDermott, NOAA.

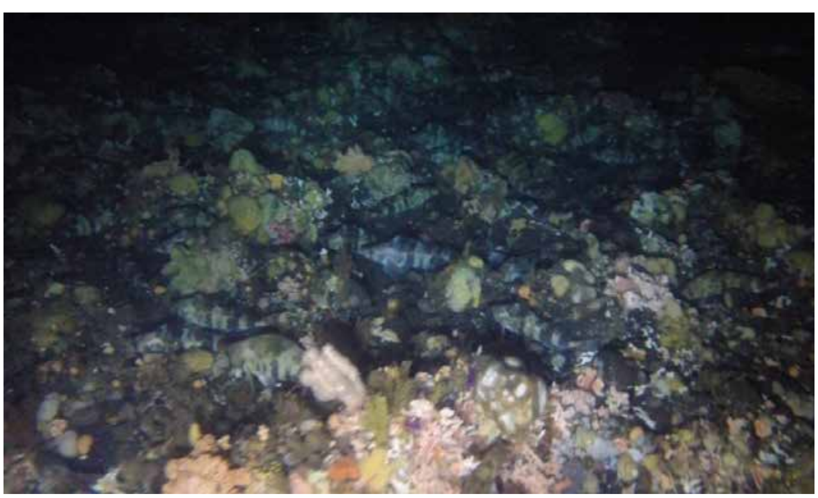


Figure 5. Example of undersea camera footage. Photo credit: Mike Levine, NOAA.

Age & Growth Program

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 30 September 2014. Total production figures were 30,871 with 7,380 test ages and 407 examined and determined to be unageable.

Species	Specimens Aged
Alaska plaice	539
Arctic cod	2,032
Arrowtooth flounder	904
Atka mackerel	1,019
Blackspotted rockfish	538
Dusky rockfish	73
Flathead sole	1,735
Greenland turbot	493
Harlequin rockfish	255
Kamchatka flounder	686
Northern rock sole	1,330
Northern rockfish	880
Pacific cod	1,351
Pacific ocean perch	1,615
Sablefish (black cod)	2,385
Saffron cod	1,004
Southern rock sole	643
Walleye pollock	11,908
Yellowfin sole	1,481

By Jon Short

Pat Livingston Retires From the Alaska Fisheries Science Center

Pat Livingston in 2005 as the newly appointed REFM Division Director.

Pat Livingston retired in January 2015 as Division Director of the Resource Ecology and Fisheries Management (REFM) Division after nearly 40 years of federal service. Pat Livingston grew up in Farmington, Michigan, where her talents as a biologist were apparent at an early age. Her interest in aquatic biology came from discovering creatures in the stream that flowed near her family's home. As early as grade school, her classmates used to tell her that she was going to be a scientist because of her great interest and budding natural ability in that area. Pat became interested in biology while she attended an all-girls high school. Shortly after the first Earth Day, her school offered one of the first high school level courses in ecology, which may have been the stimulus for the years of research that followed.

After high school pat attended nearby Michigan State University because of their notable wildlife department, but eventually changed her major to fisheries and began taking classes in fish biology and ecosystem modeling. During this time she took her first ecosystem modeling class, contributing to the microbial loop submodel of a freshwater lake. Pat completed her undergraduate work in three years and entered graduate school at the University of Washington's College of Fisheries. Here, Pat began to study the population dynamics of North Pacific marine fishes. Her master's degree research involved parameterizing and sensitivity analysis of a mass balance model of the Gulf of Alaska. While she worked toward her M.S. degree, she started part-time work at what was then the NMFS Northwest and Alaska Fisheries Center located at the Montlake Laboratory in Seattle. Her job involved parameterizing, running and debugging various ecosystem models for areas from the California Current system to the eastern Bering Sea for Taivo Laevastu. On the completion of her degree in 1980, Pat obtained a permanent position in the Resource Ecology and Modeling Task of the AFSC's REFM Division. In response to the results of her graduate research that highlighted the importance of fish food habits data for more accurate multi-species and ecosystem models, Pat built a solid groundfish feeding ecology field and laboratory program within the group, designed to quantify the food web linkages that are so critical to these models.

Development of this field program gave Pat the opportunity to get away from computers for a while and get out on fishery research vessels, where she participated in cruises from Washington State to the Bering Sea. The field collection program that she initiated created a food habits database that now holds diet information and provides a solid basis for the present day multi-species modeling efforts of the northern California Current System, and the continental shelf and slope areas of the Gulf of Alaska, Aleutian Islands and eastern Bering Sea. In addition to sampling the groundfish communities in the North Pacific, Pat herded fur seals on Bogoslof Island, counted Steller sea lions on Ugamak (rumor had it that she was the first woman to be on the island), and even tried handlining for squid on the Bering Sea slope when the automatic jigging machines were broken.

During this period, Pat received some exposure to policy analysis and public administration in the Center Director's office of the Northwest and Alaska Fisheries Center. This initial exposure sparked her interest in this different way of looking at the world and enterprise of science. So instead of following the traditional route of returning to school to obtain a Ph.D. degree in her current field of study, she decided to pursue a master's degree in public administration with an emphasis in natural resources policy and administration at the University of Washington. Her research topic describes that interesting mix of science, management, and politics that affects natural resource managers around the world.

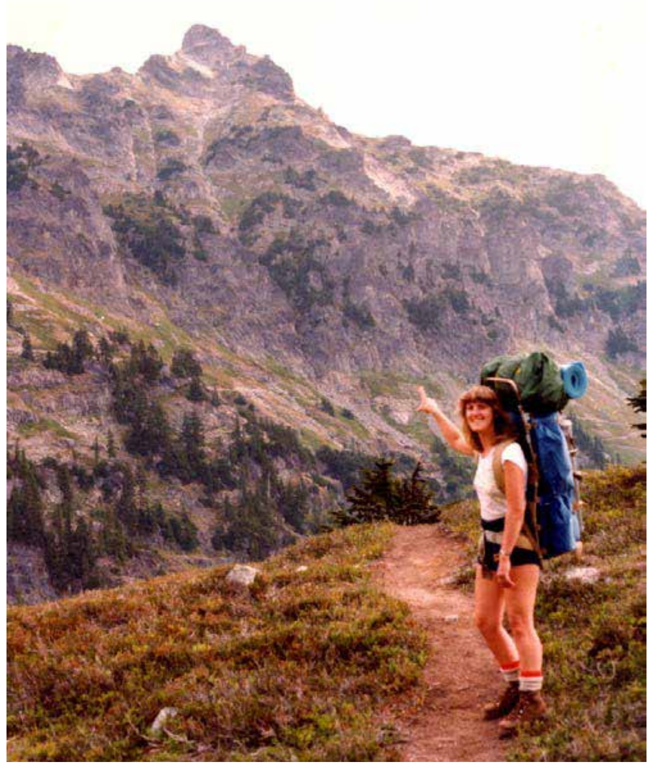
Over the years, Pat was involved in a number of research planning and coordination activities, particularly involving the Bering Sea ecosystem research. She was a key member and workshop organizer for research plans that were developed to bring an ecosystem perspective to what had formerly been a single-discipline approach to marine research planning. An affiliate faculty member at the University of Washington since 1989, Pat served on many graduate student committees. She provided guidance, data, and financial support to students over the years who have been interested in questions of groundfish feeding ecology and multi-species interactions. Her lab provided the University with highly capable graduate students who went on to successful careers. Starting in 1995, Pat helped bring scientists together to agree on Bering Sea research priorities in response to mandates of the Marine Mammal Protection Act, inter-agency research coordination plans, GLOBEC, PICES, and coordinated on several Bering Sea research plans for the National Science Foundation.

Pat served as Program Manager of the Division's *Resource Ecology and Ecosystem Modeling Program* from 1997 to 2004. In 2005, Pat was appointed Director of the *REFM* Division. She also served as a member of the North Pacific Fishery Management Council's Scientific and Statistical Committee. Pat has been involved in several aspects of PICES since its inception, beginning with a brief appointment to the Bering Sea Working Group (WG 5) near the end of its work, and going on to be a MODEL Task Team member of the PICES GLOBEC Climate Change and Carrying Capacity (CCCC) Program. From 1996 to 1998, Pat served as the national representative to the Implementation Panel of the CCCC Program and as the Co Chairman (with Professor Yutaka Nagata) of this program. Pat also served as the Chairman of the PICES Science Board from 1999 to 2001. In addition to her involvement in PICES, Pat has been an active member of several scientific societies, including the American Fisheries Society, the Association for Women in Science, and the American Institute of Fishery Research Biologists.

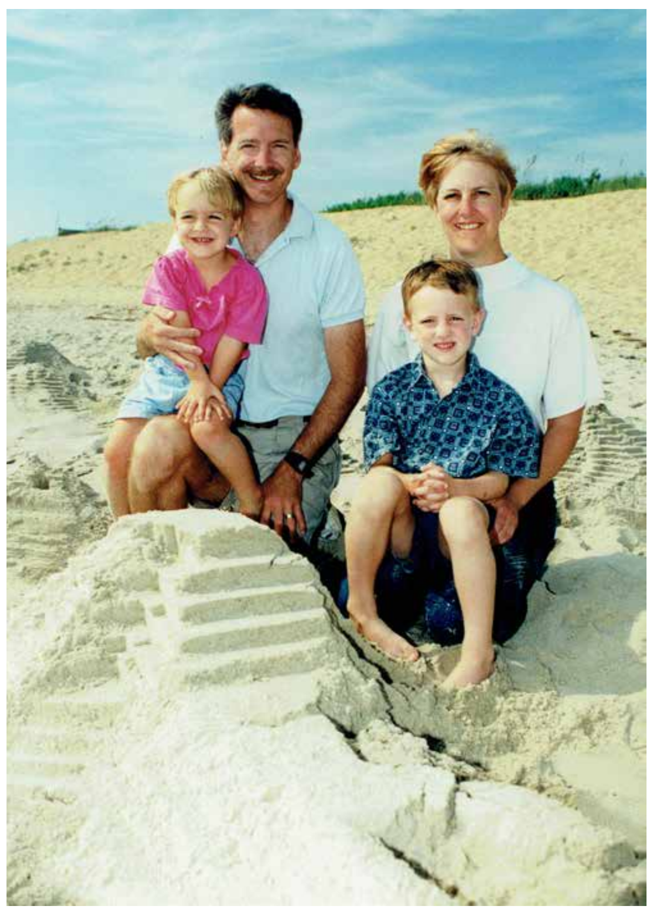
Pat's main research focus has been to implement various ecosystem and upper-trophic level models of the North Pacific. Her research has centered on understanding groundfish trophic interactions relative to marine birds and mammals, particularly in the eastern Bering Sea. She authored more than 50 publications many of which relate to groundfish predation and population models incorporating predation, with particular emphasis on cannibalism by walleye pollock in the eastern Bering Sea. She has been involved in and also led numerous research planning and science plan development workshops for cooperative ecosystem research in the eastern Bering Sea. Pat worked to integrate ecosystem research into the fishery management arena and on coordinating an ecosystem status report for the eastern Bering Sea/Aleutian Islands and Gulf of Alaska regions to accompany the groundfish stock assessment advice that goes to the *North Pacific Fishery Management Council*.

Pat was a dedicated, intelligent, and charismatic Director of the REFM Division and her leadership will be dearly missed. Pat will enjoy her retirement by traveling and exploring the outdoors with her friends and family.

By Susan Calderon, Gary Duker, and Ron Felthoven



Pat on the Pacific Crest Trail between Snoqualmie Pass and Stevens Pass with a heavy pack and sore feet in 1979. Always ambitious, Pat is pointing at the top of the peak where she plans on having lunch!



Pat and her husband Jim Hughes, daughter Riley, and son Paul on vacation in the 1990s.

Publications and reports for October, November, December 2014.
Authors citing affiliation with the AFSC are denoted in **boldface**.

Baker, C.S., D. Steel, J. Calambokidis, E. Falcone, U. Gonzalez-Peral, J. Barlow, A.M. Burdin, **P. J. Clapham**, J.K.B. Ford, C.M. Gabriele, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urban, **P. R. Wade**, D. Weller, B.H. Witteveen, and M. Yamaguchi.

2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306.

Burns, J., H. Aderman, T. Askoak, and **D. Withrow**

2012. Local and scientific knowledge of freshwater seals in Iliamna Lake, Alaska, p. 211-227. In C. Carother, K. R. Criddle, C. P. Chambers, P. J. Cullenberg, J. A. Fall, A. H. Himes-Cornell, J. P. Johnsen, N. S. Kimball, C. R. Menzies, and E. S. Springer (editors), Fishing People of the North: Cultures, Economies, and Management Responding to Change. Alaska Sea Grant, University of Alaska, Fairbanks, Fairbanks, AK.

Castellote, M., T.A. Mooney, L. Quakenbush, **R. Hobbs**, C. Goertz, and E. Gaglione.

2014. Baseline hearing abilities and variability in wild beluga whales (*Delphinapterus leucas*). J. Exp. Biol. 217:1682-1691.

Copeman, L.A., **B.J. Laurel**, and C.C. Parrish.

2013. Effect of temperature and tissue type on fatty acid signatures of two species of North Pacific juvenile gadids: a laboratory feeding study. J. Exp. Mar. Biol. Ecol. 448:188-196.

Donnelly-Greenan, E.L., J.T. Harvey, H.M. Nevins, M.M. Hester, and **W.A. Walker**

2014. Prey and plastic ingestion of Pacific northern fulmars (*Fulmarus glacialis rogersii*) from Monterey Bay, California. Mar. Pollut. Bull. 85:214-224.

Douglas, A.B., J. Calambokidis, L.M. Munger, M.S. Soldevilla, **M.C. Ferguson**, A.M. Havron, D.L. Camacho, G.S. Campbell, and J.A. Hildebrand.

2014. Seasonal distribution and abundance of cetaceans off Southern California estimated from CalCOFI cruise data from 2004 to 2008. Fish. Bull., U.S. 112:198-220.

Duncan, C.G., R. Tiller, D. Mathis, R. Stoddard, GJ. Kersh, **B. Dickerson**, and **T. Gelatt**.

2014. Brucella placentitis and seroprevalence in northern fur seals (Callorhinus ursinus) of the Pribilof Islands, Alaska. J. Vet. Diagn. Invest. 26:507-512.

Felthoven, R., and **S. Kasperski**.

2013. Socioeconomic indicators for United States fisheries and fishing communities. PICES Press 21(2):20-23.

Felthoven, R., J. Lee, and K. Schnier.

2014. Cooperative formation and peer effects in fisheries. Mar. Resour. Econ. 29:133-156.

Hawkyard, M., **B. Laurel**, and C. Langdon.

2014. Rotifers enriched with taurine by microparticulate and dissolved enrichment methods influence the growth and metamorphic development of northern rock sole (Lepidopsetta polyxystra) larvae. Aquaculture 424-42:151-157.

Hollowed, A., and S. Sundby.

2014. Change is coming to the northern oceans. Science 344:1084-1085.

Howard, J., E. Babij, R. Griffis, B. Helmuth, A. Himes-Cornell, P. Niemier, M. Orbach, L. Petes, S. Allen, G. Auad, R. Beard, M. Boatman, N. Bond, T. Boyer, D. Brown, P. Clay, K. Crane, S. Cross, M. Dalton, J. Diamond, R. Diaz, E. Duffy, D. Fauquier, W. Fisher, M. Graham, B. Halpern, L. Hansen, B. Hayum, S. Herrick, **A. Hollowed**, D. Hutchins, E. Jewett, D. Jin, N. Knowlton, D. Kotowicz, T. Kristiansen, P. Little, C. Lopez, P. Loring, R. Lumpkin, A. Mace, K. Mengerink, J.R. Morrison, J. Murray, K. Norman, J. O'Donnell, J. Overland, R. Parsons, N. Pettigrew, L. Pfeiffer, E. Pidgeon, M. Plummer, J. Polovina, J. Quintrell, T. Rowles, J. Runge, M. Rust, E. Sanford, U. Send, M. Singer, C. Speir, D. Stanitski, C. Thornber, C. Wilson, and Y. Xue.

2013. Oceans and marine resources in a changing climate, p. 71-192. In R. N. Hughes, D. J. Hughes, and I. P. Smith (editors). Oceanography and Marine Biology: An Annual Review, Vol. 51. CRC Press.

Kuhn, C.E., J. D. Baker, **R.G. Towell**, and **R.R. Ream**.

2014. Evidence of localized resource depletion following a natural colonization event by a large marine predator. J. Anim. Ecol. 83:1169-1177.

Lew, D.K., and **C. Seung**.

2014. On the statistical significance of regional economic impacts from changes in recreational fishing harvest limits in southern Alaska. Mar. Resour. Econ. 29:241-257.

Marsh, J.M., **N. Hillgruber**, and **R.J. Foy**

2012. Temporal and ontogenetic variability in trophic role of four groundfish species—walleye pollock, Pacific cod, arrowtooth flounder, and Pacific halibut—around Kodiak Island in the Gulf of Alaska. Trans. Am. Fish. Soc. 141:468-486.

Matkin, C.O., **J.W. Testa**, G.M. Ellis, and E.L. Saulitis.

2014. Life history and population dynamics of southern Alaska resident killer whales (Orcinus orca). Mar. Mammal Sci. 30:460-479.

Monnahan, C.C., T.A. Branch, K.M. Stafford, **Y.V. Ivashchenko**, and E.M. Oleson.

2014. Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. PLOS ONE 9(6):e98974. doi: 10.1371/journal.pone.0098974

Morrison Paul, C.J., **R.G. Felthoven**, and M. de O. Torres.

2010. Productive performance in fisheries: Modeling, measurement and management. Aust. J. Agr. Resour. Econ. 54:343-360.

Punt, A.E., D. Poljak, M.G. Dalton, and **R.J. Foy**

2014. Evaluating the impact of ocean acidification on fishery yields and profits: the example of red king crab in Bristol Bay. Ecol. Model. 285:39-53.

Russell, D.J.F., S. Brasseur, D. Thompson, G.D. Hastie, V.M. Janik, G. Aarts, **B.T. McClintock**, J. Matthiopoulos, S.E.W. Moss, and B. McConnell.

2014. Marine mammals trace anthropogenic structures at sea. Curr. Biol. 24:R638-R639.

Schnier, K., and **R. Felthoven**.

2011. Accounting for spatial heterogeneity and autocorrelation in spatial discrete choice models: Implications for behavioral predictions. Land Econ. 87:382-402.

Som, N.A., P. Monestiez, **J.M. Ver Hoef**, D.L. Zimmerman, and E.E. Peterson.

2014. Spatial sampling on streams: Principles for inference on aquatic networks. Environmetrics 25:306-323.

Stachura, M.M., T.E. Essington, N.J. Mantua, **A.B. Hollowed**, M.A. Haltuch, **P.D. Spencer**, T.A. Branch, and M.J. Doyle.

2014. Linking Northeast Pacific recruitment synchrony to environmental variability. Fish. Oceanogr. 23:389-408.

Thompson, K.A., S.S. Heppell, and **G.G. Thompson**.

2014. The effects of temperature and predator densities on the consumption of walleye pollock (Theragra chalcogramma) by three groundfish in the Gulf of Alaska. Can. J. Fish. Aquat. Sci. 71:1123-1133.

Torres, M., and **R. Felthoven**.

2014. Productivity growth and product choice in catch share fisheries: the case of Alaska pollock. Mar. Policy 50:280-289.

Vulstek, S.C., T.P. Linderoth, **J.R. Guyon**, and D.A. Tallmon.

2013. Spatio-temporal population genetic structure and mating system of red king crab (Paralithodes camtschaticus) in Alaska. J. Crustacean Biol. 335:691-701.

Tech Memos[1]

Allen, **B.M.**, and **R.P. Angliss**.

2014. Alaska marine mammal stock assessments,2013. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-277, 294 p.

Goddard, P., **R. Lauth**, and **C. Armistead**.

2014. Results of the 2012 Chukchi Sea bottom trawl survey of bottomfishes, crabs, and other demersal macrofauna. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-278, 110 p.

Fissel, B.E.

2014. Economic indices for the North Pacific groundfish fisheries: Calculation and visualization. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-279, 47 p.

Himes-Cornell, A., and **K. Kent.**

2014. Involving fishing communities in data collection: a summary and description of the Alaska Community Survey, 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-280, 170 p.

Faunce, C., J. Cahalan, J. Gasper, **T. A'mar**, **S. Lowe**, **F. Wallace**, and R. Webster.

2014. Deployment performance review of the 2013 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-281, 74 p.

Processed Reports[2]

Orr, J.W., **D.T. Drumm**, **G.R. Hoff**, and **D.E. Stevenson**.

2014. Species identification confidence in the Bering Sea Slope surveys (1976-2010). AFSC Processed Rep. 2014-05, 71 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

[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*.

[2] The AFSC Processed Report series is not formally reviewed and individual reports do not constitute publications. The reports are for information only and a limited number of copies are available from the author.

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