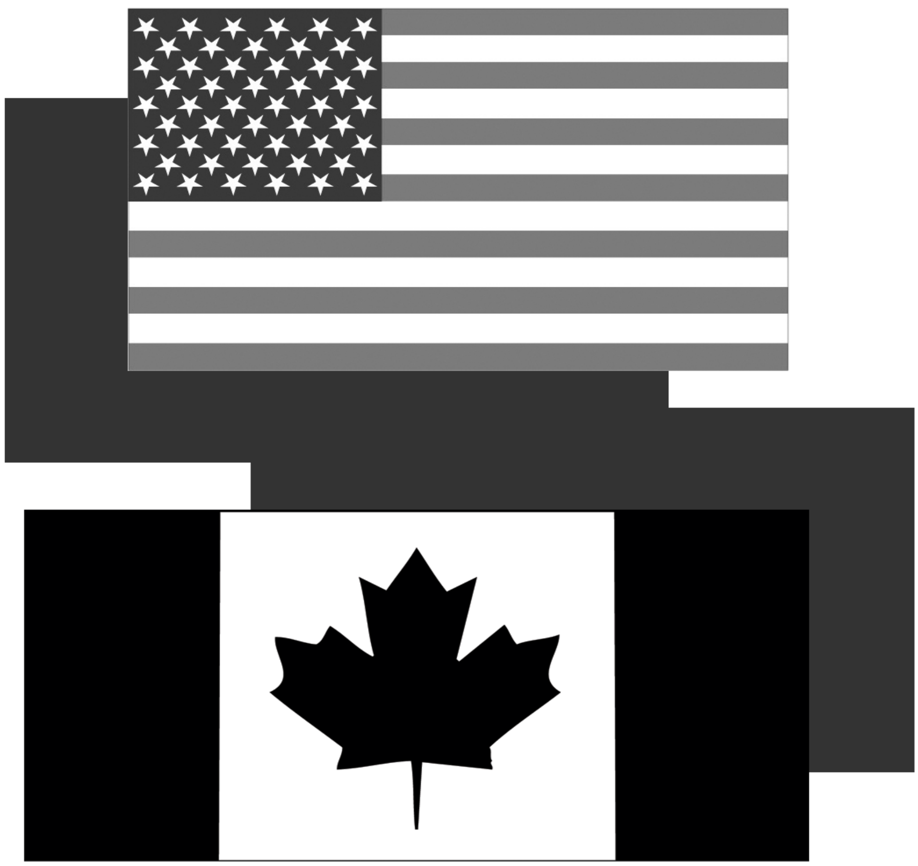
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

58th Annual Meeting of the TSC

April 25 – 26, 2017
Juneau, Alaska



Appointed by the Second Conference on Coordination of Fisheries Regulations between Canada and the United States

Compiled by the Pacific States Marine Fisheries Commission

History of TSC Meeting Locations, Hosts and Chairpersons

YEAR	DATES	LOCATION	HOST	CHAIR
1984	June 20-22	British Columbia	Westrheim	Rigby
1985	June 25-27	Juneau, AK	Morrison	Westrheim
1986	June 19-19	Ashland, OR	Demory	Westrheim
1987	June 9-11	Seattle, WA	Jagielo	Demory
1988	June 7-9	Carmel, CA	Henry	Demory
1989	June 6-9	Ladysmith, BC	Saunders	Jagielo
1990	June 5-7	Sitka, AK	Bracken	Jagielo
1991	June 4-6	Newport, OR	Barss	Wilkins
1992	May 5-7	Seattle, WA	Jagielo	Wilkins
1993	May 5-7	Point Lobos, CA	Thomas	Saunders
1994	May 3-5	Nanaimo, BC	Saunders	Saunders
1995	May 2-3	Seattle, WA	O’Connell	Bracken
1996	May 7-9	Newport, OR	Barss	O’Connell
1997	May 6-8	Tiburon, CA	Thomas	Barss
1998	May 5-7	Olympia, WA	Jagielo	Barss
1999	May 4-6	Seattle, WA	Methot	Barnes
2000	May 9-10	Nanaimo, BC	Saunders	Barnes
2001	May 8-10	Newport, OR	Schmitt	Schmitt
2002	May 7-8	Point Lobos, CA	Barnes	Methot
2003	May 6-7	Sitka, AK	O’Connell	Jagielo
2004	May 4-5	Coupeville, WA	Wilkins	Jagielo
2005	May 3-4	Parksville, BC	Stanley	Stanley
2006	May 2-3	Otter Rock, OR	Parker	Stanley
2007	April 24-25	Santa Cruz, CA	Field	Brylinsky
2008	May 6-7	Seattle, WA	Wilkins	Brylinsky
2009	May 5-6	Juneau, AK	Clausen	Clausen
2010	May 5-6	Nanaimo, BC	Stanley	Clausen
2011	May 3-4	Astoria, OR	Phillips	Clausen
2012	May 1-2	Newport Beach, CA	Larinto	Clausen
2013	April 30-May 1	Seattle, WA	Palsson	Larinto
2014	April 29-30	Seattle, WA	Dykstra	Larinto
2015	April 28-29	Sidney, BC	Yamanaka	Larinto
2016	April 26-27	Newport, OR	Whitman	Yamanaka
2017	April 25-26	Juneau, AK	Heifetz	Yamanaka

Table of Contents

A. History and Purpose

Purpose:

The Technical Subcommittee (TSC) of the Canada-U.S. Groundfish Committee was formed in 1960 out of a need to coordinate fishery and scientific information resulting from the implementation of commercial groundfish fisheries operating in US and Canadian waters off the West Coast. Today, representatives from Canadian and American state and federal agencies meet annually to exchange information and to identify data gaps and information needs for groundfish stocks of mutual concern from California to Alaska. Each agency prepares a comprehensive annual report highlighting survey and research activities, including stock assessments. These reports are compiled into an annual TSC report that is published online (www.psmfc.org/tsc2). The TSC reviews agency reports and recommends collaborative work or plans workshops on topics of shared interest. Historically, the TSC has prepared catch databases that led to the development of the Pacific Fisheries Information Network (PacFIN) catch reporting system, hosted 21 scientific/management workshops, organized 27 working groups, and created the Committee for Age Reading Experts (CARE). Each year the committee discusses and recommends actions to improve and coordinate groundfish science among agencies and these recommendations are sent to agency heads and managers to inform research and management priorities.

History:

Before the U.S. and Canada implemented exclusive domestic fisheries off their respective coasts, commercial fishers from either country could fish in both American and Canadian waters. In 1959, an International Trawl Fishery Committee (later renamed the Canada-U.S. Groundfish Committee) was established by groundfish management and research agencies to track transboundary fisheries and examine biological questions pertinent to the stocks and fisheries. This committee established the Technical Subcommittee (TSC), which held its first meeting in 1960 and has held annual meetings ever since. Initial activities and concerns focused on reporting and resolving catch estimates, stock identification and assessment, tagging, ageing techniques, and hydroacoustic techniques. These earlier studies focused on Petrale, Rock, and English Soles; Lingcod; Pacific Ocean Perch; and Sablefish. The TSC has fostered new science and improved methodologies by forming workgroups to focus on specific problems and by holding workshops to bring scientists and managers together to discuss aspects of groundfish science that are of mutual concern. Some recent workshops include Trawl and Setline Survey Methods, Catch Reconstruction, Visual Survey Methods and Developing Electronic Data Capture Systems.

Evolution:

Over time, the TSC's role has changed with the implementation of new management and legislative authorities but the annual reports provide a common and concise forum to both disseminate information on current groundfish science and to learn about agency programs and activities. The TSC continues to highlight timely research topics, hold workshops, and establish workgroups, as well as send their recommendations to agency directors, fishery managers, and program managers to lay the foundation for trans-boundary coordination through open communication.

October 24, 2016

B. Executive Summary

The TSC met at the Alaska Fisheries Science Center/the Auke Bay Laboratories/ Ted Stevens Marine Research Institute in Juneau, Alaska, April 25 - 26, 2017.

This year's meeting was hosted by the AFSC, Auke Bay Lab (list of attendees is included in the minutes). The meeting was chaired by Lynne Yamanaka, Department of Fisheries and Oceans, Canada. As is done each year at the meeting, participants review previous year (2016) research achievements and projected current year (2017) research for each agency. Each agency also submits a written report summarizing groundfish accomplishments for the previous year.

The TSC again noted the valuable ongoing work of the Committee of Age Reading Experts (CARE) (http://care.psmfc.org/), a long-standing TSC Working Group that was originally created by the TSC in 1982. The purpose of CARE is to facilitate among agencies the standardization of groundfish age determination criteria and techniques. The TSC encouraged care to review yelloweye aging again.

The TSC discussed the need for TSC representative to be on the Western Groundfish Conference organizing committee, possibly the person in the state that is hosting. IPHC holds the funds for the conference and Lara Erikson volunteered them to serve on the steering committee.

There were several suggestions for TSC workshops in the future: marine mammal depredation, specifically for sablefish and halibut. DFO is interested in this workshop because it is becoming larger issue there. They are considering adding depredation to the Canada halibut logbook. There was a discussion about having a conference in 2017 or 2018, but no one volunteered to organize this workshop.

In addition to workshops there could be TSC-led sessions at the Western Groundfish Conference. Options for session topics included: coast-wide assessments, which could include sablefish, Pacific cod, Pacific Ocean perch, etc.; depredation by whales; rockfish descending; climate change impacts, and stitching data from surveys together/species distribution models coast-wide; and managing species that are difficult to distinguish (e.g., blackspotted and rougheye rockfish). Communications with the

Western Groundfish Conferences contacts should be initiated soon to see if our ideas fit into their vision of the conference.

If there are workshops planned that coincide with the Western Groundfish Conference it should be clear to people if these workshops are part of the conference and if the workshops are open to everyone.

Dayv Lowry, WDFW, is the new Chair of the TSC. The next TSC meeting will be held April 24-25, 2017 in Santa Cruz, California at the Southwest Fisheries Science Center (SWFSC).

Minutes
Fifty Seventh Annual Meeting of the
Technical Subcommittee (TSC) of the
Canada-U.S. Groundfish Committee
April 26-27, 2016

Guin Library, Hatfield Marine Science Centre
Newport, Oregon

<u>Tuesday, April 26</u>

I. Call to order (8:30 am Tuesday, April 25th)

II. Appointment of Rapporteurs: Cara Rodgveller, AFSC and Maria Surry, DFO.

III. Housekeeping:

IV. Introductions:

Lynne Yamanaka: Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada (DFO), Nanaimo, BC (Lynne.Yamanaka@dfo-mpo.gc.ca) (Chair)

Stephen Phillips: Pacific States Marine Fisheries Commission (PSMFC), Portland, OR, (SPhillips@psmfc.org)

Xi He: Groundfish Analysis, Southwest Fisheries Science Center (SWFSC), NOAA, La Jolla, CA (Xi.He@noaa.gov)

Dayv Lowry: Washington Department of Fish and Wildlife (WDFW), Fish Management Division, Marine Fish Science Unit, Olympia, WA, (Dayv.Lowry@dfw.wa.gov)

Andrew Olson: Alaska Department of Fish and Game (ADFG), Division of Commercial Fisheries, Douglas, AK (Andrew.Olson@alaska.gov)

Maria Surry: Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada (DFO), Nanaimo, BC (Maria.Surry@dfo-mpo.gc.ca)

Greg Workman: Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada (DFO), Nanaimo, BC (Greg.Workman@dfo-mpo.gc.ca)

Tom Wilderbuer: Resource Ecology and Fisheries Management, Alaska Fisheries Science Center (AFSC), NOAA, Seattle, WA (Tom.Wilderbuer@noaa.gov)

Lara Erikson: International Pacific Halibut Commission (IPHC), Seattle, WA (Lara@iphc.int)

Leif Rasmuson: Marine Resources Program, Oregon Department of Fish and Wildlife (ODFW), Newport, OR, (leif.k.rasmuson@state.or.us)

Tracee Geernaert: International Pacific Halibut Commission, Seattle, WA (tracee@iphc.int)

Wayne Palsson: Resource Assessment and Conservation Engineering, Alaska Fisheries Science Center (AFSC), NOAA, Seattle, WA, (Wayne.Palsson@noaa.gov)

Jim Armstrong: North Pacific Fishery Management Council (NPFMC), Anchorage, AK (james.armstrong@noaa.gov)

Jon Heifetz: Auke Bay Laboratories, Alaska Fisheries Science Center (AFSC), NOAA, Auke Bay Laboratories, Juneau, AK (Jon.heifetz@noaa.gov)

Jennifer Stahl: Alaska Department of Fish and Game (ADFG), Division of Commercial Fisheries, Douglas, AK (Jennifer.Stahl@alaska.gov)

Cara Rodgveller: Alaska Fisheries Science Center (AFSC), NOAA, Auke Bay Laboratories, Juneau, AK (Cara.Rodgveller@noaa.gov)

Caroline McKnight: Marine Region, California Department of Fish and Wildlife (CDFW), Monterey, CA, (caroline.mcknight@wildlife.ca.gov)

Kari Fenski, Auke Bay Laboratories, Alaska Fisheries Science Center (AFSC), NOAA, Auke Bay Laboratories, Juneau, AK (*Kari.Fenske*@noaa.gov)

V. Approval of Agenda

Two agenda items were added: Review the active working group list and Review the Western Groundfish Conference recommendations to the TSC.

VI. Approval of 2016 Report

Lynne Yamanaka move to approve the report and Jon Heifetz seconded the motion

VII. Agency Overviews

Alaska

AFSC (Tom Wilderbuer): Angie Greig and Liz Conners will retire this year.
ADFG (Andrew Olson): Kray VanKirk departed ADFG. He was working on an age-structured model for yelloweye rockfish and sablefish. A new biometrician will be hired this fall to continue to develop these age structure assessments.
AFSC (Wayne Palsson): Dave Somerton retired last year. RACE hired three people. The acoustics group also had new hires in the past year.
AFSC (Jon Heifetz): Phil Rigby retired and Jon Heifetz is the new groundfish program manager. There are two new hires: Kari Fenski (Sablefish Spatial Modeling) and Curry Cunningham (Management Strategy Evaluation). Chris Lunsford will become a supervisor in 2017.

NPFMC (Jim Armstrong): The Council has been working towards setting bycatch limits for Pacific halibut in the Bering Sea. There would be limits of how much the bycatch index could go up and down. There will be policy changes in the future. The salmon Fishery Management Plan was excluded and management was given to the state. There was a lawsuit that argued that salmon management in one area of Alaska be transferred to the Federal Government. The NPFMC has to respond to the court finding. This could have implications for other areas in Alaska or other areas in the country. In recent years there has been expanded observer coverage and increased onboard electronic monitoring.

Canada

DFO (Greg Workman): There was a major re-organization of the Science branch and the creation of a new Ecosystems Division. This brings Science up to 5 Divisions: John Holmes leads the Aquatic Resource Research and Assessment Division (ARRAD), Eddy Kennedy now leads the Ecosystem Science Division, Nathan Taylor leads the Aquatic Diagnostics, Genomics & Technology Division, Dave Prince leads the Canadian Hydrographic Service, and Kim Huston leads the Ocean Science Division. Within ARRAD, Greg Workman leads the Offshore (Groundfish) Assessment Section; Lynne Yamanaka leads the Inshore (mostly Invertebrates) Assessment Section, Bruce Patten leads the Fishery and Assessment Data Section, Arlene Tompkins leads the Salmon Assessment Section, Diana Dobson leads Salmon Coordination, and Robyn Forrest leads the Quantitative Assessment Methods (QAM) Section. Greg Workman lost some quantitative staff to Robyn's Section. More resources have been diverted to marine conservation targets and protected areas. There is a mandate with the new government that requires 5% of marine and coastal waters be protected by 2017 and 10% by 2020. Some staff have been redistributed to accomplish this goal. The list of assessments that will be done this year has not been completed. Rob Kronlund, Andy Edwards, Kendra Holt moved to the QAM Section and are not all working on groundfish species. Last year (June 2016) the CCGS W.E. Ricker, DFO's trawl research vessel, was decommissioned due to mechanical issues. To complete survey work, while the new research vessel is under construction, DFO will use charters vessels.

Washington

WDFW (Dayv Lowry): Kari Fenski moved to Juneau (to work for the AFSC) and was replaced by Phill Dionne, who will be working on forage fish. Dayv Lowry's position has changed so that he currently works only on groundfish, including being appointed to the SSC of the NPFMC. There has been a shift to researching and managing inshore/benthic and offshore/pelagic fish separately. There is a new ocean policy position, which is just a reclassification of Michele Culver (previously the Regional Director for the Olympic Peninsula). Michele and her staff (Corey Niles, Heather Reed, and Jessi Doerpinghaus) currently support PFMC management needs for the Department.

NWFSC: Not present and nothing to add.

Oregon

ODFW (Leif Rasmuson): Leif is new to his position, which is research focused. Bob Hannah retired last year.

IPHC

Lara Erikson: There are new personnel, retirees, and promotions at IPHC: Josep Planas is the head of research; Allen Hines work is stock assessment; Heather Gilroy retired as the manager of the Fishery Statistics Program and was replaced by Jamie Goen; Keith Jernigan is the new manager of IT; Bruce Leaman retired as the IPHC Director and was replaced by David Wilson from Australia; Tracee Geernaert is the new survey manger; Lara Erikson is now the new Commercial Fisheries Data Manager; Claude Dykstra moved into a new position with a focus on research and work with the NPFMC.

California

CDFW (Caroline McKnight): Bob Leos retired and the position was backfilled. There has been some restructuring of personnel and programs.
SWFSC (Xi He): Melissa Munk is a new hire in the assessment program, managed by John Field. There will be assessments for sculpin, bocaccio, others? This year.

VIII. CARE Report Summary

Report Given to TSC by Tom Wilderbuer (AFSC): A committee was formed to develop best practices for short and long-term storage of otoliths, which was suggested by the TSC as a long term goal for agencies.

IX. Surveys

Alaska

AFSC (Wayne Palsson): There was a bottom trawl survey in 2016 on the Bering Sea shelf that included 400 stations. Last year was the 3rd warmest year ever. Pollock biomass decreased by 23% and Pacific cod by 11%. In even years there is a trawl survey in the Aleutian Islands. In this survey Pacific Ocean perch (POP) are the dominant species and catch is increasing, as it is in the Gulf of Alaska. Atka mackerel are the second most common species caught in the in Aleutian Islands. The acoustic survey (MACE Program) conducts a winter acoustic trawl survey in the Shumagin area and in Shelikof Strait. The acoustic abundance of pollock is trending down. Every other year there is a survey in the Aleutian Islands, nearby Bogoslof Island. Pollock were up tremendously in the last survey. This is a big rebound after a decline. Sonars are being added to bottom trawl survey charters vessels. Pollock trends in the acoustic and trawl surveys are similar and increasing in the Bering Sea. In even years they do acoustics on the NOAA *R/V* Oscar Dyson. That data showed that pollock on the Bering Sea shelf are increasing in abundance.

AFSC (Jon Heifetz): The longline survey is done every year in the Gulf of Alaska and in alternating years in the Aleutian Islands and the Eastern Bering Sea. The survey is sablefish focused, but is also used for the assessment of the backspotted/rougheye rockfish complex, shortspine thornyhead, and dogfish. There was a 20% increase in catch of sablefish in 2016. There may be good year classes that will be seen in the fishery in the near future. Sablefish were deployed with pop-up satellite archival tags during the longline survey over the past several years. There was a study to sample fish to relate them to sperm whale diets. There was also a project to identify individual sperm and killer whales. There is now a population index for more shallow strata on the survey; these will be used in the Pacific cod assessment. The longline survey population indices are available online. Besides the longline survey there are other surveys conducted out of Auke Bay Laboratories. There is a surface trawl survey in the north and south Eastern Bering Sea and one in the Gulf of Alaska. In the Bering Sea they mainly catch pollock, Pacific cod, and flounder. In the Gulf there is a plan to focus on sablefish recruitment surveys.

ADFG (Andrew Olson): There was a new trap survey for hagfish in 2016. This occurred in Ernest Sound and Behm Canal. There were two demersal shelf rockfish ROV surveys that occurred in Northern Southeast Outside (NSEO) and Central Southeast Outside (CSEO). The funding for the ROV survey in Prince William Sound was cut. Out of Kodiak there was a black and dark rockfish hydroacoustic survey. There is a sablefish mark/tag survey using pots and a longline survey every year in southeast Alaska.

Canada

DFO (Greg Workman): DFO conducts annual trawl, trap and longline surveys. There was a shortened bottom trawl survey off of the west coast of Vancouver Island due to a major vessel breakdown. The dominant species in the catch were arrowtooth flounder, dogfish, Pacific Ocean perch and yellowtail rockfish. There has been a decline in dogfish recently. There was also a bottom trawl survey off the west coast of Haida Gwaii in waters from 200-1100 m. This survey is done in collaboration with the commercial bottom trawl industry. The dominant species in that survey was Pacific Ocean perch; their population index was flat in 2016. In 2016 the biennial multi-species longline hook and line hard bottom survey of the outside waters covered the southern area of the BC coast, this survey is done in collaboration with the commercial Halibut industry. The industry contracts the vessels and sea going technicians, DFO provides the survey design and some equipment as well as data processing and analysis. The index of inshore rockfish from that survey has been down the last three surveys, yelloweye rockfish in particular. A longline survey in inside waters is conducted on the Coast Guard vessel, Neo-Caligus. The northern section was done in 2016, from the Campbell River to the top of Vancouver Island. The Yelloweye Rockfish stock index trended up slightly. There is an annual coast-wide sablefish pot survey undertaken with the commercial industry. They provide the vessel and technicians and DFO provides the chief scientist and Lab supervisor. This survey takes 4-5 weeks. Samples from Rougheye/Blackspotted complex have been collected over the past 7 years for genetics analysis. Sablefish abundance is down significantly since 2003. DFO, with the halibut industry, also pays IPHC for an extra technician onboard the IPHC surveys to conduct whole catch accounting and biological sampling of rockfish. Groundfish samplers are also deployed on the shrimp trawl survey conducted off the southwest of Vancouver Island in shallow water. This shrimp trawl survey also provides an index for flatfish recruitment.

Washington

WDFW (Dayv Lowry): Instead of fishing stations multiple times on the trawl survey they fish a station and then choose to fish that station again on the fly depending on catch composition (both diversity and abundance). They have added plankton sampling, gut contents, and more aging (see CARE report). The dominate species in this trawl survey are flatfish, ratfish, invertebrates, and Dungeness crab. In 2016 they caught bocaccio for the second time ever; 1 fish was caught in 2012 and 11 in 2016. All fish were 5-6 inches long and samples were taken for genetics. Hake were up this year (12 times higher than the previous estimate). This can partly be explained by a small number of hauls that contained large numbers of hake and variable catch rates.

Navy boats can be exempted from critical habitat closures, but they have to collect data. The Navy pays WDFW to do surveys. When these areas were surveyed, no adult habitat was located because it had been dredged in the past. No ESA-listed rockfish were found.

In central and south Puget Sound there are no spawning herring found for two populations for three years in a row. They may shut down the bait fish fishery.

On the outer coast there is a hydroacoustic survey for yelloweye rockfish, a longline survey, and a hook and line survey. Few yelloweye rockfish have been found on any gear type.

A synoptic catch reconstruction is ongoing for rockfish (particularly for yelloweye rockfish) and lingcod composition and abundance. A history of the fishery is being written up and catch summaries are being generated for all bottomfish species as time allows.

Oregon

ODFW (Leif Rasmuson): ODFW started a pilot electronic monitoring project and found that there are no benefits in time savings at-sea but there is time savings back at lab. There is also an acoustic/visual inshore survey being developed statewide for blue and black rockfish. They are also in the process of establishing a statewide video survey for yelloweye rockfish. Acoustic surveys can be useful for individual species because the acoustic strength varies by species.

California

CDFW (Caroline McKnight): There were high densities of rockfish and lingcod in last year’s survey. There was also a large die-off of algae, but an increase in sea urchins. There is currently an effort to compile data.

SWFSC (Xi He): There was a survey of bottom habitat with an ROV as well as the CalCOFI survey, which is a midnight mid-water trawl for larvae that was started in 1950. This survey is used as a rockfish prerecruitment index.

Lynne reported for the NWFSC: There was an acoustic hake ecology survey in the California current and there will be a winter trawl research cruise in 2017.

IPHC

IPHC: In 2016 there were 14 boats, and waters from southern Oregon to the eastern Bering Sea and western Aleutian Islands were surveyed. The survey is done on a 10 by 10 nmi grid. This is the 3rd year of deep-water and shallow-water expansion. Last year they sampled 1366 stations and the expansion was done in the Bering Sea. In 2017 they will expand into the Western AI. The survey was also expanded in WA, OR, and CA. The grid in northern WA was densified and there were stations added in Puget Sound. Next year the survey will be expand into Strait of Georgia. Tablets were used last year for data collection and it was a success. Tagging of halibut is still ongoing and the size range was increased to include fish under 32 inches. They are expecting to tag 200 fish per region. Pop-up satellite archival tags will be deployed in Bowers Ridge. Rockfish data will be collected this year for DFO. IPHC put two people of the NMFS trawl surveys for collections of halibut. PSMFC and IPHC are working cooperatively on electronic monitoring validation.

X. Reserves

Alaska

AFSC: Southeast Alaska is still closed to trawling, but there are no marine reserves.

ADFG (Andrew Olson): The Edgecumbe pinnacles off of Sitka is currently the only marine reserve in Alaska which is closed to all groundfish fishing.

Canada

DFO (Greg Workman): There are Sponge Reef closures in Hecate Strait which exclude all forms of bottom contact fishing. They will become marine protected areas (MPAs) in early 2017. Survey activities will no longer be permitted within these closures once designated as MPAs. There is a National Marine Wildlife Conservation Area for seabirds around the Scott Islands (northwest tip of Vancouver Island). This is relatively new and having been in the works for five years. New targets for Marine Conservation identified in the Ministers Mandate Letter in 2016 were to achieve by 2017, protection of 5% of coastal waters in each region of Canada and 2020 fully 10 % of coastal waters are to be protected. Offshore areas (seamounts) are also being considered for protection. This is a nationwide requirement and it is unclear how much B.C. will contribute to the total of 5 and 10%. The Ecosystem Science Division is focused on closed area work. Currently, fishery regulations specify that there is no fishing deeper than 2000 m without a special permit (i.e. closed to fishing without a permit). This year they are looking at what they already have that could count towards the 5%.

Washington

WDFW (Dayv Lowry): They are currently working on a summary report of dive surveys inside and outside on marine protected areas. The conclusion of the report will be that 15 years of data may not be a long enough time series because the fish are slow growing and recruitment is sporadic. The hope is to add another dive survey because more work is needed. The reserves are mostly in diveable depths and all depths deeper than 120 ft are closed to bottomfish fishing even though these depths are not defined as marine protected areas. This summer descending devices will be required for rockfish whenever targeting bottomfish. They anticipate that people will want to fish in >120 ft if descending is a regulation. Dayv Lowry is writing regulations for using unmanned aerial systems (aka drones) for surveying fishing effort, landings, and distribution of various natural resources. The Enforcement Program of the Department is writing a second policy for regulation compliance monitoring.

Oregon

ODFW (Leif Rasmuson): Volunteers are providing monitoring of marine reserves using hook and line. There were ROV surveys that include 74 transects at 3 sites. Longline surveys were conducted to compare to hook and line surveys. There are some small spp. differences, but hook and line caught fish can be released, so this is going to be the preferred survey gear. They are also conducting surveys in comparison sites outside of reserves. Lynne Yamanaka (DFO) noted that the Canada policy excludes fishing is reserves. Leif Rasmuson noted that stakeholders pushed for regulations to require sampling within reserves for monitoring. ROVs are sometimes used for surveys, but this is weather dependent. Charter boats are required to descend fish instantly. Devices used are usually Seaqualizers and Fish Grips. Grants provide descending devices to be provided to the public at no cost.

California

CDFW (Caroline McKnight): California has 24 marine protected areas and 15 are no take. Reserves comprise 16% of state waters. There is funding for marine protected area work and they are conducting a 5 year management review. Links to the review reports are in the California TSC reports. There is a very structured frame work for how research can be conducted in the protected areas. These include a combination of policy and permitting, a master plan for marine protected areas, ecological impact assessment tools, public input, and estimates of impacts of scientific collecting.

SWFSC (Xi He): nothing to report.

NWFSC (reported by Lynne Yamanaka): In the TSC report there is a project on how home range affects defining marine reserves.

XI. Review of Agency Groundfish Research, Assessment and Management by Species or Species Group

A. Hagfish

Alaska
ADFG (Andrew Olson): There is currently no management plan for hagfish in Alaska and is managed using a Commissioner's permit where limitations such as, gear, guideline harvest levels, etc. are set, which have only been issued in southern southeast Alaska near Ketchikan. The primary species that is harvested is black hagfish while we have limited information on Pacific hagfish. Hagfish surveys began in 2016 as an opportunistic sampling that was added as an extra project on an existing annual pre-season spot shrimp stock assessment survey. Gear design included using five gallon bucket traps that were longlined and stations chosen based on muddy habitat and historical records of hagfish evidence and bycatch in other fisheries and surveys. Catch rates were high in muddy habitat and was skewed towards females. Last year 192 specimens were collected, including the largest recorded for black hagfish (770 mm for female and 620 mm for male). Currently working estimate size at maturity, length-weight relationships, fecundity, and other basic life history for this poorly described species in Alaska. The survey will be conducted again in 2017. The fishery is still small; there was only one landing last year. Hagfish are also found in outside waters, near Dixon Entrance on a muddy bank. Tracee Geernaert (IPHC) noted that there is data on the first 20 hooks for hagfish on the IPHC survey. They are differentiating by species. Jennifer Stahl (ADFG) added that they are recording hook slime of the ADFG longline survey because this may affect CPUE.

Canada
DFO (Greg Workman): There has been a Pacific Hagfish depletion survey conducted by the industry. The design is systematic with a visit to each site every 2 months for the past 3 years. There were over 1,000 tons of hagfish landed. Fishermen were supposed to fish until CPUE dropped off, but they did not follow depletion experiment protocols. It is thought that they were not fishing in authorized areas and not keeping fish depletion fishing protocol. An experimental fishery is not authorized and there is only one area with hagfish, Juan de Fuca Eddy.

Washington
WDFW (Dayv Lowry): There is a hagfish fishery in WA and OR: 1.5-2 million lbs every year. The target Pacific Hagfish but also catch a small amount of Black Hagfish.

NWFSC: nothing to add.

Oregon
ODFW (Leif Rasmuson): The fishery was 1.5 million lbs last year.

California
CDFW (Caroline McKnight): A hagfish fishery reemerged in 2016, with landings from 1 vessel in Monterey. Samples were taken from the landings. There was a regulation to use a 40 gallon barrel, but this was changed to specify size dimensions and not volume.
SWFSC (Xi He): SWFSC: nothing to add.

IPHC
IPHC: nothing to add.

B. Dogfish and other sharks

Alaska
AFSC (Jon Heifetz): Pop-up satellite archival tags were deployed on 180 dogfish over time. There was a paper published in the Lowell Wakefield data limited symposium that estimated catchability of dogfish for the trawl survey. The authors estimated a catchability under 1 because dogfish spend time off bottom. A study of sleeper shark genetics showed that there are two populations that overlap geographically and that Pacific sleeper shark are a different species than Greenland sharks. In the Bering Sea/Aleutian Islands sharks are tier 6, which uses average catch to set allowable catch and overfishing limits. In the Gulf of Alaska they are also tier 6, but for spiny dogfish only the biomass is used using a tier 5 calculation (which biomass estimates) and average catch is used for other shark species. Sleeper sharks have shown a decline in catch rates over time. There is no retention of dogfish and there has not been any recent attempts to develop a fishery.

ADFG (Andrew Olson): A research project on the reproductive biology of salmon sharks via blood hormone concentrations began in 2010 and another project examining the energetics of salmon sharks began in 2012 and the department hopes to continue this work in 2017. A collaborative effort with the National Institute of Polar Research in Japan, ADF&G, University of California Santa Barbara, the Institute for Ocean Conservation Science at Stony Brook University and the Scottish Oceans Institute's School of Biology at the University of St Andrews, resulted in the publication of a paper on the ecological significance of endothermy in fishes.

Canada
DFO (Greg Workman): There has not been an assessment since 2010. Dogfish are the most common species in the bottom trawl survey, but they have been trending down for the past 4 years, last year being the lowest. They are caught in all surveys in all areas in outside waters. There was a basking shark critical habitat assessment because they are endangered. There was not enough data to identify critical habitat. Their foraging areas and behavior is unknown, except that they spent time where there are copepods. There are confirmed sightings periodically on the coast. There are discard mortality rates (under 100%) used for spiny dogfish in trawl fisheries. Landings of dogfish were 30,000 kg last year, but it was all as bycatch. There are discards in seins and gillnets but there is not good monitoring. Sharks other than dogfish were moved to another program.

Washington
WDFW (Dayv Lowry): Dayv Lowry made an outreach video teaching recreational fishers how to fish for dogfish so that they have something else to fish for when salmon runs are light. There is a tribal commercial dogfish fishery in north Puget (Lummi Indian Nation); in 2016 there were 262,000 lbs landed. It is a drift gillnet fishery in small bays and almost all fish caught are female. Fish are shipped gutted to Europe (England and Norway).

There was a slight uptick in the bottom trawl survey trend for dogfish in 2016, but there was no Puget Sound assessment. They hope to do a full assessment in the next few years.

There is a new book coming out on Northeast Pacific sharks in 2017, edited by Dayv Lowry and Shawn Larson from the Seattle Aquarium. Chapters include information on a wide variety of topics, from biology to fisheries to ecotourism, and chapter authors include experts from Alaska to southern California. The book should be published this winter.

NWFSC: no assessments or other work.

Oregon
ODFW (Leif Rasmuson): nothing to add.

California
CDFW (Caroline McKnight): nothing to add.

SWFSC (Xi He): nothing to add.

IPHC
IPHC (Tracee Geernaert): IPHC is collecting dogfish counts and lengths by sex in all areas. They are also collecting samples for a genetic analysis of six gill sharks coast wide, including Puget Sound, where they are abundant. Shark species, other than dogfish, have been on a declining trend in 2B (BC) over the past 10 years.

C. Skates

Alaska
AFSC (Wayne Palsson): The NPFMC designated eight skate nursery sites where egg cases have been found. There is an NPRB project to predict nursery habitat, examine genetics of skates at nursery sights, and the impacts of fisheries (observers will define if a skate eggs case caught in fisheries are viable or empty).
ADFG (Andrew Olson): There is no skate assessment and no directed fishery, but bycatch retention is allowed. There was some commercial interest in 2016, but those who applied for a Commissioner’s permit were denied due to lack of data on skates in southeast Alaska.

Canada
DFO (Greg Workman): Skates were tagged from 2003-2006 in Hecate Strait and the last tag return was in 2013. The last assessment was in 2013. An assessment was done because Pacific halibut were under MSC review and there is a high amount of skate bycatch in the P. halibut fishery. There is a requirement for quota for skate bycatch.

Washington
WDFW (Dayv Lowry): In the bottom trawl survey there were a lot of small skates, but a formal assessment is not conducted for any species of skate in State waters.
NWFSC: nothing in 2016.

Oregon
ODFW (Leif Rasmuson): nothing to add.

California
CDFW (Caroline McKnight):
SWFSC (Xi He): nothing to add.

IPHC
IPHC (Tracee Geernaert): there will be a special collection in 2018 on the survey.

D. Pacific Cod

Alaska
AFSC (Wayne Palsson): There is a research project aimed at estimating Pacific cod abundance in the water column and comparing this to catch in a net. One goal is to determine if vessels force fish deeper and away from the net. The industry is requesting that a winter spawning survey be done because the assessment relies on summer trawl survey data and P. cod may have seasonal movement and distribution shifts. There are current analyses of how fisher behavior is affected by economics

AFSC (Tom Wilderbuer): There was an assessment, which reported that there was good recruitment in Bering Sea. There are proposals that have been submitted to FATE and NPRB.
ADFG (Andrew Olson): Pacific cod will be tagged on the sablefish mark/tag pot survey this year if they reach the sablefish tagging goal. This will be around Cape Fanshaw in Southeast Alaska. There is currently no limit in the sport fish fishery.

Canada
DFO (Greg Workman): In 2016 there were collections for genetics for an analysis of stock structure in Queen Charlotte Sound and Hecate Strait. It is possible that there are two stocks in these areas. There will be a stock assessment 2017. They will use data limited tools or a delay difference model.

Washington
WDFW (Dayv Lowry): There is biological sampling every year. There is genetic diversity in Puget Sound and genetics affects their response to warm water. This data may be applicable to aquaculture. Wayne Palsson added that AFCS has submitted a proposal to NPRB to examine genetics of Pacific cod.
NWFSC: nothing to add.

Oregon
ODFW (Leif Rasmuson): nothing to add.

California
CDFW (Caroline McKnight): nothing to add.
SWFSC (Xi He): nothing to add.

IPHC
IPHC (Tracee Geernaert): There will length sampling in the western Aleutian Islands.

E. Walleye Pollock

Alaska
AFSC (Jon Heifetz): Work is focusing on age -0 Pollock, especially in the Bering Sea. Work has found that fish condition going into first winter is correlated with the fat content of the food Pollock are eating (copepods). As a result, strong year classes are correlated with cold years, when the copepods have higher fat content. The last few years have been warmer; therefore it is predicted that Pollock production will be lower.

AFSC (Tom Wilderbuer, Wayne Palsson): A study has been conducted using midwater trawl gear with a fine mesh to target age-0 Pollock. The method deploys the trawl as oblique tows to look at what is in the water column. Results have made it possible to map out the location of Pollock in a grid covering the inner & mid shelf areas.

They are also looking at the “blob” (now called a “marine heat wave”). Studies have focused on early life stages of Pollock. In warmer years they generally do better, in contrast to Bering Sea shelf. However, in warm blob years they are doing worse.

A study has been conducted on the microchemistry of otoliths, to try to identify sources of production. They have found consistent differences between the Kodiak and Semidi regions, based on strontium, calcium, and barium.

ADFG (Andrew Olson): In Prince William Sound they are looking at excluder devices. There was no fishing for Pollock, despite two permits for purse seine and jig.

Canada
DFO (Greg Workman): There are four potential Pollock stocks in BC (note that fish in northern BC may be part of a SE Alaska stock); the coastwide Total Allowable Catch (TAC) is distributed among the four areas. In general, Pollock from the Strait of Georgia

and Juan de Fuca Strait tend to be too small for market; Pollock taken in Queen Charlotte Sound and off the West Coast of Haida Gwaii are taken incidentally in the hake fishery; Pollock in Hecate Strait and Dixon Entrance fish are larger, resulting in targeted fishing.

The next Pollock assessment will be presented in May 2017.

Washington
WDFW (Dayv Lowry): nothing to add.

NWFSC: nothing to add.

Oregon
ODFW (Leif Rasmuson): nothing to add.

California
CDFW (Caroline McKnight): nothing to add.

SWFSC (Xi He): nothing to add.

F. Pacific Whiting (Hake)

Alaska: nothing to add

Canada
DFO (Greg Workman): Note that 2017 quota is larger than previous years

Washington
WDFW (Dayv Lowry): nothing to add.

NWFSC: nothing to add.

Oregon
ODFW (Leif Rasmuson): nothing to add.

California
CDFW (Caroline McKnight): nothing to add.

SWFSC (Xi He): nothing to add.

G. Grenadiers

AFSC (Jon Heifetz): Research has been conducted on otolith shape variation. Some generalized genetics work (bar code of life) has been completed. Age readers did a quantitative analysis of otolith shape and found significant differences; however the differences are not correlated to genetics, and instead seem to be related to different growth patterns. The mechanism is unknown.

Grenadiers are huge bycatch in sablefish fishery. The used to be a regularly assessed species, but they have been moved into the ecosystem component of AKFSC. The species continues to be monitored but there are no harvest rules. There is currently no market, so catch is all discarded.

H. Rockfish – nearshore, shelf, and slope

AFSC (Jon Heifetz): Notes that there is some suggestion of differences in otolith morphometrics; otolith morphometrics plus size and age may be able to distinguish Rougheye from Blackspotted rockfish – implications for looking at historical species composition.

ADFG (Andrew Olson): Research has begun on extracting bone and tissue samples from female yelloweye rockfish to determine if hormones could be extracted from rockfish age structures within a temporal context. This project is led by Kevin McNeel at the ADF&G age-determination unit.

Genetic studies have been conducted on Rougheye and Shortraker historical tissue samples to try to separate cryptic species complexes (e.g. rougheye/blackspotted complex).

A collaborative project is underway with the USGS regarding habitat mapping.

Within the sports fishery, they are looking at descender survivability for different species.

Assessments are summarized in the report.

An ROV survey was conducted in SE Alaska – this was the first time the NSEO [LT1]management area has been surveyed since ~1994. The previous survey was conducted using a sub; however, despite the different methodologies, the numbers from the recent survey are very similar to those from the previous surveys. They saw lots of juvenile yelloweye. WDFG notes they’ve also seen juvenile yelloweye in hood canal recently in shallower depths than usual. They are conducting two surveys this summer, looking to see if they see similar trends.

Canada

DFO (Greg Workman): For nearshore rockfishes, the report highlights work by Dana Haggarty on RCA effectiveness, and subsequent publications.

A descenders workshop was held in October 2016 to see what other jurisdictions have done. Our recreational sector very interested in implementing these so they can keep fishing after they catch their first fish. Some charter operators are already using descenders – however, the issue with fisheries management is how to account for mortality of released fish.

Washington

WDFW (Dayv Lowry)**:** As of July 1, 2017 all sports fishers (charter and individuals) will be required to have a descender on board and ready to go any time they are fishing for groundfish from a vessel. The issue is enforcement – having the device ready can be enforced, but it's difficult to regulate them actually using it. The regulation was originally for any vessel fishing in or near deep water or for halibut; in the end it excluded halibut because they're not classified as 'groundfish' by Washington state law; another loophole is that the regulation specifies fishing from a vessel, but includes "vessels" for which it's not really necessary (e.g., kayaks). While the regulation represents a great first step toward use of descenders it will likely be modified after a year or two once an evaluation of its efficacy can occur.

NOAA Fisheries just delisted the first marine fish from the ESA based on genetic data from a between the NWFSC, WDFW, Puget Sound Anglers, Puget Sound Charterboat Captain's Association, and the Kitsap Poggie Club. They canvassed the user group for fishing locations in order to increase sampling opportunities of Yelloweye, Canary, and Bocaccio. They also used known locations of these species from WDFW ROV surveys. The goal was to get genetic samples from a diversity of locations to test the validity of the current listing status. The outcome for Yelloweye was that the geographic designation needs to be expanded northwards into BC. The outcome for Canary Rockfish was that the Puget Sound population is in fact not separate from the outside population, resulting in delisting. There were only three samples for Bocaccio, so there is nothing to report yet.

See the report for video survey info. There are now some very good estimates of population abundance in Puget Sound.

Longline, hook and line, and ROV surveys are planned for Outside (nearshore 3-miles).

A Yelloweye Rockfish life history project is underway in collaboration with NWFSC. This has identified an issue with aging of Yelloweye Rockfish. There appears to be bias (up to 10-15 years) between labs, and among reviewers within labs, which may impact assessments. CARE is aware of the issue and is seeking methods to reduce the variability (see CARE report).

Oregon

ODFW (Leif Rasmuson): ODFW has conducted a combined visual/acoustic survey for semi-pelagic rockfishes.

A study has been conducted on Yelloweye Rockfish barotrauma after descending (and re-descending); fish were held in tanks in the lab and looked at 30 days later; they still had compromised internal organs, despite looking good externally within as little as two days. They have also done camera studies on behavior for 24 h after descending, and results are not encouraging.

Video lander surveys have been conducted using a bait bag. However, territoriality by Yelloweye Rockfish once a bait bag is found may confound survey results – presence/absence may give better results.

Studies are ongoing on Deacon Rockfish nearshore/offshore migration. These include monthly hook and line sampling, catching age-0 rockfish on sabiki rigs; in addition a telemetry study has been ongoing for 16 month but has no strong evidence of movement/migration.

<u>California</u>
CDFW (Caroline McKnight): The department has been using recreational samplers try to increase the number of samples for species like Yelloweye Rockfish which are difficult to get. CDFW submitted 94 samples for ageing that will be included in the upcoming stock assessment. This was a significant contribution to the number of available Yelloweye Rockfish samples. Ages ranged from 3-66 (mostly 10-22) years old.

A study is ongoing looking at targeting/avoiding specific species.

More than 60 scientific collecting permits are in place for groundfish species.

There are no regulations in place regarding use of descenders. CDFW has been focusing on education and outreach to encourage use of descenders. From a management perspective, recreational fishers can get “credit” for reduced bycatch mortality – the assumption is that descended rockfish are not 100% dead.

The forensic lab in Sacramento is conducting necropsies on lions, bears etc. They are trying to start a genetic inventory for California species, including marine fishes. This is mainly for enforcement purposes. Other jurisdictions have similar inventories.

SWFSC (Xi He): See the report. Two full assessments are coming up: Blue Deacon Rockfish, for which the last assessment was 10 years ago, and California Scorpion Fish (*Scorpaena*), for which the last assessment was 12 years ago.

<u>Shelf/slope rockfish</u>

<u>Alaska</u>
AFSC (Jon Heifetz): Research is ongoing regarding rockfish survival following decompression, to answer questions about survival/mortality after using a descender. They have had some good survival from a couple of specimens of rockfish that were decompressed and kept in the lab.

Research is ongoing looking at whether groundfish species can be identified from environmental DNA in seawater in areas that can’t otherwise be sampled (e.g.

untrawlable bottom). One issue is that the half-life of DNA in marine systems remains unknown.

AFSC (Tom Wilderbuer, Wayne Palsson): A rockfish reproductive study is underway in the Kodiak area with the objective of providing life history parameters (e.g. more accurate growth rates, etc.). In addition, researchers are looking at variability between habitat types. For deep water rockfishes, they are frequent or extensive spawning omission from year to year.

The acoustic group is looking at using a multibeam system to do transects over a trawlable/untrawable survey grid to get more detailed habitat information and to eventually develop a predictive habitat model. They also towed drift cameras over untrawlable areas to get density estimates.

In response to a NOAA strategic initiative on untrawlable habitat, researchers have been using stereo cameras like video landers to look at fish densities in rocky habitats; they are also able to estimate a relative proportion of rockfish in and above the 'dead' zone.

Canada

DFO (Greg Workman): For the rougheye/blackspotted complex, it was noted that aging methods are well aligned between Canada and the US. Within the Canadian zone, there is mixed composition depending on latitude, depth, and distance from shore. In Canada, specimens are identified as the complex, with DNA collected for later analysis, while in the US, specimens are identified as one or the other species, with DNA collected to confirm ID. Identification of cryptic species was noted as a possible workshop topic for the next Western Groundfish Conference.

California

SWFSC (Xi He): Two stock assessment updates will be conducted in 2017. The new assessment of Blackgill Rockfish will incorporate a lot of new age/fecundity information. The new assessment of Bocaccio will incorporate additional data from the last two years.

IPHC

IPHC (Tracee Geernaert): The IPCH surveys are platforms of opportunity for rockfish research. Some examples of ongoing work by the IPHC in support of other agencies' research are as follows:

- Yelloweye counts in area 2C (Fairweather and parts of Yakutat);
- Yelloweye expansion stations in Washington - 8 rockfish index stations;
- Gear comparison work
- Additional observer on Canadian portion

I. Thornyheads

Alaska
AFSC (Jon Heifetz): Auk Bay lab has conducted an extensive tagging program for Shortspine Thornyheads. Tag recoveries indicate that Shortspine Thornyheads cross international boundaries (76% recovered in Alaska but > 20% were recovered in BC, and a few were recovered from the US west coast). There appears to be a hotspot off Haida Gwaii for tag returns; the lab has requested any information that DFO may have regarding why there might be such a concentration of recoveries in this area.

Canada
DFO (Greg Workman): Described some issues with the 2015 assessment, and noted that development of aging methods is on hold.

J. Sablefish

Alaska
AFSC – Auk Bay (Jon Heifetz): Satellite tagging is ongoing to look at spawning areas. Tags are programmed to pop off at the time spawning is predicted to occur. The main challenges are the very large volume of data, as well as getting geolocation to work at northern latitudes.

Juvenile sablefish studies have been ongoing since the 1980s. A tagging study was conducted in 2016 in St. John Baptist Bay and Silver Bay near Sitka which indicates a strong 2015 year-class. In addition, a big increase in in small fish was noted in a longline survey.

The summer LL survey collects sex and maturity data (maturity determined by observation at sea). In 2015, ovary histology was looked at for all females for which aging was conducted (~600 fish). All oocytes were in different stages of development, so it is difficult to say if a female would mature or not in the current year – i.e. maturities are on a continuum. The conclusion is that summer data are not good for maturities. There are apparent differences in age at maturity in different areas of Alaska. In addition, large differences exist between at-sea maturity and histological maturity, which could be due to a sampler effect.

There are have been some major improvements to the sablefish assessment. These include a whale depredation correction for survey data (i.e. increase survey catch rate to include depredated catch) and including area-based estimates of depredation in the fisheries in estimates of total removals. The IPHC notes that feedback from fishers indicates reluctance to report depredation because it can reduce TACs.

There is a strong desire to do a coastwide assessment (because fish in Northern BC and Alaska tend to mix, etc.). Discussions are ongoing with the various agencies. The first step will be to compile all the available data and answer the questions, what data is available, what surveys exist, what are the differences in spatial coverage of the data, etc. It was noted that “coastwide assessments” might be a good workshop topic for the Western Groundfish Conference.

More early life-history work is planned for the Eastern Gulf of Alaska but may be constrained due to budget issues.

AFSC (Wayne Palsson): Larval sablefish have been collected in order to validate daily growth increments in otoliths, along with other early life history parameters.

ADFG (Andrew Olson): There is no assessment for Prince William Sound; therefore federal results are used to manage the fishery.

Longline permits are going to become longline/pot permits in Southern Southeast Inside (SSEI) subdistrict/Clarence Strait which will allow longliners the ability to fish pot gear during the pot season

ADFG is transitioning their sablefish subsistence and personal use harvest permit to be available online with the ability to report harvest online as well.

Canada
DFO (Greg Workman): See report, which describes the updates to the management system.

A study is ongoing looking at sablefish heads. This is an attempt to increase the number of samples of sablefish available from the commercial fishery: the goal is for industry to submit heads (containing otoliths, and with sex marked visually using specific cuts), and length and weight would be estimated based on head measurements. Various head measurements have been collected and correlated to length and/or weight. Results are very encouraging based on a sample of 400 heads collected from 2016 surveys.

K. Lingcod

Alaska
ADFG (Andrew Olson): A tagging program has been ongoing since 1996; see report for return numbers.

Canada
DFO (Greg Workman): A slow recovery of lingcod is apparent in the Strait of Georgia after ~25 years of closure.

Washington
WDFW (Dayv Lowry): An aging study is ongoing looking at age structures. Ages continue to use fin rays (the only validated method). A coastwide assessment is planned.

There is no lower length limit on the outer coast now.

Some brief discussion regarding aging methods – CARE has recommended using fin rays. ADFG still uses otoliths as they are less noisy than fin rays, and asked whether CARE is recommending fins coastwide, or if the recommendation will be region-specific.

Oregon
Oregon has 16 years of daily lingcod recruitment samples which might help with a coastwide assessment.

California
CDFW (Caroline McKnight): A reduction in bag limits has occurred; this is due to policy rather than scientific information.

L. Atka Mackerel

Alaska
AFSC (Tom Wilderbuer, Wayne Palsson): AKFSC has been conducting GoPro surveys piggy-backed on endangered sea lion surveys which cover areas where bottom trawls can't go. Sea lions forage in nearshore waters: the study is looking at what fish are in the nearshore/on-bottom community vs. what is in the sea lion diet. The GoPros were adequate for the task, but it was noted that for not much more money you can get a much higher quality of camera

Jim Armstrong (NPFMC): TAC in Alaska increased: bumped up to 3000 t from 2000 t.

M.Flatfish

AFSC (Wayne Palsson): See report, especially in relation to yellowfin sole and acoustic habitat studies.

Auk Bay (Jon Heifetz): Archival tag analysis has been conducted on Greenland turbot. Greenland turbot are a very northern species so may be significantly affected by climate change; population was at a low level and has been closed to trawling; there was a big recruitment event recently

NPFMC
Jim Armstrong (NPFMC): Stock assessment prioritization exercise occurred recently to explore less frequent assessments for stocks of lesser commercial importance, data poor stocks, etc. Several flatfish stocks fell into this category of going from annual full assessment update to an update every four years.

The revised groundfish stock assessment schedule is attached at the end of this document (Table 1).

ADFG (Andrew Olson): There has been no directed fishery for flatfishes since 1999 although permits are available for flounder and sole spp.

Canada

DFO (Greg Workman): See report, nothing further to add.

Washington

WDFW (Dayv Lowry): See report; update is just in relation to surveys. Policy and management elements associated with fisheries in federal waters are not provided as part of the annual WDFW report but may be obtained by contacting Michele Culver (Michele.Culver@dfw.wa.gov).

N. Pacific Halibut & IPHC activities

IPHC (Tracee Geernaert): See report for details.
There has been lots of new research as a result of Josep's hiring:
- 5 year plan: reproduction, growth, discard mortality, migration, genetics
- 7 new projects plus 8 continuing projects including the following:
- sex marking at sea: industry marking with an operculum cut for males or dorsal fin cut for females; project expanded coastwide this year; feedback from industry once they try it is good; hope to make it regulation but no idea how successful this would be (note: California wonders if they could participate – info is on the IPHC website).
    - discard mortality rates and injury classification (grant dependent)
    - using tails: natural markers to distinguish individual halibut
- commercial port program for the collection of logbooks and bio samples; collecting weights instead of doing LW conversions; collecting tissue samples (fin clips) for sex id

Regulatory changes include the following:
- bringing IPHC in line with NMFS regulations
- work with DFO on electronic log books (through Archipelago Marine Research)
- dockside LW estimates: head off vs. head on
- head accounted for 9-18% of weight of halibut
- coastwide average ~13% but different depending on how heads are cut
- IPHC has put forth a proposal to keep fish head on while onboard vessel
- issue with enforcement with weights still being recorded head off at plants
- exemption for frozen halibut (still can land head off)
- electronic reporting now includes marine mammal info (for depredation); some indication that this change may be coming to the Canadian halibut fishery also

Alaska

AFSC (Wayne Palsson): Halibut excluders were implemented on trawls; however, they reduced the catch of target species also, so this proposal has gone back to the drawing board.

Jim Armstrong (NPFMC): The halibut management framework is a living document. PSMFC will be adding research priorities to the document.

The process for estimating and setting halibut discard mortality rates for the groundfish fishery has changed in terms of administering them to the fleet. Moving forward, a working group will continue to improve estimation methods. The new process is looking at operational categories of the fleet for what is affecting discard mortality rather than target species (e.g. factory trawlers would have different mortality to a catcher vessel that discards right off the deck). The working group recommends mortality rates as part of the harvest specifications for the upcoming year at the Council's December meetings. Note that these mortality rates are not size-based so further refinements are needed to address this as well as other potentially important factors. The IPHC is working on reviewing the basis for discard mortality rates associated with different condition factor categories – existing mortality rates may be based on outdated studies).

O. Other groundfish species

XII. Ecosystem Science

I. Ecosystem Studies

Alaska

AFSC (Jon Heifetz): In the future there will be species profiles, a "report card", added to the stock assessment reports. The goal is to add ecosystem information into the stock assessments, in the ecosystem considerations section and not necessarily in the models. For a separate project, there is a benthic habitat study for 5 focal species. For this project nearshore mapping is used in conjunction with a model to predict nursery areas.

AFSC (Wayne Palsson): There is an NPRB project with the objective to predict spatial distribution due to a warming ocean. This includes surveys along coast (Canada and Alaska). Thus far the data indicates that young fish stayed in warm water and older fish moved to deeper, cooler water. A geospatial approach is being used to stitch together surveys along coast for all gear types. This will be available later this year. A deep-water coral and sponge initiative was finished after 3 years of sampling. Growth rates of *Primnoa* were collected, which provides data on the effects of fishing by gear type and the recovery rates. Bottom trawl survey data and images from cameras are being used to verify and improve a predictive habitat model of corals and sponges. These benthic habitat models were used to redefine essential fish habitat for fish in Bering Sea, Aleutian Islands, and the Gulf of Alaska, which is useful for assessment. There is an ongoing project to consolidate smooth-sheet bathymetry data for the Gulf and Bering Sea shelf and slope and the Aleutian Islands. These data are available online. There is a new pilot study to see if coral and sponge serve as habitat for fish larvae. A plankton pump will be used next to corals to sample larvae. This method will be tested in in the western Gulf this year. The recruitment processes program submitted projects to do surveys in Bering Sea and the Gulf for larval collections (see report for details). There is a stand-alone ecosystem chapter produced annually in the stock assessment report. There is also an economics model of the fishing economy in Alaska.
ADFG (Andrew Olson): nothing to report

DFO

DFO (Greg Workman): DFO is evaluating a tiering system for BC Groundfish. A workshop in May of 2016 to review a literature review on Tiered Approaches, a data checklist for classifying data richness, provisional tiering trees (similar to ICES) and a tool for data poor species (DLMTool). The outcome of that meeting is that as well as a data driven tiering system DFO Groundfish is exploring a suite of software called DLMTool that allows the analysts to evaluate the performance of different assessment approaches and harvest control rules using closed loop feedback simulation. This allows the examination of performance metrics (i.e., a risk vs yield comparison) for a given assessment approach and level of data richness. They are moving forward with 6 candidate species. There will be results this fall. Workshop proceedings are available.

Washington

WDFW (Dayv Lowry): WDFW is working on predictive models of fish occurrence in Puget Sound with the goal of better defining critical rockfish habitat. Also a separate project, there is a large scale project to remove derelict gear in Puget Sound. They have completed a large clean-up (thousands of legacy nets) and there is a hotline for people to report derelict gear and newly lost gear. The derelict gear removal program is a long-term collaboration between the WDFW and the Northwest Straits Foundation.

There is a mid-water trawl survey coupled with hydroacoustics to sample pelagic and forage fish in new areas not previously studied, which are away from herring spawning areas. Sampling cruises were conducted every other month since February 2016. They still caught a lot of herring even though they were trying to avoid spawning grounds. Although, they were targeting schools with hydroacoustics. A lot of shad were caught in Puget Sound, which is unusual, as were a lot of hake and Pollock, which was more expected.

California

CDFW (Caroline McKnight): Kelp survey information was used to create an index that could provide a qualitative contribution as an ecosystem consideration for southern California portion of the blue rockfish assessment.
SWFSC (Xi He): There were diet studies, trawl surveys, lab studies, and economic studies (see report).

IPHC

IPHC (Tracee Geernaert): There has been benthic profiling work on the survey since 2009 (*SeaCAT* profiling and oceanographic data).

XIII. Progress on Previous Year's Recommendations

A. From TSC to Itself

Working groups:

Lynne Yamanaka (DFO) led the discussion:

Lingcod working group in 3C: inactive. Coastwise assessment lead by Melisa Haltuch (for CA, OR, WA). Let lingcod assessors at each agency know there is a working group.

Sablefish SA, coast-wide: Jon Heifetz: there is a desire to obtain funding to hold a meeting or there should be an increase in communications. DFO and AFSC hope to reestablish the working group. There is desire to develop coast-wide assessment. Jon Heifetz will write a write a paragraph about this topic.

3 – 25: are inactive or should be combined with other groups (e.g., there are several sablefish working groups that can combined into one). All working groups should be in a table with their active dates and if they are currently active. Status options could include reestablish, inactive, or active.

There will be a yellowtail rockfish assessment this year in OR. Sablefish, lingcod and yellowtail are the only three working groups that may become active.

B. From TSC to Parent Committee

If there were no recommendations it should be noted here.

XIV. Current Year Recommendations

A. From TSC to CARE

Ask CARE to review yelloweye aging again.

B. From TSC to Itself

There should be a TSC representative on the WGC organizing committee, possibly the person in the state that is hosting. IPHC holds the funds for the conference and Lara Erikson volunteered them to serve on the steering committee all of the time. TSC to itself – parent committee agrees.

California will have difficulty traveling in the future for professional development. They may not be able to go to the Western Groundfish Conference (WGC), even if it is in CA. Jon Heifetz (AFSC) and Greg Workman (DFO) noted that they need to remember to look into data sharing policies, specifically for sablefish data.
TSC to itself – data sharing policies

Workshops/Western Groundfish Conference:
There were several suggestions for TSC workshops in the future: marine mammal depredation, specifically for sablefish and halibut. DFO is interested in this workshop because it is becoming larger issue there. They are considering adding depredation to the Canada halibut logbook. There was a discussion about having a conference in 2017 or 2018, but no one volunteered to organize this workshop.

In addition to workshops there could be TSC-led sessions at the Western Groundfish Conference. Options for session topics included: coast-wide assessments, which could include sablefish, Pacific cod, Pacific Ocean perch, etc.; depredation by whales;

rockfish descending; climate change impacts, and stitching data from surveys together/species distribution models coast-wide; and managing species that are difficult to distinguish (e.g., blackspotted and rougheye rockfish). Communications with the Western Groundfish Conferences contacts should be initiated soon to see if our ideas fit into their vision of the conference.

If there are workshops planned that coincide with the Western Groundfish Conference it should be clear to people if these workshops are part of the conference and if the workshops are open to everyone.

C. From TSC to Parent Committee

XV. Identify member to update the Accomplishments document on the TSC website

Wayne Palsson volunteered t do this.

XVI. Schedule time and location of the Next Meeting (selection of next Chair, if needed)

Dayv Lowry was selected as the next chair and the location of the 2018 meeting was tentatively set as Santa Cruz. Xi He volunteered to help initiate contact with John Field and others to firm up the location and dates.

As Chair, Dayv Lowry agreed to contact the WGC Organizing Committee to open the discussion of another TSC workshop on a topic TBD. Wayne Palsson agreed to help foster communication.
Lab.

XVII. Adjourn at 12:00 noon Wednesday, April 26th

Table 1. The NPFMC's groundfish assessment schedules for the Gulf of Alaska (top) and the Bering Sea / Aleutian Islands (bottom)

	Gulf of Alaska											
Stock / Stock Complex	**Old Schedule**				**Change**	**New SAPP Schedule**						
	2013	**2014**	**2015**	**2016**	**in freq.**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
W/C GOA Pollock	x	x	x	x	N/A	x	x	x	x	x	x	x
Pacific cod	x	x	x	x	N/A	x	x	x	x	x	x	x
Sablefish	x	x	x	x	N/A	x	x	x	x	x	x	x
EGOA Pollock	x	x	x	x	1 - 2	x		x		x		x
Atka mackerel	x		x		N/A	x		x		x		x
Octopus	x		x		N/A	x		x		x		x
POP	x		x		N/A	x		x		x		x
Rougheye & blackspotted rockfish	x		x		N/A	x		x		x		x
Other rockfish	x		x		N/A	x		x		x		x
Shortraker rockfish	x		x		N/A	x		x		x		x
Skates	x		x		N/A	x		x		x		x
Squid	x		x		N/A	x		x		x		x
Arrowtooth flounder	x		x		N/A	x		x		x		x
Demersal shelf rockfish	x		x		N/A	x		x		x		x
Thornyheads	x		x		shift		x		x		x	
Northern rockfish	x		x		shift		x		x		x	
Dusky rockfish	x		x		shift		x		x		x	
Sharks	x		x		shift		x		x		x	
Forage species	x		x		shift		x		x		x	
Shallow water flatfish		x		x	2 - 4	x				x		
Northern and southern rock sole	x		x		2 - 4	x				x		
Rex sole	x		x		2 - 4	x				x		
Flathead sole	x		x		2 - 4	x				x		
Deepwater flatfish (Dover)	x		x		2 - 4			x				x
Sculpins	x		x		2 - 4	x				x		
Grenadiers (BSAI/GOA)		x		x	2 - 4				x			

Table 1. (continued)

Stock / Stock Complex	Bering Sea / Aleutian Islands											
	Old Schedule				Change in freq.	New SAPP Schedule						
	2013	2014	2015	2016		2017	2018	2019	2020	2021	2022	2023
EBS Pollock	x	x	x	x	N/A	x	x	x	x	x	x	x
EBS Pacific Cod	x	x	x	x	N/A	x	x	x	x	x	x	x
AI Pacific cod	x	x	x	x	N/A	x	x	x	x	x	x	x
Sablefish	x	x	x	x	N/A	x	x	x	x	x	x	x
Yellowfin sole	x	x	x	x	N/A	x	x	x	x	x	x	x
Atka mackerel	x	x	x	x	N/A	x	x	x	x	x	x	x
Bogoslof Island Pollock		x		x	N/A	x		x		x		x
AI Pollock	x	x	x	x	1 - 2	x		x		x		x
Forage Species		x		x	N/A	x		x		x		x
Greenland Turbot	x	x	x	x	1 - 2		x		x		x	
Arrowtooth flounder	x	x	x	x	1 - 2		x		x		x	
Kamchatka flounder		x		x	N/A		x		x		x	
Northern Rock sole	x	x	x	x	1 - 2		x		x		x	
Flathead sole	x	x	x	x	1 - 2		x		x		x	
Alaska plaice		x		x	N/A		x		x		x	
Other flatfish	x	x	x	x	1 - 2		x		x		x	
Pacific ocean perch		x		x	N/A		x		x		x	
Rougheye & blackspotted rockfish		x		x	N/A		x		x		x	
Shortraker rockfish		x		x	N/A		x		x		x	
Other rockfish	x	x	x	x	1 - 2		x		x		x	
Squid		x		x	N/A		x		x		x	
Skates		x		x	N/A		x		x		x	
Sharks		x		x	N/A		x		x		x	
Octopus		x		x	N/A		x		x		x	
Northern rockfish		x		x	shift			x		x		x
Sculpins	x		x		2 - 4			x				x
Grenadiers (BSAI/GOA)		x		x	2 - 4				x			

Report of the Technical Subcommittee
of the
Canada-United States Groundfish Committee

AGENCY REPORTS

---

1. ALASKA FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERES SERVICE

2. CANADA, BRITISH COLUMBIA GROUNDFISH FISHERIES

3. INTERNATIONAL PACIFIC HALIBUT COMMISSION (IPHC)

4. NORTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

5. SOUTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

6. STATE OF ALASKA – ALASKA DEPARTMENT OF FISH AND GAME

8. STATE OF CALIFORNIA – DEPARTMENT OF FISH AND GAME

7. STATE OF OREGON – OREGON DEPARTMENT OF FISH AND WILDLIFE

8. STATE OF WASHINGTON – WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

Alaska Fisheries Science Center of the National Marine Fisheries Service

2016 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

April 2017

Compiled by Wayne Palsson, Tom Wilderbuer, and Jon Heifetz

VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2016

I. Agency Overview

Essentially all groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, the Fisheries Monitoring and Analysis (FMA) Division, and the Auke Bay Laboratories (ABL). The RACE and REFM Divisions are divided along regional or disciplinary lines into a number of programs and tasks. The FMA Division performs all aspects of observer monitoring of the groundfish fleets operating in the North Pacific. The ABL conducts research and stock assessments for Gulf of Alaska and Bering Sea groundfish. All Divisions work closely together to accomplish the missions of the Alaska Fisheries Science Center. A review of pertinent work by these groups during the past year is presented below. A list of publications pertinent to groundfish and groundfish issues is included in Appendix I. Yearly lists of publications and reports produced by AFSC scientists are also available on the AFSC website at http://www.afsc.noaa.gov/Publications/yearlylists.htm , where you will also find a link to the searchable AFSC Publications Database.

Lists or organization charts of groundfish staff of these four Center divisions are included as Appendices II - V.

A. RACE DIVISION

The core function of the Resource Assessment and Conservation Engineering (RACE) Division is to conduct quantitative fishery surveys and related ecological and oceanographic research to measure and describe the distribution and abundance of commercially important fish and crab stocks in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska and to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat. The staff is comprised of fishery and oceanography research scientists, geneticists, technicians, IT Specialists, fishery equipment specialists, administrative support staff, and contract research associates. The status and trend information derived from both regular surveys and associated research are analyzed by Center stock assessment scientists and supplied to fishery management agencies and to the commercial fishing industry. RACE Division Programs include Fisheries Behavioral Ecology, Groundfish Assessment Program (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes, Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.

In 2016 one of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish species of the northeast Pacific Ocean and Bering Sea. Regularly scheduled bottom trawl surveys in Alaskan waters include an annual survey of the crab and groundfish resources of the eastern Bering Sea shelf and biennial surveys of the Gulf of Alaska (odd years) and the Aleutian Islands and the upper continental slope of the eastern Bering Sea (even years). Three Alaskan bottom trawl surveys of groundfish and invertebrateresources were conducted during the summer of 2016 by RACE Groundfish Assessment Program (GAP) scientists: the annual Eastern Bering Sea Shelf Bottom Trawl Survey, the biennial Eastern Bering Sea Slope survey, and the biennial Aleutian Islands Bottom Trawl Survey.

RACE scientists of the Habitat Research Team (HRT) continue research on essential habitats of groundfish including identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, investigating activities with potentially adverse effects on EFH, such as bottom trawling, and benthic community ecology work to characterize groundfish habitat requirements and assess fishing gear disturbances.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock abundance during the summer in the eastern Bering Sea as well as winter acoustic trawl surveys in the eastern Bering Sea and Gulf of Alaska. Research cruises investigating bycatch issues also continued.

For more information on overall RACE Division programs, contact Division Director Jeffrey Napp at (206)526-4148 or Deputy Director Michael Martin at (206) 526-4103.

B. REFM DIVISION

The research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. Specifically, REFM's activities are organized under the following Programs: Age and Growth Studies, Economics and Social Sciences Research, Resource Ecology and Ecosystem Modeling, and Status of Stocks and Multispecies Assessment. REFM scientists prepare stock assessment documents for groundfish and crab stocks in the two management regions of Alaska (Bering Sea/Aleutian Islands and Gulf of Alaska), conduct research to improve the precision of these assessments, and provide management support through membership on regional fishery management teams.

For more information on overall REFM Division programs, contact Division Director Ron Felthoven at (206) 526-4114.

C. AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL’s Marine Ecology and Stock Assessment Program (MESA) is the primary group at ABL involved with groundfish activities. Major focus of the MESA Program is on research and assessment of sablefish, rockfish, and sharks in Alaska and studies on benthic habitat. Presently, the program is staffed by 13 scientists and 2 post docs. ABL’s Ecosystem Monitoring and Assessment Program (EMA) and Recruitment Energetics and Coastal Assessment Program (RECA) also conduct groundfish-related research.

In 2016 field research, ABL's MESA Program, in cooperation with the AFSC's RACE Division, conducted the AFSC's annual longline survey in Alaska. Other field and laboratory work by ABL included: 1) continued juvenile sablefish studies, including routine tagging of juveniles and electronic archival tagging of a subset of these fish; 2) satellite tagging and life history studies of spiny dogfish and sablefish; 3) recompression experiments on rougheye and blackspotted rockfish; 4) age of maturity and reproductive of sablefish; 5) large-scale, integrated ecosystem surveys of Alaska Large Marine Ecosystems (LME) including the Gulf of Alaska, southeastern Bering Sea and northeastern Bering Sea conducted by the EMA Program and; 6) analysis of juvenile groundfish collected on AFSC surveys to assess their growth, nutritional condition and trophodynamics conducted by the RECA Program.

Ongoing analytic activities in 2016 involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of eleven status of stocks documents for Alaska groundfish: Alaska sablefish, Gulf of Alaska Pacific ocean perch (POP), northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "Other Rockfish", thornyheads, and sharks and Eastern Bering Sea sharks. Integrated ecosystem research focused on the impact of climate change and variability on Alaska LME's and response of fishes (walleye pollock, sablefish, POP, Pacific cod, arrowtooth flounder, Pacific salmon) to variability in ecosystem function.

For more information on overall programs of the Auke Bay Laboratories, contact Laboratory Director Phil Mundy at (907) 789-6001 or phil.mundy@noaa.gov.

D. FMA DIVISION

The Fisheries Monitoring and Analysis Division (FMA) monitors groundfish fishing activities in the U.S. Exclusive Economic Zone (EEZ) off Alaska and conducts research associated with sampling commercial fishery catches, estimation of catch and bycatch mortality, and analysis of fishery-dependent data. The Division is responsible for training, briefing, debriefing and oversight of observers who collect catch data onboard fishing vessels and at onshore processing plants and for quality control/quality assurance of the data provided by these observers. Division staff process data and make it available to the Sustainable Fisheries Division of the Alaska Regional Office for quota monitoring and to scientists in other AFSC divisions for stock assessment, ecosystem investigations, and an array of research investigations.

For further information or if you have questions about the North Pacific Groundfish and Halibut Observer Program please contact Chris Rilling, (206) 526-4194.

II. Surveys

2016 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP

The thirty-fifth annual, standardized eastern Bering Sea (EBS) continental shelf bottom trawl survey was conducted between 26 May 2016 and 30 July 2016 aboard the AFSC chartered fishing vessels *Vesteraalen* and *Alaska Knight*, which together bottom trawled at 387 stations over a survey area of 492,898 km^2. The data collected by these annual resource surveys serves to provide 1) fishery-independent abundance estimates and population dynamics of ecologically and commercially exploited groundfish and crab stocks to the State of Alaska and to the

NPFMC, 2) information on inter-annual changes to the distribution and abundance of groundfish and crab species to the fishing industry, other stakeholders and the public, and 3) a time-series of environmental data and abundance indices for a variety of demersal macrofauna to be used for ecosystem forecast modeling in support of ecosystem-based fisheries management. On the survey, researchers processed and recorded the data from each trawl catch by identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. The bottom trawl survey also collected supplementary biological and oceanographic data to improve the understanding of life history of the groundfish and crab species and the ecological and physical factors affecting their distribution and abundance.

A total of 376 stations were successfully sampled in 2016. During the 2016 bottom trawl survey, a total of 94 fish taxa and 232 individual invertebrate taxa were identified. Survey estimates of total biomass on the eastern Bering Sea shelf for 2016 were 4.9 million metric tons (t) for walleye pollock, 986.0 thousand t for Pacific cod, 2.86 million t for yellowfin sole, 1.46 million t for northern rock sole, 22.4 thousand t for Greenland turbot, and 153.7 thousand t for Pacific halibut. The estimated survey biomass decreased for most major fish taxa compared to 2015 levels. Walleye pollock biomass decreased 23%, Pacific cod 11%, Greenland turbot 11%, and Pacific halibut 11%. The estimated survey biomass increased by 48% for yellowfin sole and 4% for northern rock sole.

The summer 2016 survey period was warmer than the long-term average for the third consecutive year. Sea surface temperatures recorded during the 2016 survey ranged from 3.1 °C to 14.1 °C. The mean bottom temperature increased from 2015 to 4.5 °C, and was the warmest average near-bottom temperatures for this time series. The mean surface temperature was 9.5 °C, which was greater than the grand mean over 35 years, and was the warmest average sea surface temperature observed during this period.

For further information, contact Robert L. Lauth, (206)526-4121, Bob.Lauth@noaa.gov .

2016 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Aleutian Islands – RACE GAP

The National Marine Fisheries Service Alaska Fisheries Science Center (AFSC) Resource Assessment and Conservation Engineering (RACE) Division chartered the fishing vessels *Alaska Provider* and *Sea Storm* to conduct the 2016 Aleutian Islands Biennial Bottom Trawl Survey of groundfish resources. This was the fourteenth survey in the series which began in 1984, was conducted triennially for most years until 1999, and then biennially since. The two vessels were each chartered for 70 days. The cruise originated from Dutch Harbor, Alaska on June 6th and after the vessels were loaded and other preparations (*e.g.*, wire measuring, wire marking, and test towing), the first survey tows were conducted on ?? June. The cruise progressed from Unimak Pass in the east and progressed to west to Stalemate Bank. A few unoccupied stations were sampled on the return leg and the survey concluded back at Dutch Harbor on August 18th (Figure 1). Sampled depths range from approximately 15 to 500 m. The cruise was divided into three legs with breaks at Adak to change crews and re-provision.

A primary objective of this survey is to continue the data time series begun in 1980 to monitor trends in distribution and abundance of important groundfish species. During these surveys, we measure a variety of physical, oceanographic, and environmental parameters while identifying and enumerating the fishes and invertebrates collected in the trawls. Specific objectives of the 2016 survey include: define the distribution and estimate the relative abundance of principal groundfish and important invertebrate species that inhabit the Aleutian archipelago, measure biological parameters for selected species, and collect age structures and other samples. We also conducted a number of special studies and collections for investigators both from within the AFSC and from elsewhere.

The survey design is a stratified-random sampling scheme based 45 strata of depths and regions and applied to a list of known, trawlable stations identified from previous surveys. Stations were allocated amongst the strata using a Neyman scheme weighted by stratum areas, cost of conducting a tow, past years' data, and the ex-vessel values of key species. Stations were sampled with the RACE Division's standard four-seam, high-opening Poly Nor'Eastern survey trawl equipped with rubber bobbin roller gear. This trawl has a 27.2 m headrope and 36.75 m footrope consisting of a 24.9 m center section with adjacent 5.9 m "flying wing" extensions. Accessory gear for the Poly Nor'Eastern trawl includes 54.9 m triple dandylines and 1.8 × 2.7 m steel V-doors weighing approximately 850 kg each. The charter vessels conducted 15-minute trawls at pre-assigned stations. Catches were sorted, weighed, and enumerated by species. Biological information (sex, length, age structures, individual weights, stomach contents, etc.) were collected for major groundfish species. Specimens and data for special studies (*e.g.*, maturity observations, tissue samples, photo vouchers) were collected for various species, as requested by researchers at AFSC and other cooperating agencies and institutions. Specimens of rare fishes or invertebrates, including corals, sponges, and other sessile organisms were collected on an opportunistic basis.

Biologists completed 419 of 420 planned stations in the entire shelf and upper slope to a depth of 500 m. Trawling operations began on June 7th and were completed on August 8th. RACE GAP biologists attempted 468 bottom trawl hauls at 426 stations, 419 of which were successfully sampled, in depths ranging from 45-460 m along the shelf and upper slope of the Aleutian archipelago. There were 138 fish and 518 invertebrate taxa were collected weighing 491,120 kg and 11,186 kg. During this survey, biologists vouchered at least 374 specimens for further identification. Totals of 118,590 lengths and 6,638 otoliths were collected for ageing, constructing population length composition, and to support special collections for ecological studies and life history characterization.

Pacific ocean perch or POP (*Sebastes alutus*) was the most abundant species with an estimated biomass of 982,522 metric tons (t). Atka mackerel (*Pleurogrammus monopterygius*) and northern rockfish (*Sebastes polyspinis*) were also abundant with estimated biomasses of 447,976 and 253,215 t, respectively. Catches of POP were large throughout the survey area at intermediate depths. Arrowtooth flounder (*Atheresthes stomias*) was the most abundant flatfish species, having almost twice the biomass of second-place northern rock sole (*Lepidopsetta polyxystra*). The skate assemblage was primarily comprised of three skate species, whiteblotched (*Bathyraja maculata*), Aleutian (*B. aleutica*), and leopard (*B. panthera*) skates, with a wide diversity of species captured in the eastern portion of the survey area.

A validated data set was finalized on 27 September 2016, and final estimates of abundance and length composition of managed species and species groupings were delivered to the Groundfish Plan Team (Plan Team) of the NPFMC at that time. Data and distributin maps are available at https://www.afsc.noaa.gov/RACE/groundfish/survey_data/data.htm and at https://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm. The Plan Team incorporated these survey results directly into Aleutian Islands stock assessment and ecosystem forecast models that form the basis for groundfish harvest advice on the 2016 ABCs and TACs.

The data report from the 2015 GOA Bottom Trawl Survey (von Szalay et al. 2016) is available at https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-325.pdf

For further information contact Wayne Palsson (206) 526-4104, Wayne.Palsson@noaa.gov

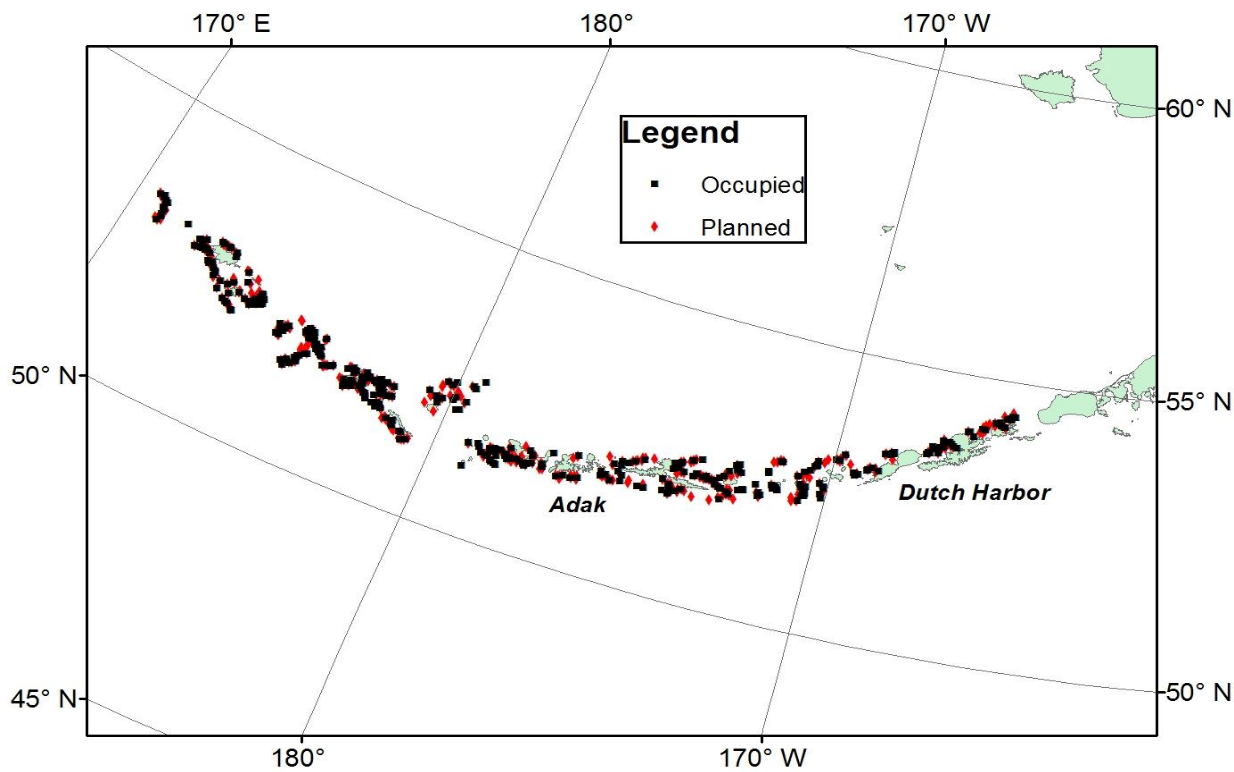


Figure 1. Planned and occupied stations during the 2016 Aleutian Island Biennial Bottom Trawl Survey.

Winter Acoustic-Trawl Surveys in the Gulf of Alaska -- MACE Program

Two AT surveys of walleye pollock (*Gadus chalcogrammus*) were conducted in the GOA during the winter of 2016. The first (cruise DY2016-02) surveyed the Shumagin Islands area (comprising Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Sanak Trough, and Morzhovoi and Pavlof bays from 13-17 February. A second AT survey (cruise DY2016-04) covered Shelikof Strait and Marmot Bay from 14-24 March.

All surveys were conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. Midwater and near-bottom acoustic backscatter at 38 kHz was sampled using an Aleutian Wing 30/26 Trawl (AWT) to estimate the abundance of walleye pollock. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques. The trawl hauls conducted in the GOA winter surveys included a CamTrawl stereo camera attached to the net forward of the codend. The CamTrawl was used to capture stereo images for species identification and fish length measurements as fishes passed through the net toward the codend, primarily as a comparison with lengths measured from fish caught in the net in support of research on automated image analysis.

In the Shumagin Islands, acoustic backscatter was measured along 756 km (408 nmi) of transects. The survey transects were spaced 1.9 km (1.0 nmi) apart directly south and east of Renshaw Point and in the eastern half of Unga Strait, 4.6 km (2.5 nmi) apart in Stepovak Bay and West Nagai Strait, and 3.7 km (2.0 nmi) in the western half of Unga Strait, and 9.3 km (5.0 nmi) apart in Shumagin Trough. The majority of walleye pollock in the Shumagin Islands were between 35 and 45 cm fork length (FL), which is characteristic of age-4 walleye pollock, and suggests the continued success of the 2012 year-class. This size range accounted for 93% of the numbers and 90% of the biomass of all pollock observed in this area. These walleye pollock were present in the inner portion of Shumagin Trough, off Renshaw Point, in Stepovak Bay, and in the West Nagai Strait area. Although adult pollock > 45 cm FL have historically been detected off Renshaw Point, they were basically absent from this area in 2016. The majority of the pollock were scattered throughout the water column below 25 m, and occasionally formed small, very dense (i.e., “cherry ball”) schools. The maturity composition of males > 40 cm FL (n = 71) was 17% immature, 20% developing, 38% pre-spawning, 24% spawning, and 1% spent. The maturity composition of females > 40 cm FL (n = 133) was 17% immature, 29% developing, 53% pre-spawning, 0% spawning, and 1% spent. The biomass estimate of 20,706 t (with a relative estimation error of 7.2%), based on data from acoustic transects and specimens collected from eight AWT hauls, is nearly one-third of the 2015 estimate (61,369) and 26% of the historical mean of 75,351 t for this survey.

In Sanak Trough, acoustic backscatter was measured along 191 km (103 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 24 and 70 cm FL with a dominant length mode between 35 and 45 cm FL. This mode accounted for 81% of the numbers and 72% of the biomass of all pollock observed in Sanak Trough and likely represents age-4 fish. Pollock > 45 cm accounted for 27% of the pollock biomass in this area. The majority of walleye pollock was located in the eastern portion of the middle of the surveyed Trough and was scattered throughout the water column below 40 m. The maturity composition of males > 40 cm FL (n = 37) was 0% immature, 30% developing, 57% pre-spawning, 14% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 31) was 0% immature, 39% developing, 55% pre-spawning, 6% spawning, and 0% spent. The biomass estimate of 3,556 t (with a relative estimation error of 6.9%), based on data from acoustic transects and specimens collected from two AWT hauls, is 20% of the 2015 estimate (17,863 t) and 8% of the historic mean of 43,107 t for this survey.

In Morzhovoi Bay, acoustic backscatter was measured along 70 km (38 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 28 and 65 cm FL with a dominant length mode between 35 and 45 cm FL (Fig. 5). This mode accounted for 65% of the numbers and 50% of the biomass of all pollock observed in Morzhovoi Bay and likely represents age-4 fish. Pollock > 45 cm accounted for 49% of the pollock biomass in this area, the highest percentage of all areas surveyed during the 2016 winter GOA cruises. The majority of walleye pollock was located in the southern portion of the surveyed area and was scattered throughout the water column below 40 m. The maturity composition of males > 40 cm FL (n = 14) was 0% immature, 14% developing, 36% pre-spawning, 29% spawning, and 21% spent. The maturity composition of females > 40 cm FL (n = 41) was 15% immature, 12% developing, 51% pre-spawning, 15% spawning, and 7% spent. The biomass estimate of 11,412 t, based on data from acoustic transects and specimens collected from one AWT haul (with a relative estimation error of 12.0%), is comparable to the biomass estimate observed during the first year the Bay was surveyed (2006 = 11,700 t) and 5 times higher than the three estimates generated between 2007 and 2013 (mean 2,259 t; standard deviation = 397 t).

In Pavlof Bay, acoustic backscatter was measured along 84 km (45 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 33 and 67 cm FL with a dominant length mode between 35 and 45 cm FL (Fig. 5). This mode accounted for 78% of the numbers and 66% of the biomass of all pollock observed in Pavlof Bay and likely represents age-4 fish. Pollock > 45 cm accounted for 33% of the pollock biomass in this area. The majority of walleye pollock was located in the mouth of the bay and was scattered throughout the water column below 60 m. The maturity composition of males > 40 cm FL (n = 30) was 0% immature, 10% developing, 40% pre-spawning, 40% spawning, and 10% spent. The maturity composition of females > 40 cm FL (n = 77) was 8% immature, 12% developing, 61% pre-spawning, 12% spawning, and 8% spent. The biomass estimate of 2,130 t (with a relative estimation error of 14.7%), based on data from acoustic transects and specimens collected from one AWT haul, is the first estimate generated for this area. A survey of Pavlof Bay was also conducted in 2002 and 2010, but an equipment malfunction and inclement weather, respectively, prevented trawling.

In the Shelikof Strait sea valley, acoustic backscatter was measured along 1,496 km (808 nmi) of transects spaced 13.9 km (7.5 nmi) apart. The majority of walleye pollock in Shelikof Strait were between 35 and 45 cm fork length (FL), which is characteristic of age-4 walleye pollock, and suggests the continued success of the 2012 year-class. This size range accounted for 90% of the numbers and 88% of the biomass of all pollock observed in this area. Smaller fish (< 35 cm FL) made up a very small portion of the biomass (3%), and no pollock less than 22 cm FL were observed. Large adults (≥ 45 cm) also contributed little (9%) to overall biomass in 2016. Walleye pollock biomass was observed throughout the surveyed area and was most abundant in the north-central part of the surveyed area between 75 and 250 m. Dense midwater pollock aggregations of 35-45 cm FL pollock were encountered throughout the survey area. Spawning aggregations historically observed in the northwestern part of the Strait were not seen in 2016, which is in contrast to previous years. The maturity composition of males > 40 cm FL (n = 237) was 4% immature, 3% developing, 12% pre-spawning, 80% spawning, and 2% spent. The maturity composition of females > 40 cm FL (n = 259) was 10% immature, 14% developing, 64% pre-spawning, 5% spawning, and 5% spent. The biomass estimate of 1,633 million fish weighing 665,059 t (with a relative estimation error of 6.5%), based on acoustic data and specimens collected from 19 AWT hauls, is nearly 80% of the 2015 estimate (2,212 million fish weighing 845,306) and 37% higher than the mean of 2,787 million fish weighing 486,391 t observed 1992-2015.

In Marmot Bay, acoustic backscatter was measured along 139 km (75 nmi) of transects spaced 3.7 km (2 nmi) apart in the Spruce Island Gully and inner Marmot Bay. Weather and available time limited acoustic backscatter in the outer Bay to be measured along 43 km (23 nmi) of zig-zag trackline. Walleye pollock ranged between 24 and 66 cm FL with a dominant length mode between 35 and 45 cm FL. This mode accounted for 77% of the numbers and 65% of the biomass of all pollock observed in Marmot Bay and likely represents age-4 fish. The majority of walleye pollock biomass occurred in aggregations in the inner Bay north of Spruce Island and in Spruce Island Gully and was scattered throughout the water column below 30 m. The maturity composition of males > 40 cm FL (n = 66) was 0% immature, 0% developing, 0% pre-spawning, 91% spawning, and 9% spent. The maturity composition of > than 40 cm FL (n = 108) was 0% immature, 6% developing, 35% pre-spawning, 28% spawning, and 31% spent. The biomass estimate of 37, 161 t (with a relative estimation error of 9.9% in the inner trough and 17.9% in the outer trough), based on data from acoustic transects and specimens collected from three AWT hauls plus one Cam-Trawl only (i.e., open codend) haul, is the highest in the history of the Marmot survey and 24,481 t higher than the historic mean for this survey (12,680).

Winter acoustic-trawl surveys of walleye pollock in the Aleutian Basin near Bogoslof Island

An acoustic-trawl survey of walleye pollock in the southeastern Aleutian Basin near Bogoslof Island was conducted 4-8 March, 2016 aboard the NOAA Ship *Oscar Dyson* (cruise DY2016-03). Acoustic backscatter was measured at 38 kHz along 36 north-south parallel transects, which were spaced 5.6 km (3-nmi) apart. The survey covered 1,400 nmi^2 of the Central Bering Sea Convention Specific Area.

Eleven trawl hauls were conducted midwater to identify the species composition of acoustic backscatter. Pollock were the dominant catch by weight and by number, and they ranged from 34 cm to 69 cm fork length, with modes at 45 and 47 cm fork length. Across the entire surveyed region, over 60% of the female pollock were in the post-spawning maturity condition, with only about 7% in the pre-spawning stage. For the pre-spawning females, the average gonado-somatic-index was 0.09.

The pollock abundance estimates for the southeastern Aleutian Basin near Bogoslof Island were 866 million fish, weighing 507 thousand t (relative estimation error 11%). The 2016 estimates represent a 665% increase in abundance and a 352% increase in biomass from the 2014 survey estimates. Fifty eight percent of the 2016 estimated biomass was distributed in the Samalga Pass region, and 42% was distributed in the Umnak region.

The estimated pollock population in 2016 was dominated by younger pollock. Ninety-one percent of the 2016 population was 50 cm or smaller and 97% was less than 9 years of age. The most abundant year class was represented by 7-year-old fish from the 2009 year class (42%), followed by 4-year-old fish from the 2012 year class (20%), and 6-year-old fish from the 2010 year class (19%).

Summer acoustic-trawl survey of walleye pollock in the eastern Bering Sea

The MACE Program conducted an AT survey of midwater walleye pollock between 12 June and 17 August 2016 aboard the NOAA ship *Oscar Dyson* (cruise DY2016-08). This survey has been conducted since 1979; triennially through 1994, and biennially or annually since then. The survey design covered the EBS shelf between roughly the 50 m and 1000 m isobaths, from about 161° W to the U.S.–Russian Convention Line. Permission to survey pollock in the Cape Navarin area of Russia was requested, but not granted for the first time since 2006. The 2016 survey consisted of 28 north-south transects spaced 37 km (20 nautical miles (nmi)) apart, totaling 9323 km (5034 nmi) and covering a 334,951 km^2 (100,674 nmi^2) area. The primary objective was to collect daytime, 38-kHz acoustic backscatter and trawl data to estimate the abundance of walleye pollock. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques. Additional survey sampling included conductivity-temperature-depth (CTD) measurements to characterize the Bering Sea shelf temperature conditions, and supplemental trawls to improve acoustic species classification and to obtain an index of euphausiid abundance using multiple frequency techniques. Specialized sampling devices used during the survey included a trawl-mounted stereo camera (CamTrawl) designed to identify species and determine size and density of animals as they pass by the camera during a haul, a broadband acoustic instrument for estimating fish sizes, and large and small lowered cameras with either red or white strobe lights for a fish-camera avoidance experiment. We deployed 2 Saildrones equipped with echosounders, compared their acoustic systems to the *Oscar Dyson*, and used them in a fur seal prey experiment.

Biological data and specimens were collected from 162 trawl hauls, 104 with an Aleutian wing 30/26 trawl (AWT), 4 with an 83-112 Eastern bottom trawl, 48 with a Methot trawl and 6 with a modified Marinovich trawl. The majority of hauls targeted backscatter during daytime for species classification. Among midwater hauls used to classify backscatter for the survey, walleye pollock was the most abundant species by weight (90%) and by number (94%), followed by northern sea nettle jellyfish (*Chrysaora melanaster*) (8% by weight and 4% by number). Among bottom trawls, pollock was the most abundant species (81% by weight and 74% by number) followed by rock sole spp. (5% by weight and 9% by number). In Marinovich hauls, *Aequorea* sp. (42%) and northern sea nettle (35%) jellyfish dominated the catch by weight, while euphausiids (56%) and age-0 pollock (26%) dominated the catch numerically. Finally, Methot hauls were dominated by northern sea nettles (58%), euphausiids (21%), and moon jellies (10%) by weight, respectively, and numerically, by euphausiids (91%).

Mean EBS shelf water temperatures in 2016 (surface and near bottom) as measured during the AFSC bottom trawl survey were the highest on record since the early 1980s, continuing a warming trend evident since 2013. About 56% of the summed acoustic backscatter at 38 kHz observed between near the surface and 3 m off bottom during the 2016 survey was attributed to adult or juvenile walleye pollock. This was similar to that in the past two AT surveys (45% in 2014 and 56% in 2012). The remaining non-pollock water column backscatter was attributed to an undifferentiated plankton-fish mixture (42%), or in a few isolated areas, to rockfishes (*Sebastes* spp.) or other fishes (~2%). Most walleye pollock were distributed evenly across the shelf from a region north of Port Moller on the Alaska Peninsula to the Convention Line, between roughly the 50 m and 200 m isobaths. Midwater pollock aggregations were observed farther east in Bristol Bay in 2016 than they had been during the previous decade.

Estimated pollock abundance in midwater (between 16 m from the surface and 3 m off bottom) in the U.S. EEZ portion of the Bering Sea shelf was 10.8 billion fish weighing 4.06 million t (relative estimation error 2.1%). This was about 18% higher than the 2014 biomass estimate (3.439 million t) and higher than has been observed since the late 1980s. Pollock abundance east of 170° W was 2.82 billion fish, weighing 1.52 million t (37% of total midwater biomass)*;* 4-year-old pollock (41 cm modal FL) from the large 2012 year-class comprised 75% of that biomass. This was an increase in biomass from 2014, and was the highest pollock biomass observed east of the Pribilof Islands in over 2 decades. Pollock biomass increased by a similar amount inside the Steller sea lion conservation area (SCA); annual variation in SCA biomass is well correlated with the entire survey estimates ($r^2 = 0.79$, $p < 0.001$). In U.S. waters west of 170° W, pollock numbered 7.95 billion and weighed 2.54 million t (63% of total shelf-wide biomass). Dominant modal lengths were 24, 33, and 40 cm fork length, corresponding to pollock aged 2, 3, and 4 years, and comprising 2%, 43% and 34% of the biomass west of the Pribilofs, respectively.

In terms of age composition, the 2016 survey estimated the largest group of four-year olds in the AT survey time series since prior to 1994. Most of these 4-year old fish were observed east of the Pribilof Islands. Pollock ages 2, 3, and 4 were dominant numerically (accounting for 9%, 41% and 38% of the total shelf-wide population, respectively.) These three age groups represented 80% of the total biomass. Pollock (ages 5+) totaled 12% of the population numerically, and made up 20% of the total biomass. Age-1 pollock were rarely observed in 2016 and made up less than 0.03% of the total biomass.

Summer 2014-2015 acoustic vessel of opportunity (AVO) index for midwater Bering Sea walleye pollock

In an effort to obtain annual information for midwater walleye pollock (*Gadus chalcogrammus*), acoustic backscatter at 38 kHz collected by the chartered AFSC bottom trawl survey vessels for a portion of the eastern Bering Sea shelf, from near surface to 3 m off bottom, was used to develop an abundance index that strongly correlated with the total estimated AT survey pollock biomass ($r^2 = 0.904$, $p = 0.004$, 2006-2012). This midwater pollock abundance index from 'vessels of opportunity' (AVO) has been estimated annually since 2006. It is an important component of the Bering Sea pollock stock assessment because it provides information on midwater pollock in years when the AT survey is not conducted. Every two years, AVO index estimates are provided to pollock stock assessment scientists and also summarized in a report available on the AFSC website.

The most recent AVO index results are from 2014-2015. The 2014 AVO index increased 29% from the 2013 index value, and 36% from 2012. The 2015 AVO index increased slightly (6%) from 2014. Both estimates (2014, 2015) exceeded all earlier time series estimates (2006-2013) based on non-overlapping 95% confidence intervals. Most pollock backscatter appeared to be distributed broadly across the shelf between 50 and 200 m isobaths in 2014 and 2015. The percentage of pollock backscatter east of the Pribilof Islands (east of 170° W longitude) in the AVO index was 24% in 2014 and 25% in 2015. This was similar to the percentage in 2013

(26%), but much greater than reported for summers 2010-2012 (range 4-9%). This implies that there has been more midwater pollock biomass east of the Pribilof Islands in recent years, consistent with findings from the biennial AT survey; comparison of the AVO index and AT survey time series continues to show a strong correlation ($r^2 = 0.90$, $p = 0.0011$).

Midwater hauls were conducted for the first time in 2014 to sample midwater pollock aggregations during the 2014 (n = 31) and 2015 (n = 32) BT surveys to investigate the feasibility of using these hauls to convert the AVO backscatter index to abundance at length or age. Some portions of the AVO index area were not sampled by these hauls in both years. Preliminary analyses of these haul data (ability to target and catch pollock, catch composition, and length-frequency comparisons) showed 1) hauls targeted appropriate fish layers and were dominated by pollock, 2) bottom trawls and midwater trawls caught pollock of different length compositions and 3) length modes in midwater hauls from BT and AT surveys were similar, but occurred in different proportions even when restricted to the same subarea. Due to a number of factors including logistical and staffing constraints, and to consensus that the AVO backscatter index time series provides useful information to the stock assessment in its current form, full evaluation of how well BT survey haul data could be used to convert AVO backscatter to number of fish at length or age was deferred to a later time.

For more information, contact MACE Program Manager, Chris Wilson, (206) 526-6435.

Longline Survey – ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2016. The survey is a joint effort involving the AFSC's Auke Bay Laboratories and Resource Assessment and Conservation Engineering (RACE) Division. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978 to 1994 and also samples gullies not sampled during the cooperative longline survey. In 2016, the thirty-seventh annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Aleutian Islands was conducted. One hundred-forty-eight longline hauls (sets) were completed during June 1 – August 26 by the chartered fishing vessel *Ocean Prowler*. Total groundline set each day was 16 km (8.6 nmi) long and contained 160 skates and 7,200 hooks except in the eastern Bering Sea where 180 skates with 8,100 hooks were set.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), shortspine thornyhead (*Sebastolobus alascanus*), and Pacific halibut (*Hippoglossus stenolepis*). A total of 74,139 sablefish, with an estimated total round weight of 200,725 kg (442,523 lb), were caught during the survey. This represents an increase of 16,000 sablefish over the 2015 survey catch. Sablefish, shortspine thornyhead, and Greenland turbot (*Reinhardtius hippoglossoides*) were tagged with external Floy tags and released during the survey. Length-weight data and otoliths were collected from 2,238 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at five stations in the western Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 18 stations in 2016. Sperm whales were observed depredating on the gear at one station in the Aleutian Islands, five stations in the central Gulf of Alaska, five stations in the West Yakutat region, and six stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2016 longline survey. Satellite pop-up tags were deployed on sablefish throughout the Gulf of Alaska. Information from these tags will be used to investigate movement patterns within and out of the Gulf of Alaska and potentially help identify spawning areas for sablefish. Stable isotope samples were collected from major prey species of sperm whales to create baseline data for a sperm whale stable isotope diet project. Finally, opportunistic photo identification of both sperm and killer whales were collected for use in whale identification projects.

Longline survey catch and effort data summaries are available through the Alaska Fisheries Science Center's website: http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.php. Full access to the longline survey database is available through the Alaska Fisheries Information Network (AKFIN). Catch per unit effort (CPUE) information and relative population numbers (RPN) by depth strata and management regions are provided. These estimates are available for all species caught in the survey. Previously RPN's were only available for depths that corresponded to sablefish habitat but in 2013 these depths were expanded to 150m - 1000m. Inclusion of theshallower depths provides expanded population indices for the entire survey time series for species such as Pacific cod, Pacific halibut, and several rockfish species.

For more information, contact Chris Lunsford at (907) 789-6008 or chris.lunsford@noaa.gov.

2016 Northern Bering Sea Integrated Ecosystem Survey – ABL

A surface trawl survey was conducted by the Ecosystem Monitoring and Assessment program of the Alaska Fisheries Science Center from Aug 27 to Sep 14, 2016 aboard the F/V Cape Flattery and included the collection of data on pelagic fish species and oceanographic conditions in the Northern Bering Sea shelf from 60°N to 65.5°N (Fig. 1). Overall objectives of the survey were to provide an integrated ecosystem assessment of the northeastern Bering Sea to support 1) the Alaska Fisheries Science Center's, Loss of Sea Ice Program and Arctic Offshore Assessment Activity Plan, 2) the Alaska Department of Fish and Game Chinook Salmon Research Initiative program, 3) the North Pacific Research Board proposal #1423, Defining critical periods for Yukon and Kuskokwim river Chinook salmon, that includes expanding the southeastern Bering Sea integrated ecosystem model to the Northeast Bering Sea shelf, and 4) sample collections within Region 2 of the Distributed Biological Observatory. Participating institutions included: 1) Alaska Fisheries Science Center (AFS), Auke Bay Laboratories, Juneau, AK, 2) Alaska Department of Fish and Game (ADFG), Commercial Fisheries Division, Anchorage, AK, 3) U.S. Fish and Wildlife Service (USFWS), Office of Migratory Bird Management, Anchorage, AK, 4) Ocean Associates (contracting agency for AFSC), and 5) the National Institute of Fisheries Science, Korea.

Physical and biological data were collected from 32 surface trawl stations and oceanographic data were collected at 3 Distributed Biological Observatory stations in 2016. Headrope and footrope depth and temperature were monitored with temperature and depth loggers (SBE39) at each station.

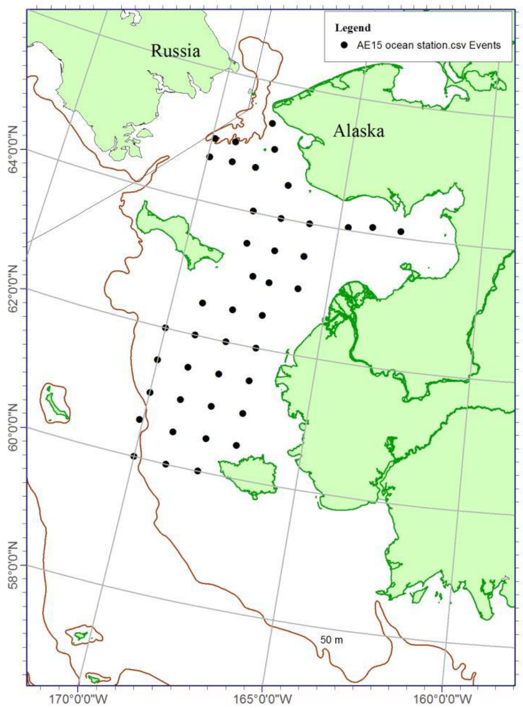


Figure 1. Stations planned to be sampled during the August 27 to September 14, 2016 integrated ecosystem survey in the northern Bering Sea.

For more information, contact Kris Cieciel at (907) 789-6089 or Kristin.Cieciel@noaa.gov

2016 Gulf of Alaska Integrated Ecosystem Survey – ABL

The Gulf of Alaska assessment is a fisheries and oceanographic survey conducted in the eastern Gulf of Alaska during the summer season. This survey has been completed each year since 2010, and is a continuation of the monitoring efforts established by the Gulf of Alaska Integrated Ecosystem Research Project. The scientific objective of the survey is to assess Young of the Year (YOY) groundfish, salmon, zooplankton, and oceanographic conditions in the coastal, shelf, slope, and offshore waters of the eastern Gulf of Alaska. In 2016, the chartered fishing vessel Northwest Explorer (B&N Fisheries) was the sampling platform used to provide information on species distribution, ecosystem structure, and marine productivity in response to changes in climate patterns and temperature anomalies (i.e. the warm blob, and El Niño). All collection locations for fish, plankton, and oceanography were made at pre-determined master station locations.

Specific objectives listed in the Cruise Plan:

1) Observe epi-pelagic fish communities by sampling with a rope trawl at the surface. Fish species of interest that were retained from trawl: age-0 arrowtooth flounder (*Atheresthes stomias*), age-0 rockfish species (*Sebastes* spp.), age-0 walleye pollock (*Gadus chalcogrammus*), age-0 Pacific

cod (*Gadus macrocephalus*), juvenile Pacific salmon (*Onchorhynchus* spp.), age-0 sablefish (*Anoplopoma fimbria*) and forage fishes.

2) Collect electronic oceanographic data including CTD (Conductivity-temperature-depth) vertical profiles of temperature, salinity, light transmission, chlorophyll a fluorescence, and photosynthetically available radiation (PAR).
3) Collect biological oceanographic samples by oblique bongo tows and water sampling via carousel and niskin botles.

Survey transect lines run parallel to one another and perpendicular to the coast. Along the coast, transect lines are spaced 20 nautical miles apart, with the exception of the 10 nm Cross Sound and Yakutat Valley lines (Figure 1). This was to increase the spatial resolution in these high interest areas. Onshore-offshore spacing was variable. Over the shelf, stations were spaced 10 nm apart, over the slope and basin, stations were spaced 20 nm apart. In the areas south of Yakutat Valley and North of Yakobi Island (south end of Cross Sound), transect lines stretched to 100 nm offshore with spacing previously described. An additional offshore grid, following these same conventions, was added in 2016 to survey out to the Exclusive Economic Zone for age-0 rockfishes and sablefish. Operations were completed between 0700 and 1900 daily.

The total sampling effort during 2016 included 109 occupied stations where fish sampling occurred. A total of 89 casts were made with a SeaBird Electronics 25 CTD. A total of 74 bongo tows were made using standard bongo array. A total of 369 chlorophyll a, 429 nutrient samples, and 30 salinity samples were collected.

Average surface (top ten meters) temperatures ranged from 11.780^{o} to 15.650^{o} Celsius. Average surface salinity ranged from 27.49‰ to 32.28‰. Surface temperatures rose in 2014, and continue to be elevated through the 2016 survey season. Maximum temperatures observed during 2015 were above 16^{o} Celsius.

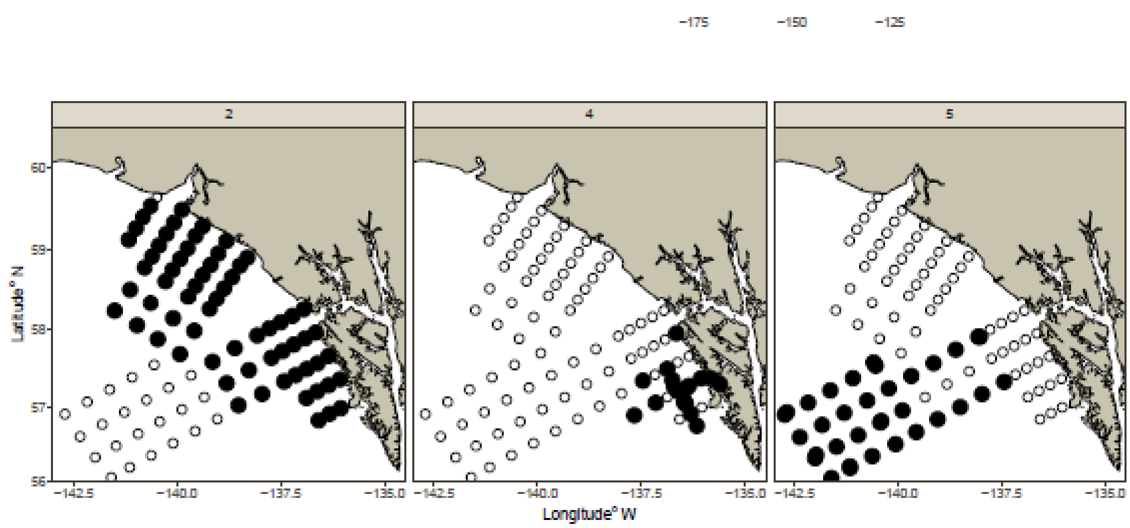


Figure 1. Station locations for the 2016 Gulf of Alaska integrated ecosystem survey conducted during July to August.

For more information contact Wes Strasburger at (907) 789-6009 or **wes.strasburger@noaa.gov**

2016 Southeastern Bering Sea Integrated Ecosystem Survey – ABL

Late-Summer Pelagic Trawl Survey (BASIS) in the Southeastern Bering Sea, September – October 2016

Scientists from the Recruitment Processes Alliance (RPA) of the Alaska Fisheries Science Center (AFSC) conducted a fisheries-oceanographic survey in the southeastern Bering Sea (SEBS) during the early fall aboard the NOAA Vessel *Oscar Dyson* from August 20 to October 7, 2016. The survey design covered the SEBS shelf between roughly the 50 m and 200 m isobaths, from 162º W to 171º W (Figure 1). Surface trawls (top 20 m) were conducted at selected stations and a midwater trawl was used to obliquely sample the entire water column (200 m maximum) at each station. In addition, the survey included sampling the 70 m isobath and the Distributed Biological Observatory (DBO) stations, that are two long-term time series describing the physical and biological properties of the Bering Sea shelf, from approximately 56.5º N to 63.5º N. Prior to the RPA surveys, fisheries-oceanographic surveys were conducted annually (2002-2012, 2014) as part of the Bering-Aleutian Salmon International Survey (BASIS) and eventually the Bering Sea Project (BSP). The main objective of the RPA surveys in the SEBS is to collect ecosystem data with a priority to provide mechanistic understanding of the factors that influence recruitment of walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*).

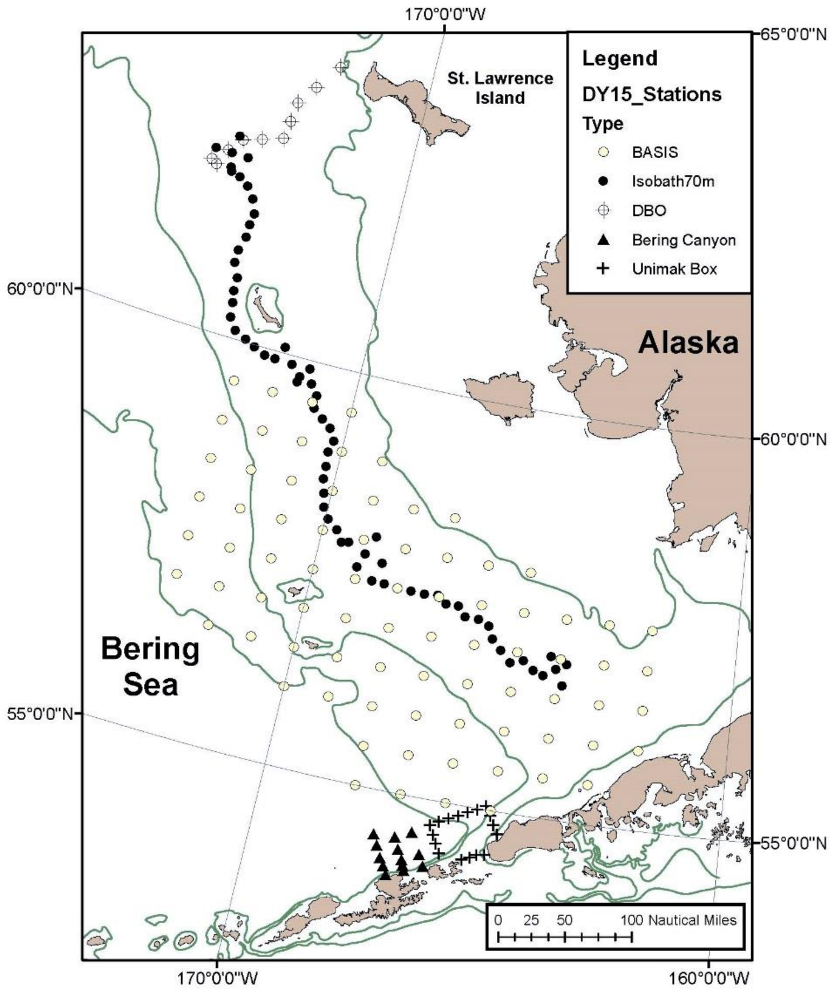


Figure 1. Station locations for the August to October 2016 southeastern Bering Sea integrated ecosystem survey also known as BASIS.

For more information contact Alex Andrews at (907) 789-6655 or Alex.Andrews@noaa.gov

North Pacific Groundfish and Halibut Observer Program (Observer Program) – FMA

The North Pacific Groundfish and Halibut Observer Program (Observer Program) provides the regulatory framework for NMFS-certified observers to obtain information necessary to conserve and manage the groundfish and halibut fisheries in the Gulf of Alaska (GOA) and the Bering Sea and Aleutian Islands (BSAI) management areas. Data collected by well-trained, independent observers are a cornerstone of management of the Federal fisheries off Alaska. These data are needed by the North Pacific Fishery Management Council (Council) and NMFS to comply with the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the

Marine Mammal Protection Act, the Endangered Species Act, and other applicable Federal laws and treaties.

Observers collect biological samples and fishery-dependent information used to estimate total catch and interactions with protected species. Managers use data collected by observers to manage groundfish and prohibited species catch within established limits and to document and reduce fishery interactions with protected resources. Scientists use observer data to assess fish stocks, to provide scientific information for fisheries and ecosystem research and fishing fleet behavior, to assess marine mammal interactions with fishing gear, and to assess fishing interactions with habitat. Although NMFS is working with the Council and industry to develop methods to collect some of these data electronically, currently much of this information can only be collected independently by human observers.

The current Observer Program was implemented in 2013 when the previous Observer Program was restructured to address sampling issues associated with non-random observer deployment on some vessels and fisheries. At that time, observer coverage was expanded to include vessels that were previously unobserved, and increased the number of vessels in the full observer coverage category with the overall goal to improve estimates of catch and bycatch. The Council has recommended several amendments to the Observer Program to clarify and refine which vessels are in the full coverage category and which are in the partial coverage. The following regulatory and FMP amendments have been implemented since 2013 to modify observer coverage requirements for specific groups of vessels under North Pacific Observer Program:

- BSAI Amendment 112 and GOA Amendment 102 revised observer coverage requirements for certain small catcher/processors (81 FR 17403, March 29, 2016). Effective March 29, 2016.
- BSAI Amendment 109 revised observer coverage requirements for catcher vessels less than or equal to 46 ft LOA when groundfish CDQ fishing (81 FR 26738, May 4, 2016). Effective June 3, 2016.
- A regulatory amendment revised observer coverage requirements for BSAI trawl catcher vessels (81 FR 67113, September 30, 2016). Effective October 31, 2016.

Under the restructured Observer Program, all vessels and processors in the groundfish and halibut fisheries off Alaska are assigned to one of two observer coverage categories (1) a full coverage category; or (2) a partial coverage category.
Vessels and processors in the full observer coverage category must have comply with observer coverage requirements at all times when fish are harvested or processed. Specific requirements are defined in regulation at 50 CFR § 679.51(a)(2). The full coverage category includes:

- catcher/processors (with limited exceptions),
- motherships,
- catcher vessels while participating in programs that have transferable prohibited species catch (PSC) allocations as part of a catch share program,
- catcher vessels using trawl gear that have requested placement in the full coverage category for all fishing activity in the BSAI for one year, and
- inshore processors when receiving or processing Bering Sea pollock.

Independent estimates of catch, at-sea discards, and PSC are obtained aboard all catcher/processors and motherships in the full observer coverage category. At least one observer on each catcher/processor eliminates the need to estimate at-sea discards and PSC based on industry provided data or observer data from other vessels.

Catcher vessels participating in programs with transferable PSC allocations as part of a catch share program also are included in the full coverage category. These programs include Bering Sea pollock (both American Fisheries Act and Community Development Quota [CDQ] programs), the groundfish CDQ fisheries (CDQ fisheries other than halibut and fixed gear sablefish), and the Central GOA Rockfish Program.

Inshore processors receiving deliveries of Bering Sea pollock are in the full coverage category because of the need to monitor and count salmon under transferable PSC allocations.

The partial observer coverage category includes:

- catcher vessels designated on a Federal Fisheries Permit when directed fishing for groundfish in federally managed or parallel fisheries, except those in the full coverage category;
- catcher vessels when fishing for halibut individual fishing quota (IFQ) or sablefish IFQ (there are no PSC limits for these fisheries);
- catcher vessels when fishing for halibut CDQ, fixed gear sablefish CDQ, or groundfish CDQ using pot or jig gear (because any halibut discarded in these CDQ fisheries does not accrue against the CDQ group's transferable halibut PSC allocation);
- catcher/processors that meet criteria that allows assignment to the partial coverage category;
- shoreside or stationary floating processors, except those in the full coverage category.

Vessels in the partial coverage category had the option to "Opt in" to a voluntary Electronic Monitoring (EM) Program for 2016. The overall goal of the 2016 EM pre-implementation plan and the cooperative research was to assess the efficacy of using EM, in combination with other tools, for catch accounting of retained and discarded catch, and to identify key decision points related to operationalizing and integrating EM systems into the Observer Program for fixed gear vessels in a strategic manner. The experience and results from the data collected during this pre-implementation and research phase is being used to inform decisions and future Council alternatives for integrating electronic monitoring into the Observer Program.

For more information on the North Pacific Groundfish and Halibut Observer Program contact Chris Rilling at (206) 526-4194 or chris.rilling@noaa.gov

III. Reserves

IV. Review of Agency Groundfish Research, Assessment, and Management

A. Hagfish

B. Dogfish and other sharks

1. Research

Spiny Dogfish Ecology and Migration - ABL

A total of 183 satellite pop-off archival satellite tags (PSATs) have been deployed on spiny dogfish since 2009. Data has been successfully recovered from 153 tags. Eight tags have been physically recovered and complete data sets, with more detailed data, have been downloaded. Six spiny dogfish tagged in Puget Sound were tagged with acoustic tags in addition to PSATs, in an attempt to compare the light based geolocation used by the PSATs with known positions from the acoustic receivers. Recovered data from the PSATs, which includes temperature, depth, and geographic location derived from light, are still being analyzed. Preliminary results suggest that spiny dogfish can undertake large scale migrations rapidly and that they do not always stay near the coast (e.g. a tagged fish swam from nearby Dutch Harbor to Southern California in 9 months, in a mostly straight line, not following the coast). Also, the spiny dogfish that do spend time far offshore have a different diving behavior than those staying nearshore, with the nearshore animals spending much of the winter at depth and those offshore having a significant diel diving pattern from the surface to depths up to 450 m. A manuscript examining the availability of spiny dogfish to the GOA groundfish bottom trawl survey was published as part of the 2015 Lowell Wakefield Symmposium (Hulson et al. 2016) and another manuscript detailing the results of the double tagged fish in Puget Sound is in preparation.

For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Population Genetics of Pacific Sleeper Sharks - ABL

The purpose of this study is to investigate the population structure of Pacific sleeper sharks in the eastern North Pacific Ocean. Tissue samples have been opportunistically collected from ~200 sharks from the West Coast, British Columbia, the Gulf of Alaska, and the Bering Sea. Sequences from three regions of the mitochondrial DNA, cytochrome oxidase c- subunit 1 (CO1), control region (CR), and cytochrome b (cytb), were evaluated as part of a pilot study. A minimum spanning haplotype network separated the Pacific sleeper sharks into two divergent groups, at all three mtDNA regions. Percent divergence between the two North Pacific sleeper shark groups at CO1, cytb, and CR respectively were all approximately 0.5%. We obtained samples from Greenland sharks, *S microcephalus*, which are found in the Arctic and North Atlantic, to compare to the two observed groups in the North Pacific samples. The Greenland shark samples were found to diverge from the other two groups by 0.6% and 0.8% at CO1, and 1.5% and 1.8% at cytb. No Greenland shark data was available for CR. Results suggest that Greenland shark do not comprise one of the groups observed in the North Pacific sleeper shark samples. The consistent divergence from multiple sites within the mtDNA between the two groups of Pacific sleeper sharks indicate a historical physical separation. There appears to be no modern phylogeographic pattern, as both types were found throughout the North Pacific and Bering Sea. Continued sample collection and development of nuclear markers (microsatellites) is currently underway and will allow for a better understanding of the level of introgression, if any, between these two ‘populations’ of sharks.

For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

2. Stock Assessment

Sharks - ABL

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) are on biennial cycles. The GOA assessment coincides with the biennial GOA trawl survey in odd years (the last survey was in 2015) and the BSAI assessment is in even years, when there are trawl surveys in the BSAI. There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI or GOA, and most incidentally captured sharks are not retained.

In the 2016 assessments, catch estimates from 2003-2016 were updated from the NMFS Alaska Regional Office's Catch Accounting System. In the GOA, total shark catch in 2016 was 2,016 t, which was up from the 2015 catch of 1,414 t. One impact of observer restructuring (beginning in 2013) was that estimated shark catches in NMFS areas 649 (Prince William Sound) and 659 (Southeast Alaska inside waters) for Pacific sleeper shark and spiny dogfish by the halibut target fishery increased. Second, the average Pacific sleeper shark and spiny dogfish catch in NMFS areas 649 and 659 was 67 t and 135 t, respectively, compared to the historical average of < 1 t and ~14 t (SD = 23), respectively. There were approximately 2 t of salmon shark and other shark catch estimated in these areas as well. The catch in NMFS areas 649 and 659 does not count against the federal TAC, but if it were included the total catch of sharks in 2016 would be 2,238 t (instead of 2,016), which would still be below the ABC and OFL.

The last GOA trawl survey was in 2015. The 2015 survey biomass estimate (51,916 t, CV = 25%) is about a third of the 2013 biomass estimate of 160,384 t (CV = 40%); this variability is typical for spiny dogfish. The trawl survey biomass estimates are used only for ABC and OFL calculations for spiny dogfish and are not used for other shark species. The random effects model for survey averaging was used to estimate the 2015 GOA biomass for spiny dogfish (56,181 t), which was used for "Tier 5" calculations of spiny dogfish ABC and OFL.

For the GOA assessment, all sharks are managed under "Tier 6" as a complex. However, spiny dogfish ABC and OFL are calculating using "Tier 5" methods. They are not managed separately as a "Tier 5" species because of the "unreliable" nature of their biomass estimates. All other sharks in the GOA have species-specific ABC and OFLs set under "Tier 6" rules. The recommended GOA-wide ABC and OFL for the entire complex is based on the sum of the ABC/OFLs for the individual species, which resulted in an author recommended ABC = 4,514 t and OFL = 6,020 t for 2017 and 2018.

Because the survey biomass estimates on the BSAI are highly uncertain and not informative, all shark species are considered "Tier 6". In 2016 the "Tier 6" calculations in the BSAI are now based on the maximum catch of all sharks from the years 2003-2015 (changed from the years 1997-2007). The resultant recommended values for 2017 and 2018 were ABC = 517 t and OFL = 689 t. In the BSAI, estimates of total shark catch from the Catch Accounting System from 2016 were 126 t, which is not close to the ABC or OFL. Pacific sleeper shark are the primary species caught. These catch estimates incorporate the restructured observer program, but the impact appears to be minimal for BSAI sharks.

For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

C. Skates

1. Research

Skate Nurseries as Unique Habitats in the Eastern Bering Sea-RACE

Gerald Hoff, Duane Stevenson, Ingrid Spies, Chris Rooper, and James Orr

Recent HAPC designation of 8 skate nursery sites in the eastern Bering Sea by the North Pacific Fisheries Management Council has highlighted the recognition of these important habitats. This study focuses the uniqueness of the nursery habitats and the impact of fisheries encounters on nursery sites.

Currently there are approximately 8 nursery sites known in the eastern Bering Sea for the most abundant skate species, the Alaska skate. We are studying three aspects of its nursery habitat:

1) Using a predictive model to determine the most likely skate nursery habitat in the eastern Bering sea using environmental and benthic habitat data sets

2) Examining the genetic conductivity amongst nursery sites to determine if sites are vectors for population structure within a large marine ecosystem

3) Determining the impact fisheries may have on nursery sites by determining the species of skate eggs most encountered and the frequency of viable eggs vs empty cases. This aspect is conducted through the FMA observer program.

For further information, contact Gerald Hoff, (206)526-4580, Jerry.Hoff@noaa.gov.

2. Assessment

Bering Sea-The 2016 EBS shelf survey biomass estimate was substantially higher than in 2014 and the 2016 assessment featured the following new information: The total 2015 year-end catch was updated and incomplete 2016 catches were provided. New biomass estimates from the 2016 eastern Bering Sea (EBS) shelf, EBS slope and Aleutian Islands bottom trawl surveys were added. The Alaska skate model now incorporates EBS shelf survey biomass estimates through 2016, EBS shelf size composition through 2016, fishery length compositions through 2015, catch data through 2016, and an additional length-at-age dataset from vertebrae collected during 2015 on the EBS shelf trawl survey.

There were no changes to the assessment methodology. Model 14.2, accepted in 2014, continues to be the preferred model to estimate the dynamics of Alaska skate. Model 14.2 was updated to include new catch and survey data as well as a new length-at-age dataset. The random effects model continues to be used for estimating biomass for the "other skates" group, and was updated to include 2015 and 2016 survey biomass estimates.

The results of the Alaska skate model were similar to those presented in 2014. Even though the 2016 EBS shelf survey biomass estimate was substantially higher than in 2014, the model predicted a slight decline in spawning biomass. Total skate biomass increased on the EBS shelf after 2014, while it declined in the Aleutian Islands. Total skate biomass on the EBS slope was slightly lower in 2016 relative to 2012.

Since 2011, the Alaska skate portions of the ABC and OFL have been specified under Tier 3, while the "other skates" portions have been specified under Tier 5. Because projected spawning biomass for 2017 (108,926 t) exceeds $B_{40\%}$ (72,222 t), Alaska skates are managed in sub-tier "a" of Tier 3. Other reference points are $maxF_{ABC} = F_{40\%} = 0.079$ and $F_{OFL} = F_{35\%} = 0.092$. The Alaska skate portions of the 2017 and 2018 ABCs are 33,634 t and 31,498 t, respectively, and the Alaska skate portions of the 2016 and 2017 OFLs are 39,050 t and 36,570 t. The "other skates" component is assessed under Tier 5, based on a natural mortality rate of 0.10 and a biomass estimated using the random effects model. The "other skates" portion of the 2017 and 2018 ABCs is 7,510 t for both years and the "other skates" portion of the 2017 and 2018 OFLs is 10,013 t for both years. For the skate complex as a whole, OFLs for 2017 and 2018 total

49,063 t and 46,583 t, respectively, and ABCs for 2017 and 2018 total 41,144 t and 39,008 t, respectively.

Alaska skate, which may be viewed as an indicator stock for the complex, is not overfished and is not approaching an overfished condition. The skate complex is not being subjected to overfishing.

Gulf of Alaska- Skates are normally assessed on a biennial schedule, with full assessments presented in odd years to coincide with the timing of survey data. The 2016 assessment is an executive summary prepared with updated catch data.
The survey biomass trend was mixed between the stocks covered. Big skate biomass increased, other skates decreased, and longnose skates were stable.

Catch as currently estimated does not exceed any gulf-wide OFLs, and therefore, is not subject to overfishing. It is not possible to determine the status of stocks in Tier 5 with respect to overfished status. The random effects model was used for estimating proportions by area. Big and longnose skates have area-specific ABCs and gulf-wide OFLs; other skates have a gulf-wide ABC and OFL.

For more information contact Olav Ormseth (206) 526-4242 or olav.ormseth@noaa.gov.

D. Pacific Cod

1. Research

Examining the no-vertical-response assumption of Pacific cod to survey bottom trawls--GAP

Pacific cod stock assessment assumes a catchability of 47.3% (fish length = 60 – 81 cm) in the Bering Sea. This value was based upon an archival tag study (Nichol et al, 2007). Ten years of acoustic data gathered during summer Bering Sea Shelf surveys have been analyzed to investigate the assumption of a ‘no-vertical-response’ of Pacific cod to vessel noise or oncoming net. Acoustic data consist of calibrated 38 kHz Simrad ES60 echosounder data, corresponding to trawl catches exceeding 100 kg of Pacific cod, where other air-bladdered fish were <15% by weight. Nautical area scattering coefficients (NASC) values calculated for the 0 – 2.5 m regions of each tow were compared to those from 2.5 – 7 m regions. There is no empirical evidence to support a no-vertical-response assumption in Pacific cod in the Bering Sea.
For further information, contact Elaina Jorgensen, (206)526-4562, Elaina.Jorgensen@noaa.gov.

Climate Change and Location Choice in the Pacific Cod Longline Fishery-REFM/ESSR

Alan Haynie* and Lisa Pfeiffer
**For further information, contact Alan.Haynie@NOAA.gov*

Pacific cod is an economically important groundfish that is targeted by trawl, pot, and longline gear in waters off Alaska. An important sector of the fishery is the “freezer longliner” segment of the Bering Sea which in 2008 accounted for $220 million of the Pacific cod first wholesale value of $435 million. These vessels are catcher/processors, meaning that fish caught are processed and frozen in a factory onboard the ship.

A dramatic shift in the timing and location of winter season fishing has occurred in the fishery since 2000. This shift is related to the extent of seasonal sea ice, as well as the timing of its descent and retreat. The presence of winter ice cover restricts access to a portion of the fishing grounds. Sea ice also affects relative spatial catch per unit effort by causing a cold pool (water less than 2°C that persists into the summer) that Pacific cod avoid. The cold pool is larger in years characterized by a large and persistent sea ice extent. Finally, climate conditions and sea ice may have lagged effects on harvesters' revenue through their effect on recruitment, survival, total biomass, and the distribution of size and age classes. Different sizes of cod are processed into products destined for district markets. The availability and location of different size classes of cod, as well as the demand for these products, affects expected revenue and harvesters' decisions about where to fish.

Understanding the relationship between fishing location and climate variables is essential in predicting the effects of future warming on the Pacific cod fishery. Seasonal sea ice is projected to decrease by 40% by 2050, which will have implications for the location and timing of fishing in the Bering Sea Pacific cod longline fishery. Our research indicates that warmer years have resulted in lower catch rates and greater travel costs, a pattern which we anticipate will continue in future warmer years. This manuscript is being revised and will be submitted to a scientific journal in December 2016.

2. Stock Assessment

Bering Sea

Survey abundance in 2016 (944,621 t) was down by 35% from 2015 (1,102,261 t) and biomass in 2016 was 14% less than in 2014 (1,079,712 t). As estimated in the present model, spawning biomass is well above $B_{40\%}$ and has been increasing since 2010 due to a number of strong year-classes including 2006, 2008, 2011 and 2013. However, spawning biomass is projected to begin declining again in the near future.

Substantive changes have been made in the EBS Pacific cod assessment since 2015.
1. Catch data for 1991-2015 were updated, and preliminary catch data for 2016 were incorporated.
2. Commercial fishery size composition data for 2015 were updated, and preliminary size composition data from the 2016 commercial fisheries were incorporated.
3. Size composition data from the 2016 EBS shelf bottom trawl survey were incorporated.
4. The numeric abundance estimate from the 2016 EBS shelf bottom trawl survey was incorporated
(the 2016 estimate of 640 million fish was down about 35% from the 2015 estimate).
5. Age composition data from the 2015 EBS shelf bottom trawl survey were incorporated.

Additionally, many changes were made or considered in the stock assessment model since the 2015 assessment (Thompson 2015). Six models were presented in this year's preliminary assessment (Appendix 2.1), as requested in May and June by the Joint Team Subcommittee on Pacific Cod Models and the SSC. After reviewing the preliminary assessment, the BSAI Plan

Team and SSC requested that two models from the preliminary assessment (one of which is the base model that has been used for setting harvest specifications since the 2011 assessment) and four new models be presented in the final assessment.

Changes to the model of choice used in setting harvest specifications for 2017 and 2018 include elimination of intra-annual seasons, collapsing all gear types into a single fishery, internal estimation of the natural mortality rate and trawl survey catchability, forcing the fishery and survey selectivity schedules to be asymptotic, and removal of all time variability from both fishery and survey selectivity.

This stock is assigned to Tier 3a. The maximum 2017 ABC in this tier as calculated using the present model fit is 239,000 t, and the recommend ABC is the same. An ABC of 255,000 t was set for the preliminary 2018 ABC. The 2017 OFL from this new model is 284,000 t, which is less than the projected OFL from the previous assessment. The 2018 projected OFL is 302,000 t.

EBS Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Gulf of Alaska

The 2017 spawning biomass is projected at 91,198 t, well-above the $B_{40\%}$ estimate was 78,711 t. Recruitment was above average for the 2005-2013 period and below average for 2014-2016. Spawning biomass is expected to increase in 2018 and then decline thereafter.

The fishery catch data was updated for 2015 and 2016 (2016 expected total year catch was projected). Fishery size composition data were updated for 2015, preliminary fishery size composition were included for 2016, and weight and age at length and age composition data for the 2015 bottom trawl survey were included. For the first time, AFSC longline survey relative population numbers (RPNs) and length composition data for 1990 – 2016 were included. A major difference in the new models examined was that all the data were annually aggregated rather than stratified by season.

The author evaluated several models and presented a subset of models that included the model configuration from 2015 with updated data (Model 15.3), models similar to those presented at the September Plan Team meeting with updated data and extension of modeled ages to 20 years, and five additional model configurations. Model tuning was also evaluated.

Model 16.08.25 was recommended by the author and the Plan Team concurred. This model's performance in both fit to available data and retrospective patterns was better than other models. Major features of this model included dome shaped selectivity for pot and trawl fishery length compositions and survey length and age compositions. Natural mortality and survey catchability (Q) was estimated within the model. The estimate of natural mortality was considerably higher than the fixed value used in Model 15.3 (0.47 vs 0.38). The higher M resulted in a higher proportion of the population observed by the surveys compared to last year's assessment. The higher M (0.47) implies higher productivity but lower overall abundance than in previous assessments, which results in a higher $F_{40\%}$. This stock is in Tier 3a because the 2017 spawning biomass is estimated to be greater than $B_{40\%}$. The $F_{35\%}$ and $F_{40\%}$ are 0.652 and 0.530, respectively. The maximum permissible ABC of 88,342 t is a 10.4% decrease from the 2016 ABC of 98,600 t.

The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

For further information, contact Dr. Grant Thompson at (541) 737-9318 (BSAI assessment) or Dr. Steve Barbeaux (GOA assessment) (206) 526-4211.

E. Walleye Pollock

1. Research

Fall Energetic Condition of Age-0 Walleye Pollock Predicts Survival and Recruitment Success - ABL

Description of indicator: Average Energy Content (AEC; kJ/fish) is the product of the average individual mass and average energy density of age-0 Walleye Pollock (*Gadus chalcogrammus*; hereafter pollock) collected during the late-summer BASIS survey in the southeastern Bering Sea (SEBS). Fish were collected from surface trawls between 2003-2014 and from oblique (water column) trawls in 2015. The average individual mass is calculated by dividing the total mass by the total number of age-0 pollock caught in each haul. The average energy density is estimated in the laboratory from multiple (2-5) fish within ± 1 standard deviation of the mean length (see Siddon et al., 2013a for detailed methods). The haul-specific energy value is weighted by catch to estimate average energy density per station. The product of the two averages represents the average energy content for an individual age-0 pollock in a given year.

We relate AEC to the number of age-1 and age-3 recruits per spawner (R/S) using the index of adult female spawning biomass as an index of the number of spawners. Relating the AEC of age-0 pollock to year class strength from the age-structured stock assessment indicates the energetic condition of pollock prior to their first winter predicts their survival to age-1 and recruitment success to age-3.

Status and trends: Energy density (kJ/g), mass (g), and standard length (SL; mm) of age-0 pollock have been measured annually since 2003 (except 2013 when no survey occurred). Over that period, energy density has varied with the thermal regime in the SEBS. Between 2003 and 2005 the southeastern Bering Sea experienced warm conditions characterized by an early ice retreat. Thermal conditions in 2006 were intermediate, indicating a transition, and ice retreated much later in the years 2007-2012 (i.e., cold conditions). Warm conditions returned in 2014 and have persisted through at least summer 2016.

The transition between warm and cold conditions is evident when examining energy density over the time series (Fig. 1). Energy density was at a minimum in 2003 (3.63 kJ/g) and increased to a maximum of 5.26 kJ/g in 2010. In contrast, the size (mass or length) of the fish has been less influenced by thermal regime. The AEC of age-0 pollock in 2003-2015 accounts for 46% of the variation in the number of age-1 recruits per spawner and 47% of the variation in the number of age-3 recruits per spawner (Fig. 2).

Factors influencing observed trends: The AEC of age-0 pollock integrates information about size and energy density into a single index, therefore reflecting the effects of size dependent mortality over winter (Heintz and Vollenweider, 2010) as well as prey conditions during the age-0 period. Late summer represents a critical period for energy allocation in age-0 pollock (Siddon et al., 2013a) and their ability to store energy depends on water temperatures, prey quality, and foraging costs (Siddon et al., 2013b).

Prey availability for age-0 pollock differs between warm and cold years with cold years having greater densities of large copepods (e.g., *Calanus marshallae*) over the SEBS shelf (Hunt et al., 2011). Zooplankton taxa available in cold years are generally higher in lipid content, affording age-0 pollock a higher energy diet than that consumed in warm years. Lower water temperatures also optimize their ability to store lipid (Kooka et al., 2007).

Implications: The current model indicates that the 2015 year-class is predicted to have intermediate overwinter survival to age-1 and recruitment success to age-3. The SEBS is experiencing warm conditions, although age-0 pollock in 2015 may have utilized the cold pool as a refuge which may act as a buffer against recruitment declines for this year class (Duffy-Anderson et al., submitted).

Literature Cited:

Duffy-Anderson, J.T., P.J. Stabeno, A. Andrews, L.B. Eisner, E.V. Farley, C.E. Harpold, R.A. Heintz, F. Sewall, E.C. Siddon, A. Spear, E. Yasumiishi. Submitted. Return of warm conditions in the southeastern Bering Sea: phytoplankton – fish. PLOS ONE.

Heintz, R., and J.J. Vollenweider. 2010. The influence of size on the sources of energy consumed by overwintering walleye pollock (*Theragra chalcogramma*). Journal of Experimental Marine Biology and Ecology. 393: 43-50.

Hunt Jr., G.L., K.O. Coyle, L. Eisner, E.V. Farley, R. Heintz, F. Mueter, J.M. Napp, J.E. Overland, P.H. Ressler, S.Salo, and P.J. Stabeno. 2011. Climate impacts on eastern Bering Sea food webs: A synthesis of new data and an assessment of the Oscillating Control Hypothesis. ICES 68:1230-1243.

Ianelli, J.N., T. Honkalehto, S. Barbeaux, and S. Kotwicki, K. 2015. Assessment of the walleye pollock stock in the Eastern Bering Sea. In 2015 North Pacific Groundfish Stock Assessment and Fishery Evaluation Reports for 2016. North Pacific Fishery Management Council. pp 53-152.

Kooka, K., O. Yamamura, A. Nishimura, T. Hamatsu, and T. Yanagimoto. 2007. Optimum temperature for growth of juvenile walleye pollock *Theragra chalcogramma*. Journal of Experimental Marine Biology and Ecology 347: 69-76.

Siddon, E.C., R.A. Heintz, F.J.Mueter. 2013a. Conceptual model of energy allocation in walleye pollock (*Theragra chalcogramma*) from larvae to age-1 in the southeastern Bering Sea. Deep Sea Research II 94: 140-149.

Siddon, E. C., T. Kristiansen, F.J. Mueter, K. Holsman, R.A. Heintz, and E.V. Farley. 2013b. Spatial match-mismatch between juvenile fish and prey explains recruitment variability across contrasting climate conditions in the eastern Bering Sea. PLoS ONE 8(12): e84526. doi:10.1371/journal.pone.0084526.

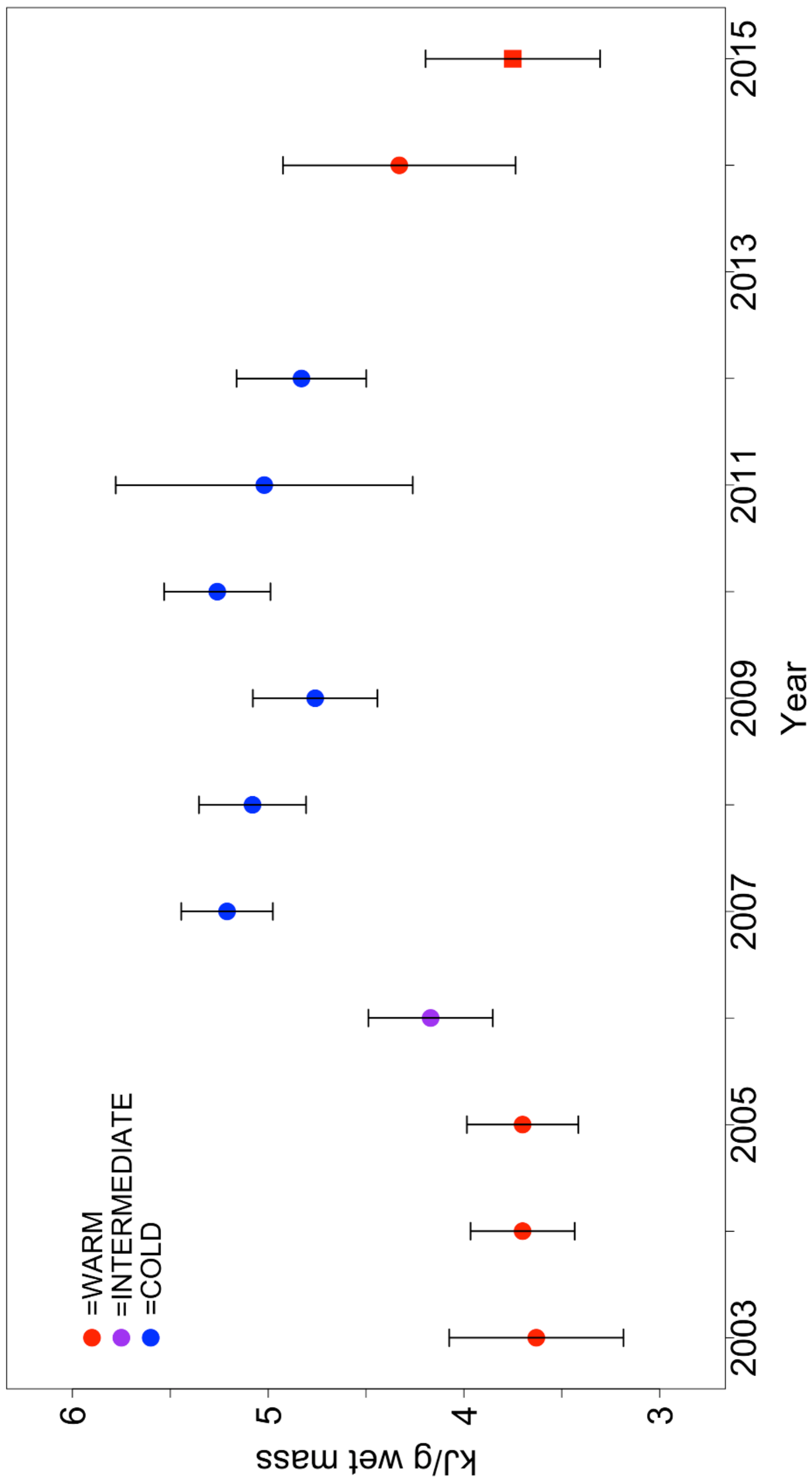


Figure 1. Average energy density (kJ/g) of young-of-the-year Walleye Pollock (*Gadus chalcogrammus*) collected during the late-summer BASIS survey in the eastern Bering Sea 2003-2015. Fish were collected with a surface trawl in 2003-2014 and an oblique trawl in 2015.

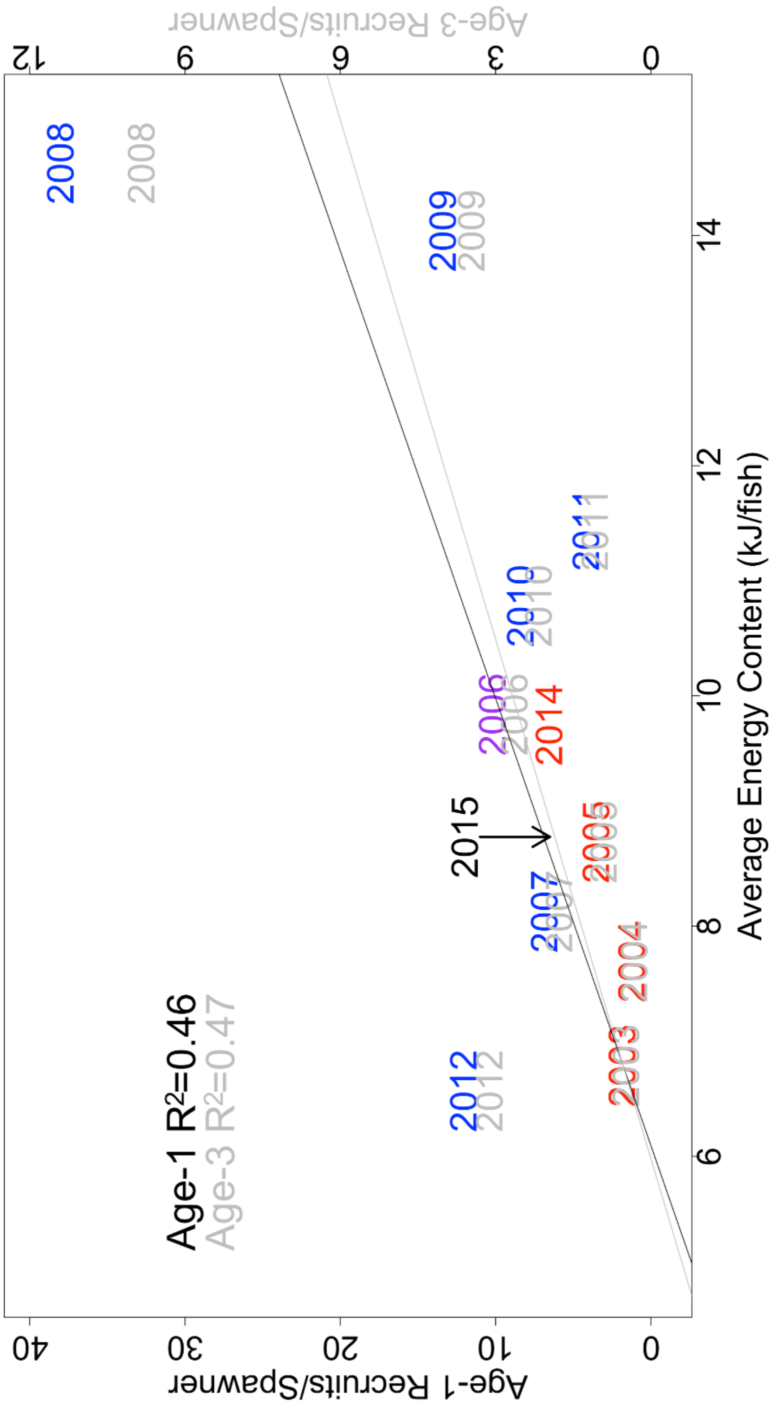


Figure 2. Relationship between average energy content (AEC) of individual young-of-the-year Walleye Pollock (*Gadus chalcogrammus*) and the number of age-1 and age-3 recruits per spawner from the 2015 stock assessment (Ianelli et al., 2015). Fish were collected with a surface trawl in 2003-2014 and an oblique trawl in 2015.

For more information, contact Elizabeth Siddon (907) 789-6055, Elizabeth.Siddon@noaa.gov

Pre- and Post-Winter Temperature Change Index and the Recruitment of Bering Sea Pollock - ABL

Description of indicators: The temperature change (TC) index is a composite index for the pre-and post-winter thermal conditions experienced by walleye pollock (*Gadus chalcogrammus*) from age-0 to age-1 in the eastern Bering Sea (Martinson et al., 2012). The TC index (year t) is calculated as the difference in the average monthly sea surface temperature in June (t) and August (t-1) (Figure 1) in an area of the southern region of the eastern Bering Sea (56.2°N to 58.1°N latitude by 166.9°W to 161.2°W longitude). Time series of average monthly sea surface temperatures were obtained from the NOAA Earth System Research Laboratory Physical Sciences Division website. Sea surface temperatures were based on NCEP/NCAR gridded reanalysis data (Kalnay et al., 1996, data obtained from http://www.esrl.noaa.gov/psd/cgibin/data/timeseries/timeseries1.pl). Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock.

Status and trends: The 2016 TC index value is -3.19, higher than the 2015 TC index value of -5.96, indicating improved conditions for pollock from 2015 to 2016 due to the lower difference in sea temperature from late summer to the following spring. However, both the late summer sea surface temperature (11.7 °C) in 2015 and the spring sea temperatures (8.5 °C) in 2016 were warmer than the long-term average of 9.7 °C in late summer and 5.1 °C in spring since 1950. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-4 from 1964 to 2015, but not significantly correlated for the shorter period (1995-2015).

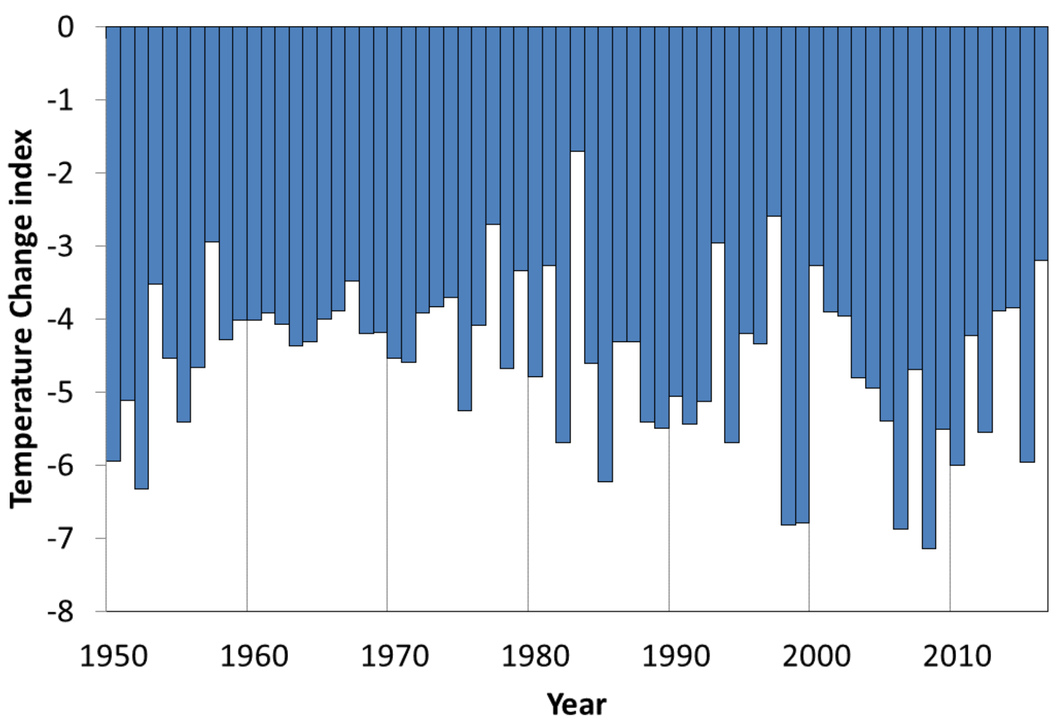


Figure 1: The Temperature Change index values from 1950 to 2015.

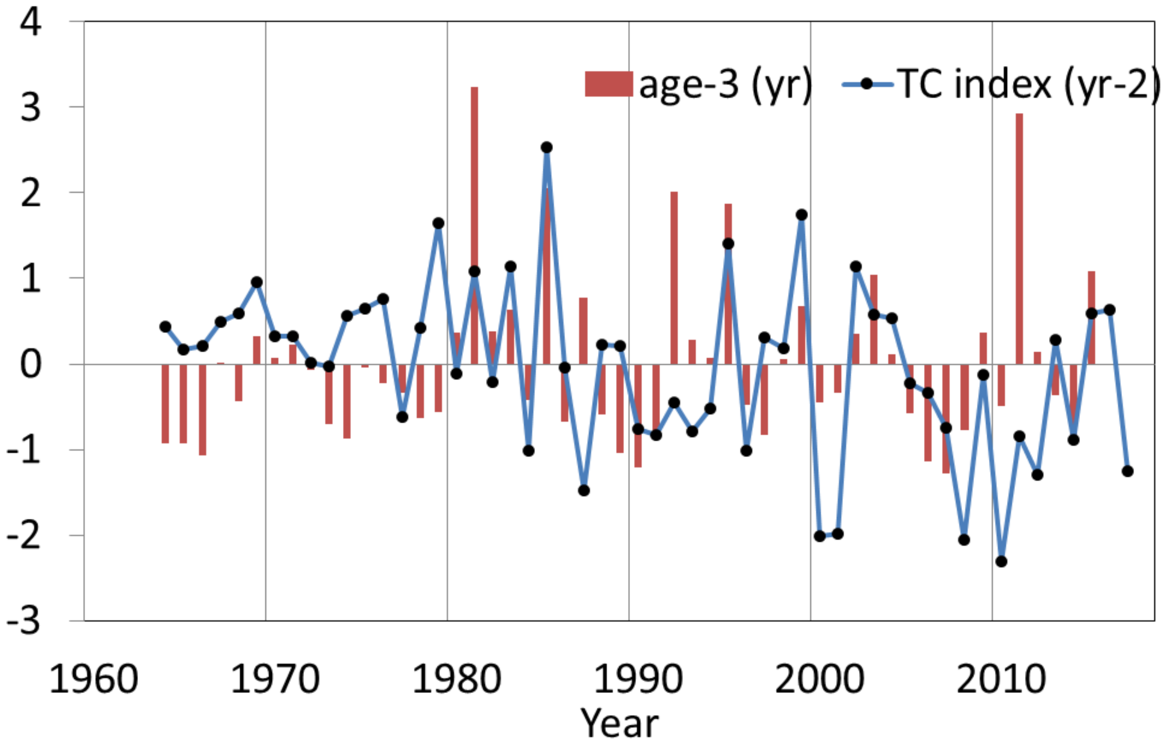


Figure 2: Normalized time series values of the temperature change index (t-2) and the estimated abundance of age-3 walleye pollock in the eastern Bering Sea (t) from Table 1.25 in Ianelli et al. 2015.

Table 1: Pearson's correlation coefficient relating the Temperature Change index to subsequent estimated year class strength of pollock. Bold values are statistically significant ($p < 0.05$).

Correlations						
	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
1964-2015	**0.35**	**0.34**	**0.31**	0.26	0.22	0.22
1996-2015	0.35	0.31	0.31	0.38	0.37	0.36

Factors causing observed trends: According to the original Oscillating Control Hypothesis, warmer spring temperatures and earlier ice retreat led to a later oceanic and pelagic phytoplankton bloom and more food in the pelagic waters at an optimal time for use by pelagic species (Hunt et al., 2002). The revised OCH indicated that age-0 pollock were more energy-rich and have higher over wintering survival to age-1 in a year with a cooler late summer (Coyle et al., 2011; Heintz et al., 2013). Therefore, the colder later summers during the age-0 phase followed by warmer spring temperatures during the age-1 phase are assumed favorable for the survival of pollock from age-0 to age-1.

Implications: The 2015 TC index values of -5.96 was below the long-term average, therefore we expect lower than average recruitment of pollock to age-3 in 2017 from the 2014 year class (Figure 2). The 2016 TC index value of -3.19 was above the long-term average of -4.60, therefore we expect slightly above average recruitment of pollock to age-3 in 2018 from the 2015 year class.

Literature Cited

Coyle, K. O., Eisner, L. B., Mueter, F. J., Pinchuk, A. I., Janout, M. A., Cieciel, K. D., ... & Andrews, A. G. (2011). Climate change in the southeastern Bering Sea: impacts on pollock stocks and implications for the oscillating control hypothesis. *Fisheries Oceanography*, *20*(2), 139-156.

Heintz, R. A., Siddon, E. C., Farley, E. V., & Napp, J. M. (2013). Correlation between recruitment and fall condition of age-0 pollock (Theragra chalcogramma) from the eastern Bering Sea under varying climate conditions.*Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 150-156.

Hunt Jr, G. L., Stabeno, P., Walters, G., Sinclair, E., Brodeur, R. D., Napp, J. M., & Bond, N. A. (2002). Climate change and control of the southeastern Bering Sea pelagic ecosystem. *Deep Sea Research Part II: Topical Studies in Oceanography*, *49*(26), 5821-5853.

Hunt, G. L., Coyle, K. O., Eisner, L. B., Farley, E. V., Heintz, R. A., Mueter, F., ... & Stabeno, P. J. (2011). Climate impacts on eastern Bering Sea foodwebs: a synthesis of new data and an assessment of the Oscillating Control Hypothesis. *ICES Journal of Marine Science: Journal du Conseil*, fsr036.

Martinson, E. C., Stokes, H. H., & Scarnecchia, D. L. (2012). Use of juvenile salmon growth and temperature change indices to predict groundfish post age-0 yr class strengths in the Gulf of Alaska and eastern Bering Sea. *Fisheries Oceanography*, *21*(4), 307-319.

For more information contact Ellen Yasumiishi (907) 789-6604, ellenyasumiishi@noaa.gov

Large zooplankton abundance as an indicator of pollock recruitment to age-1 and age-3 in the southeastern Bering Sea - ABL

Description of indicator: Interannual variations in large zooplankton abundance (sum of most abundant large taxa, typically important in age 0 pollock diets, Coyle et al. 2011) were compared to age-1 and age-3 walleye pollock (*Gadus chalcogrammus*) abundance (millions of fish) and abundance per biomass (thousands of tons) of spawner for year classes 2002-2012 on the southeastern Bering Sea shelf (south of 60°N, < 200 m bathymetry). Zooplankton samples were collected with oblique bongo tows over the water column using 60 cm, 505 µm mesh nets for 2002-2011 data, and 20 cm, 153 µm mesh and 60 cm, 505 µm nets, depending on taxa, for 2012 and 2014 data. Taxa included in the index are large copepods (copepodite stage 3-adult), *Calanus marshallae/glacialis*, *Eucalanus bungii*, *Metridia pacifica*, and *Neocalanus* spp., the chaetognath, *Parasaggita elegens*, and the pteropod, *Limacina helicina* (505 µm net only). Data were collected on BASIS fishery oceanography surveys during mid-August to late September, for four warm years (2002-2005) followed by one average (2006), six cold (2007-2012) and one warm year (2014) using methods in Eisner et al. (2014). Pollock abundance and biomass was available from the stock assessment report for the 2002-2015 year classes (Ianelli et al., 2015).

Status and trends: A positive significant (P = 0.04) linear relationship was found between mean abundance of large zooplankton during the age-0 stage of pollock and estimated abundance of age-1pollock from Ianelli et al. (2015) for the 2002-2012 year classes (Fig.1). Age-1 pollock abundance is primarily derived from age-3 data, therefore relationships between large zooplankton and age-1 and age-3 abundances are similar. No significant relationship occurred between large zooplankton abundance and recruits-per-spawner for the 2002-2012 year classes, unlike the prior update for 2003-2010 data. The prior update also used geometric instead of arithmetic mean large zooplankton abundance. Using the 2014 zooplankton abundance (185 m^{-3}), we compared the model prediction with the "observed" abundance of age-1 pollock for the 2014 year class from Ianelli et al. (2015) (Fig. 2). Our regression models predicted an abundance of 27,303 million age-1 pollock with a standard error of 4,897 million and an abundance of 7,303 million age-3 pollock with a standard error of 1,268 million for the 2014 year class.

Factors influencing observed trends: Increases in sea ice extent and duration were associated with increases in large zooplankton abundances on the shelf (Eisner et al., 2014, 2015), increases in large copepods and euphausiids in pollock diets (Coyle et al., 2011) and increases in age-0 pollock lipid content (Heintz et al., 2013). The increases in sea ice and associated ice algae and phytoplankton blooms may provide an early food source for large crustacean zooplankton reproduction and growth (Baer and Napp 2003; Hunt et al., 2011). These large zooplankton taxa contain high lipid concentrations (especially in cold, high ice years) which in turn increases the lipid content in their predators such as age-0 pollock and other forage fish. Increases in energy density (lipids) in age-0 pollock allow them to survive their first winter (a time of high mortality) and eventually recruit into the fishery. Accordingly, a strong relationship has been shown for energy density in age-0 fish and age-3 pollock abundance (Heintz et al., 2013).

Implications: Our results suggest that increases in the availability of large zooplankton prey during the first year at sea were favorable for age-0 pollock overwinter survival to age-1 and recruitment into the fishery at age-3. If the relationship between large zooplankton and age-1 (age-3) pollock remains significant in our analysis, the index may be used to predict the recruitment of pollock one (three) years in advance of recruiting to age-1 (age-3), from zooplankton data collected one (three) years prior. This relationship also provides further support for the revised oscillating control hypothesis that suggests as the climate warms, reductions in the extent and duration of sea ice could be detrimental large crustacean zooplankton and subsequently to the pollock fishery in the southeastern Bering Sea (Hunt et al., 2011).

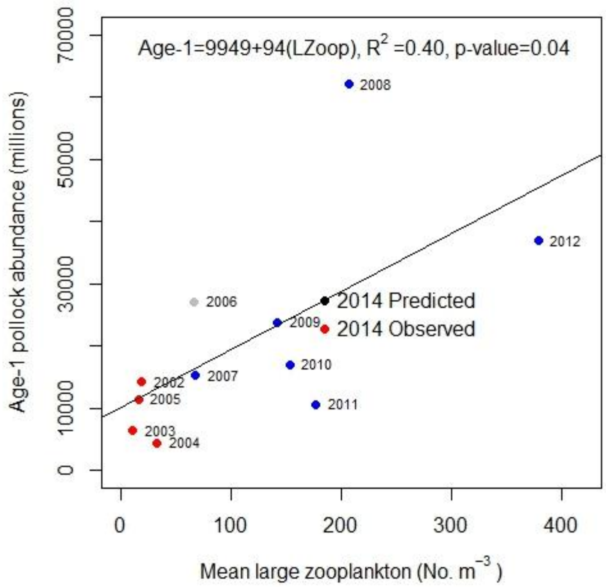


Figure 1. Linear relationships between mean large zooplankton abundance during the age-0 life stage of pollock and the estimated abundance of age-1 pollock abundance of the year class 2002-2012, from Ianelli et al. (2015). The 2014 points are the "observed" stock assessment estimates of age-1 pollock from Ianelli et al. (2015) and the "predicted" age-1 pollock estimates are from our regression model using large zooplankton abundance for 2014. Points are labeled with year class. Red points are warm (low ice) years, blue are cold (high ice) years, and gray is an average year.

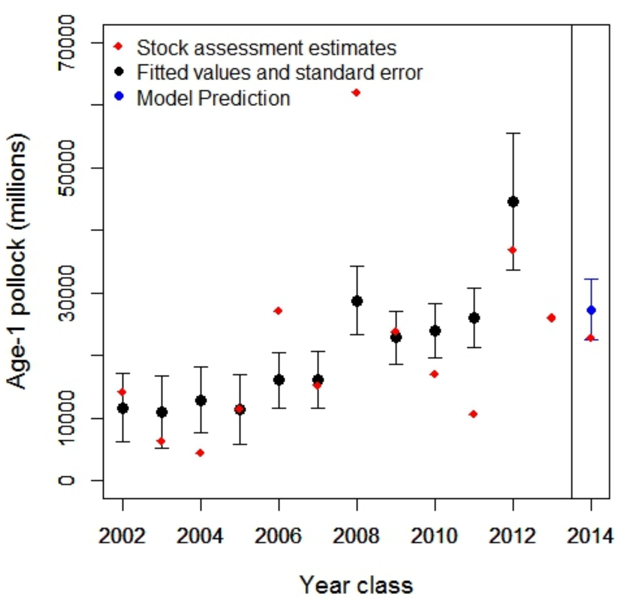


Figure 2. Fitted values and standard errors of age1 pollock abundance, estimated from the linear regression model relating the abundance of age-1 pollock from Ianelli et al. (2015) to the abundance of large zooplankton during the age-0 life stage of pollock. Red symbols are stock assessment estimates (Ianelli et al., 2015).

Literature cited:

Baier, C.T., Napp, J.M., 2003. Climate-induced variability in *Calanus marshallae* populations. J. Plankton Res. 25, 771–782.

Coyle, K., Eisner, L., Mueter, F., Pinchuk, A., Janout, M., Cieciel, K., Farley, E., Andrews, A. 2011. Climate change in the southeastern Bering Sea: impacts on pollock stocks and implications for the Oscillating Control Hypothesis. Fish. Oceanog. 20(2): 139-156.

Eisner, L., Napp, J., Mier, K., Pinchuk, A., Andrews A. 2014. Climate-mediated changes in zooplankton community structure for the eastern Bering Sea. Deep Sea Res II, DOI: 10.1016/j.dsr2.2014.03.004.

Eisner, L., Siddon, E., Strasburger, W., 2015. Spatial and temporal changes in assemblage structure of zooplankton and pelagic fish across varying climate conditions in the eastern Bering Sea. Izvestia TINRO, vol 181, 141-160.

Heintz, R.A., Siddon, E.C., Farley Jr., E.V., Napp, J.M., 2013. Climate-related changes in the nutritional condition of young-of-the-year walleye pollock (*Theragra chalcogramma*) from the eastern Bering Sea. Deep Sea Res. II 94,150–156.

Hunt, G., Aydin, K., Coyle, K., Eisner, L., Farley, E., Heintz, R., Mueter, F., Napp, J., Ressler, P., Stabeno, P. 2011. Climate impacts on eastern Bering Sea food webs: A synthesis of new data and revision of the Oscillating Control Hypothesis. ICES J. Mar Sci. 68: 1230-1243.

Ianelli, J.N., Honkalehto, T., Barbeaux, S., Kotwicki, S. 2015. Assessment of Alaska pollock stock in the eastern Bering Sea. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. M. Sigler & G. Thompson (eds) Anchorage: North Pacific Fisheries Management Council, pp. 53–152.

For more information contact Lisa Eisner at (206) 526-4060, lisa.eisner@noaa.gov

Salmon, Sea Temperature, and the Recruitment of Bering Sea Pollock - ABL

Description of indicator: Chum salmon growth, sea temperature, and adult pink salmon abundance were used to predict the year class strength of walleye pollock (*Gadus chalcogrammus*) (Yasumiishi et al. 2015). The intra-annual growth in body weight of immature and maturing age-4 chum salmon incidentally captured in the commercial fisheries for walleye pollock in the eastern Bering Sea was used as a proxy for ocean productivity experienced by age-0 pollock on the eastern Bering Sea shelf. A linear regression model was used to describe stock assessment estimates of pollock abudance from Ianelli et al. (2015) for the 2001-2011 year classes as a function of chum salmon growth, sea temperature, and adult pink salmon, provided by Irvine and Ruggerone (2016). Model parameters and updated biophysical indices were used to predict the abundance of age-1 and age-3 pollock for the 2013-2015 year classes.

Status and trends: For last years model (2015 model), an alternating year pattern was observed in the residuals, so this year we added adult pink salmon abundance as a predictor in the model due to their alternating life cycle and interaction with age-0 and age-1 pollock. The best fit 2016 model (lowest Bayesian information criterion) included chum salmon growth during the age-0 stage, spring sea temperature during the age-1 stage, and adult pink salmon returns during the age-0 stage, indicating that adult pink salmon are possible predators of age-0 pollock (R^2 = 0.85; p –value = 0.003).

The model parameters (2001-2011) and biophysical indices from 2013 to 2016 were used to predict the abundance of age-1 and age-3 pollock for the 2013-2015 year classes (Figure 1). For the 2013 year class, high chum salmon growth (0.97 kg) in 2013, average spring sea temperatures (3.95°C) in 2014, and high adult pink salmon returns to Asia and North America in 2013 (806,999 metric tonnes) produced a forecast of 7,166 million age-1 pollock (S.E.=155 million) and 39 million age-3 pollock (S.E.=1,855). For the 2014 year class, average chum salmon growth (0.79 kg), warm spring sea temperatures (4.00°C), and low adult pink salmon returns (493,683 million) produced a forecast of 9,095 million age-1 pollock (S.E.=5,252) and 2,349 million age-3 pollock (S.E.=1,359 million). For the 2015 year class, low chum salmon growth (0.53 kg), a warm spring sea temperatures (5.50°C), and high adult pink salmon returns (742,601 million) produced a negative forecast. Our model predicted low abundance of pollock at age-3 for the 2013-2015 year classes.

Factors influencing observed trends: The 2016 biophysical indices indicated below average ocean productivity (chum salmon growth), warm spring sea temperatures in 2016 (less favorable), and high pink salmon abundances (less favorable; predation on age-0 pollock by adult pink salmon during the spring and early summer) (Coyle et al. 2011). These factors are expected to result in below average recruitment of pollock for the 2013-2015 year classes (Figure 1).

Implications: The biophysical indicators and 2016 model predicts a below average recruitment of pollock to age-1 and age-3 for the 2013-2015 year classes.

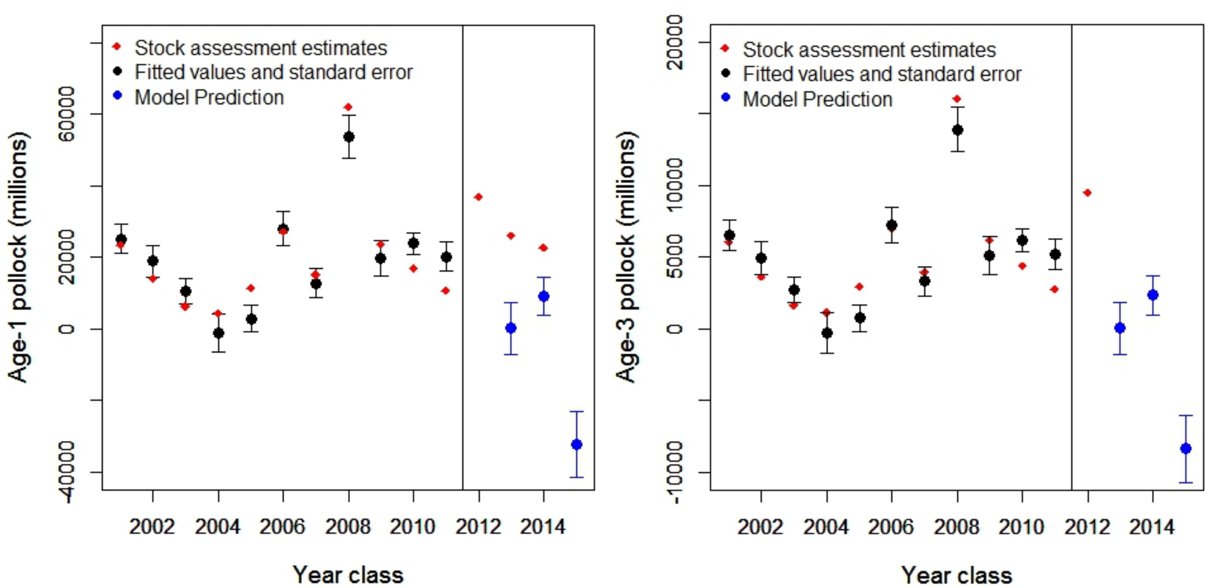


Figure 1. Output from the linear regression model relating the estimated pollock abundance from Ianelli et al. (2015) to the intra-annual growth of age-4 chum salmon during the age-0 life stage of pollock, abundance of adult pink salmon returns to Asia and North America during the age-0

stage, and spring sea temperatures in the southeastern Bering Sea during the age-1 life stage of pollock.

Literature Cited

Ianelli, J.N., Honkalehto, T., Barbeaux, S., and S. Kotwicki, S. 2015. Assessment of walleye pollock stock in the Eastern Bering Sea. *In*: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. Anchorage: North Pacific Fisheries Management Council, pp. 53–152.

Stram, D.L. and Ianelli, J.N. 2009. Eastern Bering Sea pollock trawl fisheries: variation in salmon bycatch over time and space. American Fisheries Society Symposium 70:827–850.

Yasumiishi, E.M., K. Criddle, N. Hillgruber, F.J. Mueter, and J.H. Helle. 2015. Chum salmon (*Oncorhynchus keta*) and temperature indices as indicators for the year-class strength of age-1 walleye pollock (*Gadus chalcogramma*) in the eastern Bering Sea. Fisheries Oceanography. 24:242-256.

For more information contact Ellen Yasumiishi, 907-789-6604, ellen.yasumiishi@noaa.gov.

Age-0 walleye pollock distribution in the southeast Bering Sea during summer 2016-RPP

A midwater trawl (NETS 156 trawl) was deployed for the second year as part of the 2016 BASIS southeastern Bering Sea ecosystem survey. The midwater trawl was deployed in an oblique manner to a depth of 10 meters off bottom at a grid of 34 stations, along with the standard BASIS survey surface Canada trawl. Age-0 pollock was the largest component of the trawl fish catch by both number and by weight (Figure 1). Age-0 pollock midwater catches were highest in the middle and inner domains (Figure 2), and generally corresponded to the areas of the highest age-0 pollock catches in the surface trawl, although the two trawl types do not fish the same part of the water column and catch selectivity for both trawls is unknown. Several jelly taxa comprised the top 99% by weight of the invertebrate catch (Figure 1).

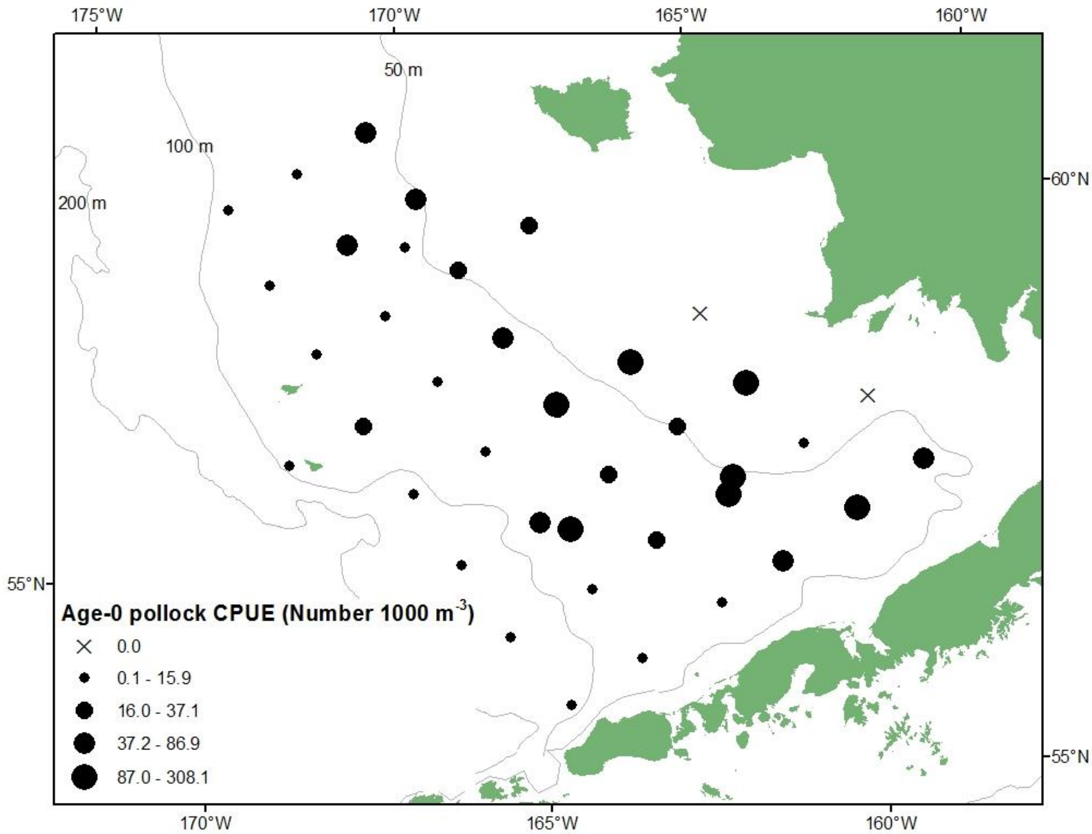


Figure 1. Age-0 pollock catch per unit effort (Number of fish 1000m^{-3}) in the NETS 156 midwater trawl.

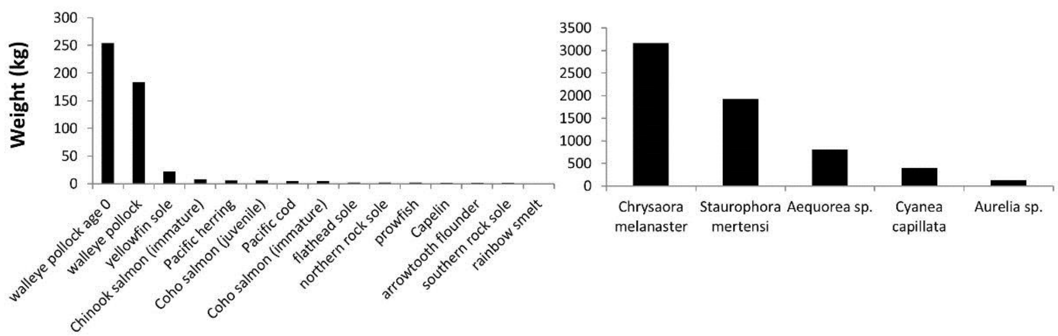


Figure 2. Weight of fish (left panel) and invertebrate (right panel) taxa caught using the NETS 156 trawl during the 2016 BASIS cruise. Only the taxa with the greatest catch weights comprising 99% of the total catch are shown.

For more information, contact Dan Cooper at dan.cooper@noaa.gov

Responses of walleye pollock early life stages to the 2015 warm anomaly in the Gulf of Alaska-RPP

In 2014 and 2015, anomalous ecological conditions were reported across the NE Pacific Ocean coinciding with persistent and widespread ocean warming (nicknamed "The Blob"). Studying the ecological responses to such an event can provide insights into the mechanisms underlying recruitment success and links to climate conditions. In this study, we revisit proposed mechanisms linking climate and recruitment in Walleye Pollock in the Gulf of Alaska, and evaluate these mechanisms in light of the 2015 year class. In spring of 2015, pollock larvae were observed at their lowest abundance in 31 years of surveys by the AFSC EcoFOCI program. A subsequent survey at end of summer caught few age-0 pollock, and those observed were in poor condition. Estimated survival rates were low for both larval and early juvenile stages relative to past years (Figure 1). In previous years, warm conditions during spring have been associated with favorable conditions for larval survival, especially during the first week post-hatch (Bailey et al. 1996); however, more recent results suggest that larvae hatch earlier and at a smaller size under warm temperatures (Dougherty et al. in review), which may have consequences for their fitness. Work is ongoing to characterize the zooplankton community in spring and late-summer to assess the importance of temperature-driven changes in zooplankton for pollock condition and survival in the Gulf of Alaska. Results suggest that responses of pollock to the 2014/2015 warm event differed from previous warm years (e.g. 2005). This highlights the importance of looking beyond environmental covariates in order to understand the mechanisms linking climate conditions to recruitment, which will be critical for forecasting species-specific responses to climate change.

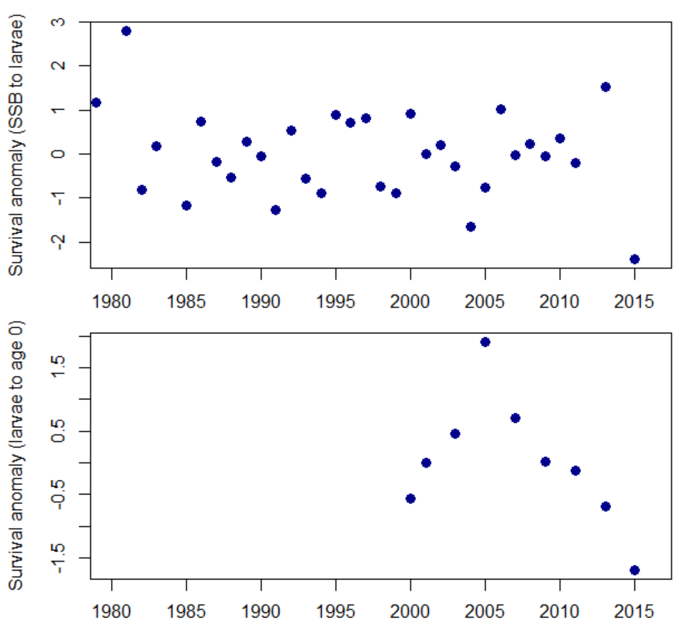


Figure 1: Survival anomalies calculated from time-series of estimated spawning stock biomass (SSB), larval abundance indices, and abundance of age-0 pollock in late summer. Larval and age-0 pollock abundances are estimated from spring and late-summer EcoFOCI surveys in the Gulf of Alaska.

For more information, contact Lauren Rogers at **lauren.rogers@noaa.gov**

Geographic variation in otolith chemistry of age-0 juvenile walleye pollock (*Gadus chalcogrammus*) in relation to regional hydrography.--RPP

For many coastal marine fishes, uncertainty about juvenile habitat quality and nursery location greatly impedes our understanding of their recruitment process. Among age-0 walleye pollock (*Gadus chalcogrammus*) in the western Gulf of Alaska (GOA), we demonstrate for the first time that otolith elemental composition regionally discriminates age-0 juveniles in association with Alaska Coastal Current (ACC)- related hydrography. Identifying nursery location is one step toward resolving factors that affect replenishment and possible meta-population structure of important local fished populations such as pre-spawning adult walleye pollock in Shelikof Strait, and summertime aggregations in sea valleys along the Gulf side of Kodiak Island. We asked, "Can otolith chemistry be used to determine whether these populations are supported by local nurseries or one that is common to both populations?"

Elemental composition of 228 otoliths from age-0 juveniles was examined in relation to 3 hydrographic regions: Kodiak, Semidi-inner, and Semidi-outer (Fig. 1). The Semidi regions are thought to be the major nursery of walleye pollock that replenish the adult population in Shelikof Strait. Samples and data were collected with an instrumented small-mesh midwater trawl during September 2007 and October 2011. Laser ablation-inductively coupled plasma mass spectrometry was used to measure elemental composition along otolith edge and life-history (otolith edge to core) transects.

Near-surface salinity was lower in the Semidi regions than in the Kodiak region. This was consistent with greater ACC influence in the Semidi regions. The relatively low ACC salinities have been shown to reflect terrestrial runoff. The expected effect on water chemistry is barium (Ba) enrichment and strontium (Sr) dilution in ACC-influenced regions.

All within-year differences in otolith edge elemental composition were between Kodiak and Semidi regions. Semidi fish had relatively low strontium:calcium (Sr:Ca) and high barium:calcium (Ba:Ca) ratios, which was consistent with ACC influence. Canonical discriminant analysis indicated 73% (2007) and 86% (2011) successful discrimination of region by otolith chemistry (Fig. 2).

Along life history transects, Sr:Ca decreased and Ba:Ca increased markedly among Semidi juveniles ca. August-September (Fig. 3) consistent with late-summer baroclinic spin-up of the ACC. Subsequent otolith accretion in October 2011 was less regionally distinct due perhaps to fish seasonal and ontogenetic-related descent. Signal-based discrimination between Kodiak and Semidi regions was 77% (2007) and 88% (2011).

Our results indicate that otolith chemistry, especially Ba:Ca and Sr:Ca, will be useful for determining whether the pre-spawning adults in Shelikof Strait are replenished from one nursery while those in sea valleys along the Gulf side of Kodiak Island are replenished by another. If so, tracking a cohort through each population should provide insight on possible mixing between populations. It could be that larval supply to local nurseries is the principal means of mixing between these populations. If so, then post-larval mortality would be expected to exacerbate or ameliorate, depending on relative local intensity, geographic variation in population density.

For more information contact Matthew Wilson (matt.wilson@noaa.gov), Annette Dougherty, Mary Elizabeth Matta, Kathryn Mier, or Jessica Miller

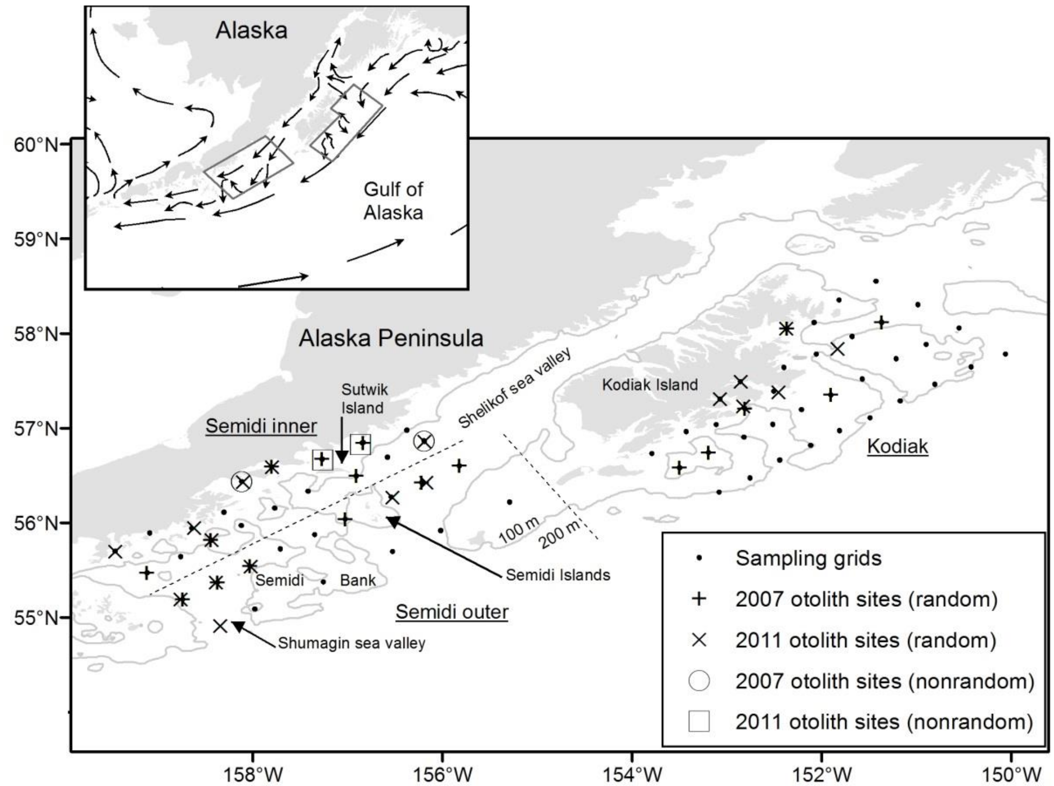


Figure 1. Sampling was conducted over 2 sampling grids (Kodiak and Semidi) in the Gulf of Alaska during September 2007 and October 2011 to measure water properties and collect age-0 juvenile walleye pollock. Sites used in statistical analyses (random) are distinguished from non-randomly selected sites (see text). Dotted lines delineate 3 geographic strata: Kodiak, and Semidi inner and outer. Inset shows sampling grids and net current transport vectors (Reed & Schumacher 1986).

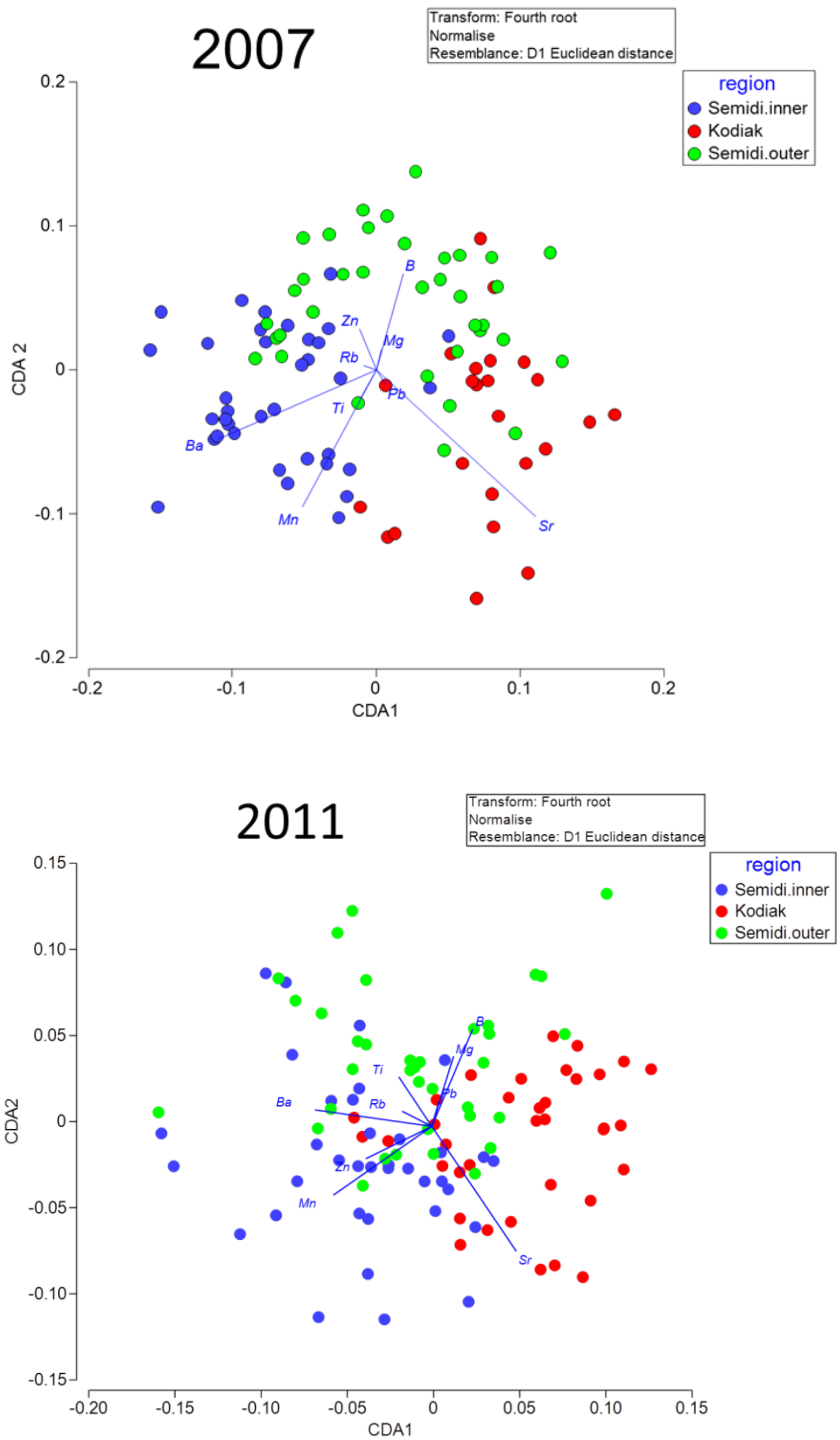


Figure 2. Canonical discriminant analysis (CDA) ordinations of age-0 walleye pollock based on otolith element composition. Fish were collected from 3 regions in the western Gulf of Alaska during September 2007 and October 2011. Vectors indicate correlation between element:Ca ratios and CDA axes.

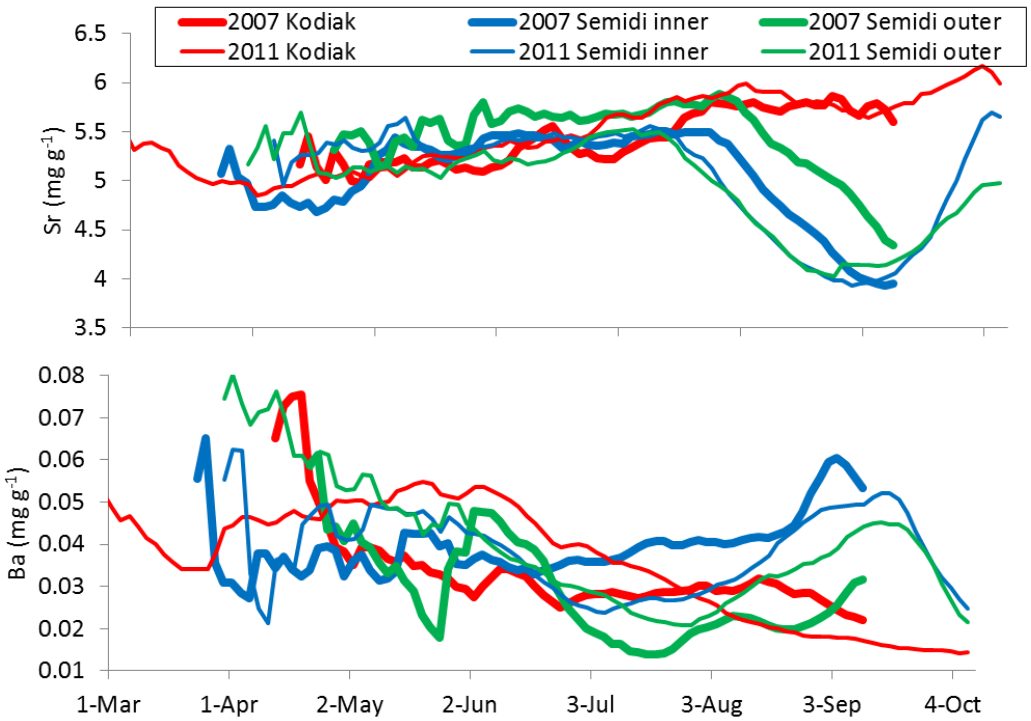


Figure 3. Mean otolith Sr (top) and Ba (bottom) by year and region across 228 age-0 juvenile walleye pollock collected in the western Gulf of Alaska during September 2007 and October 2011. The x-axis, calendar date, was estimated from mean collection date assuming mean daily increment width = 4.5µm (see text).

Using Vessel Monitoring System Data to Estimate Spatial Effort in Bering Sea Fisheries for Unobserved Trips-REFM/ESSR

Alan Haynie*, Patrick Sullivan, and Jordan Watson
For further information, contact Alan.Haynie@NOAA.gov

A primary challenge of marine resource management is monitoring where and when fishing occurs. This is important for both the protection and efficient harvest of targeted fisheries. Vessel monitoring system (VMS) technology records the time, location, bearing, and speed for vessels. VMS equipment has been employed on vessels in many fisheries around the world and VMS data has been used in enforcement, but a limited amount of work has been done utilizing VMS data to improve estimates of fishing activity. This paper utilizes VMS and an unusually large volume of government observer-reported data from the United States Eastern Bering Sea pollock fishery to predict the times and locations at which fishing occurs on trips without observers onboard. We employ a variety of techniques and specifications to improve model performance and out-of-sample prediction and find a generalized additive model that includes speed and change in bearing to be the best formulation for predicting fishing. We assess spatial correlation in the residuals of the chosen model, but find no correlation after taking into account other VMS predictors. We compare fishing effort to predictions for vessels with full observer coverage for 2003-2010 and compare predicted and observer-reported activity for observed trips. In this project, we have worked to address challenges that result from missing observations in the

VMS data, which occur frequently and present modeling complications. We conclude with a discussion of policy considerations.   Results of this work will be published in a scientific journal. We are also working with the NMFS Alaska Regional Office to attempt to improve the Region's spatial effort database and we will extend the model to other fisheries.

Using Vessel Monitoring System (VMS) Data to Identify and Characterize Trips made by Bering Sea Fishing Vessels-REFM/ESSR

Jordan Watson and Alan Haynie*
**For further information, contact Alan.Haynie@NOAA.gov*

Catch per unit effort (CPUE) is among the most common metrics for describing commercial fisheries. However, CPUE is a relatively fish-centric unit that fails to convey the actual effort expended by fishers to capture their prey. By resolving characteristics of entire fishing trips, in addition to their CPUE, a broader picture of fishers' actual effort can be exposed. Furthermore, in the case of unobserved fishing, trip start and end times may be required in order to estimate CPUE from effort models and landings data. In this project, we utilize vessel monitoring system (VMS) data to reconstruct individual trips made by catcher vessels in the Eastern Bering Sea fishery for walleye pollock (Gadus chalcogrammus) from 2003 – 2013. Our algorithm implements a series of speed, spatial and temporal filters to determine when vessels leave and return to port. We then employ another set of spatial filters and a probabilistic model to characterize vessel trips as fishing versus non-fishing. Once trips are identified and characterized, we summarize the durations of trips and the distances traveled -- metrics that can be subsequently used to characterize changes in fleet behaviors over time. This approach establishes a baseline of trip behaviors and will provide an improved understanding of how fisheries are impacted by management actions, changing economics, and environmental change. A publication on trip-identification algorithm is forthcoming in *PLOS ONE* and an additional manuscript will be submitted to a peer-reviewed journal.

References

Watson, J.T. and A.C. Haynie. 2016. "Using vessel monitoring system data to identify and characterize trips made by fishing vessels in the United States North Pacific." In Press. *PLOS ONE*.

Assessing alternative management strategies for eastern Bering Sea walleye pollock Fishery with climate change-REFM/ESSR

Chang Seung and James Ianelli*
**For further information, contact Chang.Seung@NOAA.gov*

Recent studies indicate that rising sea surface temperature (SST) may have negative impacts on eastern Bering Sea walleye pollock stock productivity. A previous study (Ianelli et al. 2011) developed projections of the pollock stock and alternative harvest policies for the species, and examined how the alternative policies perform for the pollock stock with a changing environment. The study, however, failed to evaluate quantitative economic impacts. The present study showcases how quantitative evaluations of the regional economic impacts can be applied with results evaluating harvest policy trade-offs; an important component of management strategy evaluations. In this case, we couple alternative harvest policy simulations (with and without climate change) with a regional dynamic computable general equilibrium

(CGE) model for Alaska. In this example we found (i) that the status quo policy performed less well than the alternatives (from the perspective of economic benefit), (ii) more conservative policies had smaller regional output and economic welfare impacts (with and without considering climate change), and (iii) a policy allowing harvests to be less constrained performed worse in terms of impacts on total regional output, economic welfare, and real gross regional product (RGRP), and in terms of variability of the pollock industry output.

References
Ianelli, J., A. Hollowed, A. Haynie, F. Mueter, and N. Bond. 2011. Evaluating management strategies for eastern Bering Sea walleye pollock (*Theragra chalcogramma*) in a changing environment. ICES Journal of Marine Science 68(6): 1297–1304.

2. Stock Assessment

GULF OF ALASKA – REFM

In 1998 the GOA Pollock stock dropped below $B_{40\%}$ for the first time since the early 1980s and reached a minimum in 2003 at 25% of unfished stock size. Over the years 2009-2013, the stock increased from 32% to 60% of the unfished level, but declined to 33% by 2016. The spawning stock is projected to increase again in 2017 as the strong 2012 year class starts maturing. The model estimate of female spawning biomass in 2017 is 363,800 t, which is 54.5% of unfished spawning biomass (based on average post-1977 recruitment) and above the $B_{40\%}$ estimate of 267,000 t. The large and unexplained decline in pollock biomass in the 2015 ADFG survey continued in 2016, and thus remains a concern, especially since this time series has shown relatively little variability compared to other indices.

The age-structured assessment model used for GOA W/C/WYAK pollock assessment was modified in the 2016 assessment. The changes included the use of a random effects model for processing the input fishery weight-at-age, and applying a delta-generalized linear model (delta-GLM) to develop a standardized index of abundance from the Alaska Department of Fish & Game (ADFG) trawl survey. The 2016 assessment compared four models to the 2015 model with the new data (Model 15.1a): Model 16.1 as 15.1a but using the random effects model for processing the input fishery weight-at-age, Model 16.2 as 16.1, but applying the delta-GLM to the ADFG survey instead of area-swept biomass, Model 16.3 as 16.2, but with revised Shelikof Strait acoustic survey estimates for net selectivity, and Model 16.4 as 16.2, but with a spatial generalized linear mixed model (GLMM) for the NMFS bottom trawl survey instead of area-swept biomass. Models 16.3 and 16.4 were exploratory at this stage and might be considered as options in future assessments. The authors' recommended final model configuration (16.2) that used the random effects model for processing fishery weight-at-age and the delta-GLM for the ADFG abundance index standardization was used for the 2016 stock assessment.

This year's pollock assessment features the following new data: 1) 2015 total catch and catch-at-age from the fishery, 2) 2016 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2015 biomass and age composition from NMFS bottom trawl survey, 4) 2016 biomass and 2015 age composition from the ADFG crab/groundfish trawl survey, and 5) 2013 and 2015 age compositions from the summer acoustic survey.

Model 16.2 fits to fishery age composition data were reasonable. The largest residuals tended to be at ages 1-2 in the NMFS bottom trawl survey due to inconsistencies between the initial estimates of abundance and subsequent information about year class size. Model fits to biomass estimates were like previous assessments, and general trends in survey time series were fit reasonably well. There were difficulties in fitting the rapid increase in the Shelikof Strait acoustic survey and the NMFS bottom trawl survey in 2013 since an age-structured pollock population cannot increase as rapidly as is indicated by these surveys. The model was unable to fit the extreme low value for the ADFG survey in 2015 and 2016, though otherwise the fit to this survey was quite good. The fit to the age-1 and age-2 Shelikof acoustic indices appeared adequate though variable. The addition of the 2016 data point to the age-2 acoustic indices resulted in a large outlier that degraded the fit to the entire time series.

Because the model projection of female spawning biomass in 2017 is above $B_{40\%}$, the W/C/WYAK Gulf of Alaska pollock stock is in Tier 3a. The projected 2017 age-3+ biomass estimate is 1,391,290 t (for the W/C/WYAK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock dropping below $B_{20\%}$ will be negligible in all years. The 2017 ABC for pollock in the Gulf of Alaska west of 140° W longitude (W/C/WYAK) is 203,769 t which is a decrease of 20% from the 2016 ABC. The OFL is 235,807 t for 2017. The 2017 Prince William Sound (PWS) GHL is 5,094 t (2.5% of the ABC). For pollock in southeast Alaska (East Yakutat and Southeastern areas), the ABC for both 2017 and 2018 is 9,920 t and the OFL for both 2017 and 2018 is 13,226 t. These recommendations are based on placing southeast Alaska pollock in Tier 5 of the NPFMC tier system, and basing the ABC and OFL on natural mortality (0.3) and the biomass estimate from a random effects model fit to the 1990-2015 bottom trawl survey biomass estimates in Southeast Alaska.

The assessment was updated to include the most recent data available for area apportionments within each season (Appendix C of the GOA pollock chapter). The NMFS bottom trawl survey, typically extending from mid-May to mid-August, was considered the most appropriate survey time series for apportioning the TAC during the summer C and D seasons. The Gulf of Alaska pollock stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

For more information contact Dr. Martin Dorn 526-6548.

EASTERN BERING SEA - REFM

The female spawning biomass in 2008 was at its lowest level since 1980, but has increased by 152% since then, with a further increase projected for next year, followed by a decreasing trend from projections. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent and projected increases are fueled by recruitment from the very strong 2008 and 2012 year classes (131% and 158% above average, respectively), combined with reductions in average fishing mortality (ages 3-8) from 2009-2010 and 2013-2016. Spawning biomass is projected to be 112% above B_{MSY} in 2017.

New data in this year’s assessment include the following:

The 2016 NMFS bottom-trawl survey (BTS) biomass and abundance at age estimates

The 2016 NMFS acoustic-trawl survey (ATS) biomass and abundance at age estimates

Observer data for catch-at-age and average weight-at-age from the 2015 fishery

Updated total catch as reported by NMFS Alaska Regional office 2015 and estimated catch for 2016.

Methodological changes in this year's assessment include the following:
The model was fit to survey biomass rather than survey abundance (numbers of fish)
Sample sizes specified for the robust-multinomial likelihood were revised, based on the "Francis method". The method for estimating current and future year mean body weight at age was improved. For purposes of estimating biological reference points (BRPs) and making projections (but not for estimating historical or current non-BRP parameter values or derived time series), the model was re-run with greater weight given to the prior distribution for the stock-recruitment "steepness" parameter.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates of *BMSY* and the probability density function for *FMSY*. The updated estimate of *BMSY* from the present assessment is 2.165 million t, up 9% from last year's estimate of 1.984 million t. Projected spawning biomass for 2017 is 4.6 million t, placing EBS walleye pollock in sub-tier "a" of Tier 1. As in recent assessments, the maximum permissible ABC harvest rate was based on the ratio between MSY and the equilibrium biomass corresponding to MSY. The harmonic mean of this ratio from the present assessment is 0.398, down 1% from last year's value of 0.401. The harvest ratio of 0.398 is multiplied by the geometric mean of the projected fishable biomass for 2017 (7.83 million t) to obtain the maximum permissible ABC for 2017, which is 3.12 million t, up 2% and 13% from the maximum permissible ABCs for 2016 and 2017 projected in last year's assessment, respectively. However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. They list nine reasons for doing so in the SAFE chapter.

During the period 2010-2013, ABC recommendations were based on the most recent 5-year average fishing mortality rate. Beginning in 2014 it was considered that stock conditions had improved sufficiently warranting an increase in the ABC harvest rate. Specifically, it was recommended the ABC be based on the harvest rate associated with Tier 3, the stock's Tier 1 classification notwithstanding. The Team recommends continuing this approach for setting the 2017 and 2018 ABCs, giving values of 2.800 million t and 2.979 million t, respectively.

The OFL harvest ratio under Tier 1a is 0.526, the arithmetic mean of the ratio between MSY and the equilibrium fishable biomass corresponding to MSY. The product of this ratio and the geometric mean of the projected fishable biomass for 2017 determines the OFL for 2017, which is 3.640 million t. The current projection for OFL in 2018 given a projected 2017 catch of 1.350 million t is 4.360 million t.

The walleye pollock stock in the EBS is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Aleutian Islands:

This year's assessment estimates that spawning biomass reached a minimum level of about *B30%* in 1999 and has since generally increased, with a projected value of *B38%* for 2017. The increase in spawning biomass after 1999 has resulted more from a large decrease in harvest than from good recruitment, as there is no evidence that above-average year classes have been spawned since 1989. Spawning biomass for 2017 is projected to be 77,579 t.

The new data in the model consist of updated catch information, the 2016 AI bottom trawl survey biomass estimate and the 2014 AI bottom trawl survey age composition. There were no changes to the assessment model. The SSC has determined that this stock qualifies for management under Tier 3. The assessment features the continued use of last year's model for evaluating stock status and recommending ABC. The model estimates *B40%* at a value of 81,240 t, placing the AI pollock stock in sub-tier "b" of Tier 3. The model estimates the values of *F35%* as 0.42 and *F40%* as 0.33. Under Tier 3b, with the adjusted *F40%*=0.30, the maximum permissible ABC is 36,061 t for 2017. The 2017 ABC was set at this level. Following the Tier 3b formula with the adjusted *F35%*=0.38, OFL for 2017 is 43,650 t. If the 2016 catch is 1,500 t and 1,157 for 2017 (i.e., equal to the five year average for 2011-2015), the 2018 maximum permissible ABC would be 40,788 t and the 2018 OFL would be 49,291 t.

The walleye pollock stock in the Aleutian Islands is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Bogoslof Pollock
NMFS acoustic-trawl survey biomass estimates are the primary data source used in this assessment. Between 2000 and 2014, the values varied between 292,000 t and 67,000 t. The most recent acoustic-trawl survey of the Bogoslof spawning stock was conducted in March of 2016 and resulted in a biomass estimate of 506,228 t. The random-effects method of survey averaging resulted in 434,760 t, compared to the 2016 point estimate of 506,228 t. The degree of uncertainty in the estimate increases going forward and is fairly substantial. As an alternative method, the three-survey average approach gives an estimate of 228,000 t to use for the Tier 5 calculations.

Estimated catches for 2015 and 2016 were updated and the 2016 acoustic-trawl survey biomass estimate and preliminary 2016 survey age data were included. Two methods for computing the survey average are provided: one using the random effects and the other using a simple 3-survey average.

The SSC has determined that this stock qualifies for management under Tier 5. The assessment authors recommend that the maximum permissible ABC and OFL continue to be based on the random effects survey averaging approach. Given the large degree of uncertainty in the 2016 survey estimate, and the fact that the next survey is scheduled for 2018, the biomass estimate based on the average of the three most recent surveys (228,000 t) is used to determine ABC.

The maximum permissible ABC value for 2017 is 97,428 t (assuming *M* = 0.3 and *FABC* = 0.75 x *M* = 0.225 and the random effects survey estimate for biomass). The ABC for 2017 = 228,000 x *M* x 0.75 = 51,300 t. The recommended ABC for 2018 is the same. The recommended ABC for 2017 is close to what would be obtained from a two-year stair-step (60,800 t). The OFL was calculated using the random effects estimate for the survey biomass. Following the Tier 5 formula with M=0.3, OFL for 2017 is 130,428 t. The OFL for 2018 is the same.

For further information contact Dr. James Ianelli, (206) 526-6510

F. Pacific Whiting (hake)

G. Rockfish

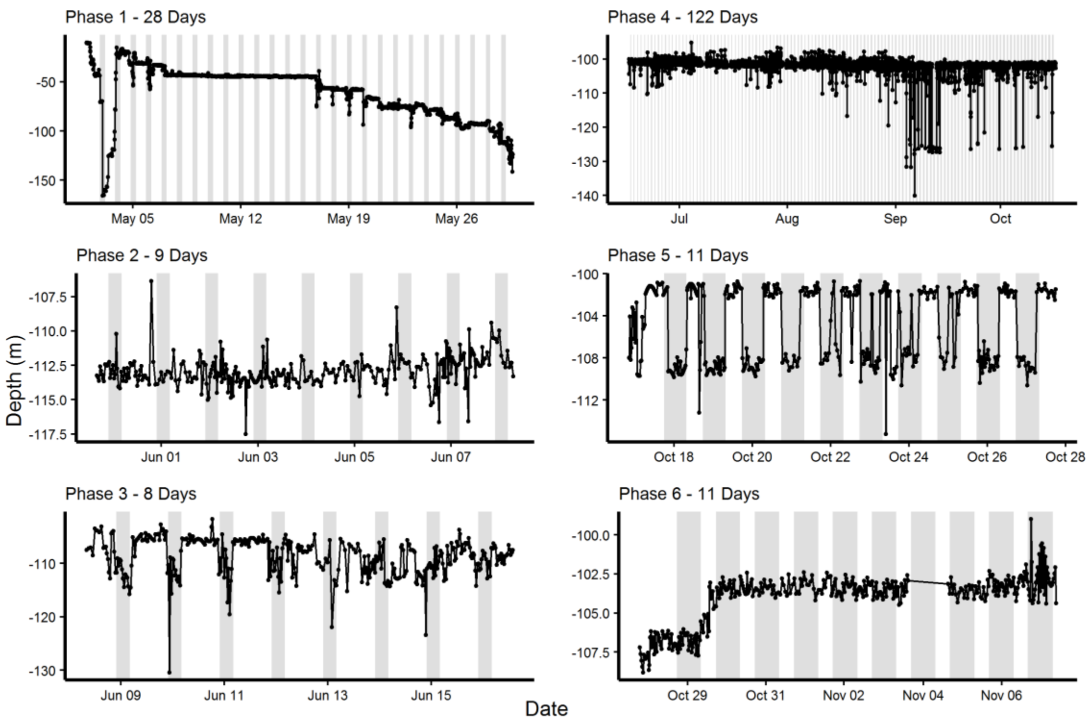
1. Research

First behavioral observations of a *Sebastes* using pop-up satellite archival tags (PSATs) post barotrauma – ABL

Pop-up satellite archival tags (PSATs) were deployed on eight blackspotted rockfish (*Sebastes melanostictus*) (37-54 cm fork length) caught at depths from 148-198 m after incurring barotrauma. The six fish released immediately after capture in a weighted cage descended quickly to what was assumed to the bottom depth. Tags ascended to the surface before the preprogrammed pop-up date after only 11-14 days. Two fish were held in captivity for eight months or four years after capture and then released at the surface. One tag came to the surface after only 12 days and a tag deployed on a 37 cm fish was retained for 190 days. Both fish made dives initially and then quickly moved to more shallow depths, indicating that rockfish may require time to acclimate to increased pressure. For the tag that was retained for 190 days, we identified six phases of vertical movement behavior. During the longest phase (123 days) the fish made rapid, 16-39 m dives (sometimes in less than 15 minutes), which were significantly deeper during the day and during high tide. During some of the shorter phases the fish was more sedentary or was deeper at night. Our results show that a Sebastes as small as 37 cm can be tagged with PSATs, if recompression and recovery are allowed to occur in captivity.

For more information contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

Figure: Depth readings from a PSAT deployed on a blackspotted rockfish during six behavioral phases over 190 days. White bars are daytime hours and dark bars encompass the time after sunset and before sunrise.



Alaska rockfish environmental DNA (eDNA) - ABL

The Auke Bay Laboratory of the Alaska Fisheries Science Center (AFSC) is responsible for stock assessments of commercially valuable rockfish species in the Gulf of Alaska (GOA). The primary information used to assess rockfish in the GOA are catches from bottom trawl surveys. However, bottom trawl survey catches may not provide adequate information for assessing and understanding rockfish populations in Alaska. Many of these species are difficult to sample using bottom trawls because they reside in untrawlable habitat. Additionally, juvenile rockfish are rarely caught using traditional sampling methods so habitat utilization of the juvenile life stages is poorly understood. Alternative sampling tools are desirable to fully understand the distribution and habitat preferences of rockfish in Alaska.

Environmental DNA (eDNA) is a relatively new but rapidly growing field of research. eDNA can be used as a surveillance tool to monitor for the genetic presence of aquatic species. Several controlled studies have shown that the DNA can persist in seawater for several days and in sediment for thousands of years. The advantage of eDNA is that the presence or absence of an organism can be determined at various locations even if they are no longer visible or able to be sampled. Our work is a pilot study examining the efficacy of this method for identifying the presence of Alaska rockfish including, Pacific ocean perch (Sebastes alutus), rougheye rockfish (S. aleutianus), blackspotted rockfish (S. melanostictus) shortraker rockfish (S. borealis), dusky rockfish (S. variabilis) and northern rockfish (S. polyspinus). By collecting water samples in areas of untrawlable habitat, we may be able to identify the presence and absence of rockfish in areas we traditionally cannot sample and ultimately better understand rockfish habitat utilization. Furthermore, this technique may eventually be used to roughly quantify rockfish populations and/or characterize their association with various habitats based on the strength of the eDNA signal.

Water samples were collected with sterilized Niskin bottles in nearshore and offshore areas off southern Baranof Island, Southeast Alaska (Figure 1). Field operations began and ended at Little Port Walter (LPW) from 4-7 August, 2016. At each sampling location, water was collected at 10 m below the surface and at approximately 2-5 m above the seafloor. Replicate 1-liter water samples were immediately vacuum-filtered through 0.45 µm nitrocellulose membranes. Membranes were folded inward with sterilized forceps, placed in tubes with 200 proof ethanol, and stored at -20° C. In the laboratory, DNA was extracted from the membranes and stored in buffer solution. Subsequent analyses will determine the concentration of DNA within the water samples and identify individual taxa.

Twenty-eight paired samples (surface and bottom, 56 samples total), as well as negative controls were collected during the 4-day survey. Locations were chosen to ensure a diverse mix of habitats were sampled, including inside and outside fjords, as well as offshore pinnacles. Samples were obtained at bottom depths that ranged between 33-307 m over varied bottom substrates including rocky reefs and soft sediments. Additionally, in an effort to maximize the probability of sampling rockfish populations, samples were obtained in areas where dense echosounder sign was observed.

To date, only preliminary laboratory processing has occurred. However, all samples, except for negative controls, contained DNA. The next phase of the analyses will be to identify several broad categories of taxa present in the water samples including phytoplankton, zooplankton, fish, crabs, shrimp, octopus, coral, sponge, otters, and whales, to name a few. Subsequent analyses will further refine the results down to specific species and relate their DNA concentrations to habitat.

For more information, contact Chris Lunsford (chris.lunsford@noaa.gov, 907-789-6008) or Patrick Malecha (pat.malecha@noaa.gov, 907-789-6415).

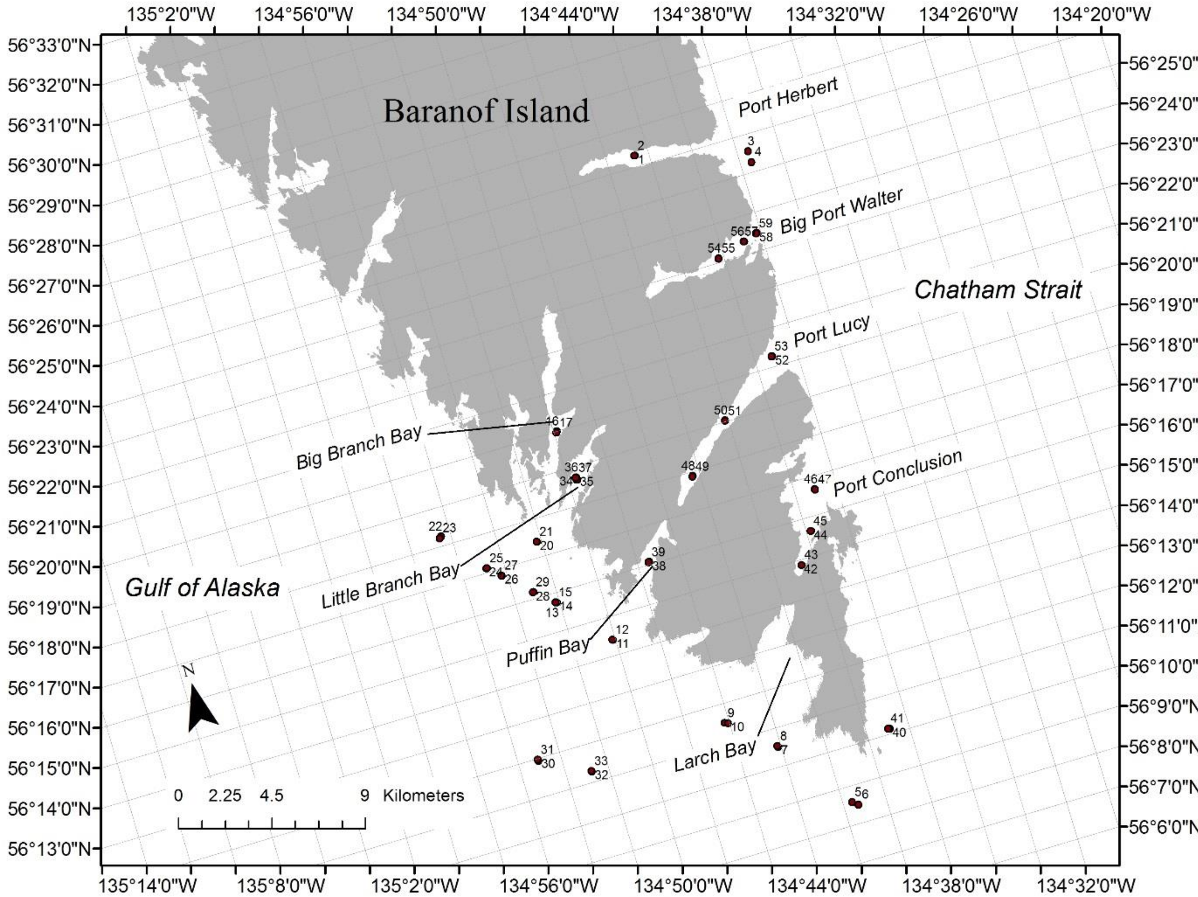


Figure 2. Map of eDNA sampling locations near southern Baranof Island.

Habitat use and productivity of commercially important rockfish species in the Gulf of Alaska - RACE GAP

The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. This project examined the productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish, *S. variabilis*) in three different habitat types during three seasons. Low relief, high relief rocky/boulder, and high relief sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska was sampled using both drop camera image analysis and modified bottom trawls. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types.

All field work for this project has been completed. Two manuscripts for this project, examining the reproductive productivity and rockfish density and community structure within different habitat types, will be completed within the next year.

For further information contact Christina Conrath, (907) 481-1732

Rockfish Reproductive Studies - RACE GAP Kodiak

RACE groundfish scientists initiated a multi-species rockfish reproductive study in the Gulf of Alaska with the objective of providing more accurate life history parameters to be utilized in stock assessment models. There is a need for more detailed assessment of the reproductive biology of most commercially important rockfish species including: the rougheye rockfish complex (rougheye and blackspotted rockfish, *S. aleutianus* and *S. melanostictus*), shortraker rockfish, *S. borealis* and other members of the slope complex. The analysis of maturity for these deeper water rockfish species has been complicated by the presence of a significant number of mature females that skip spawning. Results for rougheye rockfish, blackspotted, and shortraker rockfish are presented below. To complete these studies samples are needed from additional areas and time periods.

In addition, there is a need to examine the variability of rockfish reproductive parameters over varying temporal and spatial scales. It remains unknown if there is variability in rockfish reproductive parameters at either annual or longer time scales however, recent studies suggest variation may occur for the three most commercially important species, Pacific ocean perch, *Sebastes alutus,* northern rockfish, *S. polyspinis,* and dusky rockfish *S. variabilis.* Researchers at the AFSC Kodiak Laboratory will be examining annual differences in reproductive parameter estimates of Pacific ocean perch and northern rockfish in the upcoming years. Sampling for this study was initiated in 2009 and opportunistically continues with the anticipation that sampling will be sustained at least through the 2017 reproductive season. A proposal to examine latitudinal and spatial differences in the reproductive parameters of Pacific ocean perch and black rockfish has been submitted to obtain funds for sampling until 2020.

Rougheye and blackspotted rockfish

The recent discovery that rougheye rockfish are two species, now distinguished as ‘true’ rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further accents the need for updated reproductive parameter estimates for the members of this species complex. Current estimates for age and length at maturity for this complex in the GOA are derived from a study with small sample sizes, few samples from the GOA, and an unknown mixture of the two species in the complex. A critical step in improving the management of this complex is to understand the reproductive biology of the individual species that comprise it, as it is unknown if they have different life history parameters. This study re-examines the reproductive biology of rougheye rockfish and blackspotted rockfish within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Maturity analyses for these species and other deepwater rockfish species within this region are complicated by the presence of mature females that are skip spawning. Results from this study indicate age and length at 50% maturity for rougheye rockfish are 19.6 years and 45.0 cm FL with 36.3% of mature females not developing or skip spawning. Samples of blackspotted rockfish were also collected and analyzed during this time period. This study found age and length at 50% maturity for blackspotted rockfish are 27.4 years and 45.3 cm FL with 94% of mature females collected for this study skip spawning. The analyses of these data is complicated by the presence of both skip spawning individuals within the sample as well as a large number of large and/or old immature individuals. More samples are needed to clarify the reproductive parameters of this species. These updated values for age and length at maturity have important implications for stock assessment in the GOA. Additional samples of rougheye and blackspotted rockfish have been collected from the 2016 reproductive season and are being analyzed to compare temporal differences in reproductive parameters and rates of spawning omission.

For further information please contact Christina Conrath (907) 481-1732.

Shortraker rockfish

Currently stock assessments for shortraker rockfish, *Sebastes borealis* utilize estimates of reproductive parameters that are problematic due to limited sample sizes and samples taken during months of the years that may not be optimum for reproductive studies. The current study results indicate a length of 50% maturity of 49.9 cm which is a larger than the value currently used in the stock assessment of this species (44.5 cm). In addition this study found a skip spawning rate of over 50% for this species during the sampling period. Length at maturity data for this species were later utilized to derive an indirect age at 50% maturity for this species based on converting the length at maturity to an age at maturity. However, the ages used for this conversion were considered experimental, and additional samples are needed for updated, direct determination of the age at 50% maturity when the aging methodology for shortraker rockfish becomes validated. Researchers at the AFSC Age and Growth lab have initiated a study to initiate the aging of shortraker rockfish. Due to difficulties with aging this species which attains very old ages, additional collaborative work with other agencies is being pursued to develop a consistent methodology for aging this species. Additional samples of shortraker rockfish have been collected from the 2016 reproductive season and are being analyzed to compare temporal differences in reproductive parameters and rates of spawning omission.

For further information please contact Christina Conrath (907) 481-1732.

2. Assessment

Pacific Ocean Perch (POP) - BERING SEA AND ALEUTIAN ISLANDS - REFM

The survey biomass estimates in the Aleutian Islands were large in 2016 and consistent with the survey biomass estimates in 2010, 2012 and 2014. These continued high survey biomass estimates have contributed to a substantial increase in estimated stock size in recent years. Spawning biomass is projected to be 314,489 t in 2017 and to decline to 307,808 t in 2018. Size composition data continue to show relatively strong recent cohorts.

The current report is a full assessment and contains several important changes to the data and model. The POP assessment had included a fishery CPUE index for the years 1968 - 1977. This index has been removed. The EBS slope survey and associated compositions are now included in the recommended model. Updated data included catch for 2015, estimated catches for 2016 - 2018, 2016 survey biomass estimates for the AI and EBS Slope, and recent age and length compositions. There is also a new recommendation for weighting compositional data.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock, thereby qualifying POP for management under Tier 3. The current estimates of *B40%*, *F40%*, and *F35%* are 214,685 t, 0.082, and 0.101, respectively. Spawning biomass for 2017 (314,489 t) is projected to exceed B40%, thereby placing POP in sub-tier “a” of Tier 3. The 2017 and 2018 catches associated with the F40% level of 0.082 are 43,723 t and 42,735 t, respectively, and are the recommended ABCs. The 2017 and 2018 OFLs are 53,152 t and 51,950 t.

ABCs are set regionally based on the proportions in combined survey biomass as follows (values are for 2017): EBS = 11,789 t, Eastern Aleutians (Area 541) = 10,441 t, Central Aleutians (Area 542) = 8,113 t, and Western Aleutians (Area 543) = 13,380 t. The recommended OFLs for 2017 and 2018 are not regionally apportioned. BSAI Pacific ocean perch are not being subjected to overfishing, are not overfished, and are not approaching an overfished condition.

POP - GULF OF ALASKA – ABL

This chapter was presented in executive summary format as a scheduled “off-year” assessment. Full assessments are scheduled to coincide with years when a Gulf of Alaska trawl survey is conducted. Therefore, only the projection model was run, with updated catches. New data in the 2016 assessment included updated 2015 catch and estimated 2016 and 2017 catches. No changes were made to the assessment model.

Spawning biomass was above the *B40%* reference point and projected to be 156,563 t in 2017 and to decrease to 156,444 t in 2018. The SSC has determined that reliable estimates of *B40%, F40%*, and *F35%* exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of *B40%*, *F40%*, and *F35%* are 114,131 t, 0.102, and 0.119, respectively. Spawning biomass for 2017 is projected to exceed *B40%*, thereby placing POP in sub-tier “a” of Tier 3. The 2017 and 2018 catches associated with the *F40%* level of 0.102 are 20,806 t and 20,201 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2017 and 2018 OFLs are 27,826 t and 27,284 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2017: Western GOA = 2,679 t, Central GOA = 16,671 t, and Eastern GOA = 4,568 t. The Eastern GOA is further subdivided into West (called the West Yakutat subarea) and East (called the East Yakutat/Southeast subarea, where trawling is prohibited) of 140° W longitude using a weighting method of the upper 95% confidence of the ratio in biomass between these two areas. For W. Yakutat the ABC in 2017 is 2,786 t and for E. Yakutat/Southeast the ABC in 2017 is 1,782 t. The recommended OFL for 2017 is apportioned between the Western/Central/W. Yakutat area (25,753 t) and the E. Yakutat/Southeast area (2,073 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For more information contact Pete Hulson, ABL, at (907) 789-6060 or pete.hulson@noaa.gov.

GOA Dusky Rockfish Assessment - ABL

Dusky rockfish, *Sebastes variabilis*, have one of the most northerly distributions of all rockfish species in the Pacific. They range from southern British Columbia north to the Bering Sea and west to Hokkaido Is., Japan, but appear to be abundant only in the Gulf of Alaska (GOA).

Rockfish in the GOA are assessed on a biennial stock assessment schedule to coincide with the availability of new AFSC biennial trawl survey data. In 2016, an executive summary assessment was produced as there was no new trawl survey information available. For dusky rockfish, which are assessed using a single-species age-structured model, we run only the projection model with updated catch to determine ABC and the overfishing level (OFL).

For the 2017 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 4,278 t. This ABC is 9% lower than the 2016 ABC but similar to the 2017 projected ABC from 2015. The decrease in ABC is supported by a decline in the trawl survey biomass estimate in 2015 from 2013. A new trawl survey biomass is expected in 2017. The stock is not overfished, nor is it approaching a condition of being overfished.

For more information, contact Chris Lunsford, ABL, at (907) 789-6008 or chris.lunsford@noaa.gov.

Northern Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM

Survey biomass was sharply down in 2016 in the Aleutian Islands and slope, but was down from a high biomass estimate in 2014 and more similar to the 2012 survey estimate. Spawning biomass has been increasing slowly and almost continuously since 1977 until recent years, when it appears to be leveling off. Female spawning biomass is projected to be 107,660 t and 106,184 t in 2017 and 2018, respectively. Recent recruitment has generally been below average with few large year classes since 1998.

This chapter is a full assessment as there were surveys conducted in the Aleutian Islands, Bering Sea shelf and slope. The authors explored several different alternative models. Updated data included catch for 2015, estimated catches for 2016 - 2018, a new survey biomass estimate from the AI, and recent age and length compositions. A new approach to weighting the compositional data was also explored.

The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$ (65,870 t), $F_{40\%}$ (0.065), and $F_{35\%}$ (0.080). Because the projected female spawning biomass of 107,660 t is greater than $B_{40\%}$, sub-tier “a” is applicable, with maximum permissible $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Under Tier 3a, the maximum permissible ABC for 2017 is 13,264 t, the value recommended for the 2017 ABC. Under Tier 3a, the 2017 OFL is 16,242 t for the Bering Sea/Aleutian Islands combined. The F_{abc} decreased 7.1% from the 2014 assessment (from 0.070 to 0.065), which is attributed to a 6.1% decrease in the estimate of natural mortality (from 0.049 to 0.046). Management of this stock continues to use a combined BSAI OFL and ABC: 2017 ABC is 13,264 t and the 2017 OFL is 16,242 t.

Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For further information, contact Paul Spencer at (206) 526-4248

Northern Rockfish - GULF OF ALASKA-ABL

This chapter was presented in executive summary format, as a scheduled “off-year” assessment as full assessments are scheduled to coincide with years when a Gulf of Alaska trawl survey is conducted. Therefore, only the projection model was run, with updated catches. New data in the 2016 assessment included updated 2015 catch and estimated 2016 and 2017 catches. No changes were made to the assessment model.

Spawning biomass is above the *B40%* reference point and projected to be 29,198 t in 2017 and to decrease to 27,344 t in 2018. The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock, thereby qualifying northern rockfish for management under Tier 3. The current estimates of *B40%*, *F40%*, and *F35%* are 27,983 t, 0.062, and 0.074, respectively. Spawning biomass for 2017 is projected to exceed *B40%*, thereby placing northern rockfish in sub-tier "a" of Tier 3. The 2017 and 2018 catches associated with the *F40%* level of 0.062 are 3,214 t and 2,923 t, respectively, and were the authors' and Plan Team's recommended ABCs. The recommended 2017 and 2018 OFLs were 4,522 t and 4,175 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2017: Western GOA = 432 t, Central GOA = 3,354 t, and Eastern GOA = 4 t (note that the small ABC in the Eastern GOA is included with 'other rockfish' for management purposes). The recommended OFL for 2017 and 2018 is not regionally apportioned. Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For more information, contact Pete Hulson, ABL, at (907) 789-6060 or pete.hulson@noaa.gov.

Shortraker Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM

Estimated shortraker rockfish biomass in the BSAI has been relatively stable since 2002. Biomass estimates have decreased slightly from 23,009 t in the 2014 assessment to 22,191 t in the current assessment. For the period 2002-2016, EBS slope survey biomass estimates ranged from a low of 2,570 t in 2004 to a high of 9,299 t in 2012 with survey CVs at 0.22 and 0.57, respectively. For the period 1991-2016, the AI survey biomass estimates ranged from a low of 12,961 t in 2006 to a high of 38,487 t in 1997 with survey CVs at 0.23 and 0.26, respectively. The random effects model estimate of total biomass (AI and EBS slope combined) from 2002-2016 has been very stable, ranging from a low of 21,214 t in 2006 to a high of 23,990 t in 2002. The time series of biomass estimates from the random effects model is much smoother than the time series for the raw data, due to large standard errors associated with the survey biomass estimates.

2016 was a full assessment year for this Tier 5 stock; there were no changes in the assessment methodology. New data included updated catch from 2015, estimated catch for 2016 and the biomass estimates from the 2016 Aleutian Islands and Eastern Bering Sea slope surveys were added to the model. The 2017 biomass estimate is based on the Aleutian Island survey data through 2016 as well as the 2002 - 2012, and 2016 eastern Bering Sea slope survey data (the 2014 eastern Bering Sea slope survey was cancelled). Prior to 2012, the EBS slope survey data had not been included in previous biomass estimates for this species.

The SSC has previously determined that reliable estimates of only biomass and natural mortality exist for shortraker rockfish, qualifying the species for management under Tier 5. The 2017 biomass estimate was based on the random effects model and ABC was set at the maximum permissible level under Tier 5, where F_{ABC} is 75 percent of *M*. The accepted value of *M* for the shortraker rockfish stock is 0.03, resulting in a *max* F_{ABC} value of 0.0225. This value corresponds to an ABC of 499 t for 2017 and 2018 and the OFL is 666 t for 2017 and 2018.

Shortraker rockfish is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

Shortraker Rockfish - GULF OF ALASKA – ABL

Rockfish in the Gulf of Alaska (GOA) are assessed on a biennial assessment schedule to coincide with new data from the AFSC biennial trawl surveys in the GOA. A straightforward update of the assessment was presented in an executive summary because the GOA survey was not conducted in 2016. Catch data were updated.

Shortraker rockfish have always been classified into "Tier 5" in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level, in which a random effects model is applied to the GOA trawl survey biomass estimates from 1984-2015 to estimate exploitable biomass and determine the recommended ABC. For an off-cycle year, there is no new survey information for shortraker rockfish; therefore, the 2015 estimates are rolled over to 2016. Estimated shortraker biomass is 57,175 mt, which is identical to the 2015 assessment biomass estimate. The NPFMC's Tier 5 ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 1,286 t for the 2017 fishery. Gulfwide catch of shortraker rockfish was 578 t in 2015 and estimated at 704 t in 2016. Shortraker rockfish in the GOA are not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

For more information please contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

Blackspotted/rougheye Rockfish Complex - BERING SEA AND ALEUTIAN ISLANDS - REFM

Spawning biomass for BSAI blackspotted/rougheye rockfish in 2017 is projected to be 7,305 t and is projected to increase. This increasing trend is supported by evidence of several large recruitments in the 2000s. The most recent survey in the Aleutian Islands (2016) increased substantially from the low estimate in 2014, and is more consistent with the level of Aleutian Islands survey estimates since 1991. The 2016 trawl survey biomass estimate from the slope survey is the lowest observed in the time-series since 2002.

The 2016 SAFE report is a full assessment where a Tier 3 age-structured model is applied to the BSAI whereas previously the model was only used for the AI portion of the assessment. The new model includes the EBS Slope survey and associated age and length composition data. New data included updated catch for 2015, estimated catches for 2016 - 2018, a 2016 survey biomass estimate for the AI, and recent length and age composition data. Because some stations could not be surveyed in the 2016 EBS slope survey, the assessment utilizes previous slope surveys, through 2012.

For the BSAI, this stock qualifies for management under Tier 3 due to the availability of reliable estimates for *B40%*, *F40%*, and *F35%*. Because the projected female spawning biomass for 2017 of 7,305 t is less than *B40%*, (8,311 t) the stock qualifies as Tier 3b and the adjusted *FABC* = *F40%* values for 2017 and 2018 are 0.039 and 0.044, respectively. The maximum permissible ABC for the Aleutian Islands is 501 t, which is the authors' and Team's recommendation for the AI portion of the 2017 ABC. The apportionment of 2017 ABC to subareas is 207 t for the Western and Central Aleutian Islands and 294 t for the Eastern Aleutian Islands and Eastern Bering Sea. The overall 2017 ABC of 501 t and a 2017 OFL of 612 t is recommended.

Blackspotted/rougheye Rockfish Complex - GULF OFALASKA - ABL

Rougheye (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) have been assessed as a stock complex since the formal verification of the two species in 2008. We use a statistical age-structured model as the primary assessment tool for the Gulf of Alaska rougheye and blackspotted rockfish (RE/BS) stock complex, which qualifies as a Tier 3 stock. Rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska rockfish in off-cycle years, we usually we present an executive summary to recommend harvest levels for the next two years.

RE/BS rockfish are assessed using a statistical age-structured model. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels. The data sets used in this assessment include total catch biomass, fishery age and size compositions, trawl and longline survey abundance estimates, trawl survey age compositions, and longline survey size compositions. For an off-cycle year, we do not re-run the assessment model, but do update the projection model with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points.

There were no changes made to the assessment model or model inputs since this was an off-cycle year. New data added to the projection model included an updated 2015 catch estimate (550 t) and new catch estimates for 2016-2018. The 2016 catch was estimated by calculating an expansion factor and resulted in an estimated catch for 2016 of 628 t. To estimate future catches, we updated the yield ratio to 0.52, which was the average of the ratio of catch to ABC for the last three complete catch years (2013-2015). This yield ratio was multiplied by the projected ABCs from the updated projection model to generate catches of 685 t in 2017 and 668 t in 2018.

For the 2017 fishery, we recommend the maximum allowable ABC of 1,327 t from the updated projection model. This ABC is very similar to last year's ABC of 1,328 t and slightly more than last year's projected 2017 ABC of 1,325 t. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished.

Gulfwide catch of rougheye and blackspotted rockfish remains relatively stable in all areas, with some decrease in the longline fisheries and increase in the trawl fisheries in 2016. The majority of the RE/BS rockfish catch remains in the rockfish and sablefish fisheries. The 2016 longline survey abundance estimate (relative population number or RPN) decreased about 22% from the 2015 estimate and is slightly below the long-term mean. Estimates by area were all consistently down with the largest decrease in the East Yakutat/Southeast Outside region.

A full stock assessment document with updated assessment and projection model results will be presented in next year's Stock Assessment and Fishery Evaluation (SAFE) report.

For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

H. Thornyheads

1. Research

Shortspine Thornyhead Tagging – ABL

The Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS) has been tagging shortspine thornyhead (*Sebastolobus alascanus*, SST) in offshore waters aboard chartered commercial vessels during the NMFS annual AFSC Longline Survey in Alaska waters since 1992. Tagging of SST first occurred in 1992, but was not consistently done until 1997. Tagging has included conventional anchor tags and internally implanted electronic archival tags.

Since 1992, 13,694 SST have been tagged with conventional anchor tags and a total of 227 tagged SST have been recovered. The majority of recovered tags have been caught using commercial longline gear (160 tags), 38 tags have been recovered on trawl gear, and 1 in a trap. Fifty of the 227 total recovered tags have been caught on research surveys (all on the NMFS annual AFSC Longline Survey). The majority of tag recoveries have been from the Central (75 tags) and Eastern (83 tags) GOA.

The great circle distance traveled by a tagged SST ranges from <1 nm to 990 nm. Of the returned tags with reliable position information, 19% had traveled < 2 nm between tagging and recovery, 36% traveled 2 – 5 nm, 18% traveled 6 - 10 nm, 12% traveled 11 – 50 nm, 4% traveled 51 – 100 nm, and 11% traveled > 100 nm. The average distance traveled was 46 nm, with no apparent difference in travel distance by sex (male = 49 nm and female = 44 nm). It is important to note that an error of up to 5 nm can be expected based on the difference in location between where the AFSC longline survey gear was set (official release location) and where the fish was actually tagged and released.

There appears to be no relationship between fish size at release and movement. The average distance traveled was greatest (95 nm) for the largest size group (>400 mm), but a fish from the smallest size group (<330 mm) traveled the farthest maximum distance (990 nm). Note that these are arbitrary size breaks based on the quantity of data available data by size and size groups were not chosen for biological reasons. All fish tagged are >270 mm and are, therefore, assumed to be mature.

While the majority of tagged SST showed little to no movement (i.e., 73% of tagged recoveries traveled less than 10 nm), there have been some long-distance movements, and some fish crossed management and international boundaries. There appears to be an inclination for a SST to move in an east/southeast direction, and a number of recoveries occurred in British Columbia (BC), Canada, particularly near Queen Charlotte Island. The majority of recovered SST, however, remained within their management area of release. Shortspine thornyhead that were tagged and released in the Eastern GOA were more inclined to move than SST tagged in any other area. Of the 102 recoveries that were released in the Eastern GOA, 76% remained within the Eastern

GOA, 18% were recovered in BC, 5% were recovered in the Central GOA, and 1% were recovered on the U.S. West Coast (WC).

Nearly half (48%) of the 153 fish with reliable size information at recovery showed no change in length (39 fish) or a decrease in length (35 fish). These zero growth fish ranged in time at liberty between 33 days and almost 14 years, reiterating that SST exhibit extremely slow growth. It appears that larger fish are more prone to show negative growth; 34 of the 35 fish showing negative growth were >330 mm, and the largest decreases (>100 mm) in length were by fish >400 mm. Additionally, nearly a quarter (23%) of the fish exhibiting negative growth were recovered in BC. Fish with negative growth have been documented by recoveries on NMFS research vessels and by observers on commercial fishing vessels, where accurate length measurements are expected. Ten of the 89 tagged SST recovered on NMFS research vessels or by observers showed a decrease in size.

For more information, contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

2. *Stock Assessment*

GULF OF ALAKSA - ABL

Rockfish in the Gulf of Alaska (GOA) are assessed on a biennial assessment schedule to coincide with new data from the AFSC biennial trawl surveys in the GOA. A straightforward update of the assessment was presented in an executive summary because the GOA survey was not conducted in 2016. Catch data were updated.

Gulf of Alaska thornyheads (genus *Sebastolobus*) are assessed as a stock complex under Tier 5 criteria in the North Pacific Fishery Management Council's (NPFMC) definitions for allowable biological catch (ABC) and overfishing level (OFL). For thornyheads in the GOA, a random effects model is applied to the GOA trawl survey biomass estimates from 1984-2015 to estimate a time series of exploitable biomass and to determine the recommended ABC. Estimated thornyhead biomass is 87,155 mt. Thornyhead biomass in the GOA has generally shown an increasing pattern since 2011. This follows a steady decline since 2003. The NPFMC's "tier 5" ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of thornyhead rockfish results in a recommended ABC of 1,961 t for the 2017 fishery. Gulfwide catch of thornyhead rockfish was 1,033 t in 2015 and estimated at 984 t in 2016. Thornyhead rockfish in the GOA are not being subjected to overfishing. It is not possible to determine whether this complex is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

For more information please contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

I. Sablefish

1. *Research*

Sablefish Tag Program - ABL

The ABL MESA Program continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database during 2016. Total sablefish tag recoveries for the year were around 800. Twenty-four percent of the recovered tags in 2016 were at liberty for over 10 years. About 36 percent of the total 2016 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 35 percent within 100 – 500 nm, 21 percent within 500 – 1,000 nm, and 7 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 37 years, and the greatest distance traveled of a 2016 recovered sablefish tag was 2,364 nm. Three adult sablefish and nine juvenile sablefish tagged with archival tags were recovered in 2016. Data from these electronic archival tags, which will provide information on the depth and temperature experienced by the fish, are still being analyzed.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye rockfish are also maintained in the Sablefish Tag Database. Twenty-two thornyhead and 3 Greenland turbot (one conventional and two archival tags) were recovered in 2016.

Releases in 2016 on the groundfish longline survey totaled 3,364 adult sablefish, 766 shortspine thornyheads, and 2 Greenland turbot. Pop-up satellite tags (PSAT) were implanted on 13 sablefish. An additional 961 juvenile sablefish were tagged during an additional cruise in 2016.

For more information contact Katy Echave at (907) 789-6006, katy.echave@noaa.gov.

Juvenile Sablefish Studies – ABL

Juvenile sablefish studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2016. A total of 972 juvenile sablefish were caught, tagged, and released in St. John Baptist Bay and Silver Bay, near Sitka, AK, over 4 days (July 13th – July 16th) with 100 rod hrs. A biologist from the Alaska Department of Fish and Game participated for one of the days. Total catch-per-unit-effort (CPUE) equaled 9.72 sablefish per rod hour fished. This was up significantly from 2015 (4.91), and higher than the recent high catch in 2011 (7.63). The mean length of sablefish was considerably smaller in 2016 compared to the recent time period despite being a fairly similar time of the year for sampling and we noted the fish seemed undernourished.

In addition to the annual juvenile sablefish tagging near Sitka, two days (9/1 – 9/2/2016) were spent sampling various bays around Kodiak Island. This tagging cruise in the Central Gulf of Alaska (CGOA) was conducted as follow up to compare with the highly successful 2015 CGOA juvenile tagging. Rare reports Gulfwide of juvenile sablefish catches in the summer of 2015 led to two days sampling off Kodiak Island (8/24 – 8/25/2015) that resulted in one of the highest seen CPUEs in the time series of juvenile sablefish tagging. No juvenile sablefish were caught during the 2016 sampling. This result is interesting, as numerous reports of large juvenile sablefish catches were reported in the Eastern Gulf of Alaska in both 2015 and 2016, but only in the CGOA in 2015.

For more information contact Dana Hanselman at (907) 789-6626, dana.hanselman@noaa.gov

Sablefish Archival Tagging Study - ABL

During the 1998, 2000, 2001, and 2002 AFSC longline survey, 600 sablefish were implanted and released with electronic archival tags that recorded depth and temperature. These archival tags provide direct insight into the vertical movements and occupied thermal habitat of a fish. 127 of these tags have been recovered and reported from commercial fishing operations in Alaskan and Canadian waters. Analysis of these data began in 2011 continued in 2012 and 104 of these tags have been analyzed to date. Temporal resolution of depth and temperature data ranged from 15 minutes to one hour, and data streams for an individual fish ranged from less than a month to greater than five years. After a hiatus during 2013-2015, data analysis resumed in 2016. A manuscript is anticipated for 2017.

For more information, contact Mike Sigler at mike.sigler@noaa.gov.

Sablefish Satellite Tagging - ABL

The fifth year of extensive tagging of sablefish with pop-up satellite tags (PSATs) was conducted on the AFSC annual longline (LL) survey in 2016. Pop-off satellite tags were deployed on 13 sablefish throughout the Gulf of Alaska (GOA) and the Aleutian Islands (AI) to study daily and large-scale movements. These tags were programmed to release from the fish 1 January 2017 and 1 February 2017, in hopes of determining spawning locations and ultimately areas which may be used to help assess recruitment. Data from these tags will also provide an improved picture of the daily movements and behavior patterns of sablefish. The 2016 released tags join the 78 tags that were released in the GOA, AI, and Bering Sea (BS) on the LL Survey during 2012 -2015. This work is still in the early stages of analysis, it is still too early to determine if there is any directed movement by sablefish for spawning purposes. Admittedly, tags should be programmed to remain on the fish for an entire year in order to determine if sablefish are exhibiting any homing behavior for spawning purposes. Ideally, the fish would be tagged just before the spawning season in the winter and programmed to release the following winter during the spawning season. However, having the release location of the tag and the pop up location (location of the fish when the tag released) has provided great insight into (relatively) short term and winter behavior of sablefish.

For more information contact Katy Echave at (907) 789-6006, katy.echave@noaa.gov.

Can future spawning of female sablefish be determined in the summer in the Gulf of Alaska? – ABL

It is preferable to gauge maturity when fish that will spawn have oocytes in advanced stages of vitellogenesis. For sablefish the spawning season is estimated to peak in February or March. However, typical sampling platforms, such as the NMFS bottom trawl and longline surveys in Alaska, are available only June through August. This encompasses the time in the reproductive cycle when fish are either resting or beginning to develop. Macroscopic evaluations of sablefish ovarian development have been collected on NMFS longline surveys in Alaska since 1996. Thus far, maturity data have not been validated using histology and have not been used for assessment.

In 2015, 588 female sablefish were collected on the longline survey in the central and eastern Gulf of Alaska (Figure 1) in July and August. All sablefish were aged, livers weights were collected, maturity was classified at-sea, and ovarian tissues were prepped for a microscopic evaluation. Ovaries containing oocytes in advanced cortical alveoli (CA) stage or in vitellogenesis were considered to be maturating towards spawning in the coming season. Microscopically, fish that were predicted to skip spawning lacked developing oocytes, had a thick ovarian wall, thick tissue within the ovary, and veins within the ovary. (The advanced CA stage was chosen a cut-off because fish previously sampled in December that would skip spawning contained oocytes that were in earlier stages of development [perinucleolar or early CA]).

We found that ovaries were at a wide variety of developmental stages, indicating some ovaries that were just beginning to develop and some may not have initiated development yet. Even though I have concerns about the accuracy of maturity classifications of immature and skip spawning fish in the summer months, we examined age at maturity curves for a comparison of methodology and geographic areas (survey leg). The discrepancies in age at maturity between macroscopic and microscopic methodology varied on each survey leg (Figures 1 and 2). In addition, when using only one method for maturity classification, age at maturity curves varied by leg (Figure 2). The results indicate that 1) summer data may not provide accurate results even if microscopic methods are employed and 2) that there may be variation in maturity throughout the Gulf of Alaska, which deserves further study in the future.

For more information contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

Figure 1. Map of AFSC longline survey stations sampled on survey legs 3-7. Leg 3 is sampled in early July and the vessel heads westward, ending at the western side of the central Gulf of Alaska at the end of August.

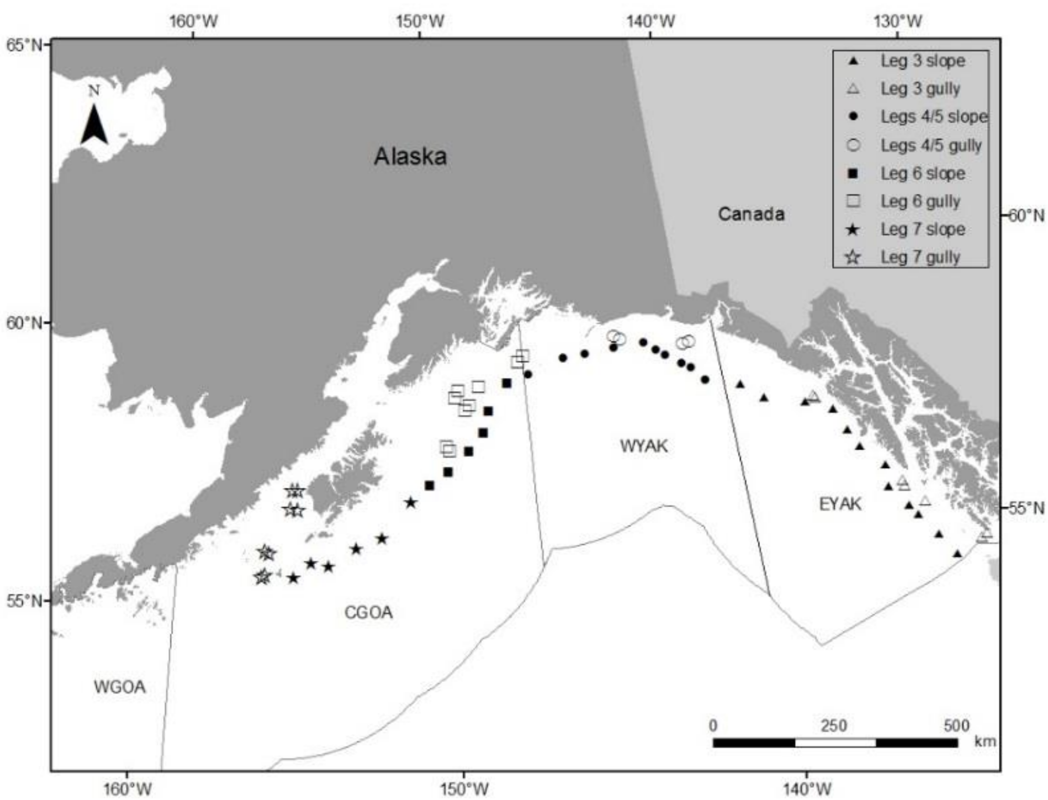
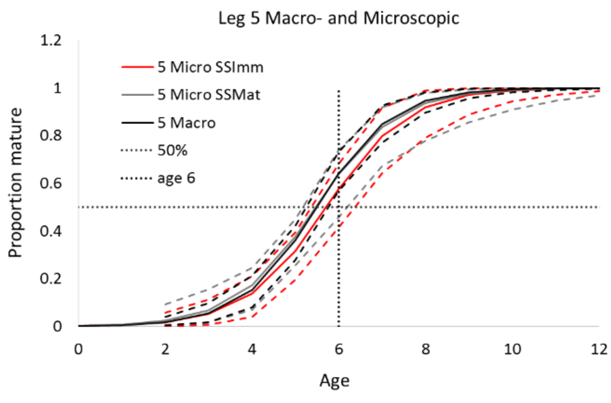
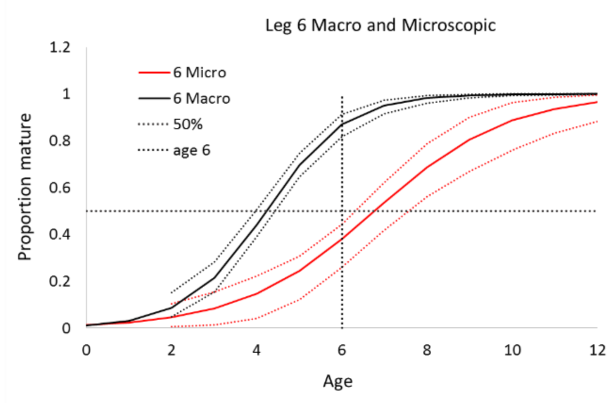


Figure 2. Age at maturity on legs 5 or 6 when maturity was determined with either macroscopic or microscopic methods. Fish that were assumed to skip spawning were either classified as

immature (SSImm) or mature (SSMat); no skip spawning fish were identified on leg 6. The lines at age 6 and 50% maturity are included as points of reference.





A second year of sampling sablefish in the central Gulf of Alaska prior to spawning – ABL

Female sablefish were sampled in December of 2011 for a study of age at maturity immediately before the spawning season near Kodiak Island, which is near the center of their Alaska distribution. Skipped spawning was documented in sablefish for the first time. Skip spawning fish could be identified on histology slides by the combination having only immature oocytes, a much thicker ovarian wall than immature fish, a thick tissue (stroma) separating oocytes, and veins within the ovarian tissue. In 2015 nearby locations and some of the same sites were sampled for the second time for a measure of skipped spawning rate and age at maturity. There were many fewer skip spawning fish in 2015, even in cross-shelf gullies where they were most prevalent in 2011. In 2015, sablefish were absent at these locations. This may indicate that skip spawning fish aggregate in gullies and spawning fish aggregate on the continental slope. In age at maturity curves skipped spawning fish were either included as “immature” or “mature”, creating two separate curves in each year. This is not the only way to model skip spawning in age at maturity curves, but the method was chosen until more data on skip spawning rates by age are available. In 2011, when skipped spawning was more prevalent, classifying them as immature increased the A_{50} substantially compared to when they were considered mature. In 2015 the two curves were virtually identical due to a small number of skipped spawning fish. It is likely that skip spawning rates vary by year depending on the environment and fish condition. The age at maturity will vary depending on the prevalence of skip spawning and its relationship with age.

For more information contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

	A_{50}	
	Skip Spawn Immature	**Skip Spawn Mature**
2011	9.9	6.8
2015	7.5	7.3

Southeast Coastal Monitoring Survey Indices and the Recruitment of Gulf of Alaska Sablefish - ABL

Description of indicator: Biophysical indices from surveys and fisheries in 2014 and 2015 were used to predict the recruitment of sablefish to age-2 in 2016 and 2017 (Yasumiishi et al. 2015a). The southeast coastal monitoring project has an annual survey of oceanography and fish in inside and outside waters of northern southeast Alaska (Orsi et al. 2012). Oceanographic sampling included, but was not limited to, sea temperature and chlorophyll *a*. These data are available from documents published through the North Pacific Anadromous Fish Commission website from 1999 to 2012 (www.npafc.org) and from Emily Fergusson (NOAA ABL). An index for pink salmon survival was based on adult returns of pink salmon to southeast Alaska (Piston and Heinl 2014). These oceanographic metrics may index sablefish recruitment, because sablefish use these waters as rearing habitat early in life (late age-0 to age-2).

Status and trends: Based on a low chlorophyll *a* value in 2014 (3.73) and 2015 (1.12) we expect an abundance of 19.7 million age-2 sablefish in 2016 and below average at 3.8 million age-2 sablefish in 2017. We modeled age-2 sablefish recruitment estimates from 2001 to 2015 (Hanselman et al. 2015) as a function of sea temperature, chlorophyll *a*, and pink salmon productivity during the age-0 stage for sablefish. The model with the lowest Bayesian information critierion (112) described the stock assessment estimates of recruitment of sablefish to age-2 as a function of late August chlorophyll *a* during the age-0 stage (Figure 1; Table 1). A regression model indicated that chlorophyll *a* during the age-0 phase was positively and signficantly correlated with sablefish recruitment ($R^2 = 0.59$; p-value = 0.0008). Sea temperature and pink salmon productivity fell out of the model with the addition of 4 years of data to the 2016 model compared to the 2015 model (Yasumiishi et al. 2015b).

Factors influencing observed trends: Warmer sea temperatures were associated with high recruitment events in sablefish (Sigler and Zenger, 1989). Higher chlorophyll *a* content in sea water during late summer indicate higher primary productivity and a possible late summer phytoplankton bloom. Higher pink salmon productivity, a co-occurring species in near-shore waters, was a positive predictor for sablefish recruitment to age-2. These conditions are assumed more favorable for age-0 sablefish, overwintering survival from age-0 to age-1, and overall survival to age-2.

Implications: Late summer chlorophyll *a* in 2014 and 2015 was used to predict the recruitment of Alaska sablefish to age-2 in 2016 and 2017. The model predicts 19.7 million age-2 sablefish in 2016 (average) and below average recruitment of sablefish to age-2 at 3.8 million in 2017.

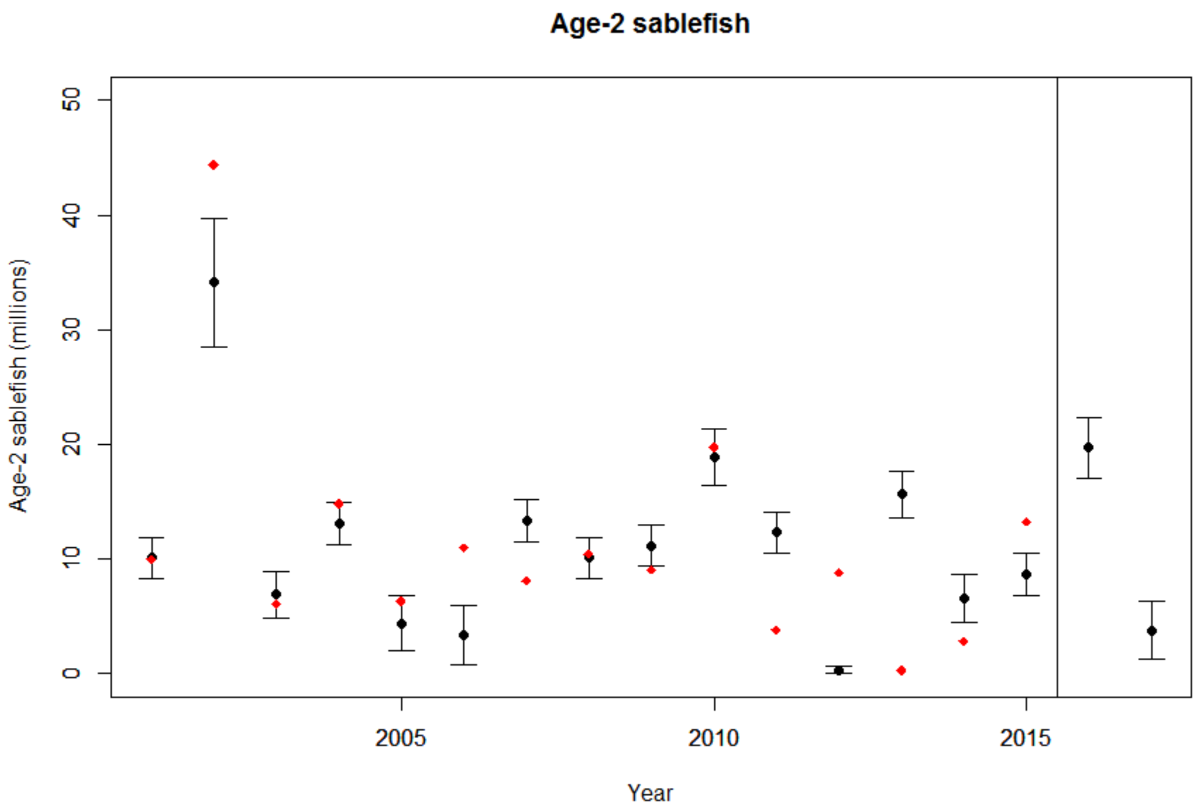


Figure 1. Stock assessment estimates (red), model estimates (black), and the 2016 and 2017 prediction for age-2 Alaska sablefish. Stock assessment estimates of age-2 sablefish were modeled as a function of late August chlorophyll *a* levels in the waters of Icy Strait in northern southeast Alaska during the age-0 stage (*t*-2).

Research conducted by Ellen Yasumiishi, Kalei Shotwell, Dana Hanselman, Joe Orsi, Emily Fergusson.

For more information contact Ellen Yasumiishi at (907) 789-6604 or (ellen.yasumiishi@noaa.gov).

References

Hanselman, D.H., Lunsford, C.R., and Rodgveller, C.J. 2015. Assessment of the sablefish stock in Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, Alaska. pp. 267–376.

Orsi, J.A., E.A. Fergusson, M.V. Sturdevant, W.R. Heard, and E.V. Farley, Jr. 2012. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2011. NPAFC Doc.1428, Rev. 1. 102 pp. Auke Bay Lab., Alaska Fisheries Science Center, National Marine Fisheries, NOAA, NMFS, 17109 Point Lena Loop Road, Juneau, 99801, USA. (Available at http://www.npafc.org).

Piston, A.W. and S.C Heinl. 2014. Pink salmon stock status and escapement goals in southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 14-14, Anchorage.

Sigler, M.F., and H.H. Zenger Jr. 1989. Assessment of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1987. U.S. Department of Commerce, NOAA Technical Memo. NMFS F/NWC-169, 54 p.

Yasumiishi, E., K. Shotwell, D. Hanselman, J. Orsi, and E. Fergusson. 2015a. Using salmon survey and commercial fishery data to index nearshore rearing conditions and recruitment of Alaska sablefish. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 7(1): 316-324. DOI: 10.1080/19425120.2015.1047070

Yasumiishi, E.M., K. Shotwell, D. Hanselman, J. Orsi, and E. Fergusson. 2015b. Southeast coastal monitoring survey indices and the recruitment of Gulf of Alaska sablefish. In: S. Zador (Ed.), Ecosystem Considerations for 2014. Appendix C of the BSAI/GOA Stock Assessment and Fishery Evaluation Report. Technical report, North Pacific Fishery Management Council, 605W. 4th Ave., Suite 306, Anchorage, AK 99501.

Table 1. Nearshore survey data fit to the stock assessment estimates of age-2 sablefish (millions of fish) from Hanselman et al. (2015). Table shows the 2016 model fitted (2001-2015), forecast (2016 and 2017) estimates and standard errors for age-2 sablefish, and the predictor variable (1999-2013).

Year	Stock assessment Estimates Sablefish (t)	Model Fitted and forecast Estimates	Standard error	Predictor variable Chlorophyll a (t-2)
2001	9.98	9.96	2.24	2.15
2002	44.39	33.48	5.14	6.08
2003	6.07	6.85	1.81	1.63
2004	14.83	12.89	1.82	2.64
2005	6.33	4.4	2.1	1.22
2006	10.97	3.38	2.55	1.05
2007	8.09	13.13	2.61	2.68
2008	10.44	9.96	1.59	2.15
2009	9.09	11.04	2.46	2.33
2010	19.76	18.58	2.08	3.59
2011	3.84	12.18	2.01	2.52
2012	8.82	0.386	0.386	0.55
2013	0.29	15.4	2.21	3.06
2014	2.82	6.55	4.17	1.58
2015	13.26	8.86	1.7	1.92
2016		19.7	2.64	3.73
2017		3.79	2.49	1.12

Pilot Study of Sablefish (*Anoplopoma fimbria*) Larval Rearing at AFSC-RPP

We conducted a pilot study of sablefish larval rearing with the following objectives:
1. Validate daily increment formation in otoliths using alizarin complexone (ALC) staining so that field-collected larvae may be correctly aged for growth studies.
2. Evaluate a cell-cycle based method for assessing condition.
3. Early-life development information (note when specific developmental traits appear, e.g., when the eyes and mouth become functional, and determine the sizes of larvae at hatch and first feeding).

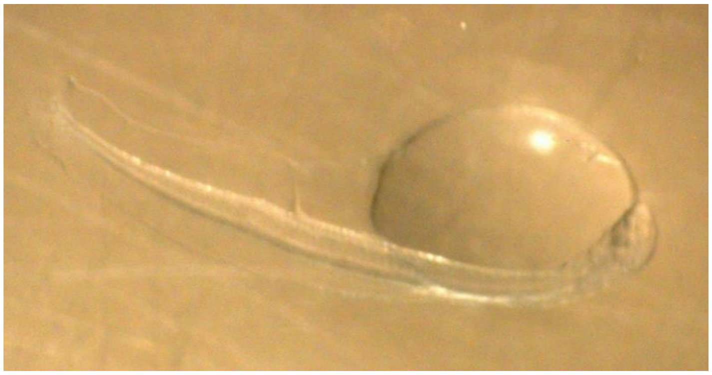
The Northwest Fisheries Science Center Laboratory at Manchester, WA provided unfertilized eggs from two females (Groups A and B) and milt from three males caught off the coast of Washington. We fertilized the eggs in our lab and kept them in the dark at 5.7°C. Group B eggs died soon after fertilization. The surviving group was reared at 5.7°C until first feeding at which time the temperature was raised to 6.9°C to emulate larvae rising into the surface water. At hatching, a 16 hour light: 8 hour dark light cycle was started and light level was kept low (< 1 µmol photon $m^{-2}s^{-1}$) by using black screen tank covers. Light level was gradually increased between hatching and first feeding by reducing the number of screens covering the tanks. Larvae were on the bottom of the tanks during the time from hatching to shortly after first feeding at which time they rose off the bottom and swam up to the surface. At that time all screens were removed (light level = 10 µmol photon $m^{-2}s^{-1}$).

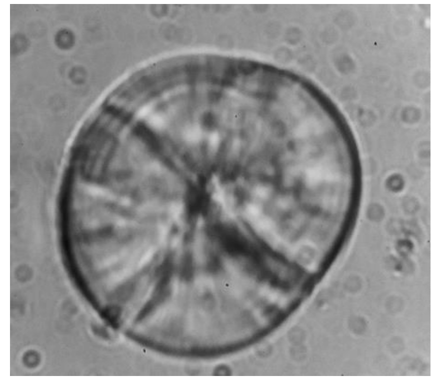
Development at 5.7°C

Fertilization to hatch = 13 days. Approximate size at hatch = 5.00 mm.
Hatch to first feeding = 27 days. Approximate size at first feeding = 8.00 mm.

<u>Developmental observations</u>

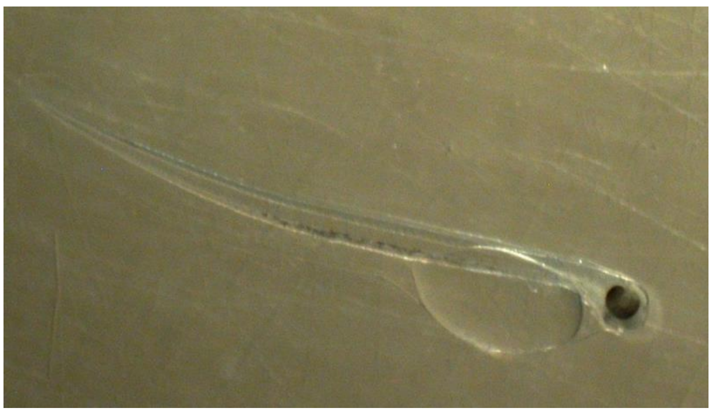
Hatch: very large yolk, no body or eye pigment, and mouth was not formed, hatch mark formed on otoliths
8 days after hatch: eyes pigmentation starts, larvae were reactive to touch and short bursts of swimming observed, gut was apparent
11 days after hatch: liver forming
12 days after hatch: eye approximately 70% pigmented, anus open
14 days after hatch: dorsal gut pigmentation begins
16 days after hatch: eyes fully pigmented (eyes may be functional at this time)
22 days after hatch: mouth is apparent but not functional
27 days after hatch: first feeding, yolk was still present
30 days after hatch: larvae attracted to light and swim to the surface of the rearing tanks
38 days after hatch: yolk depleted

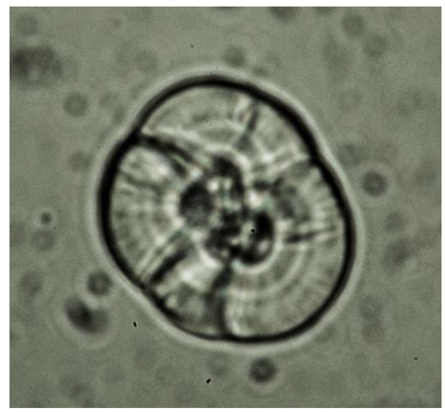




6 days after hatch
SL = 5.85 mm

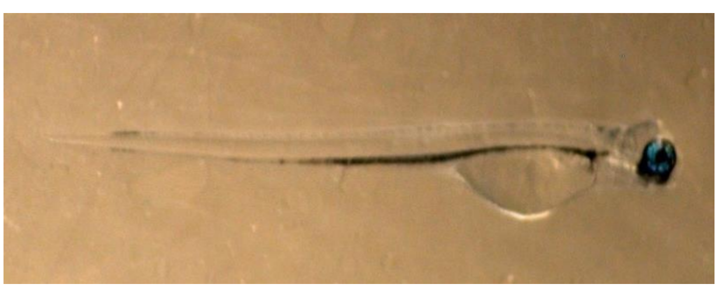
Otolith Diameter = 22 μm
SL = 5.82 mm

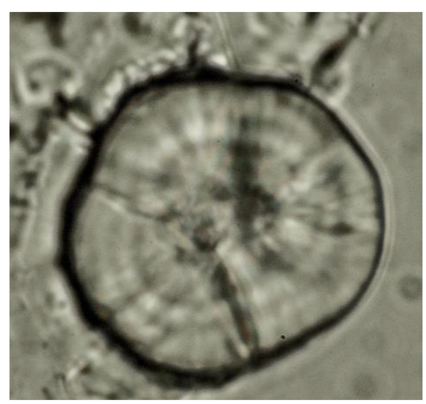




14 days after hatch
SL = 7.19 mm

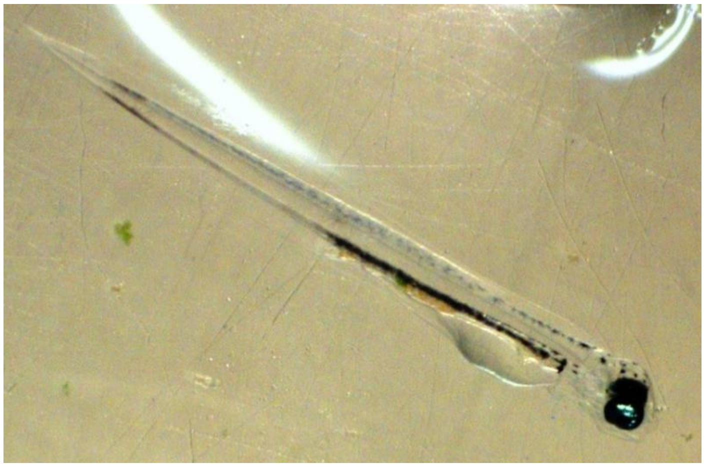
Otolith Diameter = 25μm
SL = 7.11 mm

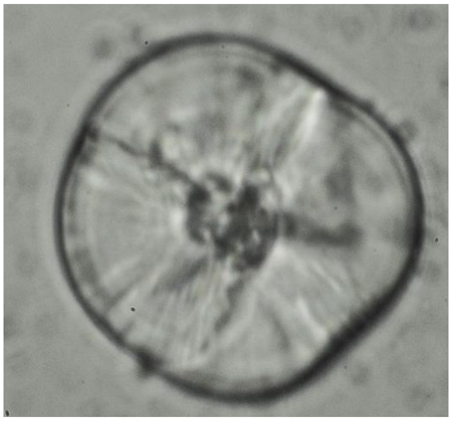




22 days after hatch
SL = 8.03 mm

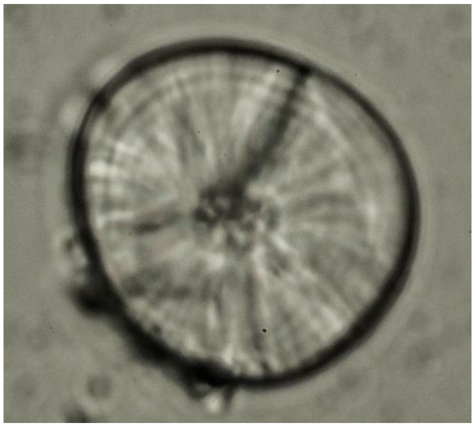
Otolith Diameter = 31 μm
SL = 7.84 mm





28 days after hatch
1 day after first feeding
SL = 7.93 mm

Otolith Diameter = 36 µm
SL = 8.65 mm



31 days after hatch

Otolith Diameter = 34 µm

For further information contact Annette Dougherty and Steve Porter

2. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA - ABL

A full sablefish stock assessment was produced for the 2017 fishery. We added relative abundance and length data from the 2016 AFSC longline survey, relative abundance and length data from the 2015 longline and trawl fisheries, age data from the 2015 longline survey and 2015 fixed gear fishery, updated 2015 catch, and estimated catches for 2016-2018.

In addition to these usual new data updates, the following substantive new changes were made to the data inputs:

1) New analytical variance calculations for the domestic longline survey abundance index
2) New area sizes for the domestic longline survey abundance index
3) Domestic longline survey estimates corrected for sperm whale depredation
4) Estimates of killer and sperm whale depredation in the fishery

The longline survey abundance index increased 34% from 2015 to 2016 following a 21% decrease from 2014 to 2015 which was the lowest point of the time series. The fishery abundance index decreased 12% from 2014 to 2015 and is the time series low (the 2016 data are not available yet). There was no Gulf of Alaska (GOA) trawl survey in 2016. Spawning biomass is projected to decrease slightly from 2017 to 2019, and then stabilize. Sablefish are currently right at the spawning biomass limit reference point and still well below the target, which automatically lowers the potential harvest rate.

The maximum permissible ABC for 2017 is 15% higher than the 2016 ABC of 11,795 t. The 2015 assessment projected a 9% decrease in ABC for 2017 from 2016. We recommended a lower ABC than maximum permissible based on newly available estimates of whale depredation occurring in the fishery. Because we are including inflated survey abundance indices as a result of correcting for sperm whale depredation, this decrement is needed in conjunction to appropriately account for depredation on both the survey and in the fishery. This ABC is still 11% higher than the 2016 ABC. This relatively large increase is supported by a substantial increase in the domestic longline survey index time series that offset the small decrease in the fishery abundance index seen in 2015. The fishery abundance index has been trending down since 2007. The International Pacific Halibut Commission (IPHC) GOA sablefish index was not used in the model, but was similar to the longline survey, hitting its time series low in 2015, down 36% from 2014. The 2008 year class showed potential to be large in previous assessments based on patterns in the age and length compositions. This year class is now estimated to be about 30% above average. There are preliminary indications of a large incoming 2014 year class, which was evident in the 2016 longline survey length compositions. Spawning biomass is projected to decline through 2019, and then is expected to increase assuming average recruitment is achieved in the future. ABCs are projected to slowly increase to 13,688 t in 2018 and 14,361 t in 2019.

Projected 2017 spawning biomass is 35% of unfished spawning biomass. Spawning biomass had increased from a low of 33% of unfished biomass in 2001 to 42% in 2009 and has now stabilized near 35% of unfished biomass projected for 2017. The 1997 year class has been an important contributor to the population; however, it has been reduced and is predicted to comprise 5% of the 2017 spawning biomass. The last two above-average year classes, 2000 and 2008, each comprise 13% and 15% of the projected 2017 spawning biomass, respectively. The 2008 year class will be about 85% mature in 2017.

For more information contact Dana Hanselman at (907) 789-6626, dana.hanselman@noaa.gov

Whale Depredation Estimation - ABL

A challenge that few fisheries and assessments face is depredation of fish off of longline gear by both killer whales and sperm whales. Depredation is when whales strip or pluck fish from the gear as it is being hauled back to the boat. For sablefish catch on the AFSC longline survey, killer whale affected sets have always been removed from catch rate calculations because of their obvious impact on catch rates, while the sperm whale depredation is more difficult to detect and had not previously been considered when calculating catch rates. Presence and evidence of depredation by sperm whales on the AFSC longline survey have increased significantly over time. We developed models that estimated that sablefish catch rate reductions caused by sperm whale depredation ranged from 12%-18% at affected longline sets under various model assumptions. Correcting for sperm whale depredation in the assessment resulted in a 3% increase in estimated female spawning biomass in the terminal year and a 6% higher quota recommendation.

When recommending a larger quota because of whale depredation on the survey, it was necessary to account for the additional mortality from whale depredation during the fishery. We used data collected by fishery observers, comparing "good performance" sets with those with "considerable whale depredation." A generalized additive mixed modeling approach was used to estimate the whale effect on commercial sablefish fishery catch rates; killer whale depredation was more severe (catch rates declined by 45%-70%) than sperm whale depredation (24%-29%). Annual estimated sablefish catch removals during 1995-2016 ranged widely from 69 t – 683 t by killer whales in western Alaska and 48 t – 328 t by sperm whales in the Gulf of Alaska from 2001-2016. We included this as additional catch in the stock assessment model and used a 3-year average of this estimated whale induced sablefish mortality to decrement from the larger ABC caused by survey corrections. These new models and changes were reviewed and approved by the Center for Independent Experts in a sablefish assessment review in 2016. These assessment changes were accepted by the North Pacific Fishery Management Council (NPFMC) and are in place for the 2017 fishery. In addition, the NPFMC and Alaska Regional Office have recently opened up the Gulf of Alaska to the use of pot, or trap, gear to the fixed gear fishery as an option to avoid whale depredation.

For more information contact Dana Hanselman at (907) 789-6626, dana.hanselman@noaa.gov

Coastwide data comparison for sablefish – ABL

Sablefish stock assessments are conducted independently for the US West Coast (California-Oregon-Washington), Canada, and both Alaska State and Federal management areas. The assessment model platforms and data available differ between areas. Since all areas show similar downward trends in estimated biomass, there is need for a more synthetic understanding of sablefish demography and dynamics. A data and model comparison effort is underway that will document the differences in the assessment models and available data for each management area. Where possible, estimated recruitment, indices of abundance, and age-specific demographic data such as maturation, length, and weight will be compared across areas. It is hoped that this review will help form a more complete picture of the population dynamics of sablefish at a coastwide scale, and potentially lead to further analyses on coastwide abundance trends via simulation studies or enhanced assessment methods. This is a collaborative project and all regions are welcome to contribute to the review. We hope this project will help foster communication and collaboration across management areas.

For more information, contact Kari Fenske at (907) 789-6653 or kari.fenske@noaa.gov

J. Lingcod

K. Atka Mackerel

1. Research

Developing a stereo camera system to survey nearshore Steller sea lion prey fields in the central and western Aleutian Islands--GAP

RACE groundfish scientists continued research of fish distribution in nearshore Steller sea lion prey fields in untrawlable habitat by conducting underwater surveys using a low cost stereo underwater camera built at the AFSC. Scientists conducted an opportunistic assessment of nearshore fishes during the Steller sea lion count survey aboard the R/V *Tigilax*. Forty-six transects were conducted in three depth strata. Habitat, species composition and size distribution were assessed using the AFSC developed SEBASTES software. All species that were present in the sea lion diets were observed in the camera transects except Pacific salmon and squid. Survey trawl estimates and camera transect estimates seemed compatible at this spatial scale which is the first step in developing this tool as a survey tool for fish in untrawlable grounds.

For more information, contact Susanne McDermott at Susanne.McDermott@noaa.gov.

Small scale abundance and movement of Atka mackerel and other Steller sea lion groundfish prey in the Western Aleutian Islands-GAP

Groundfish stocks in Alaska are managed at large scales, however commercial fishing is an activity with potential for localized effects. This NPRB Project (No. 1305) addresses concerns that local fishery effects could impact foraging success of the endangered Steller sea lion. Our project assesses the small-scale abundance and movement of Atka mackerel in the Western Aleutian Islands where sea lion populations continue to decline and where in 2011 protection measures closed the directed commercial fishery for Atka mackerel and Pacific cod to mitigate against potential competition between sea lions and the commercial fishery. We are comparing these with data collected in the Eastern Aleutian Islands where sea lion populations are stable and a fishery occurs. Information on the local abundance and movement of sea lion prey is essential to evaluate the effect of these closures and gather baseline information on prey fields around sea lion rookeries and haulouts. This is being accomplished through tagging, releasing and recovering Atka mackerel at several Atka mackerel population centers in the Western and Eastern Aleutian Islands and conducting opportunistic sampling in areas of preferred Steller sea lion foraging. Our project also assesses the relative abundance of major groundfish prey of sea lions in the summer and winter such as Pacific Cod, Pollock, and rockfish using catch-per-unit-effort abundance indices. The winter data are being compared with Steller sea lion diet samples collected by National Marine Mammal Laboratory and will thus describe the prey utilization patterns by sea lions. This project is conducted in collaboration with the North Pacific Fisheries Foundation (NPFF).

For more information, contact Susanne McDermott at Susanne.McDermott@noaa.gov.

2. Stock Assessment

Spawning biomass reached a peak in 2005, then decreased continuously through 2016 (a decline of 56%), and is projected to decrease further, at least through 2018. The 1998-2001 year classes were all very strong, but since then, the 2006 and 2007 year classes were the only ones that were above average. In particular, the 2011 year class, which was estimated to be above average in last year's assessment, is now estimated to be below average. However, the projected female spawning biomass for 2017 (145,258 t) is still above $B_{40\%}$ (125,288 t), and the stock is projected to remain above $B_{40\%}$ through the next several years.

The following new data were included in this year's assessment:
Total 2015 year-end catch was updated, and the projected total catch for 2016 was set equal to the 2016 TAC. The 2015 fishery age composition data were added and the biomass estimate from the 2016 AI bottom trawl survey was added. Methodological changes included the following: In the assessment model: Input sample sizes for compositional data were set proportional to the number of sampled hauls containing Atka mackerel, rather than the number of sampled Atka mackerel. The average sample sizes (across years) were held constant at the values used in last year's assessment, however. In the projection model the selectivity schedule was set equal to the average of the most recent five years for which model estimates are available, rather than the most recent five years (with the current year set equal to the previous year).

Catches for 2017 and 2018 were assumed to equal 62% of the BSAI-wide ABC, based on an analysis of the effect of the revised Steller Sea Lion Reasonable and Prudent Alternatives that were implemented in 2015, rather than the 80% rate that was used in last year's assessment.

The projected female spawning biomass under the recommended harvest strategy is estimated to be above $B_{40\%}$, thereby placing BSAI Atka mackerel in Tier 3a. The projected 2017 yield (ABC) at $F_{40\%}$ = 0.34 is 87,200 t, down 3% from the 2016 ABC and up 2% from last year's projected ABC for 2017. The projected 2017 overfishing level at $F_{35\%}$ = 0.40 is 102,700 t, down 2% from the 2016 OFL and up 3% from last year's projected OFL for 2017. As in last year's assessment, the standard Tier 5 random effects model was used to apportion the ABC among areas. The recommended ABC apportionments by subarea for 2017 are 34,890 t for Area 541 and the southern Bering Sea region (a 13 % increase), 30,330 t for Area 542 (and 11 percent increase), and 21,980 t for Area 543 (a 32 % decrease from the 2016 level of 32,292).

Atka mackerel is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For more information, contact Sandra.Lowe@noaa.gov.

L. Flatfish

1. Research

Availability of yellowfin sole to the eastern Bering Sea trawl survey and its effect on survey biomass--GAP

This study investigates mechanisms responsible for significant shifts of annual yellowfin sole biomass estimates in the eastern Bering Sea, and provides evidence that temperature-mediated changes in spatial availability (i.e., to the bottom trawl survey) is a major contributor. Yellowfin sole (*Limanda aspera*) distributions in the eastern Bering Sea are known to extend into waters shallower (<30 m) than the bottom trawl assessment survey, where potentially large portions of the biomass are not sampled due to high concentrations of adult fish that are spawning in inshore waters at the time of the survey (June-July). The spawning period is preceded by annual spring migration of adults from deeper shelf waters (>100 m) to nearshore areas of Bristol and Kuskokwim bays (Wakabayashi, 1989).

A portion of the annual variability in annual biomass estimates is explained by a linear relationship with bottom temperature (Nichol, 1997), where biomass has increased with annual temperature. While stock assessment models have incorporated the effect (Wilderbuer et al., 2016), the mechanism has been unclear. Two potential mechanisms behind the temperature effect have been suggested. One is temperature-mediated survey catchability, when under colder conditions, fish escapement under the trawl footrope increases and/or herding by the bridals decreases. The other involves a change in fish availability where temperature affects the timing of inshore spawning migration. In this scenario, during warmer years, the migration occurs earlier in the spring, and spawning is more progressed at the time the survey is conducted. This results in higher percentages of spent adults that have rotated out of unavailable nearshore areas, increasing the overall percentage available to the survey. This research is focused on the latter mechanism.

To test the hypothesis that distributions, and subsequently survey biomass estimates, were affected by the timing of spawning, several analyses were performed. First, we used the 35 year EBS bottom trawl survey time series (Lauth and Nichol, 2013) to plot the summer spatial distributions of yellowfin sole during representative “warm” and “cold” years, doing so separately for immature and mature males and females (maturity based on length). Overall distributions were expected to be shifted farther offshore during warmer years. Second, we examined 8 years of trawl survey CPUE data during which common stations (20 to 34) in Bristol Bay were sampled twice within the same year, once in early June and again in late July. The logic here is that if the timing of spawning affects yellowfin sole availability to the survey, with greater availability when spawning is more complete, then we should observe increases in abundance when stations are sampled later in the season. Furthermore, if males remain on the spawning grounds longer than females, as for other flatfishes (Solmundsson et al., 2003; Hirosi and Minami, 2007), we should observe increased numbers of mature females relative to mature males (e.g., sex-ratio) during the later sampling, owing to higher percentages of spent females that have migrated out of the spawning grounds.

Shifts in distributions between warm and cold years were most prominent among mature females, with concentrations much deeper (>50 m) during the warmer years. Mature males on the other hand were similarly distributed with largest concentrations at the nearshore survey edge both in warm and cold years. Immature males and females were also similarly distributed between warm and cold years. Yellowfin sole were more concentrated during the later July sampling period in all 8 years sampled. These increases included immature and mature males and females, although the largest increases occurred for mature females, both by percent and raw CPUE. In addition, mature females abundance increased at a greater proportion than mature males between early and late samplings in all but one of the eight years.

Further analyses will include the testing of various measures of temperature (i.e., bottom, surface) and winter ice extent to see which measures have the greatest effect on sex-ratio (or female proportion) and estimates of biomass.

For further information, contact Dan Nichol, (206)526-4538, Dan.Nichol@noaa.gov.

Lauth, R. R. and D. G. Nichol. 2013. Results of the 2012 eastern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate resources. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-256, 162 p.

Hirose, T., and T. Minami. 2007. Spawning grounds and maturation status in adult flathead flounder Hippoglossoides dubius off Niigata Prefecture, Sea of Japan. Fish. Sci. 73:81-86.

Nichol, D.G. 1997. Annual and between-sex variability of yellowfin sole, *Pleuronectes asper*, spring-summer distributions in the eastern Bering Sea. Fish. Bull. 96:547-561.

Solmundsson, J., H. Karlsson, and J. Palsson. 2003. Sexual differences in spawning behavior and catchability pf plaice (Pleuronectes platessa) west of Iceland. Fish. Res. 61:57-71.

Wakabayashi, K. 1989. Studies on the fishery biology of yellowfin sole in the eastern Bering Sea. [In Jpn., Engl. summ.]. Bull. Far Seas Fish. Res. Lab. 26:21-152.

Wilderbuer T. K. and D. G. Nichol, and J. Ianelli. 2016. Chapter 4. Assessment of the yellowfin sole stock in the Bering Sea and Aleutian Islands, p. 803-894. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions, November 2016. North Pacific Fishery Management Council, Anchorage, AK.

Acoustic characterization of sea floor habitats of northern rock sole using video groundtruthing--GAP

Echoview's bottom classification module was used to analyze 38 kHz Simrad ES60 echosounder data. Random Forest was used to compare the results of the bottom classification to the visual categorization of the same trawl path using camera data. Unfortunately, the majority of samples are a single bottom type which makes results from machine learning techniques suspect. The acoustic data, especially for deeper stations, suffers from substantial interference from a second sounder that was left on during sampling; quantifying or removing the interference will be required before moving forward with the project.
For further information, contact Elaina Jorgensen, (206)526-4562, Elaina.Jorgensen@noaa.gov.

Bering Sea benthic prey availability and juvenile flatfish habitat quality--GAP

Research continues in characterizing and assessing the productivity of flatfish habitat in the eastern Bering Sea (EBS) under the Essential Fish Habitat provision of the fishery management plan. Field sampling has been conducted intermittently since 2011 as special projects of the EBS

annual bottom trawl survey. The current focus is on the habitat of juvenile yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS).
The objective of the project in 2016 was to examine latitudinal differences in habitat quality and in the growth and condition of the juvenile flatfishes. In general, the distribution of the juveniles in the EBS ranged from the Alaska Peninsula in the south to Nunivak Island in the north, in inner-shelf waters ≤50 m deep. Recent studies suggested that the latitudinal shift in the distribution of NRS juveniles was linked to the thermal regime: in "warm" years, high densities of NRS juveniles have been observed around Nunivak Island ("north" habitat), whereas in "cold" years the population appeared to have shifted south towards Bristol Bay ("south" habitat). It is unknown whether YFS juveniles followed a similar pattern. During the 2016 bottom trawl survey, a 3-m beam trawl was used to sample juvenile flatfish (≤17 cm TL) and a 0.1 m^2 van-Veen-type benthic grab was used to sample the infauna prey and sediments at selected shallow, coastal stations in the north and south habitats.

Based on the composition of the main prey taxa and their respective caloric values, the north habitat had generally lower energy available to juvenile flatfish than the south. Juvenile diets were similar interspecifically and between north and south habitats, and all showed high electivity for prey and spatial mismatch with prey composition that suggested that prey availability was not limiting (Yeung and Yang, 2017). The distribution and body condition of the juveniles were not spatially correlated with the prey field, and condition was not significantly different between north and south. The putative age-0 fish were mostly found in the south, and juveniles were significantly larger at age in the south than in the north. These preliminary results showed that the north and south habitats had similarly suitable prey environment, arguing for physical environmental conditions, most prominently temperature and currents being the principal drivers of juvenile distribution.

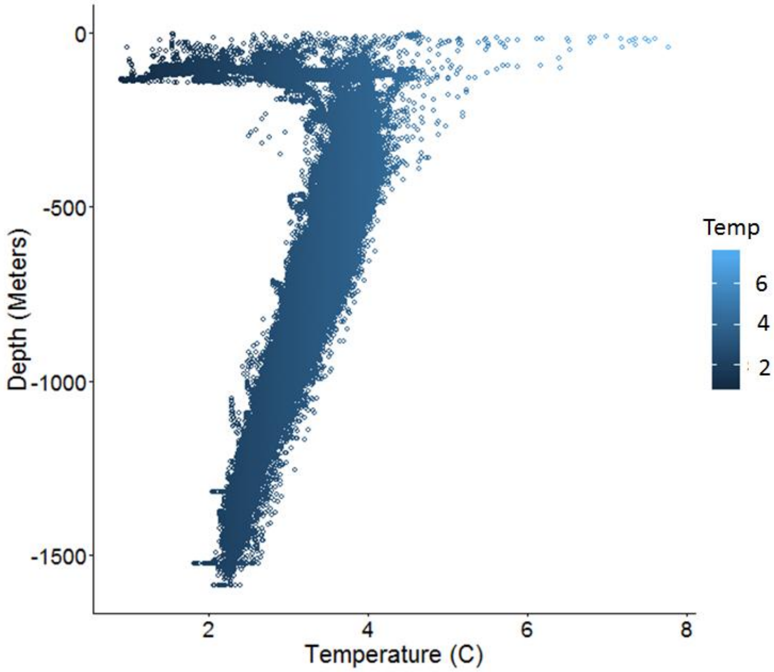
For further information, contact Cynthia Yeung, (206)526-6530, cynthia.yeung@noaa.gov.

Yeung, C., Yang, M.-S., 2017. Habitat quality of the coastal southeastern Bering Sea for juvenile flatfishes from the relationships between diet, body condition and prey availability. Journal of Sea Research 119, 17-27.

Greenland turbot archival tag analysis - ABL

Greenland turbot were opportunistically implanted with Lotek archival tags on the AFSC sablefish longline survey from 2003-2012 in order to assess turbot vertical movement and temperatures experienced in the Bering Sea. Archival tag data were recovered from 12 Greenland turbot, spanning 35-1100 days, with mean depths and temperatures for individual fish ranging from 450 – 725 meters (m) and 3.2 – 3.7 °C. The average distance between fish release and recapture location was 64 nautical miles with a maximum of 306 nautical miles and the majority of releases and recaptures occurred near or on the shelf break. All of the tagged fish that were at liberty for 1+ years (n=8) exhibited seasonal differences in depth and vertical movement with a general trend of shallower depths in the summer, suggesting movement on or towards the continental shelf. In winter months there were more occurrences of deep dives. For example, one fish descended from 850 to 1500 m within a span of 15 hours. The temperature range at depth sharply increased in depths < 200 m and there is evidence that some tagged turbot were on the continental shelf experiencing Bering Sea cold pool conditions in the summer months. Future work will investigate the relationship between vertical activity (change in depth over 15 min) and variables such as day/night, fish length, sex, temperature, and season.

Plot showing temperatures at depths experienced for combined detections of tagged Greenland turbot that recorded for 1+ years with depth on the y-axis (depicted as negative for intuitive interpretation, 0 represents the surface) and temperature on the x-axis.



For more information, contact Karson Coutré at (907) 789-6020 or Karson.coutre@noaa.gov

2. *Assessment*

Yellowfin sole Stock Assessment - BERING SEA - REFM

The 2016 EBS bottom trawl survey resulted in a biomass estimate of 2.66 million t, compared to the 2015 survey biomass of 1.93 million t (an increase of 10 percent). The stock assessment model indicates that yellowfin sole have slowly declined over the past twenty years, although they are still at a fairly high level (1.8 times B_{MSY}), due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 8 of the past 27 year classes have been at or above the long term average. However, the 2003 year class appears to be as strong as any observed since 1983 and the 2006 is also an above average contributor to the reservoir of female spawners. The 2016 catch of 130,500 t represents the largest flatfish fishery in the world and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

Changes to the input data include:
2015 fishery age composition, 2015 survey age composition, 2016 trawl survey biomass point estimate and standard error, estimate of the discarded and retained portions of the 2015 catch, And an estimate of the total catch made through the end of 2016. A catch of 150,000 t was assumed for 2017 and the 2018 projection.

Changes to the assessment methodology: Changes were made to the fishery weight-at-age where the average of the fishery aged samples from 2008-2014 were used for 2008-2016, replacing previous values that were time-invariant.

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock. The estimate of B_{MSY} from the present assessment is 424,000 t, and projected female spawning biomass for 2017 is 778,600 t, indicating that yellowfin sole qualify for management under Tier 1a. Corresponding to the approach used in recent years, the 1978-2010 age 1 recruitments (and corresponding spawning biomasses) were used this year to determine the Tier 1 harvest recommendation. This provided a maximum permissible ABC harvest ratio (the harmonic mean of the F_{MSY} harvest ratio) of 0.114. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.125. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2017 biomass estimate produced the 2017 ABC of 260,800 t, and the corresponding product using the OFL harvest ratio produces the 2017 OFL of 287,000 t. For 2018, the corresponding quantities are 250,800 t and 276,000 t, respectively.

Yellowfin sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Northern Rock Sole - BERING SEA - REFM

The northern rock sole stock is currently at a high level due to strong recruitment from the 2001, 2002, 2003 and 2005 year classes that are now contributing to the mature population biomass. The 2016 bottom trawl survey resulted in a biomass estimate of 1.46 million t, a 4% increase from the 2015 point estimate. The northern rock sole harvest primarily comes from a high value roe fishery conducted in February and March which usually takes only a small portion (25%) of the ABC because it is constrained by prohibited species catch limits and market conditions.

The stock assessment model indicates that the stock declined in the late 1990s and early 2000s due to poor recruitment during the 1990s but is now at a high level and is projected to decline in the near future due to the lack of good observed recruitment since 2005. The stock is currently estimated at over twice the B_{MSY} level.

Changes to input data in the 2006 analysis include: Estimates of catch (t) and discards for 2015-2016, 2015 fishery age composition, 2015 survey age composition and the 2016 trawl survey biomass point estimates and standard errors. The chapter contains summaries for several assessment models that examined different states of nature by varying estimates of male and female natural mortality and catchability. Model 15.1, the model that has been used for the last several years was chosen as the preferred model again for 2017.

The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning biomass for 2017 is projected to be well above the *BMSY* estimate of 257,000, placing northern rock sole in sub-tier “a” of Tier 1. The Tier 1 2017 ABC harvest recommendation is 155,100 t (*FABC* = 0.155) and the 2017 OFL is 159,700 t (*FOFL* = 0.160). The 2018 ABC and OFL values are 143,100 t and 147,300 t, respectively. Recommended ABCs correspond to the maximum permissible levels.

This is a stable fishery that lightly exploits the stock because it is constrained by PSC limits and the BSAI optimum yield cap. Usually the average catch/biomass ratio is about 3-4 percent of the northern rock sole stock.

Northern rock sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Northern Rock Sole - GULF OF ALASKA Shallow Water Complex - REFM

Shallow-water and deep-water flatfish are assessed on a biennial schedule to coincide with the timing of survey data. Since no GOA survey was conducted in 2016, a partial assessment is prepared for the 2016 off year to project the estimates of the stock status forward. An executive summary for shallow water flatfish was presented that included updated 2015 catch and the partial 2016 catch as well as 2016 catch projections for northern and southern rock sole. Projected catch to the end of 2016 is calculated as the average fraction of catch to October 13 from the last 10 years (83.4%). The projected 2017 catch is set equal to the projected 2016 catch. This is a change from previous assessments which assumed maximum permissible ABC as the catch for the upcoming year. Last year's projected 2017 biomass, OFL and ABC estimates for the shallow-water complex from the 2015 assessment used catch assumptions that were considerably higher than current estimates. This resulted in lower biomass projections than the current update. Otherwise there were no changes to the assessment methodology. The random effects model was used to estimate 2015 biomass for the Tier 5 calculations.

The rock sole assessment model estimates are used for trend and spawning biomass estimates whereas the remaining species in this complex are based solely on the NMFS bottom trawl surveys. Biomass, OFL and ABC values for 2017 and 2018 for northern and southern rock sole are estimated using projections from the 2015 assessment model with catches updated for 2015 and 2016.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. The recommended ABC for the shallow water flatfish complex is equivalent to the maximum permissible ABC. For the shallow water flatfish complex, ABC and OFL for southern and northern rock sole are combined with the ABC and OFL values for the rest of the shallow water flatfish complex. This yields a combined ABC of 44,514 t and OFL of 54,583 t for 2017.

The northern and southern rock sole component of the complex represents 78% of catch in 2016. Most recently, the catch has been less than 15% of the ABC. Northern and southern rock sole are not being subjected to overfishing and are neither overfished nor approaching an overfished condition. Information is insufficient to determine stock status relative to overfished criteria for the rest of the shallow water flatfish stock complex. Catch levels for this complex remain well below the TAC and below levels where overfishing would be a concern. The GOA northern and southern rock sole stocks are not being subjected to overfishing and are neither overfished nor approaching an overfished condition.

Flathead Sole - BERING SEA - REFM

The flathead sole assessment also includes Bering flounder, a smaller, less abundant species with a more northern distribution relative to flathead sole. The 2016 shelf trawl biomass estimate increased 13% from 2015 for flathead sole. Survey estimates indicate high abundance for both stocks for the past 30 years, with the last nine years being very stable at a lower level than the peak years. Strong, above-average recruitment was observed from 2001-2003 followed by 7 consecutive years (2004-2010) of below average recruitment. The 2011 year class is estimated to be above average. The assessment employs an age-structured stock assessment model.

This assessment was changed to a bi-ennial cycle beginning with the 2014 assessment; this is a full
assessment year. Changes to the input data in this analysis include:
- 2016 catch biomass was added to the model
- 2015 catch biomass was updated to reflect October – December 2015 catches
- 2013-2015 fishery age composition data were added
- 2015-2016 fishery length composition data were added to the model.
- 2015-2016 Eastern Bering Sea (EBS) shelf survey biomass and 2016 Aleutian Islands (AI) survey
biomass were added to the linear regression used to determine estimates of AI survey biomass in years when no AI survey occurred; a new survey biomass index was added to the assessment model for 1982-2016 based on updated linear regression results.
- 2015-2016 survey bottom temperatures were added to the model.
- 2014-2015 survey age composition data were added to the model.
- 2015-2016 survey length composition data were added to the model.
- Estimates of the length-at-age, length-weight, and weight-at-age relationships, and the length-at-age transition matrices were updated by adding data from 2001 to 2015. Growth estimates therefore include data from 1985, 1992-1995, and 2000-2015.

All age- and length-composition data were weighted using methods described in McAllister and Ianelli (1997) to approximate effective sample size for each year and data type. The harmonic mean over years was used to approximate the effective sample size for each data type and the assessment model was iteratively tuned such that input and effective sample sizes were approximately equal.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying flathead sole for management under Tier 3. The current values of these reference points are $B_{40\%}$=129,175 t, $F_{40\%}$=0.34, and $F_{35\%}$=0.41. Because projected spawning biomass for 2017 (223,469 t) is above $B_{40\%}$, flathead sole is in Tier 3a. The authors and Team recommend setting ABCs for 2017 and 2018 at the maximum permissible values under Tier 3a, which are 68,278 t and 66,164 t, respectively. The 2017 and 2018 OFLs under Tier 3a are 81,654 t and 79,136 t, respectively.

Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Flathead Sole - GULF OF ALASKA - REFM

The 2017 spawning biomass estimate (82,819 t) is above $B_{40\%}$ (36,866 t) and projected to be stable through 2018. Total biomass (3+) for 2017 is 269,638 t and is projected to slightly increase in 2018. Flathead sole remain lightly exploited in the GOA.

The flathead sole stock is assessed on a biennial schedule to coincide with the timing of survey data. This year is an off-year thus an executive summary of the assessment was compiled. The projection model was run using updated 2015 catch and new estimated total year catches for 2016-2017 to calculate the 2017 and 2018 ABC and OFL.

Flathead sole are determined to be in Tier 3a. For 2017 the maximum permissible ABC of 35,243 t was determined from the updated projection. The F_{OFL} is set at $F_{35\%}$ (0.40) which corresponds to an OFL of 43,128 t.

The Gulf of Alaska flathead sole stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. Catches are well below TACs and below levels where overfishing would be a concern. Area apportionments of flathead sole ABC's for 2017 and 2018 are based on the random effects model applied to GOA bottom trawl survey biomass in each area.

For further information, contact Ingrid Spies (206) 526-4786, or Cary McGillard (206) 526-4693.

Greenland Halibut (Turbot)

The projected 2017 female spawning biomass is 50,461 t, which is a 63% increase from last year's 2016 estimate of 31,028 t. Female spawning biomass is projected to increase to 55,347 t in 2018. The effects of the incoming 2007-2009 year classes are creating a steep increase in both the female spawning biomass and total biomass estimates. These increases are also due, in part, to the increase in average weight at age with the inclusion of the 2015 length at age data. Projections for 2017 and onward predict an increase in spawning biomass as these year classes grow and mature.

Changes to the input data include:
- Updated 2015 and projected 2016 catch data
- 2016 EBS shelf trawl survey estimates
- 2016 EBS slope trawl survey estimates
- 2016 ABL longline survey estimates
- 2016 EBS shelf survey, slope survey, and ABL longline length composition estimates
- 2015 EBS shelf survey age composition
- Updated fishery catch-at-length data for 2016

There were no changes made to the base model which has the same configuration as model 15.1 from the 2015 assessment except the addition of catch and size composition data from both the longline and trawl fisheries for 2016 as well as the addition of the 2016 Slope trawl survey index value and size composition data.

The 2016 accepted model (16.4) had a number of modifications from the base model:
To better fit the size composition data, the size bins for males and females were combined for composition lengths shorter than 52 cm. Residuals for the 2012 and 2016 Slope survey composition data also were problematic. In addition, longline fishery data had substantial residual patterns with overestimates of larger fish than what was observed. To better fit these data a new block was created for 2011 through 2016 for the Slope survey species composition

data and the longline fishery data were allowed to be dome-shaped. To simplify data conflicts, the ABL longline size composition data were removed. These data were aggregated by sex and fit poorly, likely due to the high degree of sexual dimorphism found in this species (bimodal size distribution when aggregated).

The $B_{40\%}$ value using the mean recruitment estimated for the period 1978-2014 gives a long-term average female spawning biomass of 41,239 t. The projected 2017 female spawning biomass was at 50,461 t, well above the estimate of $B_{40\%}$ (41,239 t). Because the projected spawning biomass in year 2017 is above B40%, Greenland turbot ABC and OFL levels will be determined at Tier 3a of Amendment 56. The maximum permissible value of F_{ABC} under this tier translates into an OFL of 11,615 t for 2017 and 12,831 t for 2018 and a maximum permissible ABC of 9,825 t for 2017 and 10,864 t for 2018. However, the author suggested a more conservative maximum permissible ABC of 7,000 t for both 2017 and 2018 due to the likelihood that this stock will continue to have poor recruitment for the foreseeable future. The Plan Team disagreed with the author’s ABC choice as it was subjective and not supported by the model and recommended that the ABCs for 2017 and 2018 be set at maximum permissible.

As in previous assessments, apportionment recommendations are based on unweighted averages of EBS slope and AI survey biomass estimates from the four most recent years in which both areas were surveyed. The recommended 2017 and 2018 ABCs in the EBS are 8,577 and 9,484 t. The 2017 and 2018 ABCs for the AI are 1,248 t and 1,380 t. Area apportionment of OFL is not recommended.

Greenland turbot is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Arrowtooth Flounder - BERING SEA AND ALEUTIAN ISLANDS- REFM

The projected age 1+ total biomass for 2017 is 779,195 t, a decrease from the value of 920,920 t projected for 2017 in last year’s stock assessment. The projected female spawning biomass for 2017 is 485,802 t, a decrease from the 534,347 t estimated from the 2016 SAFE report. The stock has remained at a high level for the past 20 years and is subject to light exploitation.

New information incorporated into the assessment model for this report include: Survey size compositions from the 2015 and 2016 Eastern Bering Sea shelf survey, 2016 Eastern Bering Sea slope survey, and 2016 Aleutian Islands survey. Biomass point-estimates and standard errors from the 2015 and 2016 Eastern Bering Sea shelf surveys, 2016 Eastern Bering Sea slope survey, and 2016 Aleutian Islands survey. Fishery size compositions for 2015 and 2016 and estimates of catch through October 26, 2016 were also included as well as age data from the 1993, 1994, 2012, 2014, and 2015 Bering Sea shelf and 2014 Aleutian Islands surveys, and also the 2012 Eastern Bering Sea slope survey.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Arrowtooth flounder therefore qualifies for management under Tier 3. The point estimates of $B_{40\%}$ and $F_{40\%}$ from this year’s assessment are 212,054 t and 0.129. The projected 2017 spawning biomass is above $B_{40\%}$, so ABC and OFL recommendations for 2017 were calculated under sub-tier “a” of Tier 3. The authors and Team recommend setting F_{ABC} at the $F_{40\%}$ level, which is the maximum permissible level under Tier 3a, resulting in 2017 and 2018 ABCs of 65,371 t and 58,633 t, respectively, and 2017 and 2018 OFLs of 76,100 t and 67,023 t. Arrowtooth flounder is a largely unexploited stock in the BSAI. Arrowtooth flounder is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Ecosystem Considerations
In contrast to the Gulf of Alaska, arrowtooth flounder is not at the top of the food chain on the EBS shelf. Arrowtooth flounder in the EBS are an occasional prey in the diets of groundfish, being eaten by Pacific cod, walleye pollock, Alaska skates, and sleeper sharks. However, given the large biomass of most of the predator species in the EBS, these occasionally recorded events translate into considerable total mortality for the arrowtooth flounder population in the EBS ecosystem.

Arrowtooth Flounder - GULF OF ALASKA - REFM
Arrowtooth flounder biomass estimates are derived from a projection model in even years when there is no trawl survey and are very similar to those estimated in the last full assessment in 2015. The projection model estimate of total (age 1+) biomass shows a slight decrease to 2,103,090 t in 2017. Female spawning biomass in 2017 was estimated at 1,174,400 t, well-above $B_{40\%}$, and is essentially equivalent (0.5% decrease) to the 2016 estimate in last year's assessment.

There were no changes in assessment methodology since this was an off-cycle year. Parameter values from the previous year's assessment model, projected catch for 2016, and updated 2015 catch were used to make projections for ABC and OFL estimates. Arrowtooth flounder are determined to be in Tier 3a.

This arrowtooth flounder stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

Other Flatfish - BERING SEA - REFM
The "other flatfish" complex currently consists of Dover sole, rex sole, longhead dab, Sakhalin sole, starry flounder, and butter sole in the EBS and Dover sole, rex sole, starry flounder, butter sole, and English sole in the AI. Starry flounder, rex sole, and butter sole comprise the vast majority of the species landed. Starry flounder, rex sole and butter sole comprise the majority of the fishery catch with a negligible amount of other species caught in recent years. In 2016 Starry flounder continued to dominate the shelf survey biomass in the EBS and rex sole was the most abundant "other" flatfish in the Aleutian Islands.

EBS shelf survey biomass estimates for this complex were all below 100,000 t from 1983-2003, and reached a high of 150,480 t in 2006. The EBS and AI survey estimate for 2016 was 113,450 t, about 10% above that of last year. Starry flounder, rex sole, and butter sole comprise the majority of the fishery catch with a negligible amount of other species caught in recent years. Sakhalin sole are primarily found north of the standard survey area. Distributional changes, onshore-offshore or north-south, might affect the survey biomass estimates of other flatfish. The assessment incorporates 2015 and 2016 total and discarded catch and 2016 EBS shelf trawl survey biomass, 2016 AI trawl survey biomass, and 2016 EBS slope trawl survey biomass. There were no changes to the assessment methodology. The random effects model was used to estimate biomass as in previous years.

The SSC has classified "other flatfish" as a Tier 5 species complex with harvest recommendations
calculated from estimates of biomass and natural mortality. Natural mortality rates for rex (0.17) and Dover sole (0.085) borrowed from the Gulf of Alaska are used, along with a value of 0.15 for all other species in the complex. Projected harvesting at the 0.75 *M* level (biomass-weighted) average F_{ABC} = 0.117) gives a 2016 ABC of 16,395 t for the "other flatfish" complex. The corresponding 2016 OFL (average F_{OFL} = 0.155) is 21,860 t.

This assemblage is not being subjected to overfishing. It is not possible to determine whether this assemblage is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

Deep-water flatfish - REFM GULF OF ALASKA

The deepwater flatfish complex is comprised of Dover sole, Greenland turbot, and deepsea sole. . This year is an off-year thus an executive summary of the assessment was presented and there were no changes in assessment methodology. New information available to update the Dover sole projection model consisted of updated 2015 catch and catch estimates for 2016 and 2017.

Dover sole is a Tier 3 stock which is assessed using an age-structured model. A single species projection model was run using parameter values from the accepted 2015 Dover sole assessment model. Both Greenland turbot and deepsea sole are in Tier 6. The 2017 Dover sole ABC is 9,109 t. The Tier 3a calculations for Dover sole result in 2017 OFL of 10,938 t. The 2017 Tier 6 calculation of ABC for the other species in the complex is 183 t and OFL is 244 t. The GOA Plan Team agrees with the authors' recommendation to use the combined species' ABCs and OFLs for the deep-water flatfish complex for 2017. This equates to a 2017 maximum permissible ABC of 9,292 t and OFL of 11,182 t for the deep-water flatfish complex.

Based on the results of the updated assessment, Dover sole is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. Information is insufficient to determine stock status relative to overfished criteria for Greenland turbot and deepsea sole. Since Dover sole comprises approximately 98% of the deep-water flatfish complex the species is considered the main component for determining the status of this stock complex. Catch levels for this complex remain well below the TAC and below levels where overfishing would be a concern.

Greenland turbot and deepsea sole fall under Tier 6. ABCs and OFLs for Tier 6 species are based on historical catch levels and therefore these quantities are not updated. ABCs and OFLs for the individual species in the deepwater flatfish complex are determined as an intermediate step and then summed for calculating complex-level OFLs and ABCs. Dover sole apportionment was computed using the random effects model and included the 2015 NMFS bottom trawl survey biomass distributions. Greenland turbot and deepsea sole apportionments were computed using historical survey biomass distributions of both species.

The model estimate of 2016 spawning stock biomass for Dover sole is 49,179 t, which is well above $B_{40\%}$ (22,692 t). Spawning stock biomass and total biomass are expected to remain stable through 2017. Stock trends for Greenland turbot and deepsea sole are unknown.

Apportionment for the deepwater flatfish complex was done using the random effects model to fill in depth and area gaps in the survey biomass by area for Dover sole. The resulting proportion of predicted survey biomass in each area formed the basis for apportionment of the Dover sole portion of the deep-water complex. The Greenland turbot and deepsea sole portion was based on the proportion of survey biomass for each species in each area, averaged over the years 2005-2015. The ABC by area for the deep-water flatfish complex is then the sum of the species-specific portions of the ABC.

M. Pacific halibut

1. Research

Halibut Excluders-RACE MACE Conservation Engineering

In 2016, CE scientists, in collaboration with a Bycatch Reduction Engineering Program (BREP) project led by FishNext Research (Dr. Craig Rose), executed a cooperative fishing gear research charter on the F/V *Marathon* in the Gulf of Alaska to test the use of selective herding lines in front of the trawl footrope as a bycatch reduction device for halibut. The hope was that this bycatch reduction device (BRD) would separate halibut from target species in the mouth of the net, as opposed to just in front of the codend, where most current BRD's are located. This excluder concept is based on CE observations that show halibut swimming ahead of the trawl for longer periods than smaller flatfish. The purpose of the selective herding lines is to allow halibut to escape over the wing extensions before they enter the trawl, causing less stress on escaping fish compared to an excluder just forward of the codend.

Thorough video analysis is still needed, but initial findings from fishing tows conducted with a closed codend encountered poor fishing production. There could be several reasons for low fishing productivity, including 1) low density of target species during the experiment, 2) while the selective herding lines seemingly encouraged halibut to escape over the wings, they may have also increased escape of target species, and 3) poor water quality/visibility. While plenty of halibut were encountered, the mixture of trawl-catchable fish species was different than expected. Fewer small soles were caught, replaced by more pollock, arrowtooth flounder and rockfish.

Contact: Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)

N. Other Groundfish Species

CONSERVATION ENGINEERING (CE)

Develop alternative trawl designs to effectively capture pollock concentrated against the seafloor while reducing bycatch and damage to benthic fauna--CE

The Alaska pollock fishery requires the use of pelagic trawls for all tows targeting that species. During some periods of the pollock fishery, these fish concentrate against the seafloor and, to capture them, fishermen have to put nets designed for midwater capture onto the seafloor. We are developing footropes raised slightly off of the seafloor in order to have less effect on seafloor habitats than the continuous, heavy footropes (generally chains) currently required on pelagic trawls. We have held several workshops with 20+ participants, including captains of pollock trawlers and industry representatives, as well as federal and university scientists to come up with ideas for alternative footropes to test. In May 2014 we began exploring these possibilities with experiments to compare the seafloor effects of the different alternative footropes. Preliminary results show that we reduced footrope contact with the seafloor by at least 90%. This research was funded through an award to NOAA-AFSC and Alaska Pacific University (APU) from the North Pacific Research Board, and the final report of that project is now available on the web (http://projects.nprb.org/#metadata/01f771ea-b802-41cb-b468-281ab28c8475/project). In order to better understand benthic habitat effects of current pollock trawl footropes, collaborators from APU will join a 2017 research cruise with the CE group. They will examine how the bottom contact varies along the chain footropes used by the pollock fishery under different deployment conditions.

Provide underwater video systems to fishermen and other researchers to facilitate development of fishing gear improvements --CE

We have continued to provide underwater video systems to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. Beyond their direct use, exposure to NMFS systems has motivated many companies to procure similar systems for dedicated use on their vessels. Either way, the goal of better understanding fishing gear operation and quicker development of improvements is being realized. The current systems have been in use for about 5 years now and have proven to be very easy to use, durable and flexible. All camera system components are enclosed in a single 8.9 cm (3.5 inch) diameter acrylic tube mounted on a plastic plate. The entire system measures 53.3 x 22.9 x 12.7 cm (21 x 9 x 5 inches) and is of nearly neutral buoyancy in water. The CE group now has six of these systems for both our use and for use as loaner systems. While this design is so inexpensive and functional that many vessels have acquired their own systems, there is still a need for loaner systems. In 2016, we ruggedized the existing loaner camera system design by replacing the acrylic tube with a titanium tube. This new system was successfully field tested through our loaner camera program. Representatives from the pollock fishery used four loaner cameras (one of which was the new ruggedized system) in 2016 to do their own field tests to examine if the use of light on existing salmon excluders could enhance salmon escapement during fishing.

For more information, contact MACE Program Manager, Chris Wilson, (206) 526-6435.

GROUNDFISH ASSESSMENT PROGRAM

Combining data from bottom trawl and acoustic surveys to estimate an index of abundance for semipelagic species --GAP

Fishery-independent surveys are useful for estimating abundance of fish populations and their spatial distribution. It is necessary in the case of semipelagic species to perform acoustic-trawl (AT) and bottom-trawl (BT) surveys to assure that sampling encompasses both midwater and demersal components of the population. Abundance estimates from both survey types are negatively biased because of the blind zones associated with fish vertical distribution. These biases can vary spatially and temporally, resulting in confounded trends and additional variation in abundance estimates. To improve abundance estimates for semipelagic species we propose a new method for combining BT and AT survey data using environmental variables to predict the vertical overlap. On an example of pollock AT and BT surveys in the eastern Bering Sea we show that combined estimates provide more reliable whole water column and spatial distribution estimates than either survey can by itself. Although the combined estimates are still relative they account for the uncertainty in the bias ratio between two survey methods and uncertainty associated with the extent of the water column sampled by both surveys. Our method of combining BT and AT data can be extended to other semipelagic species.

For further information, contact Stan Kotwicki, (206)526-6614, Stan.Kotwicki@noaa.gov.

Determination of Parameters for an Underwater Camera System that Maximizes Available Light for Analysis While Minimizing Visual Detection by Demersal Rockfishes in Southern California--GAP

One of the primary challenges facing researchers in developing optical sampling technologies for assessing demersal fish populations over untrawlable habitat is the need for supplemental light for species identification and assessment. This is derived from two issues, reduced ambient light due to the depth of the habitat areas of interest and the morphological similarity of species of interest (e.g. rockfishes) necessitating the addition of a color component to aid in species identification. To develop an underwater camera and lighting system for assessing southern California demersal rockfish populations that limits behavioral avoidance or attraction to the optical sampling gear while maintaining enough image information to quantitatively assess and identify species, three visual questions should be addressed: (1) what is the spectral sensitivity of the visual system of the species to be identified, (2) what are the relative optical properties of the habitat where they are encountered, and (3) what are the spectral properties of the targets that the camera must be able to identify, i.e. the body of the fish?

Microspectrophotometry (MSP) was used to describe the spectral sensitivity of 18 species of southern California rockfishes that were sampled offshore of Santa Barbara, California in April 2016. All of the rockfish sampled were found to possess a duplex retina containing rods and cones (see table). Rod visual pigments had lamda max values ranging from 486 nm to 505 nm with the lower values typically being encountered in deeper dwelling species. All of the species examined possessed a dichromatic photopic visual system consisting of short- and long-wavelength sensitive visual pigments. Generally, the lamda max for the visual pigments was shifted towards the blue region of the spectrum for deeper dwelling species. As such, a greater proportion of the spectra is available for lighting that would have limited detectability by rockfishes at longer wavelengths. A manuscript describing the visual pigments of rockfishes is nearing completion.

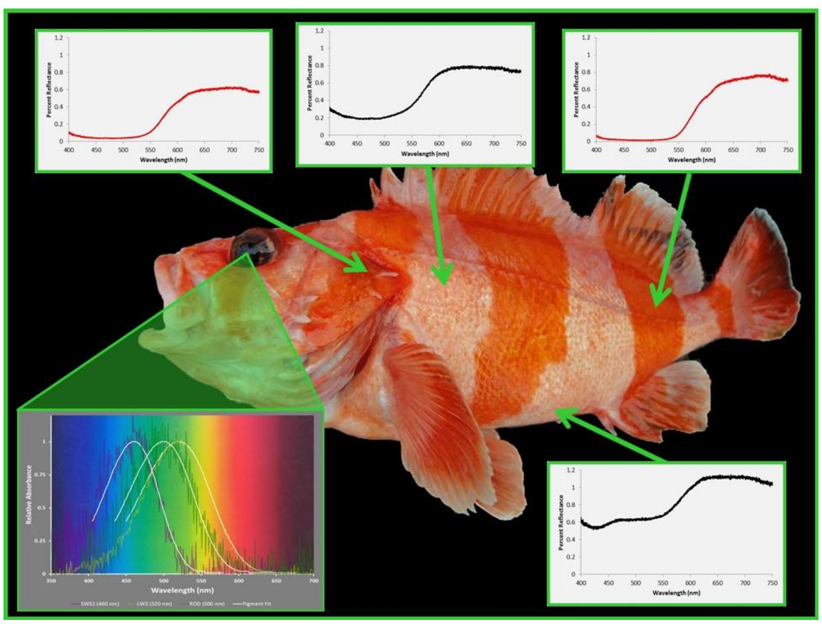
The optical properties of deep water reefs near Santa Barbara, CA, where the specimens for this study were collected are being modelled using a customized software package that we created for determining target contrast ratios at depth. This work is being combined with the third objective of this study whereby the spectral reflectance of the coloration patterns of rockfishes are being analyzed to determine the illumination characterization needed by artificial lights and camera systems to aid in species identification at depth (see figure). The manuscript describing these results is ongoing.

Species	Common Name	Max Depth*	ROD†	LWS†	SWS2/RH2†
S. chlorostictus	Greenspotted Rockfish	363	486	493	442
S. goodei	Chilipepper Rockfish	325	486	488	454
S. rosenblatti	Greenblotched Rockfish	491	489	493	438
S. elongatus	Greenstriped Rockfish	250	490	497	446
S. emphaeus‡	Puget Sound Rockfish	366	490	524	437
S. ensifer	Swordspine Rockfish	433	491	490	437
S. rubrivinctus	Flag Rockfish	200	493	516	456
S. rosaceus	Rosy Rockfish	262	495	514	446
S. constellatus	Starry Rockfish	274	496	512	453
S. caurinus	Copper Rockfish	183	496	520	460
S. mystinus	Blue Rockfish	90	497	516	449
S. flavidus‡	Yellowtail Rockfish	180	497	521	437
S. carnatus	Gopher Rockfish	80	499	519	456
S. dalli	Calico Rockfish	120	500	519	457
S. miniatus	Vermillion Rockfish	150	500	520	460
S. paucispinus	Bocaccio	250	501	519	450
S. entomelas	Widow Rockfish	210	502	518	453
S. crocotulus	Sunset Rockfish	150	503	518	452
S. serranoides	Olive Rockfish	120	503	521	455
S. auriculatus	Brown Rockfish	120	505	520	450

*Listed typical maximum depth for region where collected. Taken from Love et al 2002.

†Mean λ_{max} values collected from individual photoreceptor cells. Standard deviation was < ± 2 nm for all cell types and species.

‡Specimens collected near San Juan Island, WA. All other specimens collected near Santa Barbara, CA.



For further information, contact Lyle Britt, (206)526-4501, Lyle.Britt@noaa.gov.

Combining bottom trawls and acoustics in a diverse semipelagic environment: What is the contribution of walleye pollock (Gadus chalcogrammus) to near-bottom acoustic backscatter in the eastern Bering Sea?--GAP

The abundance of walleye pollock (Gadus chalcogrammus) in the eastern Bering Sea (EBS) is estimated in part through fisheries-independent acoustic trawl (AT) surveys, which currently use acoustic backscatter data down to 3 m above the bottom. A large portion of adult pollock are demersal and these estimates will become more accurate if the survey is extended closer to bottom. The purpose of this project was to assess the feasibility of extending the AT survey closer to the bottom by estimating the contributions of each demersal fish species to observed acoustic backscatter in the highly diverse near-bottom region. This was accomplished by fitting a regression model to simultaneously collected acoustic backscatter and bottom trawl (BT) catch data. Pollock were the dominant source of acoustic backscatter among demersal species accounting for 85.9 ± 4.8 % of acoustic backscatter (mean ± standard deviation). A method was developed to extend the AT survey to within 0.5 m of the bottom and applied to the 1994-2014 surveys, pollock biomass increased by an average of 35 ± 12 %.

For further information, contact Stan Kotwicki, (206)526-6614, Stan.Kotwicki@noaa.gov.

Kotwicki, S, Ressler, P.H., Ianelli J. N., Punt, A. E., and Horne, J. K. 2017. Combining data from bottom trawl and acoustic surveys to estimate an index of abundance for semipelagic species. CJFAS.

Kotwicki, S., Lauth, R.R., Williams, K., and Goodman, S. 2017. Selectivity ratio a useful tool for comparing size selectivity of multiple survey gears. Fisheries Research

Lauffenburger, N., De Robertis, A., and Kotwicki S. 2016. Combining bottom trawls and acoustics in a diverse semipelagic environment: What is the contribution of walleye pollock (Gadus chalcogrammus) to near-bottom acoustic backscatter? CJFAS.

Differences in sampling efficiency between two bottom trawls used in Arctic surveys of bottom fishes, crabs and other demersal macrofauna--GAP

This study compares two different research bottom trawls used in legacy surveys in the Alaska high-artic. Results from this study will provide scientists and mangers context for assessing and interpreting historical survey results as well as provide a framework for considering the ‘how’ and ‘what’ for articulating research priorities and choosing the most appropriate gear(s) and method(s) for long-term monitoring of the high-arctic benthic ecosystem. The two research bottom trawls investigated in this study were the 3-m plumb-staff beam trawl (PSBT; Norcross et al. 2013) and the 83-112 Eastern bottom trawl (EBT; Stauffer 2004). The PSBT is a small, fine-meshed trawl that has been used throughout the Chukchi Sea and Beaufort Sea since 2007 for smaller scale ecosystem surveys of oil lease sites and multidisciplinary studies (Logerwell et al. 2015, Norcross et al. 2013, Norcross et al. 2010, Norcross and Holladay 2010). The EBT is a commercial-sized large-mesh trawl that has been used for conducting a large-scale annual standardized fishery-independent survey of the eastern Bering Sea shelf for fishery stock assessment since 1976 (Pereyra et al. 1976, Conner and Lauth 2016) and a triennial red king crab survey in the northern Bering Sea from 1977 to 1991 (Soong and Banducci 2008). The same gear and methods have also been used for large-scale ecosystem surveys in the eastern Chukchi Sea in 2012 (Goddard et al. 2014), the southeastern Chukchi Sea and Norton Sound in 1976 (Wolotira et al. 1977), the northeastern Chukchi Sea in 1990 (Barber et al. 1997), the Beaufort Sea in 2008 (Rand and Logerwell 2011), and the northern Bering Sea in 2010 (Lauth 2011).

This study used a paired comparison experiment to examine the differences in sampling efficiency between the EBT and PSBT. Indices compared included taxa number and type, abundance by weight and number, and size composition. In addition, a size-selectivity ratio function (Kotwicki et al. 2017) for the PSBT and EBT was derived for snow crab, Arctic cod and five other taxonomic groups.

For further information, contact Robert L. Lauth, (206)526-4121, Bob.Lauth@noaa.gov.

Barber, W.E., R.L. Smith, M. Vallarino and R.M. Meyer. 1997. Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fish. Bull., 95, 195–209.

Conner, J., And R. R. Lauth. 2016. Results of the 2013 eastern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-331, 153 p.

Kimura, D.K. and Somerton, D.A., 2006. Review of statistical aspects of survey sampling for marine fisheries. Reviews in Fisheries Science, 14(3), pp.245-283.

Kotwicki, S., R.R. Lauth, K. Williams, and S.E. Goodman. 2017. Selectivity ratio: A useful tool for comparing size selectivity of multiple survey gears. Fisheries Research 191:76-86.

Lauth, R.R., 2011. Results of the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate fauna. Alaska Fisheries Science Center, US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 256p.

Logerwell, E., Busby, M., Carothers, C., Cotton, S., Duffy-Anderson, J., Farley, E., Goddard, P., Heintz, R., Holladay, B., Horne, J., Johnson, S., Lauth, B., Moulton, L., Neff, D., Norcross, B., ParkerStetter, S., Seigle, J., Sformo, T. 2015. Fish communities across a spectrum of habitats in the western Beaufort Sea and Chukchi Sea. Progress in Oceanography, 136, pp.115-132. doi: http://dx.doi.org/10.1016/j.pocean.2015.05.013

Norcross, B.L., Raborn, S.W., Holladay, B.A., Gallaway, B.J., Crawford, S.T., Priest, J.T., Edenfield, L.E. and Meyer, R., 2013. Northeastern Chukchi Sea demersal fishes and associated environmental characteristics, 2009–2010. Continental Shelf Research, 67, pp.77-95.

Norcross, B.L. and Holladay, B.A., 2010. Current and Historic Distribution and Ecology of Demersal Fishes in the Chukchi Sea Planning Area. University of Alaska Coastal Marine Institute, Annual Report No. 16:15-31.

Pereyra, W.T., Reeves, J.E. and Bakkala, R.G., 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. US Department of Commerce, NOAA, NMFS, Northwest & Alaska Fisheries Center.

Rand, K.M. and Logerwell, E.A., 2011. The first demersal trawl survey of benthic fish and invertebrates in the Beaufort Sea since the late 1970s. Polar Biology, 34(4), pp.475-488.

Soong, J. and Banducci, A.O., 2008. Analysis of red king crab data from the 2008 Alaska Department of Fish and Game trawl survey of Norton Sound. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services.

Stauffer, G., 2004. NOAA protocols for groundfish bottom trawl surveys of the nation's fishery resources. NOAA Tech. Memo. NMFS-F/SPO-65.

Wolotira, R.J., Sample, T.M. and Morin, M., 1977. Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea, and adjacent waters in the baseline year

1976. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center.

At-sea backdeck electronic data entry--GAP

The RACE groundfish group has been working on an effort to digitally record their survey data, as it is collected on the back deck. This new method will eventually replace the original method of recording biological sampling data on paper forms (which then needed to be transcribed to a digital format at a later time).

This effort has involved the development of in-house Android applications. These applications are deployed on off-the-shelf Android tablets. The first application developed was a length recording app, which replaced the obsolete and unsustainable "polycorder" devices already in use. The length application is now used on all groundfish surveys.

Last summer, a specimen collection app was tested on one of the groundfish surveys. This application will be deployed on all groundfish surveys in the summer of 2017.

A prototype catch weight recording application is scheduled to be tested in the summer of 2017.

Future plans include establishing two-way communication between the tablets and a wheelhouse database computer, so all collected biological data can be fully integrated into a centralized database.

This effort aims to allow us to collect more, and more accurate, biological data, in a more efficient way.

For further information, contact Heather Kenney, (206)526-4215, Heather.Kenney@noaa.gov or Alison Vijgen, (206)526-4186, Alison.Vijgen@noaa.gov.

Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2016. Orr and Wildes are continuing their work on sandlances by including Atlantic species in a global analysis and conducting more detailed population-level studies in the eastern Pacific. Similarly, they are collaborating on a study of capelin and its taxonomic status in the North Pacific. An additional study testing the hypothesis of cryptic speciation in northern populations of the eelpout genus *Lycodes* (Stevenson) is underway. Continuing progress has been made in examining identifications of rockfishes (*Sebastes aleutianus* and *S. melanostictus*) off the West Coast (Orr, with NWFSC); morphological variation related to recently revealed genetic heterogeneity in rockfishes (*Sebastes crameri*; Orr, with NWFSC) and flatfishes (*Hippoglossoides*; Orr, Paquin, Raring, and Kai); a partial revision of the lumpsucker genus *Eumicrotremus* (Stevenson, with Mecklenburg and Kai); and a study of the developmental osteology of the bathymasterid *Ronquilus jordani* (Stevenson, with Hilton and Matarese). Work on the molecular phylogenetics and morphology of the pectoral girdle of snailfishes (Orr, Stevenson, Spies, with UW) is underway. A description and naming of two new species of snailfishes from the Aleutian Islands has been published (Orr, 2016), and descriptions of other new species from Alaska continues.

In addition to taxonomic revisions, descriptions of new taxa, and guides, RACE systematists have published work in collaboration with molecular biologists at the University of Washington and within AFSC to identify snailfish eggs parasitizing king crabs (Gardner, Orr, Stevenson, Somerton, and Spies, 2016). The description and naming of a new snailfish, discovered during this project masquerading under the name of *Careproctus melanurus* in Alaska is underway. Also with AFSC geneticists, we are examining population-level genetic diversity, using NextGen sequencing techniques, in the Alaska Skate, *Bathyraja parmifera*, especially as related to its nursery areas, to be undertaken with NPRB support (Hoff, Stevenson, Spies, and Orr). Orr and Stevenson, with Spies, will also be examining the population genetics of Alaska's flatfishes using the same NextGen sequencing techniques. Molecular and morphological studies on *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies), *Eumicrotremus* (Kai and Stevenson), *Lycodes* (Stevenson and Paquin), and snailfishes (Orr, Stevenson, and Spies) are also continuing. In addition to systematic publications and projects, RACE systematists have been involved in works on summaries and zoogeography of North Pacific fishes, including collaborations with the University of Washington on a book of the fishes of the Salish Sea (Pietsch and Orr). Stevenson recently completed a section on manefishes for the FAO guide to the living marine resources of the Eastern Central Atlantic (Stevenson, Kenaley, and Britz, 2016), as well as documents summarizing species identification procedures in the North Pacific Observer Program (Stevenson et al., 2016) and species enumeration and quantification on the eastern Bering Sea shelf trawl survey (Stevenson, Weinberg, and Lauth, 2016).

Orr and Stevenson have also conducted work with invertebrates. With the support of NPRB and JISAO and in collaboration with specialists at the UW and the California Academy of Sciences, a comprehensive annotated checklist of the marine macroinvertebrates of Alaska, comprising over 3500 species, has now been published (Drumm et al., 2016). In addition, collections are now being made to evaluate the population- and species-level genetic variation among populations of the soft coral *Gersemia* (Orr and Stevenson, with NWFSC).

Publications for 2016:

Drumm, D. T., K. P. Maslenikov, R. Van Syoc, J. W. Orr, R. R. Lauth, D. E. Stevenson, and T. W. Pietsch. 2016. An annotated checklist of the marine macroinvertebrates of Alaska. *NOAA Professional Paper NMFS 19*, 289 pp.

Gardner, J. R., J. W. Orr, D. E. Stevenson, I. Spies, and D. A. Somerton. 2016. Reproductive parasitism between distant phyla: molecular identification of snailfish (Liparidae) egg masses in the gill cavities of king crabs (Lithodidae). *Copeia* 104:645–657.

Orr, J. W. 2016. Two new species of *Careproctus* (Liparidae) from the Aleutian Islands. *Copeia* 104:890–896.

Stevenson, D. E., C. P. Kenaley, and R. Britz. 2016. Caristiidae: Manefishes, p. 2519–2525. In: *The Living Marine Resources of the Eastern Central Atlantic*, Vol. 4: Bony fishes part 2 (Perciformes to Tetraodontiformes) and Sea turtles. K. E. Carpenter and N. DeAngelis (eds.), Food and Agriculture Organization of the United Nations.

Stevenson, D. E., K. L. Weinberg, and R. R. Lauth. 2016. Estimating confidence in trawl efficiency and catch quantification for the eastern Bering Sea shelf survey. *U.S. Department of Commerce*, *NOAA Technical Memorandum NMFS-AFSC-335*, 51 p.

Stevenson, D. E., M. Moon, M. Rickett, and M. Vechter. 2016. Species identification in the North Pacific Observer Program: training, protocols, and data monitoring. *Alaska Fisheries Science Center Processed Report 2016-04*, 37 p.

Orr, J. W. In press. Pleuronectidae: Righteye Flounders, 30 ms pages. In: North American Freshwater Fishes: Evolution, Ecology, and Behavior. B. Burr and M. Warren (eds.), Johns Hopkins University Press.

Orr, J. W. In press. Paralichthyidae: Sand Flounders, 20 ms pages. In: North American Freshwater Fishes: Evolution, Ecology, and Behavior. B. Burr and M. Warren (eds.), Johns Hopkins University Press.

Orr, J. W. In press. Achiridae: American Soles, 20 ms pages. In: North American Freshwater Fishes: Evolution, Ecology, and Behavior. B. Burr and M. Warren (eds.), Johns Hopkins University Press.

AUKE BAY LABORATORIES

Spatial and temporal trends in the abundance and distribution of Pacific herring (*Clupea pallasii*) in the eastern Bering Sea during late summer, 2002-2015 - ABL

Description of index: Pacific herring (*Clupea pallasii*) were captured using surface trawls in the eastern Bering Sea during the late summer (September) from 2002-2015 in the Bering Arctic Subarctic Integrated Surveys (BASIS) surveys. Abundance and distribution were estimated using a standardized geostatistical index developed for stock assessments and management by Thorson et al. (2015). Survey stations were approximately 30 nautical miles apart. A trawl net was towed in the upper 20 m of the water column for approximately 30 minutes. Fish catch was estimated in kilograms at each station. Area swept was calculated as the product of the haversine distance of the tow and the horizontal spread of the net. Geostatistical analysis were conducted using R statistical software version 0.99.896 and the SpatialDeltaGLMM package version 3l (Thorson et al. 2015) to estimate abundance and distribution. We used a lognormal distribution and estimated spatial and spatio-temporal variation for both encounter probability and positive catch rate components, and a spatial resolution with 100 knots.

Status and trends: Pacific herring had a northern and nearshore distribution in the eastern Bering Sea during late summer (Figure 1). Field densities were generally higher in warm years. North-south elongation of the anisotropy ellipse indicated that densities are correlated over a longer distance in the north-south direction than in the east-west direction (Figure 2). The distribution of herring was more nearshore and north in 2010-2012 (Figure 3) and also more contracted over a smaller area in 2010-2012 (Figure 4). Estimated abundance of Pacific herring ranged from 15,616 metric tonnes in 2002 to 145,853 metric tonnes in 2014 (Figure 5; Table 1). The general trend was of higher abundances in warm years and lower abundances in cold years.

Factors causing trends: The eastern Bering Sea has recently undergone a series of warm (2002-2006), cold (2008-2012), and warm (2014) stanzas. The estimated abundance of Pacific herring was higher in warm years and lower in cold years. Climate may influence abundance through the impact of prey quality for herring nearshore in the eastern Bering Sea (Andrews et al. 2015). This model however does not account for the age of herring so estimates of abundance likely include multiple year classes.

Implications: Possible implications for increases in abundance of herring include increase prey availability for piscivores. The herring in our survey are likely mostly from Norton Sound. Pacific herring spawn in shallow subtidal and intertidal area along the coast during spring. In the summer, Bering Sea herring move west crossing the continental shelf where they feed (Mecklenburg et al. 2002). The distribution of the late summer herring indicate that they are in feeding grounds and likely migrating offshore.

For more information contact Ellen Yasumiishi at (907) 789-6604 or (ellen.yasumiishi@noaa.gov), Kristin Cieciel, Ed Farley.

References:

Andrews, A.G., III, W.W. Strasburger, E.V. Farley, Jr., J.M. Murphy, and K.O. Coyle. 2015. Effects of warm and cold climate conditions on capelin (*Mallotus villosus*) and Pacific herring (*Clupea pallasii*) in the eastern Bering Sea. Deep-Sea Res. II http://dx.doi.org/10.1016/j.dsr2.2015.10.008i

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Pacific herring. In: Fishes of Alaska. American Fisheries Society, Bethesda, p. 134.

Thorson, J.T., A.O. Shelton, E.J. Ward, and H.J. Skaug. 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfish. ICES Journal of Marine Science; doi:10.1093/icesjms/fsu243

Tojo, N., G.H. Kruse, and F.C. Funk. 2007. Migration dynamics of Pacific herring (*Clupea pallasii*) and response to spring environmental variability in the southeastern Bering Sea. Deep Sea Research Part II: Topical Studies in Oceanography 54(23):2832-2848.

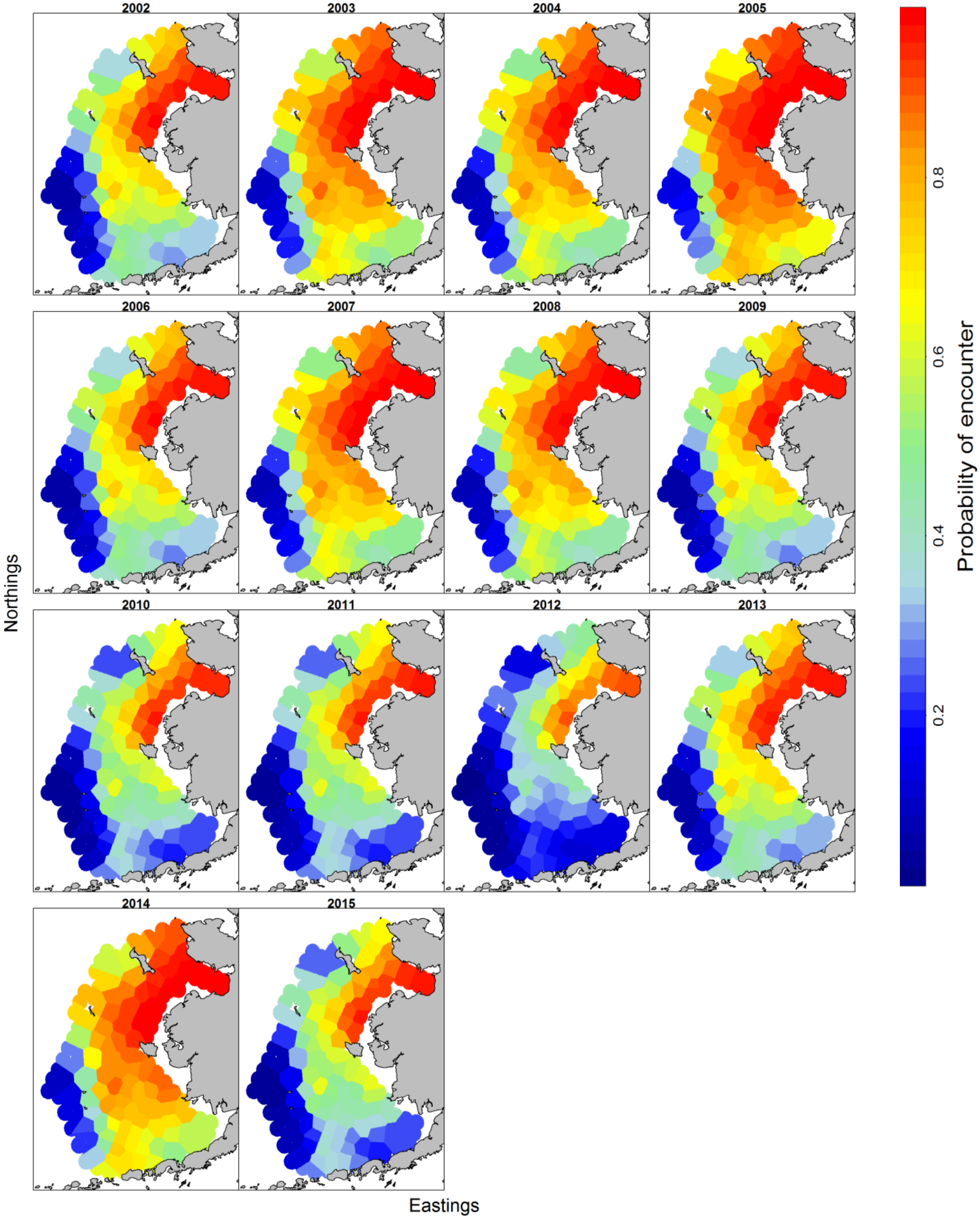


Figure 1. Density of Pacific herring in the eastern Bering Sea during late summer, 2002-2015. Densities were estimated using the geostatistical delta-generalized linear mixed model from Thorson et al. (2015).

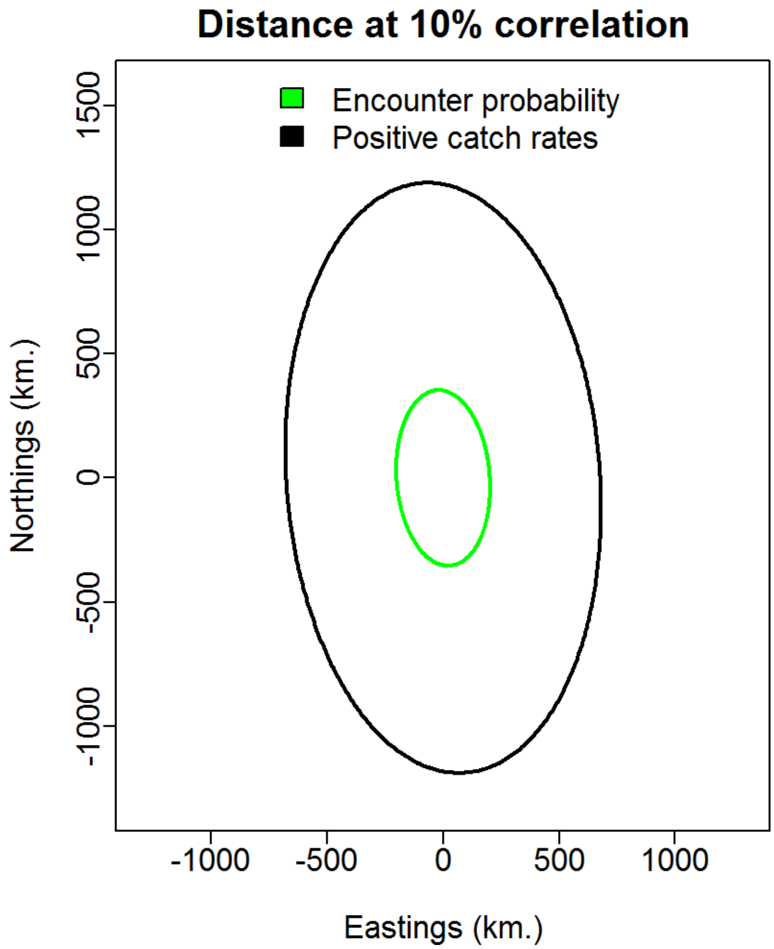


Figure 2. Geometric anisotropy plots for encounter probability of Pacific herring on the eastern Bering Sea shelf during late summer, 2002-2015.

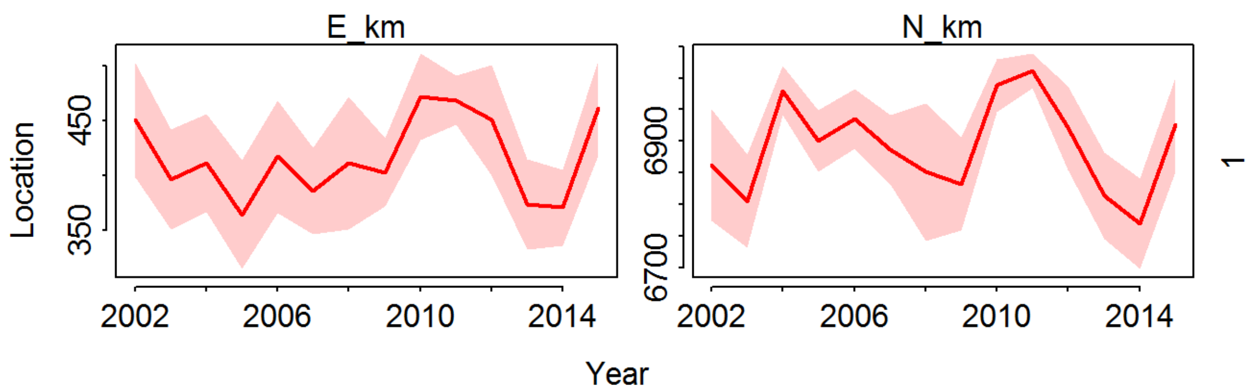


Figure 3. Northward and eastward center of gravity (distribution) in units of km for Pacific herring on the eastern Bering Sea during late summer, 2002-2015.

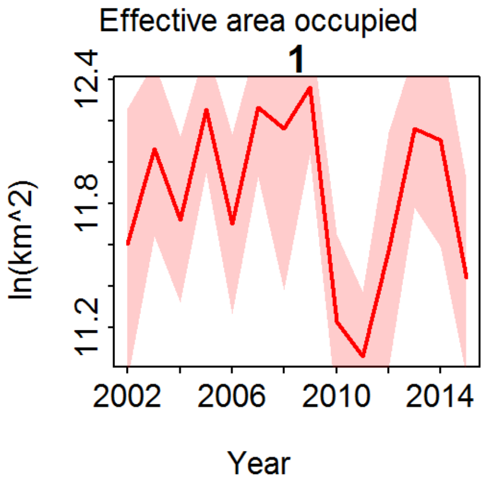


Figure 4. The effective area (ln(km^2)) occupied by Pacific herring on the eastern Bering Sea shelf during late summer, 2002-2015.

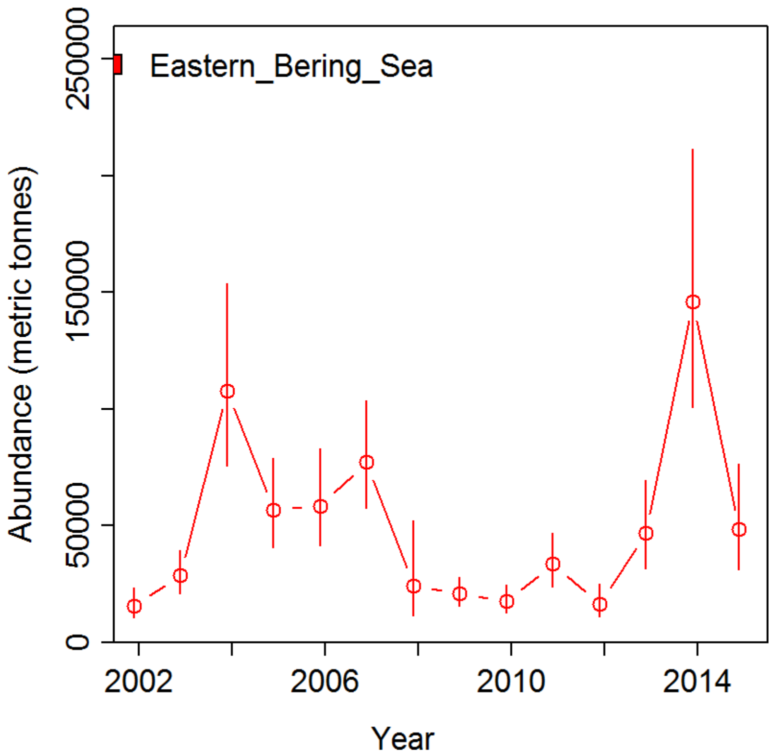


Figure 5. Estimated index of abundance with 95% confidence intervals for Pacific herring in the eastern Bering Sea during late summer, 2002-2015. Abundance was estimated using the geostatistical delta-generalized linear mixed model from Thorson et al. (2015).

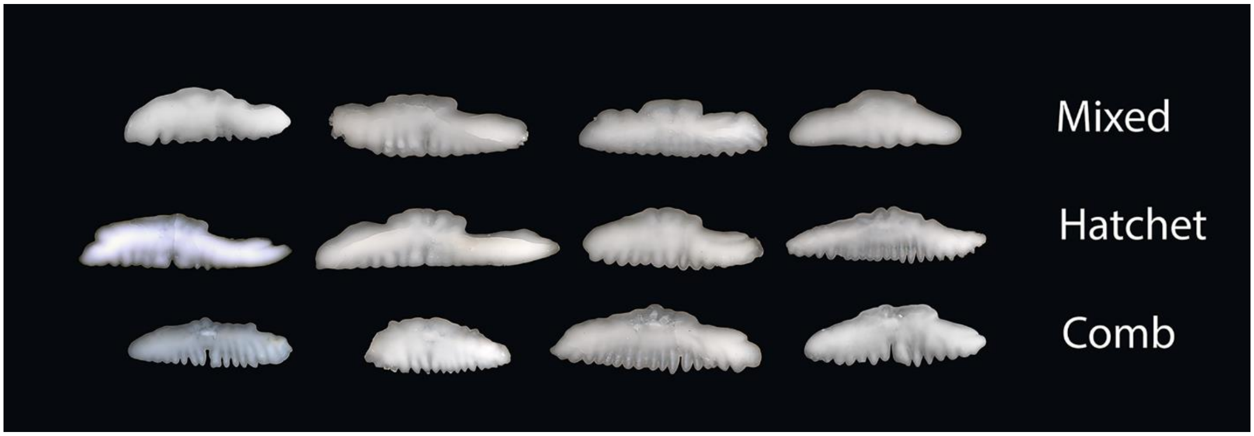
Table 1. Estimated abundance in metric tonnes of Pacific herring in the eastern Bering Sea during late summer, 2002-2015. SD is standard deviation.

Year	Estimate..metric.tonnes.	SD..log.	SD..natural.
2002	15,616	0.40	6,302
2003	28,718	0.31	9,040
2004	107,835	0.36	38,309
2005	56,747	0.33	18,767
2006	58,488	0.35	20,377
2007	77,189	0.29	22,632
2008	24,274	0.76	18,496
2009	20,817	0.29	6,039
2010	17,527	0.34	5,975
2011	33,447	0.34	11,252
2012	16,442	0.42	6,859
2013	46,892	0.40	18,544
2014	145,853	0.37	54,076
2015	48,649	0.45	21,979

Otolith shape variation and body growth differences in giant grenadier – ABL

Fish stocks can be defined by differences in their distribution, life history, and genetics. Managing fish based on stock structure is integral to successful management of a species because fishing may affect stocks disproportionately. Genetic and environmental differences can affect the shape and growth of otoliths and these differences may be indicative of stock structure. We quantified the shape of female giant grenadier, *Albatrossia pectoralis*, otoliths and compared body growth rates for fish with the three otolith shapes; shape types were classified visually by an experienced giant grenadier age reader, and were not defined by known distribution or life history differences. We found extreme variation in shape; however, the shapes were a gradation and not clearly defined into three groups. The two more extreme shapes, visually defined as “hatchet” and “comb”, were discernable based on principal component analysis (PCA) values of elliptical Fourier coefficients, and the “mixed” shape overlapped both of the extreme shapes. Body size of fish with hatchet-shaped otoliths grew faster than fish with a comb-shaped otoliths. A genetic test (the COI gene sequence data used by the Fish Barcode of Life Initiative) showed almost no variability among samples, indicating that the samples were all from one species. The lack of young specimens makes it difficult to link otolith shape and growth difference to life history. In addition, shape cannot be correlated with adult movement patterns because giant grenadiers experience 100% mortality after capture and, therefore, cannot be tagged and released. Despite these limitations, the link between body growth and otolith shape indicates measureable differences that deserve more study.

For more information contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.



V. Ecosystem Studies

Understanding and predicting patterns in northeast Pacific groundfish species movement and spatial distribution in response to anomalously warm ocean conditions—AFSC

In the fall of 2014, researchers projected a continuation of anomalously warm ocean conditions in the northeast Pacific Ocean, aka. The Blob, using a new seasonal forecasting capability. Based on the results of these forecasts, the North Pacific Research Board funded a coordinated research project to examine the impacts of the unusual warming event in the northeast Pacific. This project (NPRB #1033) evaluates a unique dataset of acoustic and bottom trawl survey data that spans from the southern California Bight to the western Gulf of Alaska. An interdisciplinary multi-national research team has been assembled to conduct this research. The NPRB provided funds to supplement existing surveys with additional oceanographic measurements to enhance our ability to describe the mechanisms underlying observed shifts in spatial distributions. This paper will present the initial observations from the 2015 acoustic and bottom trawl surveys in the Gulf of Alaska and contrast them with previous years when NMFS conducted comprehensive surveys simultaneously in both the GOA and CCS (2003, 2005, 2011 and 2013). Preliminary results suggest that the sea surface temperatures in late July along the northeast Pacific were among the warmest on record and similar to 2005. The heat content was significantly warmer. Distributional responses of Pacific hake, walleye pollock, selected flatfish and rockfish to the observed warming will be presented by length category.

One of the deliverables from this project will be the development and testing of methods to stitch together the bottom trawl survey data from three sources (AFSC, US west coast, and DFO) to provide biennial updates on the impact of climate change or climate variability on the spatial distribution of groundfish. If successful this could be a useful product for the TSC.

Contact Anne Hollowed (Anne.Hollowed@noaa.gov) for further information.

Species Profiles and Ecosystem Considerations (SPEC) – ABL

Over the past several years, a new framework has been proposed to start the process of integrating ecosystem and socioeconomic information directly into the Alaska groundfish stock assessments (Shotwell et al. 2016). These stock profiles and ecosystem considerations (SPECs) serve as a corollary stock-specific process to the large-scale ecosystem considerations report, effectively creating a two-pronged system for ecosystem based fisheries management at the AFSC. The new SPEC process creates ecosystem baselines to be included in the stock assessment fishery evaluation (SAFE) reports utilizing national initiative data currently being collected for all assessed stocks across the county. There are four primary baseline SPEC elements for a given stock or stock complex. First, an overall ecosystem status rating summarizes the results from the national initiatives to provide immediate and succinct context for the priorities of the stock or stock complex. The rating should include subjects relevant to the particular fishery management plan of the stock (e.g., data classification, prioritization, and vulnerability assessment). The rating is based on four categories of low (L), moderate (M), high (H), and very high (VH). These ratings indicate whether this particular factor is of low to high importance for the stock (e.g., a low habitat prioritization implies that more habitat research would have low impact for improvement of this stock assessment). The second element starts as an informal life history conceptual model that provides the relevant information on the stock life history stages and potential survival bottlenecks between stages. The third element, is a qualitative stock profile that follows the format of the overall rating but further identifies strengths and weaknesses over a suite of response categories (e.g., stock status, economics, biology). Finally, the first three elements are used in concert to develop a list of potential ecosystem or socioeconomic indicators that are then compiled for monitoring as time series in a graphical report card. These baselines can then be enhanced with new information from process studies (e.g. IERPs, FATE) or continued ecosystem monitoring (e.g. standard surveys, remote sensing). The SPECs initiate the active integration of ecosystem and socioeconomic data within the stock assessment process and take a giant leap toward implementing the next generation of stock assessments.

Please refer to the following report for more details:
Shotwell, S.K., D.H. Hanselman, S. Zador, and K. Aydin. 2016. Stock-specific Profiles and Ecosystem Considerations (SPEC) for Alaska groundfish fishery management plans. Report to Joint Groundfish Plan Team, September 2016. 15 pp.

For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

Benthic Habitat Research – Gulf of Alaska - ABL

The primary goal of the Gulf of Alaska (GOA) benthic habitat research project was to characterize the preferred early juvenile life stage settlement habitat for the five focal groundfish species (sablefish, pollock, Pacific cod, Pacific ocean perch, and arrowtooth flounder) specified by the GOA Integrated Ecosystem Research Project (IERP). The Final Report to the NPRB (100+pgs) included the following information for the five focal species: 1) extensive literature review of habitat preferences with life stage tables, 2) methods and maps of the high resolution suite of benthic habitat variables, 3) methods and database of the field observations for the early juvenile stages, 4) methods and maps for the literature based habitat suitability, 5) methods, model selection, model results, and final maps for the model-based habitat suitability 6) regional based habitat suitability estimates, and 7) extensive discussion of the project. A manuscript by led by J. Pirtle was accepted for the special issue of Deep-Sea Research II describing the work on the early juvenile stage habitat suitability models for the five species. The follow up Essential Fish Habitat (EFH) project (also led by J. Pirtle, HCD with C. Rooper, RACE) used the baseline habitat suitability framework from the GOA-IERP and extended this work to include new biophysical habitat metrics (e.g. production, temperature, corals) and apply the methods to a variety of groundfish species from the early juvenile life stage through adults (including the five focal species). The results from this project were included in the 2016 EFH update which was reviewed and accepted by the council process. A NOAA Technical Memorandum is currently in development to summarize the EFH project. The whole life cycle EFH results are also planned for inclusion where relevant in the new species profiles and ecosystem considerations (SPEC) sections of the stock assessment fishery evaluation (SAFE) process and may assist fishery managers in future decisions regarding survey planning and habitat assessment. During the final phase of the GOA Project Synthesis, the baseline habitat suitability models will be combined with individual based models (IBMs) in a novel approach to delineating survival trajectories for understanding recruitment of groundfish. The case studies for this approach will be Alaska sablefish and GOA arrowtooth flounder.

For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

Alaska Coral and Sponge Initiative – RACE & ABL

Deep-sea coral and sponge ecosystems are widespread throughout most of Alaska’s marine waters. In some places, such as the western Aleutian Islands, these may be the most diverse and abundant deep-sea coral and sponge communities in the world. Deep-sea coral and sponge communities are associated with many different species of fishes and invertebrates in Alaska. Because of their biology, these benthic invertebrates are potentially vulnerable to the effects of commercial fishing, climate change and ocean acidification. Since little is known of the biology and distribution of these communities, it is difficult to manage human activities and climate impacts that may affect deep-sea coral and sponge ecosystems.

Beginning in FY2012 the NOAA Deep Sea Coral Research and Technology Program (DSCRTP) initiated a field research program in the Alaska region for three years (FY2012-2015) to better understand the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats. The research priorities of this initiative include:

- Determine the distribution, abundance and diversity of sponge and deep-sea coral in Alaska;
- Compile and interpret habitat and substrate maps for the Alaska region;
- Determine deep-sea coral and sponge associations with FMP species and their contribution to fisheries production;
- Determine impacts of fishing by gear type and testing gear modifications to reduce any impacts;
- Determine recovery rates of deep-sea coral and sponge communities from disturbance; and,
- Establish a monitoring program for the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

Fieldwork for the AKCSI project was completed in FY15 with a remotely operated vehicle cruise in Southeast Alaska to examine Primnoa thickets at two study sites. The important accomplishments of this project included; the production of model-based maps of coral and sponge habitat for all of Alaska, analysis of seasonal patterns of rockfish use of coral habitat, and a number of studies examining the growth and reproduction of Primnoa corals in southeast

Alaska. A final report for this project was completed in December 2016 and will be available as a NOAA Technical Memorandum at some point in 2018. Results of this project were delivered at the International Coral Symposium in Boston, MA in September 2016.

Contact: Chris Rooper (chris.rooper@noaa.gov)

Defining EFH for Alaska Groundfish Species using Species Distribution Modeling-RACE

Principal Investigators: Chris Rooper, Ned Laman, Dan Cooper (RACE Division, AFSC)
Defining essential fish habitat for commercially important species is an important step for managing marine ecosystems in U.S. waters. Using species distribution modeling techniques (SDM), data from fishery-independent groundfish and ichthyoplankton surveys, and commercial fisheries observer data, we developed habitat-based descriptions of essential fish habitat (EFH) for all federally managed species in Alaska. We used maximum entropy (MaxEnt) and generalized additive modeling (GAM) to describe distribution and abundance of early (i.e., egg, larval, and pelagic juvenile) and later (settled juvenile and adult) life history stages of groundfish and crab species across multiple seasons in three large marine ecosystems in Alaska (Gulf of Alaska, eastern Bering Sea, and Aleutian Islands) and the northern Bering Sea. To demonstrate our methods and techniques, we present a case study of Kamchatka flounder (Atheresthes evermanni) from the eastern and northern Bering Sea as an example of over 400 SDMs we generated for > 80 unique species-region-season combinations. The resulting models and maps will be used in Alaska for marine spatial planning, and to support current and future stock assessments. The North Pacific Fishery Management Council has approved the EFH descriptions provided by the SDMs and the results have been used in conjunction with a fishing effects model to evaluate the impacts of fishing on EFH.

AFSC pilot study using TriggerCams to assess rockfish density on Footprint Bank, Channel Islands-RACE MACE & GAP

Williams, K, Rooper, C, Tuttle, V, Boldt J, Laidig T, Jones, D

This pilot project was to develop a stationary camera survey for rockfish in untrawlable habitats. Its primary objective was to test the overall survey design, deployment methods, and gear performance ahead of the Untrawlable Habitat Strategic Initiative (UHSI) efforts in FY17. This study involved 4 vessel days aboard the NOAA Channel Islands Sanctuary vessel R/V Shearwater in September 2016. A total of 26 camera drops were made using 7 camera units, resulting in sufficient data to characterize the baseline density of rockfish by species within the 150 m isobath at Footprint Bank in the Channel Islands National Marine Sanctuary. The data analyses is ongoing for this project.

Using the ME70 Multibeam to map untrawlable habitat in the Gulf of Alaska

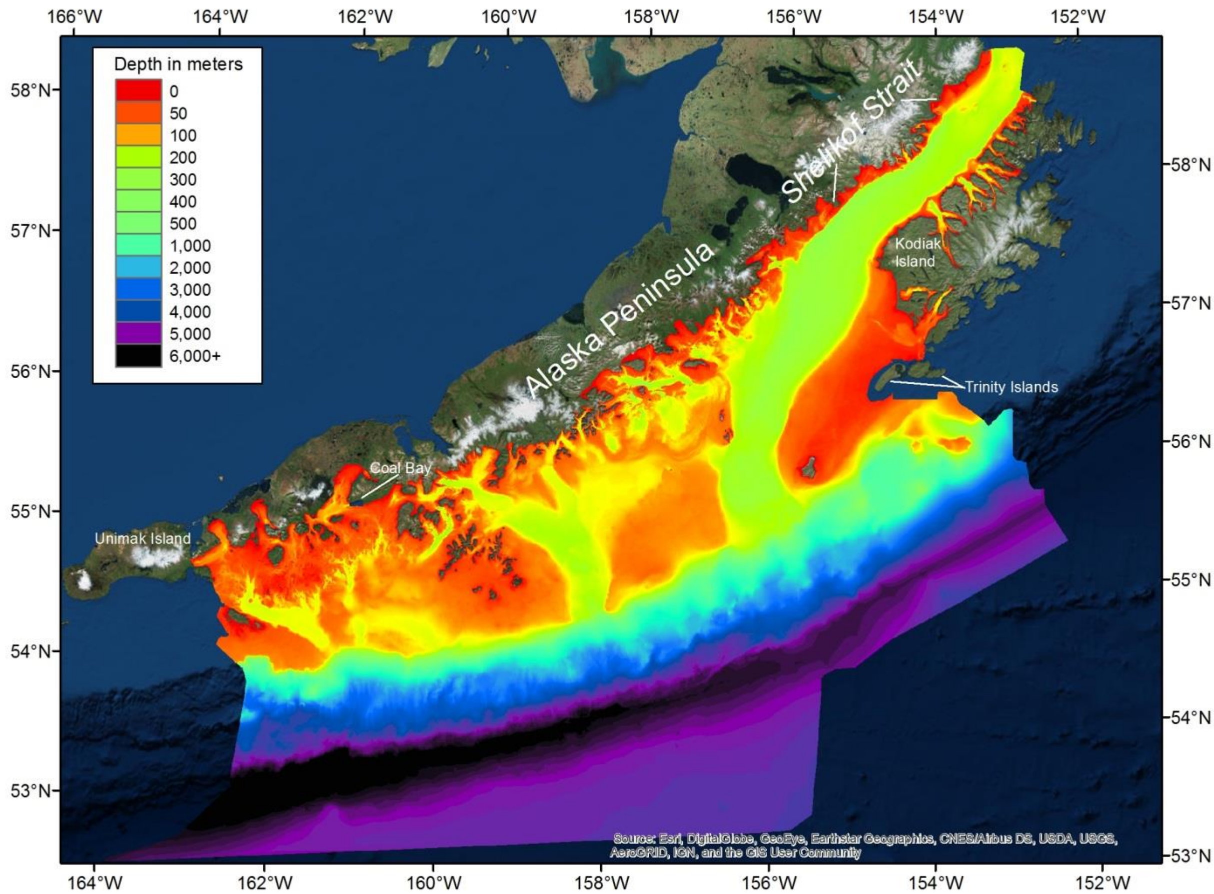
Stienessen, S, Jones, D, Rooper, C, Pirtle, J, Wilson, C, Weber, T
Fisheries independent biomass estimates used in rockfish (Sebastes sp.) stock assessments in the Gulf of Alaska (GOA) are generated from data collected during multi-species biennial groundfish bottom trawl surveys. Some rockfish species prefer rugged bottom habitat, which makes them difficult to sample with bottom trawl survey nets. Therefore, only those rockfish found in trawlable habitat are fully sampled by the biennial bottom trawl surveys and this non-random sampling can lead to disproportionate allocation of species composition and introduce biases to the biomass estimates. To improve estimates of habitat-specific groundfish biomass, Pirtle et al. (2015) developed a model that used multibeam-derived seafloor metrics to predict seafloor trawlability. The model was correct for 69% of the haul locations examined. We have

expanded upon this work to re-evaluate the trawlability designation of the seafloor in areas historically designated as trawlable or untrawlable by the bottom trawl survey. Simrad ME70 multibeam echosounder data and associated video imagery of seafloor substrates were collected in the GOA during the summers of 2013 and 2015 by NOAA scientists from the Alaska Fisheries Science Center. Multibeam data were collected along parallel transects spaced approximately 1 nmi apart at fine-scale survey sites, and video data were collected at up to 3 camera stations within these sites. Seafloor metrics were extracted from the multibeam data, and video imagery was used to determine seafloor trawlability. The data collected in 2013 and 2015 were combined with historical data and a Generalized Linear Model was parameterized to extract new model coefficients. The updated model was used to derive probabilities of trawlable and untrawlable habitat. This new information will be used to assess the proportion of the GOA that is sampled by the bottom trawl survey. In combination with habitat specific fish densities, the data can also be used to estimate the quantity of each rockfish species that is unavailable to the GOA bottom trawl survey.

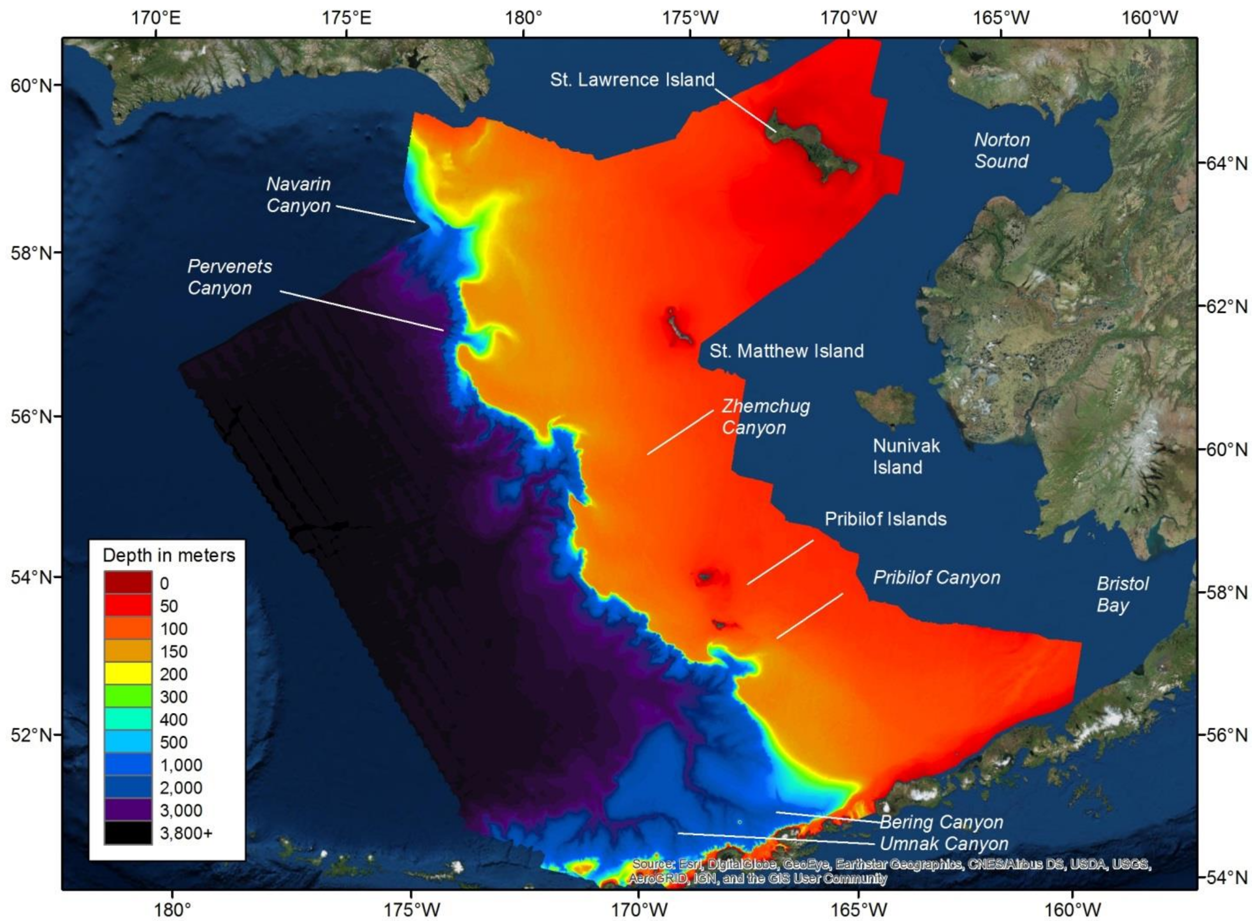
Bathymetry of the western Gulf of Alaska and eastern Bering Sea slope - RACE GAP

As a continuation of work in Alaskan waters (http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/default.htm), scientists with the AFSC's Groundfish Assessment Program (GAP) are in the process of publishing bathymetry for the western Gulf of Alaska (wGOA) and eastern Bering Sea slope (EBSS), Alaska. This work is part of a project using smooth sheets and other sources to provide better seafloor information for fisheries research.

The western Gulf of Alaska project ranged from Unimak Island on the west, along the south side of the Alaska Peninsula to Kodiak Island and through Shelikof Strait on the east. Coal Bay, on the south side of the peninsula near the western extent of this region, has never been surveyed and was therefore left blank. The area around the Trinity islands is scheduled to be mapped this summer. This wGOA compilation connects to our previously bathymetry compilations of the Aleutian Islands (https://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Aleutians.htm), the central Gulf of Alaska (https://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/CentralGOA_1.htm), and Cook Inlet (https://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Cook_Inlet_1.htm).



The eastern Bering Sea slope compilation ranged from Umnak and Bering canyons in the south and up to Navarin Canyon and St. Lawrence Island in the north. This EBSS compilation connects to our previously bathymetry compilations of Norton Sound (https://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Norton_Sound.htm) and the Aleutian Islands (https://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Aleutians.htm).



Funding from the NMFS Alaska Regional Office's Essential Fish Habitat (AKR EFH: http://www.afsc.noaa.gov/HEPR/docs/Sigler_et_al_2012_Alaska_Essential_Fish_Habitat_Research_Plan.pdf) made this work possible. These bathymetry compilations are part of a GAP (Groundfish Assessment Program) effort to create more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their environment.

Contact Mark.Zimmermann@noaa.gov

A pilot study for assessing deep-sea corals and sponges as nurseries for fish larvae in the western Gulf of Alaska-RACE GAP

Principal Investigators: Rachel Wilborn, Chris Rooper, Pam Goddard

A recent study in eastern Canada found evidence that deep-sea corals (specifically a fan-type sea pen) were consistently associated with Sebastes larvae (Ballion et al. 2012). This study found larval Sebastes inside the withdrawn polyps and branches of pennatulaceans. The prevalence of this association was widespread with 11.5 to 100% of sea pens captured with Sebastes larvae. The finding has provided one of the most direct lines of evidence for the importance of deep-sea corals as essential fish habitat for Sebastes. However, there are some questions regarding the methodology of the study, as the samples were all trawl caught and in some cases sea pens were caught in the same hauls as mature female Sebastes. This suggests that the larvae could have been extruded as a response to being captured, resulting in the observed association.

In 2016, a cursory examination of specimens of trawl caught coral (Fanellia sp.) that were retained for a genetics study yielded the finding of a fish larva, preliminarily identified as a walleye pollock (Figure 1). This anecdotal evidence raises questions about the potential role of deep-sea corals as larval habitat for commercially important fish species in Alaska. This proposal is to directly examine whether deep-sea corals serve as spawning habitat for rockfish and other species in the Gulf of Alaska.

The objectives of this project are; 1) to identify potential spawning areas for rockfish in the western Gulf of Alaska (Figure 2), 2) to collect underwater stereo imagery to identify the substrate types and species and sizes of benthic invertebrates associated with spawning activity and 3) to sample larvae in situ from spawning habitats using a newly developed plankton pump (Figure 3).

This research will be conducted on Leg 1 of the 2017 Gulf of Alaska bottom trawl survey, which is anticipated to begin in late May 2017. Objective 1 will be addressed by examining all bottom trawl survey catches for spawning or mature fish. Based on previous experience, we typically capture rockfish during Leg 1 of the bottom trawl survey that are mature or in spawning (parturition) condition. These are usually northern rockfish (Sebastes polyspinis), dusky rockfish (S. variabilis) and Pacific Ocean perch (S. alutus). The proportion of the regular length sample of females of each rockfish species that are in spawning condition will be recorded and expanded to the overall size of the catch. The trawl survey catches containing rockfish species that are spawning or mature will be recorded and the occurrence will trigger additional sampling at the station. Based on previous experiences during the bottom trawl survey, it is anticipated that about 10 individual stations will have spawning rockfish present and will trigger additional sampling. The additional sampling will consist of conducting one camera transect along the track of the bottom trawl path and two transects parallel to the path where the spawning fish were collected. These 3 transects will be five minutes in duration and will be used to identify substrate types and document the presence (and size) or absence of benthic invertebrates on and around the bottom trawl track. Next an autonomous plankton pump with a separate stereo camera (Kilburn et al. 2010, Madurell et al. 2012) will be deployed on each camera transect using crab line and a float. The plankton pump will collect samples of zooplankton and larvae in the water column at specific locations, as well as provide images of the substrate where the plankton sample was taken.

In addition to camera tow data, an autonomous plankton pump with a stereo camera (Kilburn et al. 2010, Madurell et al. 2012) will be deployed on each transect using crab line and a float. The plankton pump consists of a motor, pump, 75 and 200 micron mesh, flow meter , and a codend (Figure 3). Once the pump assembly comes to rest on the substrate the camera will record the surroundings for several minutes to identify coral, sponge, or bare habitat. The lights will then be turned off for 5 minutes to prevent attraction or visual avoidance of larval fish. A timed trigger will activate the pump to run for 10 minutes and the flowmeter will document flow rate. The lights will be turned back on after 10 minutes to assess location and record any movement. All samples will be preserved at sea in 95% ethanol for later analysis in Seattle. Larval fish will undergo genetic analysis as well to obtain accurate identification. The sample size for plankton collections will be approximately 30, given that about 10 bottom trawl hauls should contain spawning rockfish and would thus trigger additional sampling.

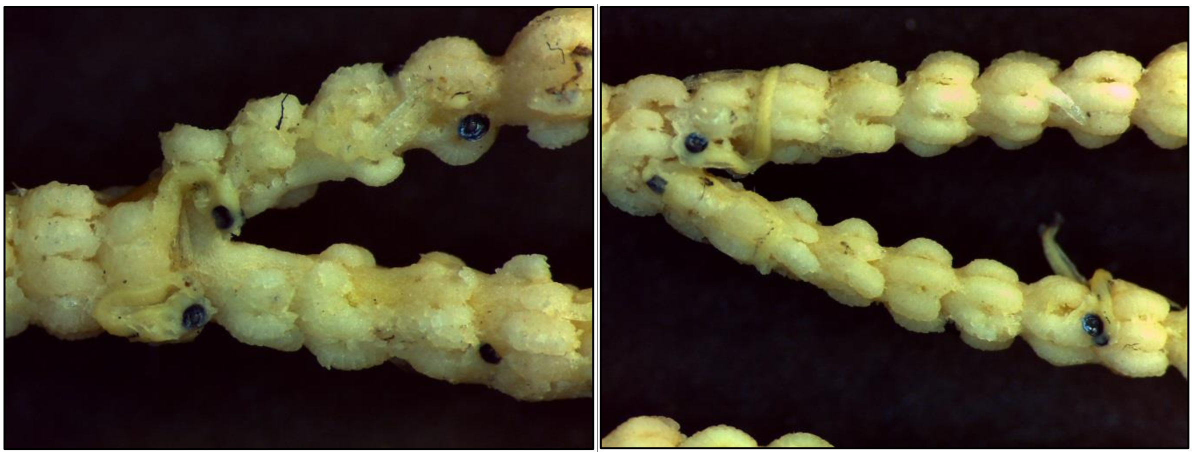


Figure 1.Fish larvae on a Fanellia gorgonian.

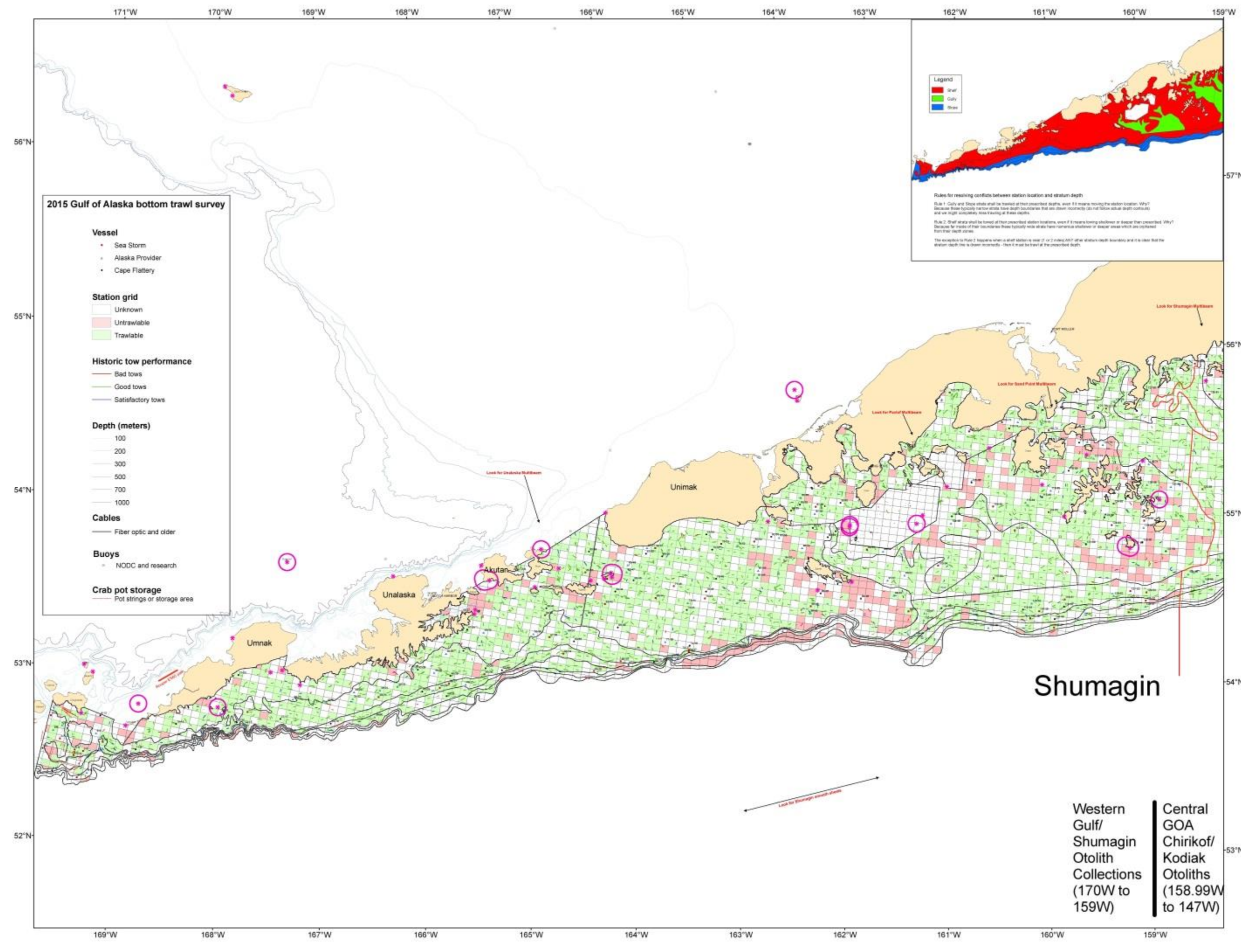


Figure 2. Map of 2015 western Gulf of Alaska bottom trawl survey stations from the Islands of Four Mountains to the Shumagin Islands as an example of the station pattern for the study. One of the survey vessels will conduct the study at its assigned stations.

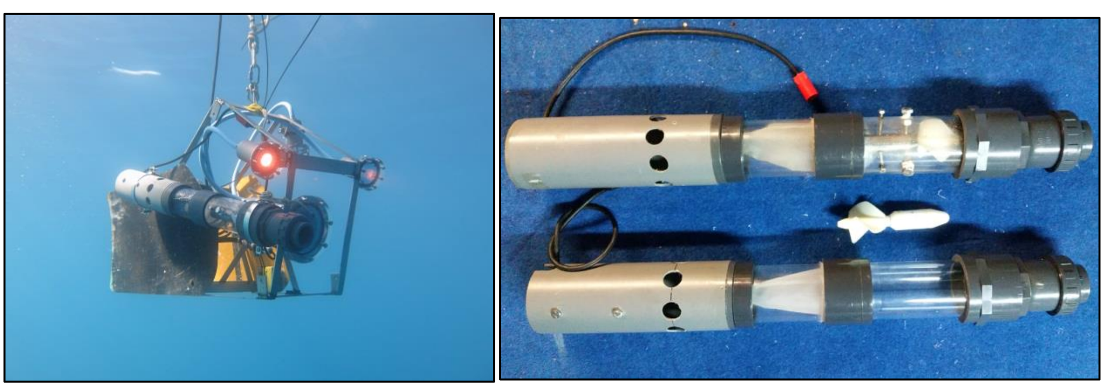


Figure 3. Plankton pump and deployment system with camera and lights. Images courtesy of ShelfReCover

RACE Recruitment Processes (RPP)

The Recruitment Processes Program's (RPP) overall goal is to understand the mechanisms that determine whether or not marine organisms survive to the age of “recruitment.” Recruitment for commercially fished species occurs when they grow to the size captured or retained by the nets or gear used in the fishery. For each species or ecosystem component that we study, we attempt to learn what biotic and abiotic factors cause or contribute to the observed population fluctuations. These population fluctuations occur on many different time scales (for example, between years, between decades). The mechanistic understanding that results from our research is applied by us and by others at the Alaska Fisheries Science Center to better manage and conserve the living marine resources for which NOAA is the steward. Below are research activities focusing on multiple species and ecosystem effects.

Contact: Janet Duffy-Anderson

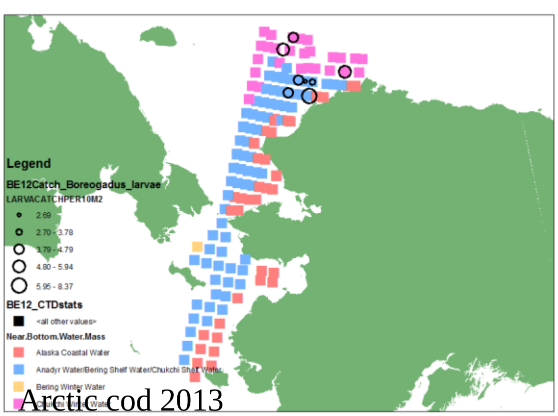
ARCTIC

Ichthyoplankton Assemblages and Distribution in the Chukchi Sea 2012-2013 - RPP

There is significant interest in the effects of climate change on the Pacific Arctic ecosystem, and in determining influences on resident biota. In summer 2012 and 2013, large-scale fisheries oceanographic surveys that included ichthyoplankton tows were conducted in the northern Bering and eastern Chukchi Seas as part of the Arctic Ecosystem Integrated Survey (Arctic Eis). Analyses are currently underway to examine the environmental drivers of larval fish distribution, and whether those drivers vary interannually as large-scale atmospheric and oceanographic forcing varies. Arctic cod were associated with two water masses, Chukchi Winter Water and a water mass made of a combination of Anadyr Water, Bering Shelf Water, and Chukchi Shelf Water. Both of these water masses are expected to be relatively high in nutrients and zooplankton prey advected from either the Chukchi Shelf or from the Bering Sea. Yellowfin sole were associated with Alaska Coastal Water. This is a water mass that is advected from the south along the coast in the Alaska Coastal Current and is expected to be relatively low in nutrients. Yellowfin sole spawn in coastal waters in the Bering Sea, so it is not surprising that they would be advected into the Chukchi Sea in this water mass. Further analyses will examine the phytoplankton and zooplankton distributions relative to larval fish distributions. A multivariate model will be constructed to quantify the effects of year, location, water mass, phytoplankton and zooplankton on larval fish distribution.

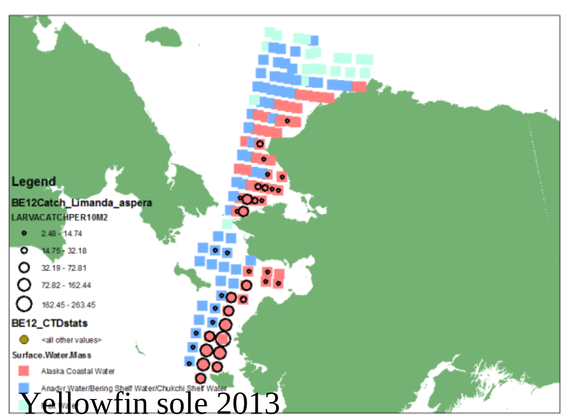
Figure 1.

Arctic cod 2012



Arctic cod 2013

Yellowfin sole 2012



Yellowfin sole 2013

BERING SEA

Copepod dynamics across warm and cold periods in the eastern Bering Sea: implications for walleye pollock (*Gadus chalcogrammus*) and the Oscillating Control Hypothesis--RPP

Differences in zooplankton populations in relation to climate have been explored extensively on the southeastern Bering Sea shelf, specifically in relation to recruitment of the commercially important species walleye pollock (*Gadus chalcogrammus*). We hypothesized that warm and cold periods would show differences in copepod life history stage abundance and estimated secondary production rates. Data on numerically dominant copepod species across 3 months (May, July, September) during a period of warmer water temperatures (2001-2005) and a period of colder water temperatures (2007-2011) were compared. For most copepod species, warmer conditions resulted in increased abundances in May; the opposite was observed in colder conditions (data not shown). Abundances of smaller sized copepod species did not differ significantly between the warm and cold periods whereas abundances of larger sized *Calanus* spp. increased during the cold period during July and September. Estimated secondary production rates in the warm period were highest in May for smaller sized copepods; production in the cold period was dominated by the larger sized *Calanus* spp. in July and September (Figure 1). We hypothesize that these observed patterns are a function of temperature-driven changes in phenology combined with shifts in size-based trophic relationships with primary producers. Based on this hypothesis, we present a conceptual model that builds upon the Oscillating Control Hypothesis to explain how variability in copepod production links to pollock variability (Figure 2). Specifically, fluctuations in spring sea-ice drive regime-dependent copepod production over the southeastern Bering Sea, but greatest impacts to upper trophic levels are driven by cascading July/September differences in copepod production.

David G. Kimmel, Lisa B. Eisner, Matthew T. Wilson, Janet T. Duffy-Anderson

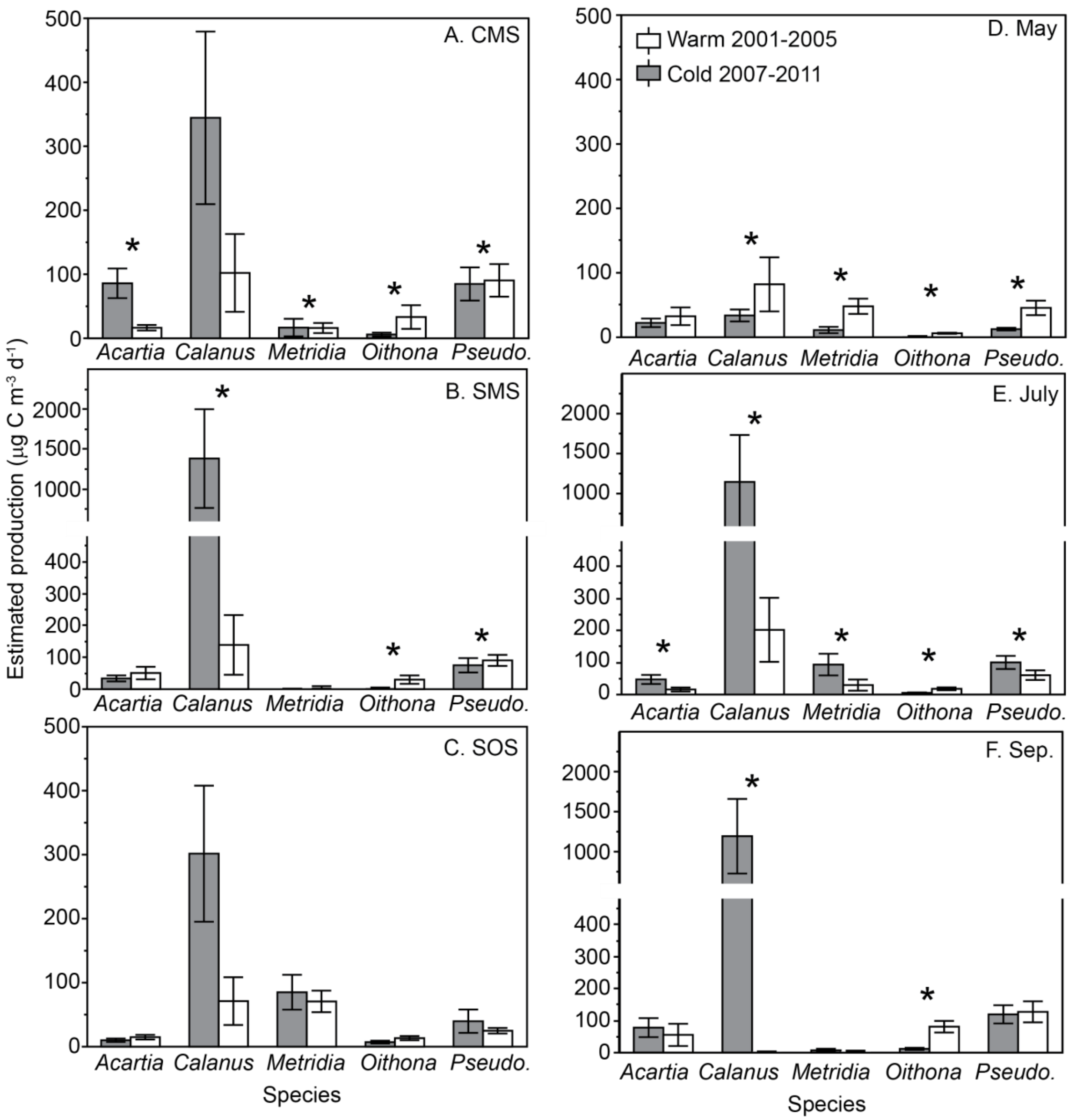


Figure 1. Copepod estimated secondary production rates (µg C m^{-3} d^{-1}) for each species (*Pseudo* is *Pseudocalanus* spp.) during cold (2007-2011) and warm (2001-2005) periods by region (all months combined): Central Middle Shelf (CMS) (A), South Middle Shelf (SMS) (B), and South Outer Shelf (SOS) (C) of the Bering Sea and by month (all regions combined): May (D), July (E), and September (F). Asterisks indicate statistical differences (ANOVA, Tukey HSD post-hoc test $p < 0.05$) between warm and cold period.

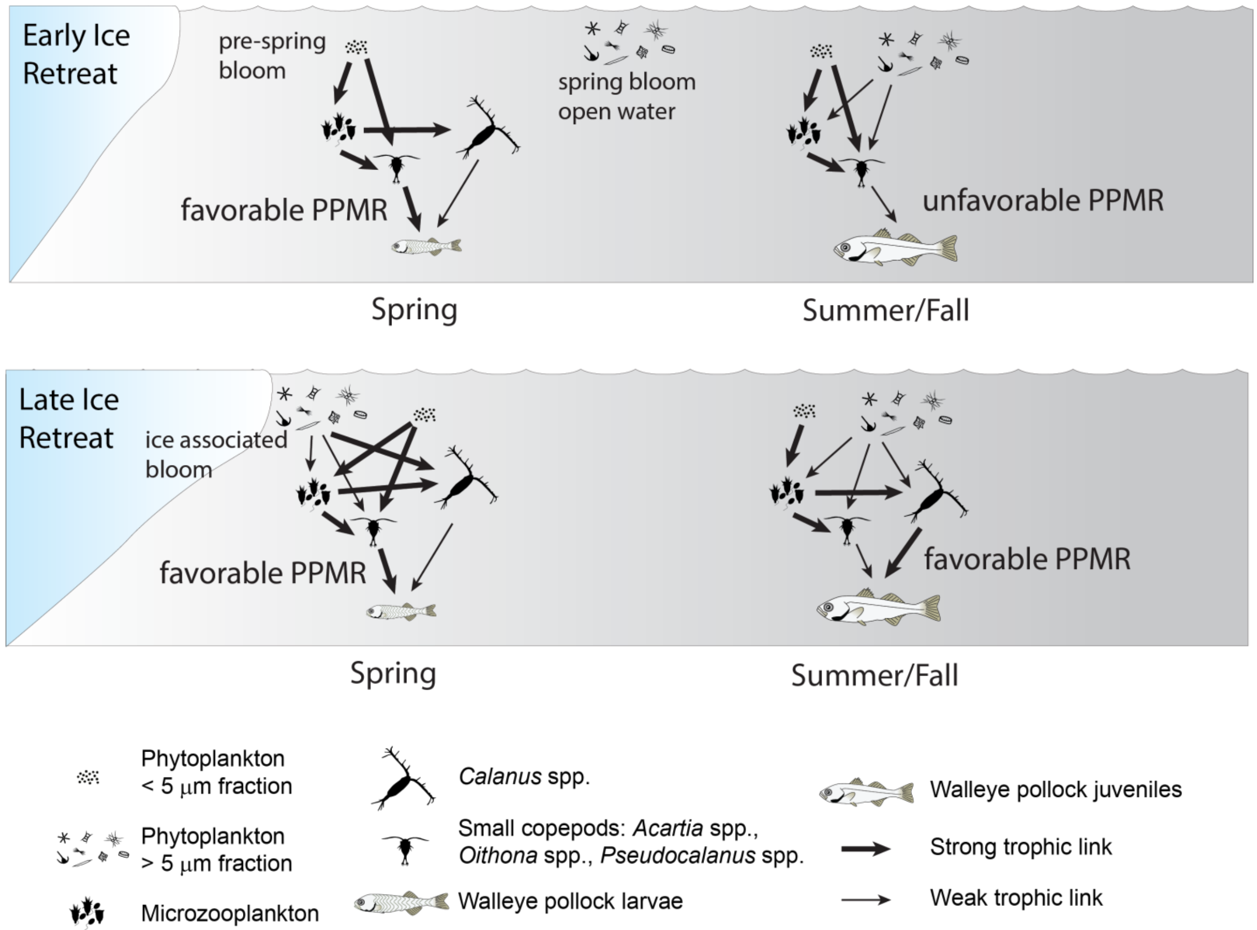


Figure 2. Conceptual model of the trophic interactions in the southeastern Bering Sea. During a year with early ice retreat (top panel) small phytoplankton cells are preyed upon by microzooplankton, small copepods, and early stages of *Calanus* spp. Warm temperatures result in higher copepod production rates and trophic transfer is high because larval walleye pollock have a favorable predator-prey mass ratio (PPMR) with their copepod prey. In the summer/fall, both large and small phytoplankton cells are present, but large copepods have disappeared from the southeastern shelf, resulting in high abundances of smaller-bodied copepods. These prey are too small to sustain the larger walleye pollock, resulting in an unfavorable PPMR and poor trophic transfer. During a year with late ice retreat (bottom panel), the spring phytoplankton bloom occurs in the marginal ice zone and in the wake of sea-ice retreat. The bloom is made up of larger sized phytoplankton cells (primarily diatoms) and is preyed upon by *Calanus* spp. early life stages; however, these prey are too large to be eaten by walleye pollock. Large phytoplankton cells are also preyed upon by microzooplankton and smaller bodied copepods that in turn provide a source of prey for walleye pollock larvae. Overall production rates are lower due to colder temperatures, but PPMR are favorable for efficient trophic transfer. In the summer/fall, *Calanus* spp. prey predominately on microzooplankton that are fueled by productive small phytoplankton cells. The larger, lipid rich *Calanus* spp. provide a favorable PPMR for walleye pollock that have switched from growth to energy provisioning in order to overwinter.

Assessing environmental DNA (eDNA) methods for use in fisheries surveys - RPP

Overall Objective:

Evaluate the performances of quantitative PCR (qPCR) and next-generation sequencing (NGS) methods for screening environmental DNA (eDNA) for species composition and relative abundances for three fish taxa (pollock, capelin and Pacific Ocean perch) that are difficult to distinguish via acoustic signatures.

Specific objectives:

1. Compare species composition and relative abundance estimates from qPCR and eDNA methods with those derived from trawling at the same sampling sites for adult walleye pollock and Pacific Ocean perch.
2. Compare species composition and relative abundance estimates from qPCR and eDNA methods with those derived from trawling at the same sampling sites for age-1 walleye pollock and capelin.
3. Evaluate the accuracy and precision of estimates from qPCR and eDNA methods using replicate samples taken from two depths in proximity to a shoal of fishes detected acoustically and subsequently sampled by trawling.

eDNA sampling and extraction

Seawater sample were collected on three dates from late June to mid-July, 2016 during a MACE hydroacoustics survey in the eastern Bering Sea. Three replicate seawater samples were taken at two discrete depths (in shoal and 10 m above shoal) on a CTD cast with 7 L Niskin bottles following the trawl. We requested that the CTD be paired as closely in time and location to the center of the trawl path as survey shipboard operations would allow. This resulted in eDNA sampling being conducted, on average, approximately 1.3 km from the center of the path with times between trawl and CTD cast ranging from 1.3 – 6.0 h (Table 1).

Table 1. eDNA collection data. Distance and time of CTD cast from center of tow path and time of trawl, respectively.

CTD date	CTD lat	CTD long	distance (km)	time (H:min)
21-Jun-16	55.2772	165.1188	1.29	1:20
1-Jul-16	55.902	168.7457	1.24	6:02
31-Jul-16	57.2945	173.8748	1.36	2:39

Filters frozen at -80 °C were thawed and incubated overnight at 65 °C in 900 μl of Longmire's solution followed by bead beating of filters. eDNA was extracted using a phenol/chloroform protocol modified from Renshaw et al. (2015). Samples were resuspended in 30-50 μL of reagent grade water prior to qPCR trials.

qPCR probe and primer design/optimization

To date, we have developed primer/probe combinations for all three target species in the project, walleye pollock, capelin and Pacific Ocean perch (Table 2). Primer pairs and FAM-labeled probes were designed using Allele ID v. 7.0 (Premier Biosoft, Palo Alto, CA).

Initial qPCR reactions consisted of 4.32 µl of reagent grade water, 6 µl of Master mix, 0.22 µl each forward and reverse primers (50 µM), 0.22 µl probe (10 µM) and 1.0 µl of template DNA. The thermocycling profile for qPCR assays consisted of denaturation at 95 °C for 10 minutes, followed by 40 cycles of: 92 °C for 15 s, 60 °C for 1 mi. qPCR assays were conducted on an ABI7900, Applied Biosystems.

qPCR protocol optimization is still in progress. Initial results from the pollock probe produced unexpectedly low estimates of pollock eDNA (discussed below). We switched from GTX Mastermix to Environmental Mastermix (Applied Biosystems) to improve assay sensitivity. The Environmental Mastermix did improve qPCR amplification in pollock, but also produced weak, late-cycle amplification in Pacific cod, Saffron cod and Arctic cod. We are currently adjusting primer concentrations to eliminate those signals while retaining optimal sensitivity for pollock eDNA.

Table 2. Species-specific qPCR primers and probes. Size refers to number of base pairs in PCR amplicon.

species	size	F primer	R primer	probe
Walleye pollock	119	CCCTATTTGTTTGAGCAG	GTCAGTTAGAAGTATTGTGA	AGCCGTGCTTCTACTTCTA
capelin	74	CCCTCTTTCCTTCTCCTCTTA	GGCGGGTAAACTGTTCAG	TAGAAGCAGGAGCCG
Pacific Ocean perch	175	GGTGAAGGGCTATAACTAG	ACCTCATTATTTGGTTGATC	CCCCTGTAAGTACA

Walleye pollock

Primer and probe development/testing for quantitative PCR (qPCR) began in late winter-early spring, 2016. The pollock assay was optimized to provide species-specific amplification for pollock (versus four other gadid species) Standard qPCR curves for pollock exhibit 96-100% amplification efficiency in the range of 0.00025 – 10.0 ng μl^{-1} of pollock genomic DNA (Fig. 1).

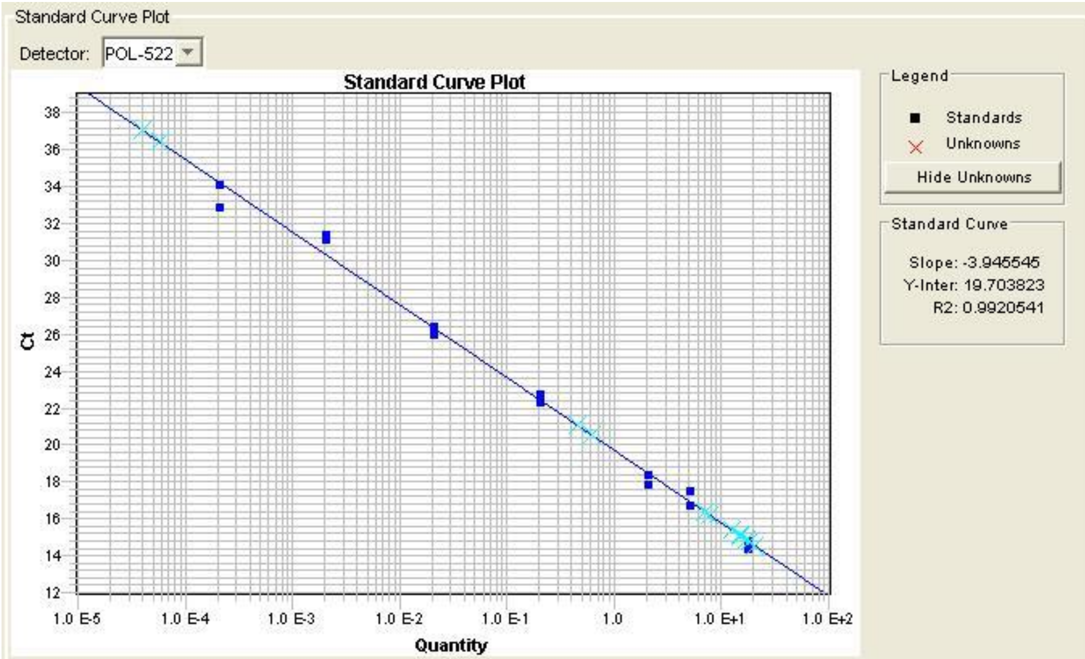


Figure 1. qPCR standard curves for walleye pollock. Replicate standard concentrations (blue boxes) range from 0.00025 – 10.0 ng ul^{-1}.

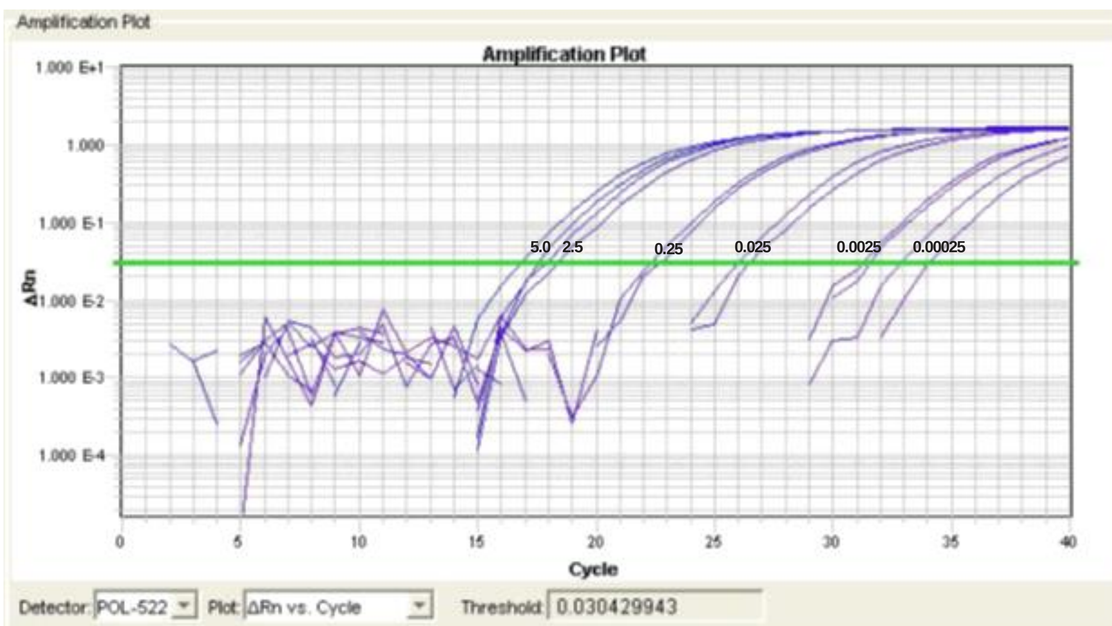


Figure 2. qPCR amplification curves for pollock genomic DNA standards ranging from 0.00025 – 5.0 ng ul^{-1}.

No significant amplification of the pollock probe was observed in the other endemic gadid species (Pacific cod, Pacific tomcod, Arctic cod and Saffron cod), the related Pacific hake, *Merluccius productus*, or replicate negative template control (NTC) samples. Estimates of pollock eDNA concentrations in the samples ranged from undetectable to 0.0003 ng μl^{-1}, considerably lower than expected given the numbers of pollock captured in tows taken in relatively close proximity in time and space (Table 3). Echogram screen shots (not shown) at the locations where water was sampled show considerable fish sign, which we assume are mostly pollock.

CTD #	Depth (m)	eDNA (ng µl^{-1})	# pollock in tow
36	51		1493
	81	0.0002	
74	91	0.0001	538
	152	0.0003	
129	221	na	16
	232	0.0001	

Table 3. Sampling depths, estimated pollock eDNA concentrations and number of pollock recorded in associated trawl near that location.

Capelin

Tests of the qPCR primers/probe combination developed for a 74 bp fragment of the *COI* gene in capelin showed similar amplification efficiency and sensitivity, but showed weak amplification with some eulachon and longfin smelt samples. Unfortunately, no capelin were recorded in the three trawls associated with the eDNA samples and only 23 individuals were captured during the entire survey. We do not expect to find capelin eDNA in the samples but have not tested the probe yet as we are optimizing the assay for high sensitivity.

Pacific Ocean perch (POP)

Primers and probe were designed to amplify a 175 bp fragment of the mitochondrial *ND4* gene in POP (Table 2). A diagnostic SNP to distinguish POP from other rockfishes was previously identified in NPRB Project #1219 (Lyon et al. 2016). Preliminary results indicate high probe efficiency and amplification in the range of 0.005 – 5.0 ng ul^{-1} genomic DNA concentration. Most importantly, seven other rockfish species in the ascertainment panel (Rougheye, Northern, Dusky, Redbanded, Harlequin, Black-spotted, Shortraker), chosen from recorded rockfish species in eastern Bering Sea shelf and slope surveys, failed to amplify with the primers/probe combination. Three of 14 POP genomic DNA samples also failed to amplify, although two of those failing have also not amplified with other mtDNA primers. We suspect that DNA degradation or potential misidentification of voucher specimens may be an issue. Only one of the three CTD stations sampled (#129) reported POP in the trawl catch. The CTD cast was taken 1.36 km from and 2.65 h after the trawl (Table 1), which recorded a catch of 122 individuals.

CTD #	depth (m)	replicate	eDNA (ng µl-1)	mean	std. dev.
129	221	1	0.0002	0.0006	0.0004
		2	0.0012		
		3	0.0003		
129	232*	1	0.0001	0.0002	0.0002
		2	0.0001		
		3	0.0005		

Table 4. eDNA sampling depths, estimated POP eDNA concentrations, and mean and standard deviations for replicate samples. * denotes sample compromised during extraction protocol.

Next generation sequencing (NGS)

NGS has not yet been conducted on eDNA samples. We are attempting to concentrate yields prior to library construction, which is expected to occur in February – March, 2017.
For further information contact Mike Canino at mike.canino@noaa.gov

Preliminary results of 2016 spring Bering Sea ichthyoplankton survey--RPP

The primary objective of the 2016 Eco-FOCI/EMA spring ichthyoplankton survey was to assess the abundance and spatial distribution pattern of Walleye Pollock *Gadus chalcogrammus* larvae over the southeastern Bering Sea shelf. An expanded sampling grid designed to determine the extent of the distribution of Walleye Pollock larvae and take into account differences in larval distribution between warm and cold years in the southeastern Bering Sea was used for the first time (Fig. 1). It consisted of a core grid of 145 stations that are always occupied, and 282 adaptive sampling stations located around the core grid that are occupied depending on at-sea counts of larval pollock. (Fig. 1). If at-sea counts are above a threshold, sampling continues to the next adaptive station along a transect line. If at-sea counts are equal to or below a threshold, indicating the edge of the distribution has been reached, then sampling moves to the next transect line.

The survey was conducted from May 18 to June 8, and 212 stations were completed, including all core stations and 67 adaptive sampling stations. Zooplankton and ichthyoplankton were sampled using a paired 20 and 60-cm bongo array with 153µm and 505µm mesh nets respectively. Tows were conducted to 10 meters off bottom or 300 meters maximum depth. A Sea-Bird FastCat CTD was mounted above the bongo array to acquire gear depth, temperature, and salinity profiles. A preliminary assessment of the pattern of larval abundance was determined at sea by counting the number of pollock larvae collected at each station by a bongo tow. These at-sea counts also determined which adaptative stations were sampled.

Larvae were abundant on the eastern side of the sampling grid consistent with previous observations of warm years in the Bering Sea (Fig. 2). All of the near-shore adaptive sampling stations were occupied. That area had not been previously surveyed for Walleye Pollock larvae and it showed that larvae were located further inshore than previously thought. In the north, abundance was greatest between approximately 50 and 100 m depth, and between 30 and 70 m in the south (Fig. 2). Zooplankton collected in bongo tows at selected stations were examined to determine the spatial distribution of the proportions of small (< 2 mm) and large (> 2 mm) copepod taxa, euphausiids, chaetognaths, and other zooplankton (Fig. 3). In the most general terms, large copepod taxa were dominant on the outer shelf, small copepod taxa dominated the middle and inner shelves, and the inner shelf had the greatest diversity of species (Fig. 3).

Conclusion: The new survey grid was successful in locating both the eastern and western extent of the larval distribution (Fig. 2). Large copepod species are lipid rich and therefore may be a more nutritious source of prey for fish than smaller species. Pollock larvae do not feed directly on the adult stage copepods described in this report, however characterization of the adult taxa provides an indication of the production and availability of earlier stages (microzooplankton) that are potentially available as prey to larvae. Comparing the distributions of larvae and zooplankton (Figs. 2 and 3) showed that larvae were most likely feeding on the early stages of the less nutritious small copepod species and this may have consequences for survival of later stages of pollock.

For further information contact: Steven Porter, Lauren A. Rogers, Kathryn Mier

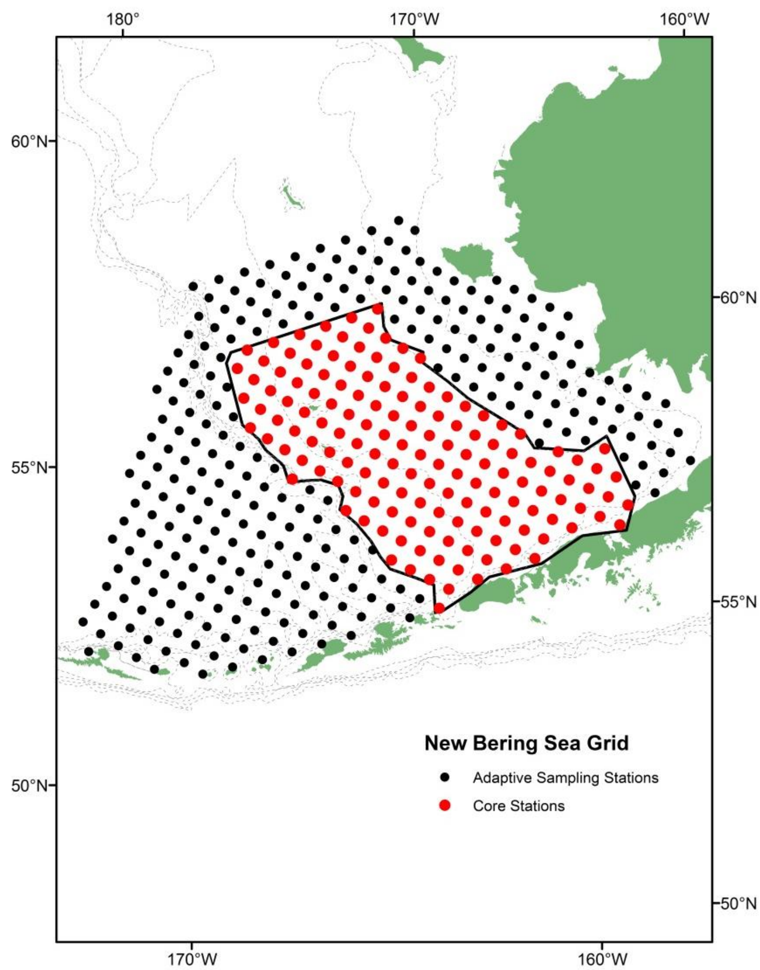


Figure 1. The new Bering Sea spring ichthyoplankton survey grid. A core grid of 145 stations is always occupied. Adaptive sampling stations are used to determine the extent of the larval distribution, and their occupation is dependent upon at sea counts of Walleye Pollock larvae.

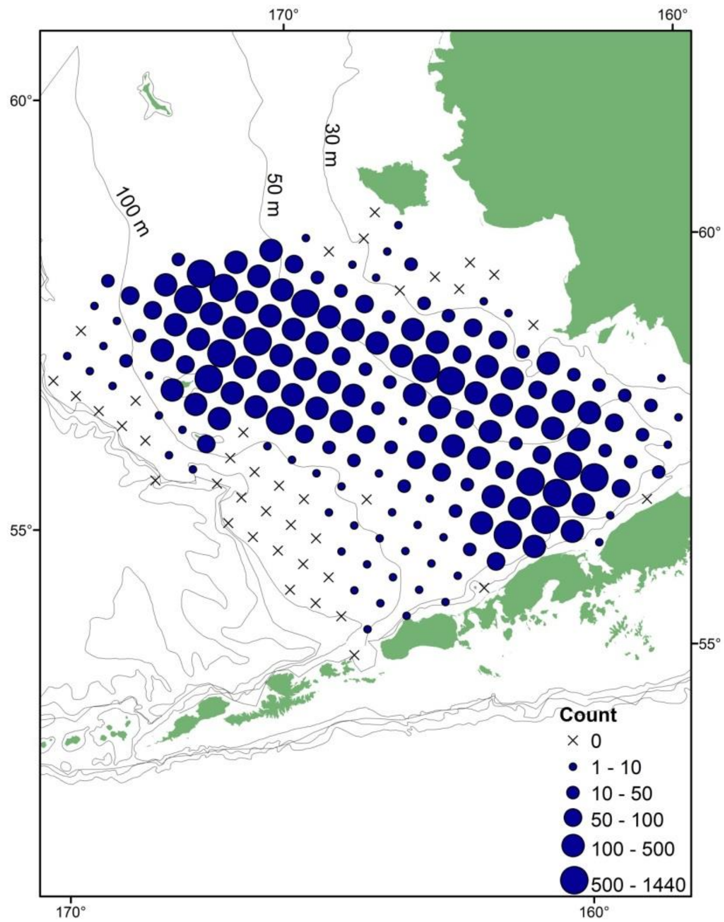


Figure 2. Abundance of Walleye Pollock larvae based on number of larvae counted at sea from bongo tows. Data are preliminary and will be verified at the AFSC.

Return of warm conditions in the southeastern Bering Sea: phytoplankton – fish--RPP

In 2014, the Bering Sea shifted back to warmer ocean temperatures (+2 ^{o}C above average), bringing concern for the potential for a new warm stanza and broad biological and ecological cascading effects. In 2015 and 2016 dedicated surveys were executed to study the progression of ocean heating and ecosystem response. We describe ecosystem response to multiple, consecutive years of ocean warming and offer perspective on the broader impacts. Ecosystem changes observed include reduced spring phytoplankton biomass over the southeast Bering Sea shelf relative to the north, lower abundances of large-bodied crustacean zooplankton taxa, and degraded feeding and body condition of age-0 walleye pollock. This suggests poor ecosystem conditions for young pollock production and the risk of significant decline in the number of pollock available to the pollock fishery in 2-3 years. However, we also noted that high quality prey, large copepods and euphausiids, and lower temperatures in north may have provided a refuge from poor conditions over the southern shelf, potentially buffering the impact of a sequential year warm stanza on the Bering Sea pollock population.

We offer the hypothesis that juvenile (age-0, age-1) pollock may buffer deleterious warm stanza effects by either utilizing high productivity waters associated with the strong, northerly Cold Pool, as a refuge from the warm, low production areas of the southern shelf or by exploiting alternative prey over the southern shelf when access to Cold Pool waters is limited. We show that in 2015, the ocean waters influenced by spring sea ice (the Cold Pool) supported robust phytoplankton biomass (spring) comprised of centric diatom chains, a crustacean copepod community comprised of large-bodied taxa (spring, summer), and a large aggregation of midwater fishes, potentially young pollock. In this manner, the Cold Pool may have acted as a trophic refuge in that year. In 2016 however, a retracted Cold Pool precluded significant refuging in the north, though pollock foraging on available euphausiids over the southern shelf may have mitigated the effect of warm waters and reduced large zooplankton prey availability. This work presents the hypothesis that, in the short term, juvenile pollock can mitigate the drastic impacts of sustained warming. This short-term buffering, combined with recent observations (2017) of renewed sea ice presence over southeast Bering Sea shelf and a potential return to average or at least cooler ecosystem conditions, suggests that recent warm year stanza (2014-2016) effects to the pollock population and fishery may be mitigated.

For further information contact Janet T. Duffy-Anderson, Phyllis J. Stabeno, Elizabeth C. Siddon, Alex Andrews, Daniel W. Cooper, Lisa B. Eisner, Edward V. Farley, Colleen E. Harpold, Ron A. Heintz, David G. Kimmel, Fletcher Sewall, Adam Spear, Ellen Yasumishii

Figure 1. Acoustic backscatter (Nautical Area Scattering Coefficient, m^2/nmi^2) estimates in 2015 indicate higher backscatter (age-0, age-1 and mixed schools including jellyfish) in the Cold Pool relative to the shelf.

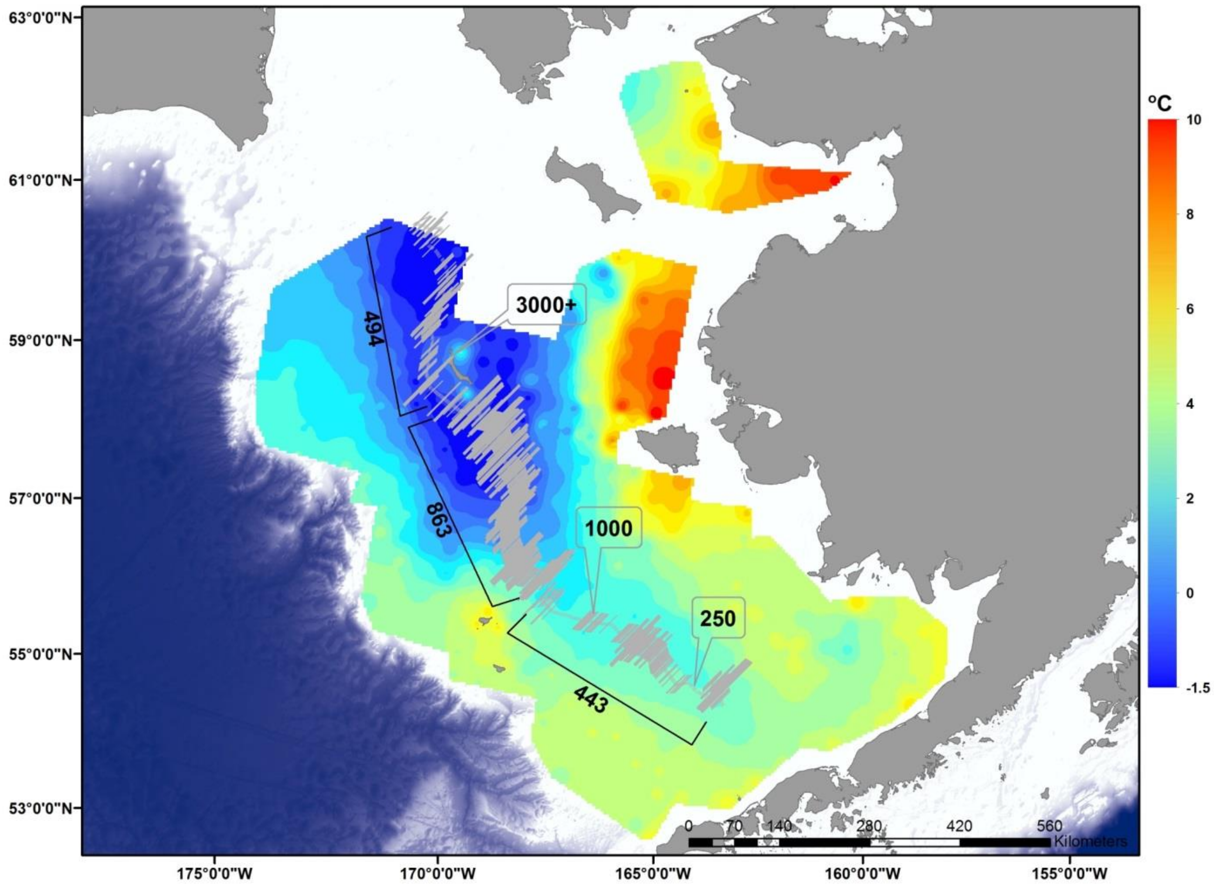
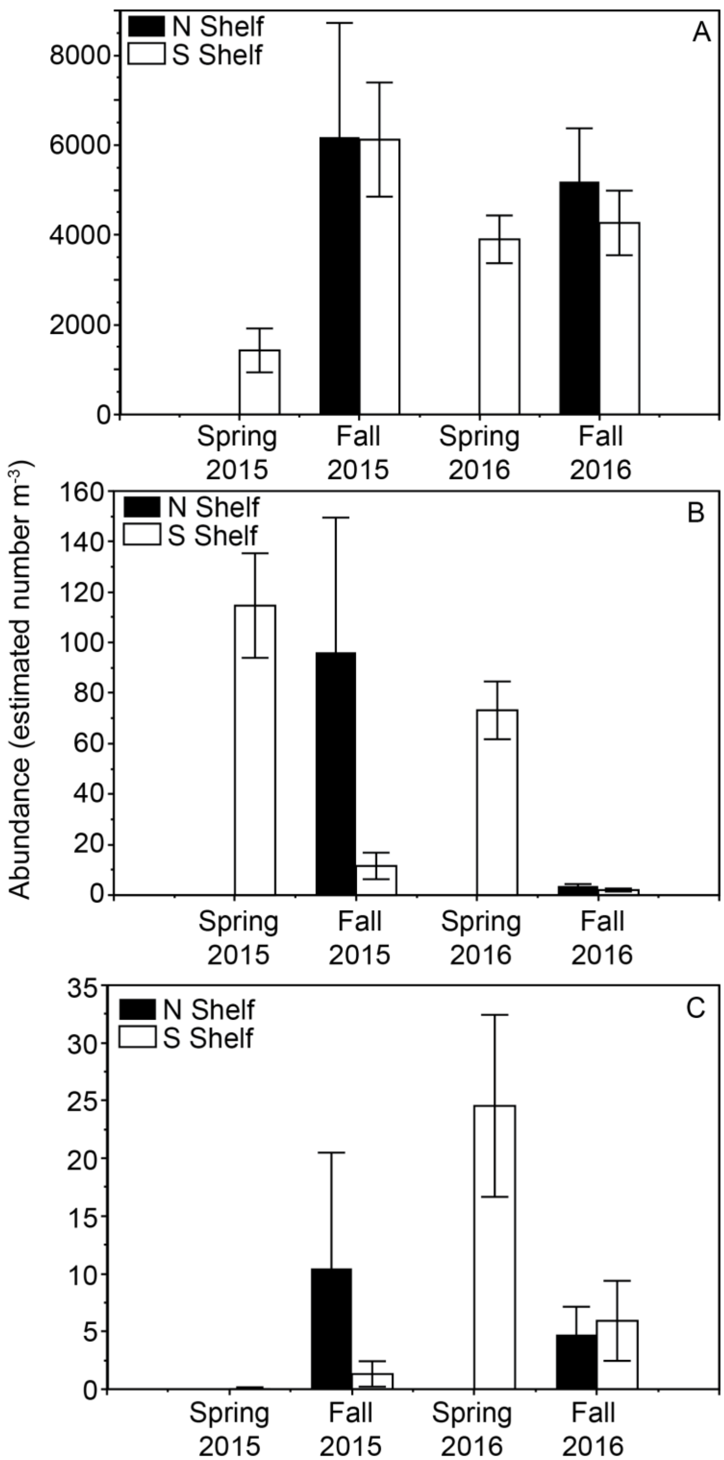


Figure 2. Mean abundance (estimated number m^{-3}) of small copepods < 2 mm (A), large copepods > 2 mm (B), and euphausiids < 5 mm (C) in the northern Bering Sea and southern Bering Sea shelf during spring and fall of 2015-2016. Error bars represent ± standard error of the mean.

.



N Shelf
S Shelf
A
8000
6000
4000
2000
0
Spring 2015
Fall 2015
Spring 2016
Fall 2016
Abundance (estimated number m-3)
N Shelf
S Shelf
B
160
140
120
100
80
60
40
20
0
Spring 2015
Fall 2015
Spring 2016
Fall 2016
N Shelf
S Shelf
C
35
30
25
20
15
10
5
0
Spring 2015
Fall 2015
Spring 2016
Fall 2016

GULF OF ALASKA

Larval Groundfish Survey in the Western Gulf of Alaska--RPP

The objectives of this project are to conduct an ichthyoplankton survey and process studies in the region between Unimak Pass and Shelikof Strait so that we may estimate the abundance, transport, and other factors influencing the survival of young walleye pollock larvae and other species such as sablefish. Sampling with the Sameoto neuston will be used to specifically target sablefish in the surface layer. We will also occupy Line 8 to continue our 29-year time series of environmental and biological conditions in Shelikof Strait. Sampling will begin near Unimak Pass and continue up through Shelikof Strait along the Kenai Peninsula, and then along the east side of Kodiak Island as time permits. In addition to this sampling, stations have been selected from the main grid for monitoring nutrients, salts, and oxygen for PMEL scientists. Satellite tracked drifters provided by PMEL may be released in areas of high larval walleye pollock abundance. Line 8 sampling will include 20-cm and 60-cm bongos and conductivity, temperature, and depth (CTD) profiles with Niskin bottle samples for chlorophyll, microzooplankton, and nutrients. Additional CTD profiles without firing the Niskin bottles may be requested throughout the survey for calibration purposes.

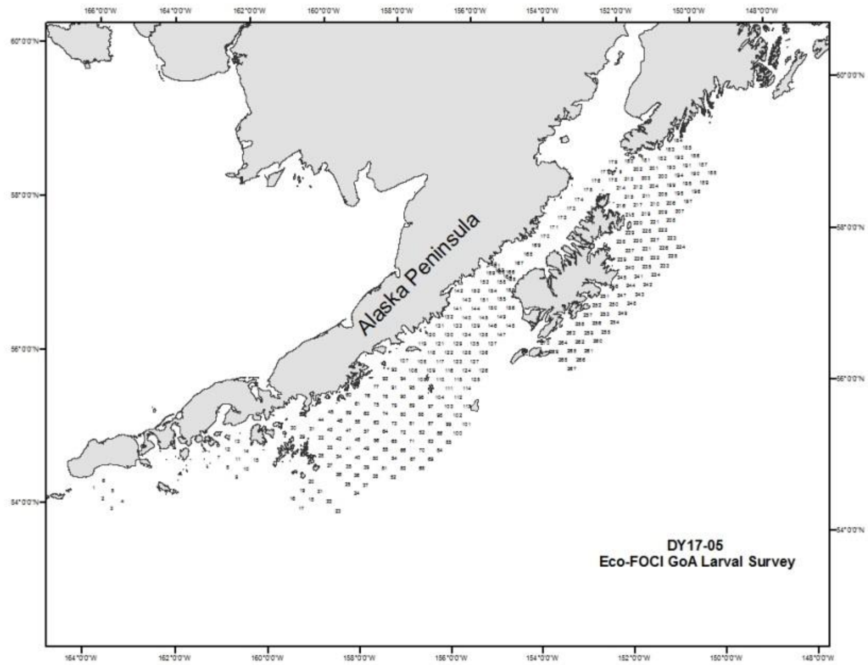
The survey will be conducted along the grid from the Gulf side of Unimak Pass to the Shumagin Islands, through Shelikof Strait, to the Kenai Peninsula and along NE Kodiak. A total of 270 stations have been planned, but all stations may not be occupied. The standard gear for this survey will be a 60-cm bongo array with 0.505-mm mesh netting. The 20-cm bongo net (0.333-mm mesh netting) will be added to the wire for sampling on alternate cross-shelf survey lines. A rapid zooplankton assessment (RZA) will be conducted to determine abundance of prey species available to larval fish at stations when the 20/60 bongo array is fished. A FastCat will be mounted above the bongo array to provide depth, temperature, and salinity data. Tows will be to 100 meters or 10 meters off the bottom, whichever is shallower.

Live tows may be conducted with the CalVET to examine larval walleye pollock condition if larvae ≤ 8 mm are found. If larvae are collected for the pollock condition study, a CalVET tow (with 53 µm mesh) to 70 meters will be conducted to collect small zooplankton. The CalVET is a vertical tow and will be deployed and retrieved at a rate of 45 - 60 m/min. The FastCat will be mounted above the CalVET.

A total of 40 Neuston tows will be conducted along the shelf break and other known areas of larval sablefish abundance to acquire specimens for special studies. The net mesh will be 505 µm and fished at a ship speed of 1.5 to 2.0 knots for 10 minutes. The ship will be standby for a rough count of sablefish larvae to determine if another Neuston tow will be conducted at that station to obtain samples for special studies (age and growth, condition, diet). The first Neuston sample conducted at each station will be a quantitative sample and preserved in 1.5% formaldehyde. The second Neuston sample will be sorted for larvae and preserved in 100% ethanol or frozen. Current laboratory rearing experiments conducted at AFSC to validate daily growth will be compared to WGoA field collected sablefish.

For further information contact Annette Dougherty and Alison Deary

Figure 1. Survey area in the western Gulf of Alaska



Gulf of Alaska Ichthyoplankton Abundance Indices 1981-2015--RPP

The Alaska Fisheries Science Center's (AFSC) Ecosystems and Fisheries Oceanography Coordinated Investigations Program (EcoFOCI) has been sampling ichthyoplankton in the Gulf of Alaska (GOA) from 1972 to the present, with annual sampling from 1981–2011 and biennial sampling thereafter. The primary sampling gear used for these collections is a 60-cm bongo sampler fitted with 333 or 505-µm mesh nets. Oblique tows are carried out mostly from 100 m depth to the surface or from 10 m off bottom in shallower water. Historical distribution of sampling effort extends from the coastal area to the east of Prince William Sound southwestwards along the Alaska Peninsula to Umnak Island, covering coastal, shelf and adjacent deep water, but has been most intense in the vicinity of Shelikof Strait and Sea Valley during mid-May through early June (Fig. 1). From this area and time, a subset of data has been developed into time-series of ichthyoplankton species abundance for 12 larval taxa in the GOA, including species of groundfish (Fig. 2).

In relation to the previous three decades of observations, 2015 was an anomalous year for most species. For walleye pollock, larval abundance was the lowest ever observed, following a very high positive anomaly in 2013. Pacific cod, flathead sole, northern rock sole, and Pacific sand lance also had record low abundances in 2015, and starry flounder and Pacific halibut showed strong negative anomalies. Only two taxa showed positive anomalies in 2015: northern lampfish and rockfish. Rockfish, which aren't identified to species, continued their steep upward trend, which started in 2007 and accelerated in 2011 and 2013.

The warm anomaly in the Gulf of Alaska in 2014 and 2015 appears to have had wide-ranging consequences for the marine ecosystem. Our data suggest that the anomalous warm conditions corresponded to extreme low abundances of larvae for many species, although the mechanism underlying such a response is still being investigated. Possibilities include a mismatch of prey availability with the period of larval first-feeding, low quality prey resources, advection of larvae out of preferred shelf habitats, or thermal stress. Investigation into these mechanisms is continuing. Icthyoplankton surveys can provide early-warning indicators for ecosystem conditions and recruitment patterns in marine fishes. While mortality during later life stages is clearly important, poor conditions during the first few weeks and months of life can already determine the potential for a large year class, emphasizing the importance of studying processes affecting mortality and abundance of early life history stages.

For further information contact Lauren A. Rogers and Kathryn Mier

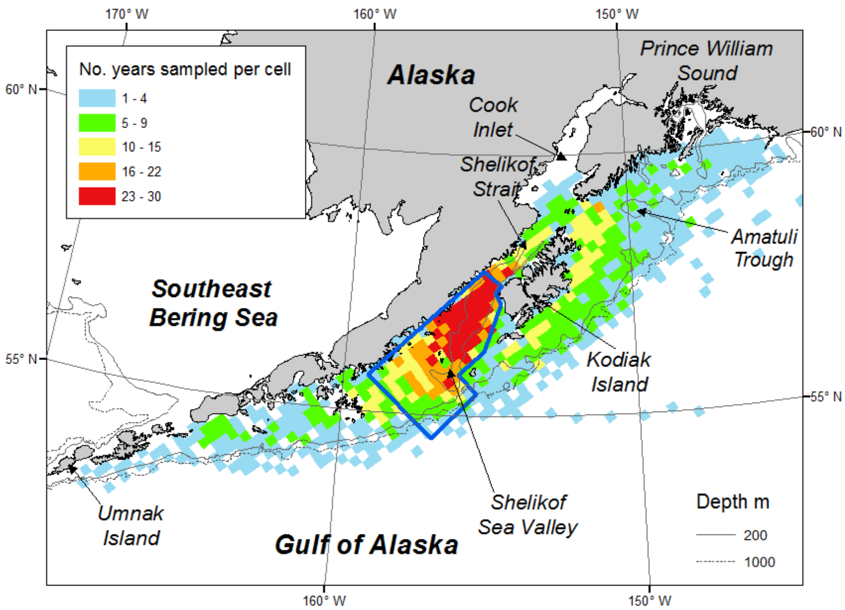


Figure 1. Distribution of historical ichthyoplankton sampling in the Gulf of Alaska. Sampling effort is illustrated by the number of years where sampling occurred in each 20 km^2 grid cell over these years. A late spring time-series ichthyoplankton abundance has been developed from collections in the area outlined in blue.

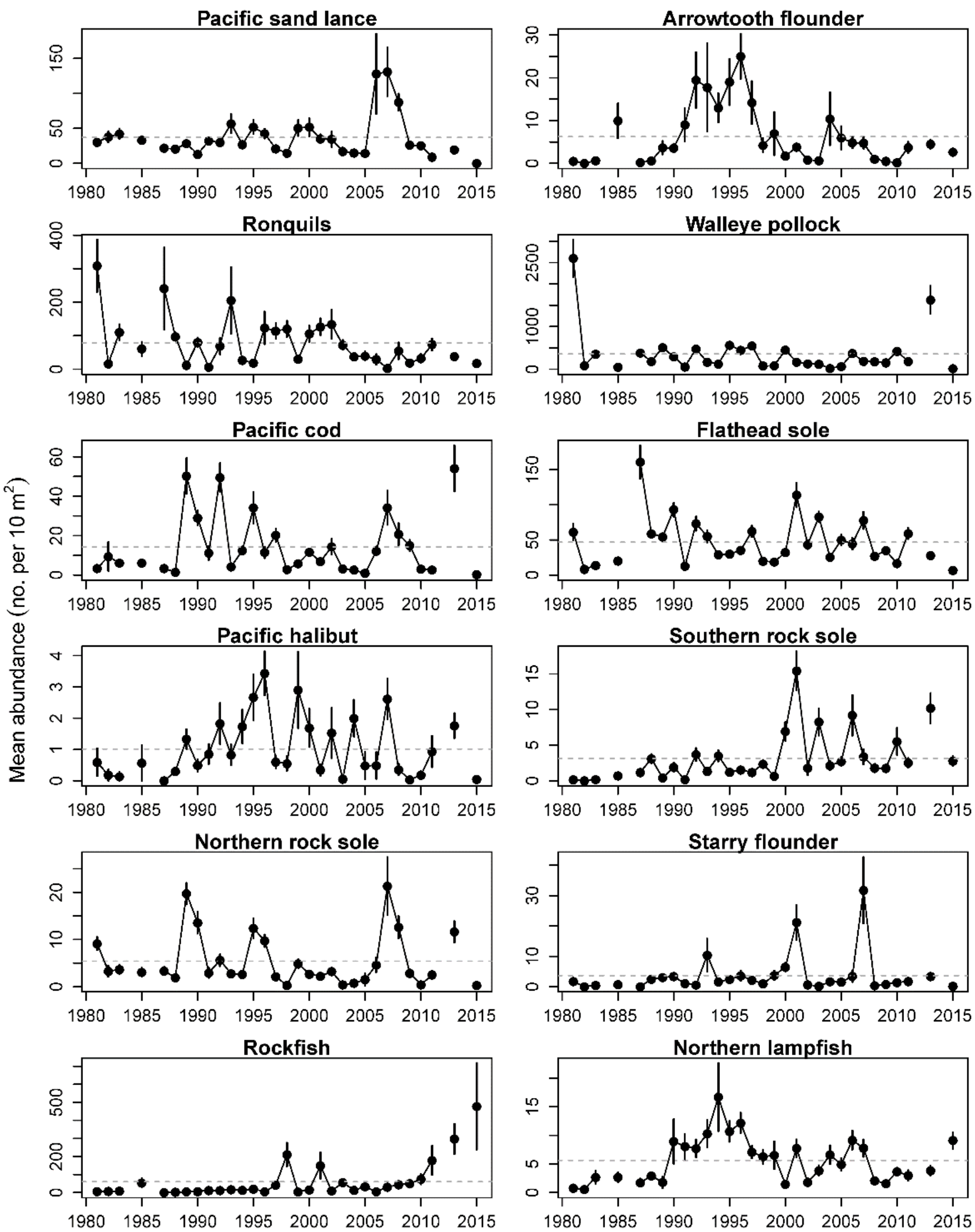


Figure 2. Interannual variation in late spring larval fish abundance in the Gulf of Alaska. The larval abundance index is expressed as the mean abundance (no. 10 m^{-2}), and the long-term mean is indicated by the dashed line. Error bars show +/- 1 SE. No data are available for 1984, 1986, 2012 or 2014.

Gulf of Alaska Project: Benthic Habitat Research - ABL

The primary goal of the Gulf of Alaska (GOA) benthic habitat research project is to characterize the preferred settlement habitat for the five focal groundfish species specified by the GOA Project Upper Trophic Level component. There are five main objectives for the habitat project: 1) conduct a literature review and synthesis of early life (EL) preferred habitat and observational data of five focal species, 2) collect, validate, digitize, and grid available benthic habitat data, 3) create benthic metrics from habitat data, 4) model species-specific habitat by early life stage, and 5) generate species-specific suitability maps of the literature and modeling results. All objectives for this project have been completed and the final report has been submitted to the North Pacific Research Board (NPRB). Additionally, a draft manuscript by Pirtle et al. (In Reivew) was submitted for review in a special issue of Deep-Sea Research II describing the work on the early juvenile stage habitat suitability models for the five species.

The Final Report to the NPRB (100+pgs) included the following information for the five focal species: 1) extensive literature review of habitat preferences with life stage tables, 2) methods and maps of the high resolution suite of benthic habitat variables, 3) methods and database of the field observations for the early juvenile stages, 4) methods and maps for the literature based habitat suitability, 5) methods, model selection, model results, and final maps for the model-based habitat suitability 6) regional based habitat suitability estimates, and 7) extensive discussion of project. The follow up Essential Fish Habitat (EFH) project (Pirtle, Shotwell, Rooper) was also completed this year. The baseline habitat suitability framework from the GOA Project was extended to include new biophysical habitat metrics (e.g. production, temperature, corals) and applied to a variety of groundfish species from the early juvenile life stage through adults (including the five focal species). The results from this project were included in the 2016 EFH update which was submitted to stock assessment scientists for review. These EFH results are also planned for inclusion in the new species-specific ecosystem considerations sections of the stock assessment fishery evaluation (SAFE) process and may assist fishery managers in future decisions regarding survey planning and habitat assessment. During the next phase of the GOA Project Synthesis, the baseline habitat suitability models will be combined with individual based models (IBMs) in a novel approach to delineating survival trajectories for understanding recruitment of groundfish. The case study for this approach will be Alaska sablefish. We will also be developing a habitat metrics geodatabase for future research.

For more information, please contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

Habitat use and productivity of commercially important rockfish species in the Gulf of Alaska - RACE GAP

The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. This project examined the productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish, *S. variabilis*) in three different habitat types during three seasons. Low relief, high relief rocky/boulder, and high relief sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska will be sampled using both drop camera image analysis and modified bottom trawls. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types. All field work for this project has been completed and sample processing and data analysis will be completed within the next year.

2016 Resource Ecology and Ecosystem Modeling Program (REFM/REEM)

Multispecies, foodweb, and ecosystem modeling and research are ongoing. Documents, symposia and workshop presentations, and a detailed program overview are available on the Alaska Fisheries Science Center (AFSC) web site at: http://www.afsc.noaa.gov/REFM/REEM/Default.php.

Groundfish Stomach Sample Collection and Analysis

The Resource Ecology and Ecosystem Modeling (REEM) Program continued regular collection of food habits information on key fish predators in Alaska's marine environment. During 2016, AFSC personnel analyzed the stomach contents of 33 species sampled from the eastern Bering Sea and Aleutian Islands regions. The contents of 20,975 stomach samples were analyzed including 2,183 stomach samples analyzed at sea during the Aleutian Islands groundfish survey and 2,388 stomach samples analyzed at sea during the eastern Bering Sea Continental Slope groundfish survey. This resulted in the addition of 53,037 records to AFSC's Groundfish Trophic Interactions Database. In addition, bill-load samples from 330 seabirds were analyzed for the Alaska Department of Fish and Game.

Collection of additional stomach samples was accomplished through resource surveys, research surveys, and special studies comparing stomach contents with prey-sampling. About 9,920 stomach samples were collected from large and abundant predators during bottom trawl and midwater trawl surveys of the eastern Bering Sea continental shelf. About 1,225 stomach samples were collected from groundfish during the bottom trawl survey of the eastern Bering Sea continental slope to supplement the 2,388 stomach samples analyzed at sea. About 1,795 stomach samples were collected from the Aleutian Islands to supplement the 2,183 stomach contents that were analyzed at sea in that region. Fishery Observers resumed collection of stomach samples from Alaskan fishing grounds in 2016, resulting in 330 additional samples.

Predator-Prey Interactions and Fish Ecology:
Accessibility and visualization of the predator-prey data through the web can be found at http://www.afsc.noaa.gov/REFM/REEM/data/default.htm. The predator fish species for which we have available stomach contents data can be found at http://access.afsc.noaa.gov/REEM/WebDietData/Table1.php. Diet composition tables have been compiled for many predators and can be accessed, along with sampling location maps at http://access.afsc.noaa.gov/REEM/WebDietData/DietTableIntro.php. The geographic distribution and relative consumption of major prey types for Pacific cod, walleye pollock, and arrowtooth flounder sampled during summer resource surveys can be found at http://www.afsc.noaa.gov/REFM/REEM/DietData/DietMap.html. REEM also compiles life

history information for many species of fish in Alaskan waters, and this information can be located at http://access.afsc.noaa.gov/reem/lhweb/index.php.

Ecosystem Considerations 2016: the Status of Alaska's Marine Ecosystems completed and posted online-- REFM/ESSR

The status of Alaska's marine ecosystems is presented annually to the North Pacific Fishery Management Council as part of the Stock Assessment and Fishery Evaluation (SAFE) report. New this year, the information was prepared in a separate report for each of three ecosystems: the eastern Bering Sea, Aleutian Islands, and the Gulf of Alaska. The goal of these Ecosystem Considerations reports 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. This information provides ecosystem context to the fisheries managers' deliberations. The reports are now available online at the Ecosystem Considerations website at: http://access.afsc.noaa.gov/reem/ecoweb/index.php.

Developing Better Understanding of Fisheries Markets-REFM/ESSR

Ron Felthoven and Ben Fissel *For more information, contact ben.fissel@noaa.gov*

Despite collecting a relatively broad set of information regarding the catch, products produced, and the prices received at both the ex-vessel and first-wholesale levels, our understanding of fishery and product markets and the factors driving those markets in the North Pacific is relatively incomplete. The primary goal of this project is to improve our understanding and characterization of the status and trends of seafood markets for a broad range of products and species. AFSC economists have met with a number of seafood industry members along the supply chain, from fish harvesters to those who process the final products available at local retailer stores and restaurants. This project will be a culmination of the information obtained regarding seafood markets and sources of information industry relies upon for some of their business decisions. The report includes figures, tables, and text illustrating the current and historical status of seafood markets relevant to the North Pacific. The scope of the analysis includes global, international, regional, and domestic wholesale markets to the extent they are relevant for a given product. To the extent practicable for a given product, the analysis addresses product value (revenues), quantities, prices, market share, supply chain, import/export markets, major participants in the markets, product demand, end-use, current/recent issues (e.g., certification), current/recent news, and future prospects. An extract of the market profiles was included in *Status Report for the Groundfish Fisheries Off Alaska, 2014*. A standalone dossier titled *Alaska Fisheries Wholesale Market Profiles* contains the complete detailed set of market profiles Wholesale_Market_Profiles_for_Alaskan_Groundfish_and_Crab_Fisheries.pdf). We are currently seeking funding to update the market profiles in 2017.

Alaska Groundfish Wholesale Price Projections REFM/ESSR

Benjamin Fissel* *For further information, contact* Ben.Fissel@NOAA.gov

For a significant portion of the year there is a temporal lag in officially reported first-wholesale prices. This is lag occurs because the prices are derived from the Commercial Operators Annual Report which is not available until after data processing and validation of the data, in August of each year. The result is a data lag that grows to roughly a year and a half (e.g. prior to August

2015 the most recent available official prices were from 2014). To provide information on the current state of fisheries markets, nowcasting is used to estimate 2014 first-wholesale prices from corresponding export prices which are available in near real time. Nowcasting provided fairly accurate predictions and displayed rather modest prediction error with most of the confidence bounds within 5-10% of the price. In addition, time series models are used to project first-wholesale prices for 2016 - 2019. Resampling methods are used estimate a prediction density of potential future prices. Confidence bounds are calculated from the prediction density to give the probability that the prices will fall within a certain range. Prediction densities also provide information on the expected volatility of prices. As prices are projected past the current year the confidence bounds grow reflecting increasing uncertainty further out in the future. The results of this project will be presented in the *Status Report for the Groundfish Fisheries Off Alaska, 2014*. A technical report, Fissel (2015), details the methods used for creating the price projections.

References
Fissel, B. 2015. "Methods for the Alaska groundfish first-wholesale price projections: Section 6 of the Economic Status of the Groundfish Fisheries off Alaska." *NOAA Technical Memorandum* NMFS-AFSC-305, 39 p. U.S. Department of Commerce

Economic Indices for the North Pacific Groundfish Fisheries: Calculation and Visualization--REFM/ESSR

Benjamin Fissel* **For further information, contact* Ben.Fissel@NOAA.gov

Fisheries markets are complex; goods have many attributes such as the species, product form, and the gear with which it was caught. The price that fisheries goods command and the products they compete against are both functions of these various attributes. For example, whitefish products of one species may compete with whitefish products of another species. Additionally, markets influence a processing company's decision to convert their available catch into different product types. During any given year it is determining whether to produce fillets or surimi, or perhaps to adjusting gear types to suit markets and consumer preferences. This myriad of market influences can make it difficult to disentangle the relative influence of different factors in monitoring aggregate performance in Alaska fisheries. This research employs a method that takes an aggregate index (e.g. wholesale-value index) and decomposes it into subindices (e.g. a pollock wholesale-value index and a Pacific cod wholesale-value index). These indices provide management with a broad perspective on aggregate performance while simultaneously characterizing and simplifying significant amounts of information across multiple market dimensions. A series of graphs were designed and organized to display the indices and supporting statistics. Market analysis based on these indices has been published as a section in the Economic Status of the Groundfish Fisheries Off Alaska since 2010. A technical report, Fissel (2014), details the methods used for creating the indices.

References
Fissel, B. 2014. "Economic Indices for the North Pacific Groundfish Fisheries: Calculation and Visualization." *NOAA Technical Memorandum* NMFS-AFSC-279, 59 p. U.S. Department of Commerce.

Economic Data Reporting in Groundfish Catch Share Programs-REFM/ESSR

Brian Garber-Yonts and Alan Haynie

**For further information, contact Brian.Garber-Yonts@NOAA.gov*

The 2006 reauthorization of the Magnuson-Stevens Fishery Management and Conservation Act (MSA) includes heightened requirements for the analysis of socioeconomic impacts and the collection of economic and social data. These changes eliminate the previous restrictions on collecting economic data, clarify and expand the economic and social information that is required, and make explicit that NOAA Fisheries has both the authority and responsibility to collect the economic and social information necessary to meet requirements of the MSA. Beginning in 2005 with the BSAI Crab Rationalization (CR) Program, NMFS has implemented detailed annual mandatory economic data reporting requirements for selected catch share fisheries in Alaska, under the guidance of the NPFMC, and overseen by AFSC economists. In 2008, the Amendment 80 (A80) Non-AFA Catcher-Processor Economic Data Report (EDR) program was implemented concurrent with the A80 program, and in 2012 the Amendment 91 (A91) EDR collection went into effect for vessels and quota share holding entities in the American Fisheries Act (AFA) pollock fishery. In advance of rationalization or new bycatch management measures in the Gulf of Alaska (GOA) trawl groundfish fishery currently in development by the NPFMC, EDR data collection will begin in 2016 to gather baseline data on costs, earnings, and employment for vessels and processors participating in GOA groundfish fisheries.

Amendment 91 EDR

The A91 EDR program was developed by the NPFMC with the specific objective of assessing the effectiveness of Chinook salmon prohibited species catch (PSC) avoidance incentive measures implemented under A91, including sector-level Incentive Plan Agreements (IPAs), prohibited species catch (PSC) hard caps, and the performance standard. The data are intended to support this assessment over seasonal variation in salmon PSC incidence and with respect to how timing, location, and other aspects of pollock fishing and salmon PSC occur. The EDR is a mandatory reporting requirement for all entities participating in the AFA pollock trawl fishery, including vessel masters and businesses that operate one or more AFA- permitted vessels active in fishing or processing BSAI pollock, CDQ groups receiving allocations of BSAI pollock, and representatives of sector entities receiving allocations of Chinook salmon PSC from NMFS. The EDR is comprised of three separate survey forms: the Chinook salmon PSC Allocation Compensated Transfer Report (CTR), the Vessel Fuel Survey, and the Vessel Master Survey. In addition to the EDR program, the data collection measures developed by the Council also specified modification of the Daily Fishing Logbook (DFL) for BSAI pollock trawl CVs and CPs to add a "checkbox" to the tow- level logbook record to indicate relocation of vessels to alternate fishing grounds for the purpose of Chinook PSC avoidance.

AFSC economists presented a report to the NPFMC in February 2014 on the first year of A91 EDR data collection (conducted in 2013 for 2012 calendar year operations) and preliminary analysis of the data. The goal of the report was to identify potential problems in the design or implementation of the data collections and opportunities for improvements that could make more efficient use of reporting burden and may ultimately produce data that would be more effective for informing Council decision making.

Notable findings in the report were that the Vessel Fuel Survey and Vessel Master Survey have been successfully implemented to collect data from all active AFA vessels and have yielded substantial new information that will be useful for analysis of Amendment 91. Quantitative fuel use and cost data have been used in statistical analyses of fishing behavior, and qualitative information reported by vessel masters regarding observed fishing and PSC conditions during A and B pollock seasons and perceptions regarding management measures and bycatch avoidance incentives has been useful to analysts for interpretation of related fishery data.

No compensated transfers (i.e., arms-length market transactions) of Chinook PSC have been reported to date (for 2012-2015), however, and it remains uncertain whether an in-season market for Chinook PSC as envisioned by the CTR survey will arise in the instance of high-Chinook PSC incidence or if the CTR survey as designed will be effective in capturing the nature of trades. A more detailed discussion of the A91 Chinook EDR is presented elsewhere in this document.

GOA Trawl and Amendment 80 EDR

During 2014, AFSC economists collaborated with NPFMC and Alaska Region staff and industry members to develop draft data collection instruments and a preliminary rule following NPFMC recommendations for implementing EDR data collection in the GOA trawl groundfish fishery. New EDR forms for GOA groundfish trawl catcher vessels and processors were developed, evaluated, and revised in workshop meetings and individual interviews with members of industry, and modifications to the existing A80 Trawl CP EDR form have been made to accommodate Council recommendations to extend the A80 data collection to incorporate A80 CPs GOA activity and capture data from non-A80 CPs in the GOA. The draft data collection forms and proposed rule were reviewed and approved by the Council at their April, 2014 meeting, and the proposed rule was published August 11, 2014 (79 FR 46758; see http://alaskafisheries.noaa.gov/sustainablefisheries/trawl/edr.htm for more information). The final rule was published in December 2014, authorizing mandatory data collection to begin with reporting of 2015 calendar year data (submitted in 2016). AFSC has been working with industry to test and refine the draft EDR forms to ensure data to be collected will meet appropriate data quality standards, including modifications to reduce the reporting burden in the A80 EDR program and improve the utility of data collected from CP vessels in non-AFA groundfish fisheries in the BSAI as well as in the GOA. The first year of data is currently under quality assurance and quality control review.

The Economic Impacts of Technological Change in North Pacific Fisheries-REFM/ESSR

Benjamin Fissel, Ben Gilbert and Jake LaRiviere*
For further information, contact Ben.Fissel@NOAA.gov

Technological advancements have had a significant impact on fishing fleets and their behavior. Technology has expanded both the range of fish stocks we are able to target and the efficiency with which we capture, process, and bring products to market. Technology induced changes in the feasibility and efficiency of fishing can impact the composition and behavior the fishing fleet. Fissel and Gilbert (2014) provide a formal bioeconomic model with technological change showing that marked technology advances can explain over-capitalization as a natural fleet behavior for profit maximizing fishermen when total catch and effort are unconstrained and the technological advancements are known. Extending this analysis to North Pacific fisheries requires research on the theory of technological change in TAC-based and catch share management regimes as well as statistical methods for identifying unknown technological events as this data hasn't been historically collected. Fissel, Gilbert and LaRiviere (2013) extends the theory of technological change to by considering the incentive to adopt new technologies under in an open-access resource setting, finding that low stock levels in particular increase adoption incentives. This ongoing project develops the theory and methods necessary to analyze technological change in North Pacific fisheries through two in-progress manuscripts. Fissel (2013) adapts statistical methods for identifying marked changes in financial times series to the fisheries context using both simulation and empirics to show and validate the methods. North Pacific fisheries are considered with these methods as a case where technological change is unknown. This manuscript is expected to be completed in 2015. Future research on this project will use the results from these papers to analyze the impact of technological advancement in North Pacific fisheries with particular attention toward the impact of on-board computers.

References
Fissel, B. and B. Gilbert. 2014. "Technology Shocks and Capital Investment in the Commons", under revision at *Environmental and Resource Economics*.

LaRiviere, J., B. Fissel and B. Gilbert. 2013. "Technology Adoption and Diffusion with Uncertainty in a Commons." *Economics Letters* 120(2): 297-301.

Fissel, B. 2014. "Estimating Unknown Productivity Shocks in Fisheries." In progress.

FishSET: a Spatial Economics Toolbox to better Incorporate Fisher Behavior into Fisheries Management-REFM/ESSR
Alan C. Haynie* and Corinne Bassin
**For further information, contact Alan.Haynie@NOAA.gov*

Since the 1980s, fisheries economists have modeled the factors that influence fishers' spatial and participation choices in order to understand the trade-offs of fishing in different locations. This knowledge can improve predictions of how fishers will respond to area closures, changes in market conditions, or to management actions such as the implementation of catch share programs.

NOAA Fisheries and partners are developing the Spatial Economics Toolbox for Fisheries (FishSET). The aim of FishSET is to join the best scientific data and tools to evaluate the trade-offs that are central to fisheries management. FishSET will improve the information available for NOAA Fisheries' core initiatives such as coastal and marine spatial planning and integrated ecosystem assessments and allow research from this well-developed field of fisheries economics to be incorporated directly into the fisheries management process.

One element of the project is the development of best practices and tools to improve data organization. A second core component is the development of estimation routines that enable comparisons of state-of-the-art fisher location choice models. FishSET enables new models to be more easily and robustly tested and applied when the advances lead to improved predictions of fisher behavior. Pilot projects that utilize FishSET are in different stages of development in different regions in the United States, which will ensure that the data challenges that confront modelers in different regions are confronted at the onset of the project. Implementing projects in different regions will also provide insight into how economic and fisheries data requirements for effective management may vary across different types of fisheries. In Alaska, FishSET is currently being utilized in pilot projects involving the Amendment 80 and AFA pollock fisheries, but in the future models will be developed for many additional fishing fleets.

Using Vessel Monitoring System Data to Estimate Spatial Effort in Bering Sea Fisheries for Unobserved Trips-REFM/ESSR

Alan Haynie*, Patrick Sullivan, and Jordan Watson
**For further information, contact Alan.Haynie@NOAA.gov*

A primary challenge of marine resource management is monitoring where and when fishing occurs. This is important for both the protection and efficient harvest of targeted fisheries. Vessel monitoring system (VMS) technology records the time, location, bearing, and speed for vessels. VMS equipment has been employed on vessels in many fisheries around the world and VMS data has been used in enforcement, but a limited amount of work has been done utilizing VMS data to improve estimates of fishing activity. This paper utilizes VMS and an unusually large volume of government observer-reported data from the United States Eastern Bering Sea pollock fishery to predict the times and locations at which fishing occurs on trips without observers onboard. We employ a variety of techniques and specifications to improve model performance and out-of-sample prediction and find a generalized additive model that includes speed and change in bearing to be the best formulation for predicting fishing. We assess spatial correlation in the residuals of the chosen model, but find no correlation after taking into account other VMS predictors. We compare fishing effort to predictions for vessels with full observer coverage for 2003-2010 and compare predicted and observer-reported activity for observed trips. In this project, we have worked to address challenges that result from missing observations in the VMS data, which occur frequently and present modeling complications. We conclude with a discussion of policy considerations. Results of this work will be published in a scientific journal. We are also working with the NMFS Alaska Regional Office to attempt to improve the Region’s spatial effort database and we will extend the model to other fisheries.

Optimal Multi-species Harvesting in Ecologically and Economically Interdependent Fisheries-REFM/ESSR

Stephen Kasperski*
**For further information, contact Stephen.Kasperski@NOAA.gov*

Single-species management of multi-species fisheries ignores ecological interactions in addition to important economic interactions to the detriment of the health of the ecosystem, the stocks of fish species, and fishery profits. This study uses a model to maximize the net present value from a multispecies groundfish fishery in the Bering Sea where species interact ecologically in the ecosystem, and economically through vessels’ multi-product harvesting technology, switching gear types, and interactions in output markets. Numerical optimization techniques are used to determine the optimal harvest quota of each species over time. This study highlights the need to incorporate both ecological and economic interactions that occur between species in an ecosystem.

This study uses the arrowtooth flounder, Pacific cod, and walleye pollock fisheries in the Bering Sea/Aleutian Islands region off Alaska as a case study and finds the net present value of the three-species fishery is over $20.7 billion dollars in the multispecies model, over $5 billion dollars more than the net present value of the single species model. This is a function of the interdependence among species that affects other species growth. Because arrowtooth negatively impacts the growth of cod and pollock, substantially increasing the harvest of arrowtooth to decrease its stock is optimal in the multispecies model as it leads to increased growth and therefore greater potential harvests of cod and pollock. The single species model does not incorporate the feedback among species, and therefore assumes each species is unaffected by the stock rise or collapse of the others. The vessels in this fishery are also shown to exhibit cost anti-complementarities among species, which implies that harvesting multiple species jointly is more costly than catching them independently. As approaches for ecosystem-based fisheries management are developed, the results demonstrate the importance of focusing not only on the economically valuable species interact, but also on some non-harvested species, as they can affect the productivity and availability of higher value species. A paper describing this project was published in *Environmental and Resource Economics* (Kasperski 2015).

References

Kasperski, S. 2015. "Optimal Multi-species Harvesting in Ecologically and Economically Interdependent Fisheries" *Environmental and Resource Economics* 61(4): 517-557.

Optimal Multispecies Harvesting in the Presence of a Nuisance Species-REFM/ESSR

Stephen Kasperski*
**For further information, contact Stephen.Kasperski@NOAA.gov*

The need for ecosystem based fisheries management is well recognized, but substantial obstacles remain in implementing these approaches given our current understanding of the biological complexities of the ecosystem and the economic complexities surrounding resource use. This study develops a multispecies bioeconomic model that incorporates ecological and economic interactions to estimate the optimal catch and stock size for each species in the presence of a nuisance species. The nuisance species lowers the value of the fishery by negatively affecting the growth of the other species in the ecosystem, and has little harvest value of its own. This study empirically estimates multispecies surplus production growth functions for each species and uses these parameters to explore the impact of a nuisance species on the management of this ecosystem. Multiproduct cost functions are estimated for each gear type in addition to a count data model to predict the optimal number of trips each vessel takes. These functions are used, along with the estimated stock dynamics equations, to determine the optimal multispecies quotas and subsidy on the harvest of the nuisance species to maximize the total value of this three species fishery.

This study uses the arrowtooth flounder, Pacific cod, and walleye pollock fisheries in the Bering Sea/Aleutian Islands region off Alaska as a case study and finds the net present value of the fishery is decreased from $20.7 billion to $8.5 billion dollars by ignoring arrowtooth's role as a nuisance species on the growth of Pacific cod and walleye pollock. The optimal subsidy on the harvest of arrowtooth summed over all years is $35 million dollars, which increases the net present value by $273 million dollars, after accounting for the subsidy. As arrowtooth flounder is a low value species and has a large negative impact on the growth of cod and pollock, it is optimal to substantially increase the harvesting of arrowtooth, lowering its population which results in increased growth and harvesting in the two profitable fisheries. Ignoring the role of the nuisance species results in a substantially less productive and lower value fishery than if all three species are managed optimally. This study highlights the role of both biological and technological interactions in multispecies or ecosystem approaches for management, as well as the importance of incorporating the impacts non-harvested species can have on the optimal harvesting policies in an ecosystem. The paper describing these results was published in *Marine Policy*.

References
Kasperski, S. 2015. "Optimal Multispecies Harvesting in the Presence of a Nuisance Species" *Marine Policy* 64: 55-63.

The Regional and Community Size Distribution of Fishing Revenues in the North Pacific-REFM/ESSR

By Chris Anderson, Jennifer Meredith, and Ron Felthoven*
**For further information, contact Ron.Felthoven@NOAA.gov*

The North Pacific fisheries generate close to $2 billion in first wholesale revenues annually. However, the analysis supporting management plans focuses on describing the flow of these monies through each fishery (e.g., NOAA AFSC 2013), rather than across the individual cities and states in which harvesters live and spend their fishing returns. In the last two decades North Pacific fisheries have undergone a series of management changes aimed at ensuring healthy and sustainable profits for those participating in harvesting and processing, and healthy fish stocks. The formation of effective cooperatives and rationalization programs that have been designed by harvesters and processors support an economically successful industry. However, a variety of narratives have emerged about the distributional effects of these management changes, and in particular their effects on the participation of people in coastal communities in the North Pacific.

Previous work has adopted a variety of perspectives to establish the effects of a changing fishing industry in the North Pacific. Carothers (2008) focuses on individual communities in the Aleutian Islands and argues that shifts in the processing industry, away from small canneries in strongly place-identified communities, are exacerbated by rationalization that monetizes historical fishing access and draws fishing activity out of small communities when fishermen fall under duress. Carothers et al. (2010) adopts a state-wide perspective on a single fishery, and finds that small fishing communities as a category were more likely to divest of halibut IFQ in the years immediately following the creation of the program. Sethi et al. (2014) propose a suite of rapid assessment community-level indicators that integrate across fisheries, and identify that Alaskan communities are affected by trends of reduced fishery participation and dependence, characterized by fewer fishermen who participate in fewer fisheries and growth in other sectors of the economy during 1980-2010. However, they also observe that this effect is primarily distributional, as total fishing revenues within communities are stable and increasing.

This study contributes by providing a regional overview of the benefits from North

Pacific fishing, looking beyond the changes in any particular community or any particular fishery. It seeks to describe the regions to which revenues from North Pacific fisheries are accruing, whether that distribution has changed significantly over the last decade, and how any changes might be caused or affected by management. This is important because managers or stakeholders may have preferences over the distribution of benefits within their jurisdiction, and while the movement of fishing activity out of communities is frequently the focus of academic and policy research, research focusing on single communities often does not follow where those benefits go. Of particular interest is whether movement of North Pacific fishery revenues is dominated by movement within coastal Alaska, or primarily shifts away from coastal communities to other regions outside of Alaska.

References

Carothers, C., D. Lew and J. Sepez. 2010. Fishing Rights and Small Communities: Alaska Halibut IFQ Transfer Patterns. *Ocean & Coastal Management*: 53:518-23.

Carothers, C. 2008. "Rationalized Out": Discourses and Realities of Fisheries Privatization in Kodiak, Alaska. In Lowe, M. and C. Carothers, ed. Enclosing the Fisheries: People, Places, and Power." *American Fisheries Society, Symposium* 69.

NOAA AFSC. 2014. "Stock Assessment and Fishery Evaluation Report for the Groundfish Fisheries of the Gulf of Alaska and Bering Sea/Aleutian Islands Area: Economic Status of the Groundfish Fisheries Off Alaska 2012." 379 pp.

Sethi, S., W. Riggs, G. Knapp. 2014. "Metrics to Monitor the Status of Fishing Communities: An Alaska State of the State Retrospective 1980-2010." *Ocean & Coastal Management*: 88:21-30.

Tools to Explore Alaska Fishing Communities-REFM/ESSR

Amber Himes-Cornell*

**For further information, contact Stephen.Kasperski@noaa.gov*

Community profiles have been produced for fishing communities throughout the state of Alaska in order to meet the requirements of National Standard 8 of the Magnuson-Stevens Act and provide a necessary component of the social impact assessment process for fisheries management actions. These profiles provide detailed information on elements of each fishing community, including location, demographics, history, infrastructure, governance, facilities, and involvement in state and federal fisheries targeting commercial, recreational and subsistence resources. A total of 196 communities from around Alaska were profiled as part of this effort.

However, these profiles are static and require manual updates as more recent data become available. In order to address this in a more effective way, social scientists in the AFSC Economic and Social Science Research Program have developed two web-based tools to provide the public with information on communities in Alaska: fisheries data maps and community snapshots. There are three distinct fisheries data maps providing a time series on community participation in commercial, recreational, and subsistence fishing. The community snapshots take the pulse of Alaskan fishing communities using information about their fishing involvement and demographic characteristics. Each snapshot provides information on:

- What commercial species are landed and processed in the community;
- The number of crew licenses held by residents;
- The characteristics of fishing vessels based in the community;
- Processing capacity
- Participation in recreational fishing (including both charter businesses and individual anglers);
- Subsistence harvesting dependence;
- Demographic attributes of the community (including educational attainment, occupations by industry, unemployment, median household income, poverty, median age, sex by age, ethnicity and race, and language and marginalization);
- Social vulnerability indices (These indices represent social factors that can shape either an individual or community's ability to adapt to change. These factors exist within all communities regardless of the importance of fishing. The indices include: Poverty, Population Composition, Personal Disruption, and Housing Disruption.); and
- Fishing engagement and reliance indices (These indices portray the importance or level of dependence of commercial or recreational fishing to coastal communities. The indices include: Commercial Engagement, Commercial Reliance, Recreational Engagement and Recreational Reliance

These web-based tools are updated as new data become available and currently include the years in parentheses below.

To access the community profiles; go to:
http://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/CPU.php

To access the *NEW* community snapshots (available for years 2000-2011); go to:
http://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/communitysnapshots/main.php

To access the commercial fisheries data maps (available for years 2000-2014); go to:
http://www.afsc.noaa.gov/maps/ESSR/commercial/default.htm

To access the recreational fisheries data maps (available for years 1998-2014); go to:
http://www.afsc.noaa.gov/maps/ESSR/recreation/default.htm

To access the subsistence fisheries data maps (available for years 2000-2008); go to:
http://www.afsc.noaa.gov/maps/ESSR/subsistence/default.htm

Developing Comparable Socio-economic Indices of Fishing Community Vulnerability and Resilience for the Contiguous US and Alaska-REFM/ESSR

Amber Himes-Cornell and Stephen Kasperski*
**For further information, contact Stephen.Kasperski@noaa.gov*

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 several years, social scientists working in NOAA Fisheries' Regional Offices and Science Centers have been engaged in the development of 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 (Colburn and Jepson, 2012; Himes-Cornell and Kasperski, 2015). 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. National-level indicators for all U.S. coastal communities can be found using the "Explore the Indicator Map" link from the main NMFS social indicators webpage here: http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/.

The Alaska Fisheries Science Center (AFSC) has compiled socio-economic and fisheries data for over 300 communities in Alaska and developed developed indices specific to Alaska communities (Himes-Cornell and Kasperski, 2016) using the same methodology as 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 the NE and SE and 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 factor analysis (PCFA), 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 this approach is that the majority of the data used to construct these indices are readily accessible secondary data and can be compiled quickly to create measures of social vulnerability and to update community profiles.

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 based on shared characteristics and logistic feasibility (Himes Cornell, et al. 2016). This qualitative data was used to test the construct validity of the quantitative well-being indices. Specifically, this methodology used a test of convergent validity: in theory, the quantitative indices should be highly correlated with the qualitative measure. This comparison helps us understand how well the estimated well-being indices represent real-world conditions observed by researchers. Study findings suggest that some index components exhibit a high degree of construct validity based on high correlations between the quantitative and qualitative measures, while other components will require refinement prior to their application in fisheries decision-making. Further, the results provides substantial evidence for the importance of groundtruthing quantitative indices so they may be better calibrated to reflect the communities they seek to measure.

Groundtruthing the results using this type of methodology 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.

References

Colburn, L.L. and M. Jepson. 2012. "Social Indicators of Gentrification Pressure in Fishing Communities: A Context for Social Impact Assessment." *Coastal Management* 40:289-300.

Himes-Cornell, A., and S. Kasperski. 2015. "Assessing climate change vulnerability in Alaska's fishing communities." *Fisheries Research* 162: 1-11.

Himes-Cornell, A. and S. Kasperski. 2016. "Using Socio-Economic and Fisheries Involvement Indices to Better Understand Alaska Fishing Community Well-being." *Coastal Management* 44(1): 36-70.

Himes-Cornell, A., C. Maguire, S. Kasperski, K. Hoelting, and R. Pollnac. 2016. "Understanding vulnerability in Alaska fishing communities: A validation methodology for rapid assessment of well-being indices". *Ocean and Coastal Management* 124: 53-65.

Jepson, M. and L.L. Colburn. 2013. "Development of Social Indicators of Fishing Community Vulnerability and Resilience in the U.S. Southeast and Northeast Regions." *NOAA Technical Memorandum* NMFS-F/SPO-129, April 2013.

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

Published January 2015 through December 2015 (AFSC authors in bold text)

BANAS, N. S., E. F. MØLLER, T. G. NIELSEN, and **L. B. EISNER**.
2016. Copepod life strategy and population viability in response to prey timing and temperature: Testing a new model across latitude, time, and the size spectrum. Front. Mar. Sci. 3:225. http://dx.doi.org/10.3389/fmars.2016.00225.

BARBEAUX, S. J., **S. ROMAIN**, **E. LOGERWELL**, and D. FRASER.
2016. Aleutian Islands Cooperative Acoustic Survey Study, 2007. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-319, 35 p. Online (.pdf, 1.2 MB).

BARTON, M.B., **J. R. MORAN**, **J. J. VOLLENWEIDER**, **R A. HEINTZ**, and K. M. BOSWELL. 2016. Latitudinal dependence of body condition, growth rate, and stable isotopes of juvenile capelin (*Mallotus villosus*) in the Bering and Chukchi seas. Polar Biol. Early online. http://dx.doi.org/doi:10.1007/s00300-016-2041-8.

BOSWELL, K. M., G. RIEUCAU, **J. J. VOLLENWEIDER**, **J. R. MORAN**, **R. A. HEINTZ**, **J. K. BLACKBURN**, and **D. J. CSEPP**.
2016. Are spatial and temporal patterns in Lynn Canal overwintering Pacific herring related to top predator activity? Can. J. Fish. Aquat. Sci. 73:1307-1318. https://dx.doi.org/10.1139/cjfas-2015-0192

CAHALAN, J., **C. FAUNCE**, J. BONNEY, and **R. SWANSON**.
2016. A field test of fisheries observer sampling methods for estimation of at-sea discards. Fish. Res. 174:219-233. http://dx.doi.org/10.1016/j.fishres.2015.10.004.

CARDENAS, S. A., and **D. K. LEW**.
2016. Factors influencing willingness to donate to marine endangered species recovery in the Galapagos National Park, Ecuador. Front. Mar. Sci. 3:60. http://dx.doi.org/10.3389/fmars.2016.00060.

CONNER, J., and **R. R. LAUTH**.
2016. Results of the 2013 eastern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-331, 153 p. Online (.pdf, 7.4 MB).

COPEMAN, L. A., **B. J. LAUREL**, K. M. BOSWELL, A. L. SREMBA, K. KLINCK, **R. A. HEINTZ**, **J. J. VOLLENWEIDER**, **T. E. HELSER**, and **M. L. SPENCER**.
2016. Ontogenetic and spatial variability in trophic biomarkers of juvenile saffron cod (*Eleginus gracilis*) from the Beaufort, Chukchi and Bering Seas. Polar Biol. 39:1109-1126. http://dx.doi.org/10.1007/s00300-015-1792-y

ECHAVE, **K. B.**
2016. Feasibility of tagging sablefish, *Anoplopoma fimbria*, with pop-off satellite tags in the northeast Pacific Ocean. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-320, 38 p. Online (.pdf, 1.5 MB).

EICH, A. M., K. R. MABRY, S .K. WRIGHT, and **S. M. FITZGERALD**. 2016. Seabird bycatch and mitigation efforts in Alaska fisheries Summary Report: 2007 through 2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/AKR-12, 47 p.http://doi.org/10.7289/V5/TM-F/AKR-12.

FARROW, K., A. BRINSON, K. WALLMO, and **D. K. LEW**.
2016. Environmental attitudes in the aftermath of the Gulf Oil Spill. Ocean Coastal Manage. 119:128-134. http://dx.doi.org/10.1016/j.ocecoaman.2015.10.001

FARRUGIA, T. J., K. J. GOLDMAN, **C. TRIBUZIO**, and A. C. SEITZ.
2016. First use of satellite tags to examine movement and habitat use of big skates *Beringraja binoculata* in the Gulf of Alaska. Mar. Ecol. Prog. Ser. 556:209-221. http://dx.doi.org/doi:10.3354/meps11842

FAUNCE, C. H.

2016. Alternative sampling designs for the 2017 annual deployment plan of the North Pacific Observer Program, 33 p. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-338, 33 p. Online. (.pdf, 860 KB).

FAUNCE, **C.**, J. GASPER, J. CAHALAN, **S. LOWE**, **S. BARBEAUX**, and R. WEBSTER.
2016. Deployment performance review of the 2015 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-322, 54 p. Online. (.pdf, 1.8 MB).

FUJIWARA, A., T. HIRAWAKE, K. SUZUKI, **L. EISNER**, I. IMAI, S. NISHINO, T. KIKUCHI, and S. I. SAITOH.
2016. Influence of timing of sea ice retreat on phytoplankton size during marginal ice zone bloom period on the Chukchi and Bering shelves. Biogeosciences 13:115-131. 10.5194/bg-13-115-2016. http://dx.doi.org/10.5194/bg-13-115-2016.

GARDNER, J. R., **J. W. ORR**, **D. E. STEVENSON**, **I. SPIES**, and **D. A. SOMERTON**.
2016. Reproductive parasitism between distant phyla: Molecular identification of snailfish (Liparidae) egg masses in the gill cavities of king crabs (Lithodidae). Copeia 104:645-657. http://dx.doi.org/10.1643/CI-15-374.

GARVIN, M. R., W. D. TEMPLIN, A. J. GHARRETT, N. DECOVICH, **C. M. KONDZELA**, **J. R. GUYON**, and M. V. MCPHEE.
2016. Potentially adaptive mitochondrial haplotypes as a tool to identify divergent nuclear loci. Methods Ecol. Evol. Early Online. http://dx.doi.org/10.1111/2041-210X.12698.

GODDARD, **P.**, **R. WILBORN**, **C. ROOPER**, **K. WILLIAMS**, **R. TOWLER**, **M. SIGLER**, and **P. MALECHA**.
2016. Results of the 2014 underwater camera survey of the eastern Bering Slope and Outer Shelf. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-313, 304 p. Online (.pdf, 63.7 MB).

GUTHRIE, **C. M. III**, **HV. T. NGUYEN**, and **J. R. GUYON**.
2016. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2014 Gulf of Alaska trawl fisheries. U.S. Dep. Commer., NOAA TM-AFSC-311, 31 p. Online (.pdf, 900 KB).

GUTHRIE, **C. M. III**, **HV. T. NGUYEN**, and **J. R. GUYON**.
2016. Genetic stock composition analysis of the Chinook salmon bycatch from the 2014 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery. U.S. Dep. Commer., NOAA-TM-AFSC-310, 25 p. Online (.pdf, 880 KB).

HANDEGARD, N., K. BOSWELL, **A. De ROBERTIS**, G. MACAULAY, G. RIEUCAU, and L. SIVLE.
2016. Investigating the effect of tones and frequency sweeps on the collective behavior of penned herring (*Clupea harengus*), p. 391-398. *In* A. N. Popper and A. Hawkins (editors), The Effects of Noise on Aquatic Life II. Springer, New York.

HIMES-CORNELL, **A.**, and **S. KASPERSKI**.
2016. Using socioeconomic and fisheries involvement indices to understand Alaska fishing community well-being. Coastal Manage. 44:36-70. http://dx.doi.org/10.1080/08920753.2016.1116671.

HIMES-CORNELL, **A.**, C. MAGUIRE, **S. KASPERSKI**, K. HOELTING, and R. POLLNAC.
2016. Understanding vulnerability in Alaska fishing communities: a validation methodology for rapid assessment of indices related to well-being. Ocean Coastal Manage. 124:53-65. http://dx.doi.org/10.1016/j.ocecoaman.2016.02.004.

HOFF, G. R.
2016. Results of the 2016 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-339, 272 p. Online (.pdf, 23 MB).

KAISER, M. J., HILBORN, R., JENNINGS, S., AMAROSO, R., ANDERSEN, M., BALLIET, K., BARRATT, E., BERGSTAD, O. A., BISHOP, S., BOSTROM, J. L., BOYD, C., BRUCE, E. A., BURDEN, M., CAREY, C., CLERMONT, J., COLLIE, J. S., DELAHUNTY, A., DIXON, J., EAYRS, S., EDWARDS, N., FUJITA, R., GAUVIN, J., GLEASON, M., HARRIS, B., HE, P., HIDDINK, J. G., HUGHES, K. M., INOSTROZA, M., KENNY, A., KRITZER, J., KUNTZSCH, V., LASTA, M., LOPEZ, I., LOVERIDGE, C., LYNCH, D., MASTERS, J., MAZOR, T., **McCONNAUGHEY, R. A.**, MOENNE, M., FRANCIS, NIMICK, A. M., OLSEN, A., PARKER, D., PARMA, A., PENNEY, C., PIERCE, D., PITCHER, R., POL, M., RICHARDSON, E., RIJNSDORP, A. D.,

RILATT, S., RODMELL, D. P., ROSE, C., SETHI, S. A., SHORT, K., SUURONEN, P., TAYLOR, E., WALLACE, S., WEBB, L., WICKHAM, E., WILDING, S. R., WILSON, A., WINGER, P. and SUTHERLAND, W. J.
2016. Prioritization of knowledge-needs to achieve best practices for bottom trawling in relation to seabed habitats. Fish Fish. 17: 637–663. http://dx.doi.org/10.1111/faf.12134.

KASPERSKI, **S.**
2016. Optimal multispecies harvesting in the presence of a nuisance species. Mar. Policy 64:55-63. http://dx.doi.org/10.1016/j.marpol.2015.11.009

KASTELLE, **C. R.**, **T. E. HELSER**, S. G. WISCHNIOWSKI, T. LOHER, **B. J. GOETZ**, and L. A. KAUTZI.
2016. Incorporation of bomb-produced ^{14}C into fish otoliths: a novel approach for evaluating age validation and bias with an application to yellowfin sole and northern rockfish. Ecol. Modell. 320:79-91. http://dx.doi.org/10.1016/j.ecolmodel.2015.09.013

KELLY, M., C. SIM-SMITH, **R. STONE**, T. SAMAAI, H. REISWIG, and W. AUSTIN.
2016. New taxa and arrangements within the family Latrunculiidae (Demospongiae, Poecilosclerida). Zootaxa 4121(1):001-048. http://dx.doi.org/10.11646/zootaxa.4121.1.1

KONDZELA, C. M., **J. A. WHITTLE**, **D. YATES**, **S. C. VULSTEK**, **H. T. NGUYEN**, and **J. R. GUYON**.
2016. Genetic stock composition analysis of chum salmon from the prohibited species catch of the 2014 Bering Sea walleye pollock trawl fishery and Gulf of Alaska groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-314, 49 p. Online (.pdf, 2 MB).

LAUREL, B. J., **M. SPENCER**, **P. ISERI**, and L. A. COPEMAN. 2016. Temperature-dependent growth and behavior of juvenile Arctic cod (*Boreogadus saida*) and co-occurring North Pacific gadids. Polar Biol. 39:1127-1135. http://dx.doi.org/10.1007/s00300-015-1761-5.

LEHNERT, H., and **R. P. STONE**.
2016. A comprehensive inventory of the Gulf of Alaska sponge fauna with the description of two new species and geographic range extensions. Zootaxa 4144:365-382. http://dx.doi.org/10.11646/zootaxa.4144.3.5.

LEW, **D. K.**, D. PUTNAM, and D. M. LARSON.
2016. Attitudes and preferences toward Pacific halibut management alternatives in the saltwater sport fishing charter sector in Alaska: Results from a survey of charter halibut permit holders. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-326, 58 p. Online (.pdf, 1.8 MB).

MATTA, M. E., **T. E. HELSER**, and B. A. BLACK.
2016. Otolith biochronologies reveal latitudinal differences in growth of Bering Sea yellowfin sole Limanda aspera. Polar Biol. 1-13. http://dx.doi.org/10.1007/s00300-016-1917-y.

McDERMOTT, **S. F.**, V. HAIST, and **K. M. RAND**.
2016. Evaluating the efficacy of trawl exclusion zones by estimating local Atka mackerel abundance and movement patterns in the central and eastern Aleutian Islands. Mar. Coastal Fish. 8:334-349. https://dx.doi.org/10.1080/19425120.2015.1135218

ORR, J. W.
2016. Two new species of snailfishes of the genus Careproctus (Liparidae) from the Aleutian Islands, Alaska. Copeia 104:890-896.
http://dx.doi.org/10.1643/CI-15-378.

PARTLOW, M., and **E. MUNK**.
2016. Saffron cod (*Eleginus gracilis*) in North Pacific archaeology. Alaska J. Anthropol. 13:19-34.

PITCHER, C. R., N. ELLIS, S. JENNINGS, J. G. HIDDINK, T. MAZOR, M. J. KAISER, M. I. KANGAS, **R. A. McCONNAUGHEY**, A. M. PARMA, A. D. RIJNSDORP, P. SUURONEN, J. COLLIE, R. AMOROSO, K. M. HUGHES, and R. HILBORN.
2016. Estimating the sustainability of towed fishing-gear impacts on seabed habitats: a simple quantitative risk assessment method applicable to data-limited fisheries. Methods Ecol. Evol. Early online.

http://dx.doi.org/10.1111/2041-210X.1270.

PINCHUK, A. I., and **L. B. EISNER**.
2016. Spatial heterogeneity in zooplankton summer distribution in the eastern Chukchi Sea in 2012–2013 as a result of large-scale interactions of water masses. Deep-Sea Res. II. Early online. http://dx.doi.org/10.1016/j.dsr2.2016.11.003.

RARING, **N. W.**, **E. A. LAMAN, P. G. von SZALAY, C. N. ROOPER**, and **M. H. MARTIN**.
2016. Data report: 2012 Aleutian Islands bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-332, 157 p. Online (.pdf, 7.7 MB).

RARING, **N. W.**, **E. A. LAMAN**, **P. G. von SZALAY**, and **M. H. MARTIN**.
2016. Data report: 2011 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-330, 231 p. Online (.pdf, 9.4 MB).

RARING, **N. W.**, **E. A. LAMAN**, **P. G. von SZALAY**, **M. E. WILKINS**, and **M. H. MARTIN**.
2016. Data report: 2005 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-329, 233 p. Online (.pdf 12.5 MB).

RARING, **N. W.**, **P. G. von SZALAY, M. H. MARTIN, M. E. WILKINS**, and **F. R. SHAW**.
2016. Data report: 2003 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-328, 319 p. Online (.pdf, 15 MB).

RENNER, M., S. SALO, **L.B. EISNER**, **P. H. RESSLER**, C. LADD, K. J. KULETZ, J. A. SANTORA, J. F. PIATT, G. S. DREW, and G. L. HUNT.
2016. Timing of ice retreat alters seabird abundances and distributions in the southeast Bering Sea. Biol. Lett. 12: 20160276. http://dx.doi.org/10.1098/rsbl.2016.0276

RODGVELLER, **C. J.**, **J. W. STARK**, **K. B. ECHAVE**, and **P-J F. HULSON**.
2016. Age at maturity, skipped spawning, and fecundity of female sablefish (*Anoplopoma fimbria*) during the spawning season. Fish. Bull., U.S. 114:89-102. http://dx.doi.org/10.7755/FB.114.1.8.

RODGVELLER, C. J., **C. A. TRIBUZIO**, **P. W. MALECHA**, and **C. R. LUNSFORD**.
2017. Feasibility of using pop-up satellite archival tags (PSATs) to monitor vertical movement of a Sebastes: a case study. Fish. Res. 187:96-102. http://dx.doi.org/10.1016/j.fishres.2016.11.012.

ROOPER, **C. N.**, **M. F. SIGLER**, **P. GODDARD**, **P. MALECHA**, **R. TOWLER**, **K. WILLIAMS**, **R. WILBORN**, and **M. ZIMMERMANN**.
2016. Validation and improvement of species distribution models for structure forming invertebrates in the eastern Bering Sea with an independent survey. Mar. Ecol. Prog. Ser. 551:117-130. http://dx.doi.org/10.3354/meps11703.

RUTECKI, **T. L.**, and **J. N. IANELLI**.
2016. Feasibility of tagging walleye pollock captured with hook and line using external tags. Mar. Coastal Fish. 8:374-381. http://dx.doi.org/.10.1080/19425120.2016.1167794.

RUTECKI, **T. L.**, **C. J. RODGVELLER**, and **C. R. LUNSFORD**.
2016. National Marine Fisheries Service longline survey data report and survey history, 1990-2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-324, 329 p. Online (.pdf, 9.8 MB).

SEUNG, **C.**
2016. Identifying channels of economic impacts: An inter-regional structural path analysis for Alaska fisheries. Marine Policy 66: 39-49. http://dx.doi.org/10.1016/j.marpol.2016.01.015

SEUNG, **C.**, and **J. IANELLI**.
2016. Regional economic impacts of climate change: a computable general equilibrium analysis for an Alaska fishery Natural Resource Modeling. Vol 29 (2): 289-333. http://dx.doi.org/10.1111/nrm.12092

SEUNG, **C.**, B. MUSE, and E. WATERS.

2016. Net Economic Impacts of Recent Alaska Salmon Fishery Failures and Federal Relief. North American Journal of Fisheries Management. 36:351–362. http://dx.doi.org/10.1080/02755947.2015.1120831

SIGLER, M., A. HOLLOWED, K. HOLSMAN, S. ZADOR, A. HAYNIE, A. HIMES-CORNELL, P. MUNDY, S. DAVIS, **J.DUFFY-ANDERSON**, **T. GELATT**, B. GERKE, and P. STABENO.
2016. Alaska Regional Action Plan for the Southeastern Bering Sea: NOAA Fisheries Climate Science Strategy. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-336, 50 p. Online (.pdf, 7 MB).

SIMONSEN, **K. A.**, **P. H. RESSLER**, **C. N. ROOPER**, and **S. G. ZADOR**.
2016. Spatio-temporal distribution of euphausiids: an important component to understanding ecosystem processes in the Gulf of Alaska and eastern Bering Sea. ICES J. Mar. Sci. 73:2020-2036. http://dx.doi.org/10.1093/icesjms/fsv272

SMITH, K. R.
2016. Reconciling ambiguity resulting from inconsistent taxonomic classification of marine fauna assessed in the field: Querying a database to reclassify by lowest accountable inclusive taxon (LAIT). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-333, 57 p. Online (.pdf, 2.4 MB).

SMITH, **T. A.**, and **R. A. McCONNAUGHEY**.
2016. The applicability of sonars for habitat mapping: a bibliography. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-317, 129 p. Online (.pdf, 2.8 MB).

STEVENSON, D. E., **K. L. WEINBERG**, and **R. R. LAUTH**.
2016. Estimating confidence in trawl efficiency and catch quantification for the eastern Bering Sea shelf survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-335, 51 p. Online (.pdf, 1.5 MB).

SURYAN, R. M., K. J. KULETZ, S. L. PARKER-STETTER, **P. H. RESSLER**, M. RENNER, J. K. HORNE, **E. V. FARLEY**, and E. A. LABUNSKI.
2016. Temporal shifts in seabird populations and spatial coherence with prey in the southeastern Bering Sea. Mar. Ecol. Prog. Ser. 549:199-215. http://dx.doi.org/10.3354/meps11653

SZYMKOWIAK, M., and **R. FELTHOVEN**.
2016. Understanding the determinants of hired skipper use in the Alaska halibut individual fishing quota fishery. N. Amer. J. Fish. Manage. 36:1139-1148. http://dx.doi.org/10.1080/02755947.2016.1184201

THORSON, J. T., **J. N. IANELLI**, E. A. LARSEN, L. RIES, M. D. SCHEUERELL, C. SZUWALSKI, and E. F. ZIPKIN.
2016. Joint dynamic species distribution models: a tool for community ordination and spatio-temporal monitoring. Global Ecol. Biogeogr. 25:1144-1158. http://dx.doi.org/10.1111/geb.12464.

THORSON, J. T., A. RINDORF, J. GAO, **D. H. HANSELMAN**, H. WINKER.
2016. Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes. Proc. R. Soc. B 283: 20161853. http://dx.doi.org/10.1098/rspb.2016.1853

VANCE, **T. C.**
2016. A primer on cloud computing, p. 1-13. *In* T.C. Vance, N. Merati, C. Yang, M. Yuan (editors), Cloud Computing in Ocean and Atmospheric Sciences. Academic Press.

VAN DER SLEEN, P., M. P. DZAUGIS, C. GENTRY, W. P. HALL, V. HAMILTON, **T. E. HELSER**, **M. E. MATTA**, C. A. UNDERWOOD, R. ZUERCHER, and B. A. BLACK.
2016. Long-term Bering Sea environmental variability revealed by a centennial-length biochronology of Pacific ocean perch *Sebastes alutus*. Climate Res. 71:33-45. http://dx.doi.org/10.3354/cr01425.

von SZALAY, **P. G.**, and **N. W. RARING**.
2016. Data report: 2015 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-325, 249 p. Online (.pdf, 10 MB).

WALLMO, K., and **D. K. LEW**.
2016. A comparison of regional and national values for recovering threatened and endangered marine

species in the United States. J. Environ. Manage.179:38-46. http://dx.doi.org/10.1016/j.jenvman.2016.04.053.

WALLMO, K., K. D. BISACK, **D. K. LEW**, and D. E. SQUIRES (editors).
2016. The economics of protected marine species: Concepts in research and management. Lausanne: Frontiers Media. http://dx.doi.org/10.3389/978-2-88919-990-7.

WATSON J. T., and **A. C. HAYNIE.**
2016. Using vessel monitoring system data to identify and characterize trips made by fishing vessels in the United States North Pacific. PLoS ONE 11(10): e0165173. http://dx.doi.org/10.1371/journal.pone.0165173.

WEINBERG, **K. L.**, **C. YEUNG**, **D. A. SOMERTON**, **G. G. THOMPSON**, and **P. H. RESSLER**.
2016. Is the survey selectivity curve for Pacific cod (*Gadus macrocephalus*) dome-shaped? Direct evidence from trawl studies. Fish. Bull., U.S. 114:360-369. http://dx.doi.org/10.7755/FB.114.3.8.

WHITEHOUSE, **G. A.**, and **K. Y. AYDIN**.
2016. Trophic structure of the eastern Chukchi Sea: an updated mass balance food web model. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-318, 175 p. Online (.pdf, 2.8 MB).

WILLIAMS, B. C., G. H. KRUSE, and **M. W. DORN**.
2016. Interannual and spatial variability in maturity of walleye pollock *Gadus chalcogrammus* and implications for spawning stock biomass estimates in the Gulf of Alaska. PLoS ONE 11:e0164797.
http://dx.doi.org/10.1371/journal.pone.0164797

WILSON, **M. T.**, **K. L. MIER**, and **D. W. COOPER**.
2016. Assessment of resource selection models to predict occurrence of five juvenile flatfish species (Pleuronectidae) over the continental shelf in the western Gulf of Alaska. J. Sea Res. 111:54-64. http://dx.doi.org/10.1016/j.seares.2015.12.005

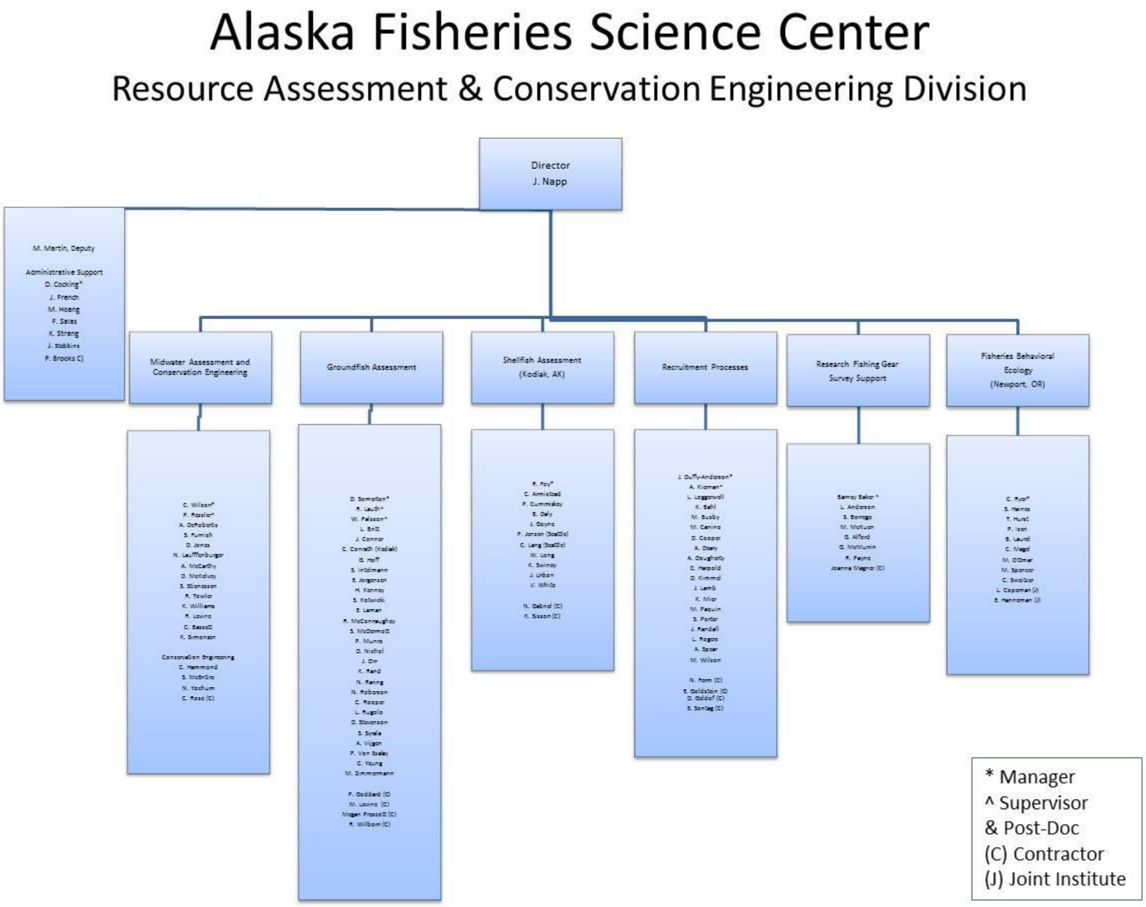
WOILLEZ, **M.**, **P. D. WALLINE**, **J. N. IANELLI**, **M. W. DORN**, **C. D. WILSON**, and A. E. PUNT.
2016. Evaluating total uncertainty for biomass- and abundance-at-age estimates from eastern Bering Sea walleye pollock acoustic-trawl surveys. ICES J. Mar. Sci.:73:2208-2226.
http://dx.doi.org/10.1093/icesjms/fsw054

YANG, M-S.
2015. Diets of spotted spiny dogfish, *Squalus suckleyi*, in Marmot Bay, Gulf of Alaska, between 2006 and 2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-337, 29 p. Online (.pdf, 1 MB).

YASUMIISHI, **E. M.**, **E. V. FARLEY**, G. T. RUGGERONE, B. A. AGLER, and L. I. WILSON.
2016. Trends and factors influencing the length, compensatory growth, and size-selective mortality of juvenile Bristol Bay, Alaska, sockeye salmon at sea. Mar. Coastal Fish. 8: 315-333. http://dx.doi.org/10.1080/19425120.2016.1167793

ZIMMERMANN, **M.**, J. A. REID, and N. GOLDEN.
2016. Using smooth sheets to describe groundfish habitat in Alaskan waters, with specific application to two flatfishes. Deep Sea Res. II 132:210-226. http://dx.doi.org/10.1016/j.dsr2.2015.02.020

APPENDIX I. RACE ORGANIZATION CHART



APPENDIX II. REFM ORGANIZATION CHART

REFM DIVISION ORGANIZATION CHART

(as of March 31, 2017)

Division Directorate
Ron Felthoven
(Division Director)

Deputy Director
D. Ito
(NEPA Coordinator)

International Coordinator (AFSC & AKR)
Vacant

REFM/RACE/FMA Support
D. Cocking -- Supervisor
P. Brooks
M. Hoang
J. Stebbins
K. Strang

Logistics & Safety
B. Goiney

IT Staff
S. Wennberg
M. Blaisdell

Status of Stocks and Multispecies Assessment
A. Hollowed -- Program Manager
S. Barbeaux
M. Dorn
J. Ianelli
P. Spencer
W. Stockhausen
G. Thompson
J. Turnock
S. Lowe -- Supervisor
M. Bryan
L. Conners
C. McGilliard
O. Ormseth
I. Spies
T. Wilderbuer

Contractors and Others
G. Lambert
L. Li

Resource Ecology and Ecosystems Modeling
K. Aydin -- Program Manager
T. Buckley
S. Fitzgerald
K. Holsman
G. Lang
M. Yang
S. Zador

Contractors and Others
R. Hibpshman
K. Kearny
I. Ortiz
C. Robinson
J. Reum
S. Rohan
K. Sawyer
A. Whitehouse

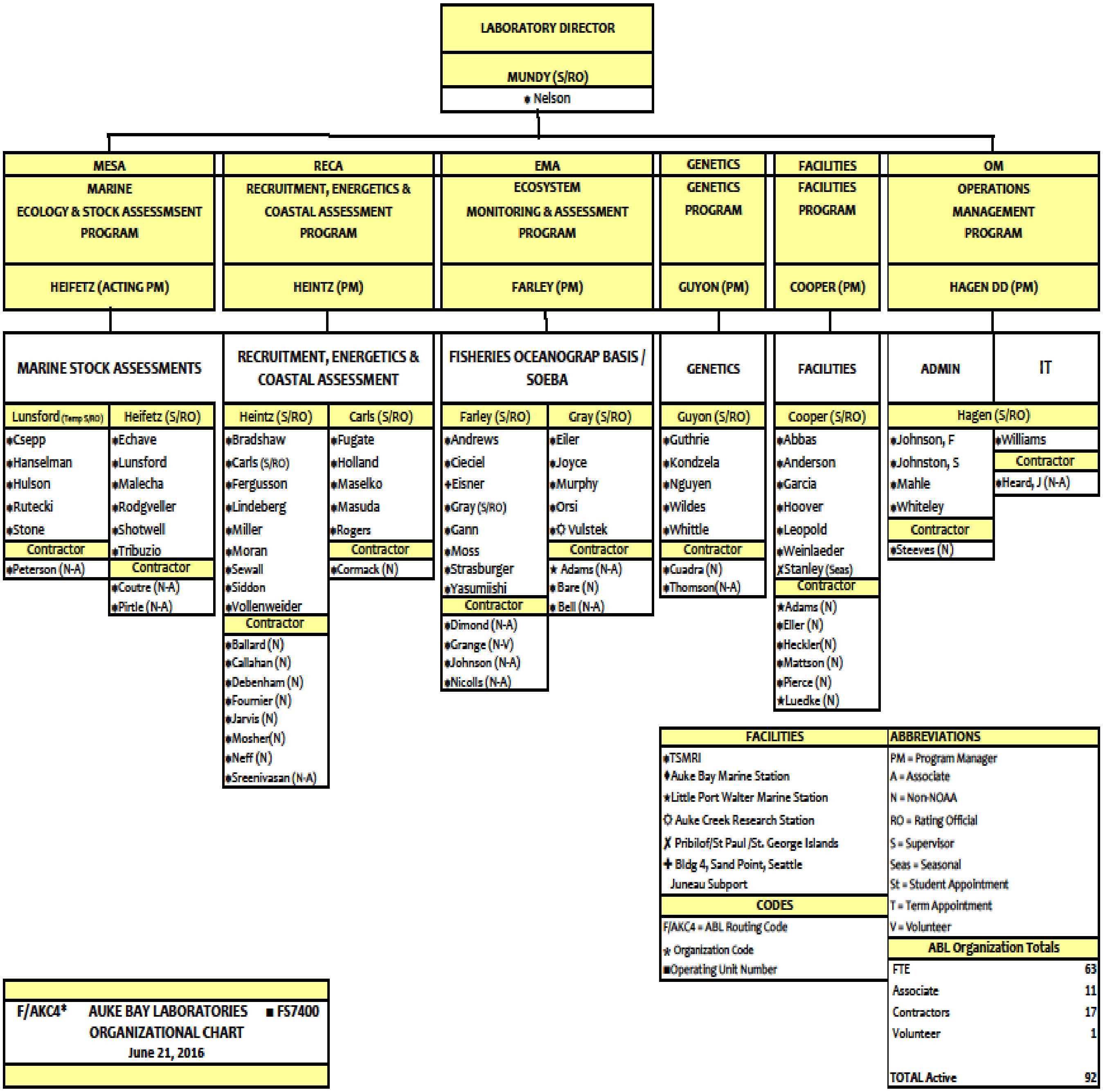
Age and Growth
T. Helser -- Program Manager
C. Kastelle
J. Short
C. Hutchinson
S. Neidetcher
T. TenBrink
D. Anderl -- Project Leader
J. Brogan
B. Matta
J. Pearce
K. Williams
B. Goetz -- Project Leader
I. Benson
C. Gburski
C. Piston

Contractors and Others
C. Blood
J. Harris
M. Arrington

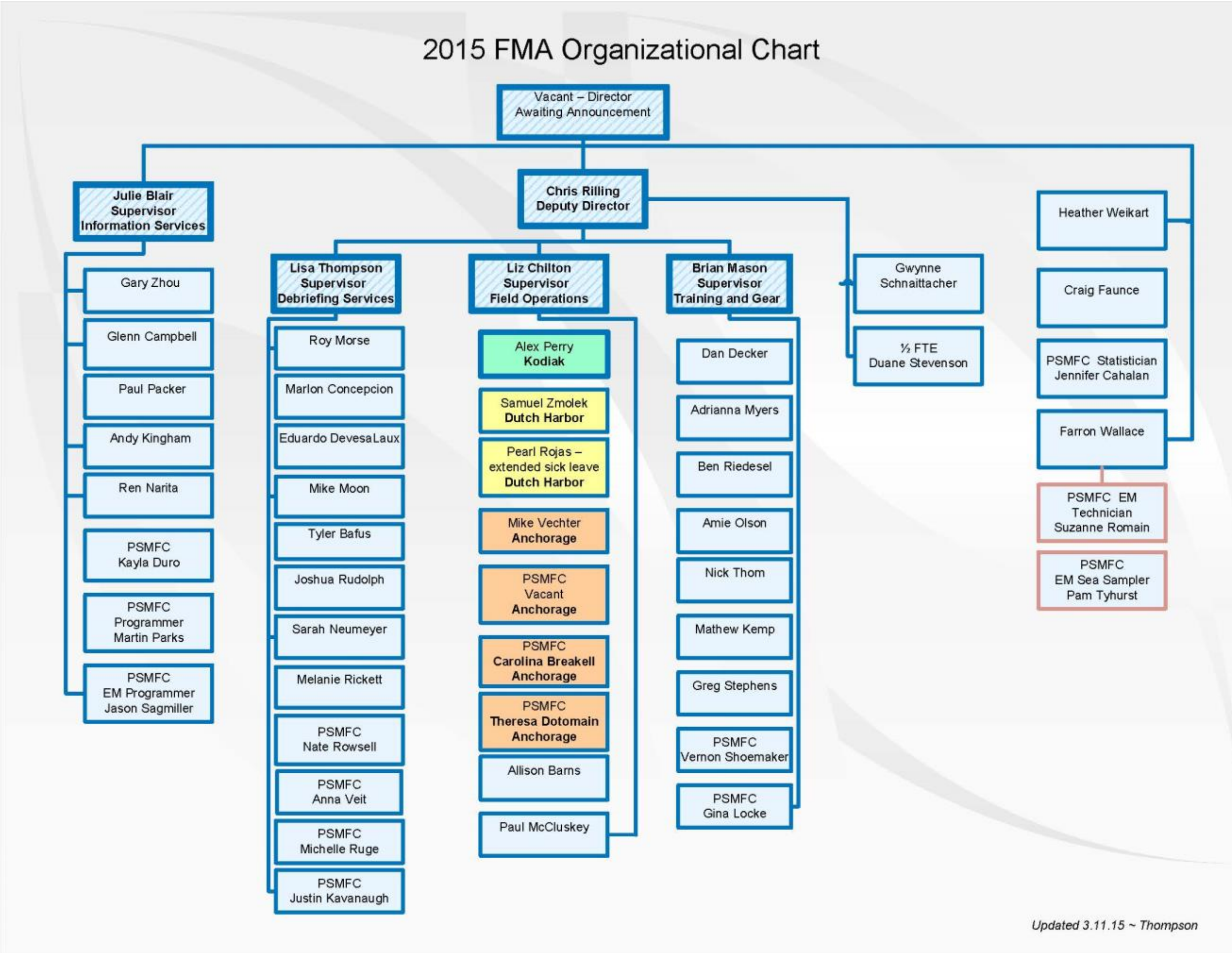
Economics and Social Sciences Research
S. Kasperski -- Program Manager
M. Dalton
B. Fissel
B. Garber-Yonts
A. Haynie
D. Lew
C. Seung

Contractors and Others
A. Chen
A. Faig
J. Lee
A. Santos
K. Sparks

APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART



APPENDIX IV – FMA ORGANIZATIONAL CHART



CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2016

April 2017

Prepared for the 58th Annual Meeting of the
Technical Sub-Committee of the Canada-United States Groundfish Committee
April 25-26, 2016, Juneau, Alaska, USA

Compiled by
G. Workman, K. L. Yamanaka and M. Surry
Fisheries and Oceans Canada
Science Branch
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

Table of Contents

Agency Overview

Fisheries and Oceans Canada (DFO), Science Branch, operates three principal facilities in the Pacific Region: the Pacific Biological Station (PBS), the Institute of Ocean Sciences (IOS), and the West Vancouver Laboratory (WVL). These facilities are located in Nanaimo, Sidney and West Vancouver, British Columbia (BC), respectively. Dr. Carmel Lowe is the Regional Director of Science. The Divisions and Sections are as follows:

Division Heads in Science Branch reporting to Dr. Lowe are:

Canadian Hydrographic Service	Mr. David Prince
Ocean Science	Ms. Kim Houston
Aquatic Diagnostics, Genomics & Technology	Dr. Nathan Taylor
Ecosystem Science	Dr. Eddy Kennedy
Aquatic Resource Research and Assessment	Dr. John Holmes

Section Heads within the Aquatic Resource Research and Assessment Division (ARRAD) are:

Offshore (mostly Groundfish)	Mr. Greg Workman
Inshore (mostly Invertebrates)	Ms. Lynne Yamanaka
Quantitative Assessment Methods	Dr. Robyn Forrest
Fisheries and Assessment Data	Mr. Bruce Patten
Salmon Assessment	Ms. Arlene Tompkins

Science Branch in the Pacific Region underwent a major re-organization during 2016 in an effort to better position itself to address its evolving and expanding mandate and distribute staff more evenly amongst divisions. Of particular note is the creation of the Ecosystem Science Division (ESD) with a mandate to focus on Ocean Act priorities (Marine Spatial Planning, Ocean Protection Program, Ecosystem Effects, etc), consolidation of all the fisheries related science in the Aquatic Resource Research and Assessment Division (ARRAD), and consolidation of Science “Services” in the Aquatic Diagnostics, Genomics & Technology Division (ADGT) (Schlerochronology Lab, Genetics, Animal health, Aquarium services). Groundfish research and stock assessment are now conducted amongst the Offshore, Fisheries and Assessment Data, and Quantitative Methods Sections within ARRAD. Groundfish specimen ageing is conducted in the Applied Technologies Section in ADGT. Acoustic fisheries research and surveys are led by the Ecology and Biogeochemistry Section in the Ocean Sciences Division.

The Canadian Coast Guard operates DFO research vessels. These research vessels include the *J.P. Tully, Vector*, and *Neocaligus*. The principle vessel used for groundfish research for the last 31 years, the *WE Ricker,* suffered a catastrophic failure of its main trawl winches during the West Coast Vancouver Island Synoptic Bottom Trawl Survey. Subsequent failures of key vessel systems have resulted in decommissioning of the ship. The replacement vessel for the *W.E. Ricker,* the *Sir John Franklin* is currently under construction with delivery anticipated in the spring of 2018. At sea operations for groundfish surveys during 2017 will be conducted aboard chartered commercial fishing vessels.

The Pacific Region Headquarters (RHQ) of Fisheries and Oceans Canada is located in Vancouver, British Columbia. Management of groundfish resources is the responsibility of the Pacific Region Groundfish Regional Manager (Mr. Neil Davis) within the Fisheries and Aquaculture Management Branch (FAM). Fishery Managers receive assessment advice from ARRAD through the Canadian Centre for Scientific Advice Pacific (CSAP) review committee which is headed by Ms. Lesley MacDougall. Historically Groundfish held at least two meetings per year, in which stock assessments or other documents underwent scientific peer review (including external reviewers who are often from NOAA). The resulting Science Advisory Report summarizes the advice to Fishery Managers, with the full stock assessment becoming a Research Document. Both documents can be viewed on the Canadian Stock Assessment Secretariat website: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm. The future frequency of review meetings and production of stock assessment advice for fisheries managers will depend on departmental, branch and regional priorities potentially resulting in less frequent advice.

The Trawl, Sablefish, Rockfish, Lingcod, North Pacific Spiny Dogfish, and Halibut fishery sectors continue to be managed with Individual Vessel Quotas (IVQs). IVQs can be for specific areas or coastwide. Within the general IVQ context, managers also use a suite of management tactics including time and area specific closures and bycatch limits. Details for the February 2016 Groundfish Integrated Fisheries Management Plan can be viewed at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.html#Groundfish.

Allocations of fish for financing scientific and management activities are identified in the Groundfish Integrated Fisheries Management Plan. Joint Project Agreements (JPAs) were developed for 2016-17 between Fisheries and Oceans Canada and several partner organizations to support groundfish science activities through the allocation of fish to finance the activities. These JPAs will be updated for 2017-18.

Surveys

A number of multi-species surveys are conducted by the Groundfish Section and Groundfish staff participate in surveys conducted by other groups. For a summary of all research survey activity in 2016, please see Appendix 1.

Reserves

Nothing to report for 2016.

Review of Agency Groundfish Research, Assessment and Management

Hagfish

Research

An experimental fishery has been conducted since 2013. The experimental program consist of three elements: 1) a systematic depth stratified survey in each of the 3 area pairs (PFMAs 23/123, 25/125, and 8-9/108-109); 2) experimental fishing to fixed effort caps in each of the area pairs; and 3) monitoring the previously selected index site within PFMA 23 (Kirby Point).

The sequence of activities intended during the initial development of the science program was to undertake a survey in each of the area pairs and conduct an initial sampling at the Kirby Point site prior to commencing the depletion experiment; once these two activities were completed experimental fishing could then start with subsequent surveys occurring every 6 months. The reason for doing the surveys and sampling first is to establish a baseline snap-shot of the species distribution, relative abundance and biological condition prior to removals. It was anticipated that once experimental fishing began, changes (reductions) in survey and fishery CPUE would be detectable after some period of fishing. The levels of effort authorized for the experimental fishery should be sufficient to impose a detectable signal in the CPUE data that should make it possible to generate a depletion estimate of abundance, at least for the locations where fishing is taking place.

Assessment

An initial summary of the experimental fishery was compiled by DFO staff and further developed by a Fisheries consultant contracted by the proponent of the experimental fishery. Both reports noted significant gaps in compliance with the experimental protocol, with limited depletion detectable due to early termination of fishing activities or movement of the participating vessel to unauthorized areas.

Management

In light of the above findings as well as fulfillment of the three year term of the experimental agreement, the proponent has been directed to develop a new proposal for review by the department before further experimental fishing will be authorized.

Dogfish and other sharks

1. Research

Ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, recreational creel surveys. Anecdotal information continued to be collected through the Shark Sightings Network.

2. Assessment

In May 2016, Basking Shark critical habitat was evaluated in the form a CSAP Science Response document. Basking Shark are currently listed under SARA as an Endangered species. Both a Recovery potential assessment (DFO 2009) and a Recovery Strategy have been completed for this species (DFO 2011). The Recovery Strategy notes that “Adequate information does not exist to identify critical habitat at this time” (p. iii). A schedule of studies was identified in the Recovery Strategy, outlining research required to contribute to the future identification of critical habitat, with the recognition that it “may take decades to address the issue of identifying critical habitat, given the long lived nature of the species, a lack of documented recent sightings in Canada, and the associated long-term scope of this recovery strategy” (p. iii).

The Science Response reviewed the available information that would support the identification of habitat necessary for the survival and recovery of Basking Shark within Canadian Pacific waters. The conclusion was that, aside from foraging, the biological functions of Basking Shark that are supported by habitat in BC waters remain unknown. Spawning, nursery, and rearing locations remain undocumented throughout the geographic range for this population. Through modeling, areas of high primary productivity have been identified; however, they do not correlate with copepod productivity. The low resolution of zooplankton data and the low numbers of Basking Shark observations do not support identification of foraging habitat. No recommendation could be made regarding the habitat needed for survival and recovery of Basking Sharks within Canadian Pacific waters.

Skates

3. Research

Ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

Pacific cod

4. Research

Ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys. Collection of DNA was initiated during 2015 in the spawning areas of Hecate Strait (PSMFC Area 5D) and continued in 2016.

Walleye pollock

5. Research

There is no directed work being conducted on Walleye Pollock, but ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

6. Assessment

Work was started on assessing Walleye Pollock along BC’s outer coast, excluding the waters in the Strait of Georgia. Saunders et al. (1988) identify four primary spawning grounds in BC waters – Dixon Entrance/northern Hecate Strait, Queen Charlotte Sound, SW Vancouver Island, and the Strait of Georgia. These are illustrated by the highest capture rates from the commercial trawl fishery (bottom + midwater, averaged over 1996-2016, *Figure* ***Error! No text of specified style in document.****.3*), which occur in Dixon Entrance (perhaps as part of a larger SE Alaska population, Thompson 1981), upper

Moresby Gully, off Juan de Fuca Strait (gyre in summer), and in the Strait of Georgia (two discrete patches north and south). The assessment is due for delivery in May 2017.

7. Management

Walleye Pollock is an IVQ (individual vessel quota) species with a 2016 TAC (total allowable catch) of 4,225 t coastwide (1,115 t in the Strait of Georgia, 1,790 t in 5AB + area 12, and 1,320 t in 5CDE). Area 3CD + area 20 did not receive an official TAC. Commercial total allowable catch for various groundfish species were allocated between the different groundfish sectors; however, Pollock was entirely (100%) allocated to the Trawl sector.

To support groundfish research and account for unavoidable mortality incurred during the 2016 Groundfish Trawl multi-species surveys planned for the west coast of Vancouver Island (WCVI, Groundfish Management Area or GMA 3C/D) and west coast of Haida Gwaii (WCHG, GMA 5E), 1.3 t and 0.3 t, respectively were accounted for before defining the Groundfish Trawl TACs.

Vessels on dedicated offshore Pacific Hake trips without an at-sea observer on board were permitted a by-catch allowance of Walleye Pollock restricted to thirty (30) percent of the offshore Hake trip landings. Any catch (other than Hake) in excess of the set allowance was relinquished. All by-catch was deducted from the vessel’s IVQ holdings. Fishers who retained more than the by-catch allowance while on dedicated Hake trips were obliged to carry at-sea observers for those trips.

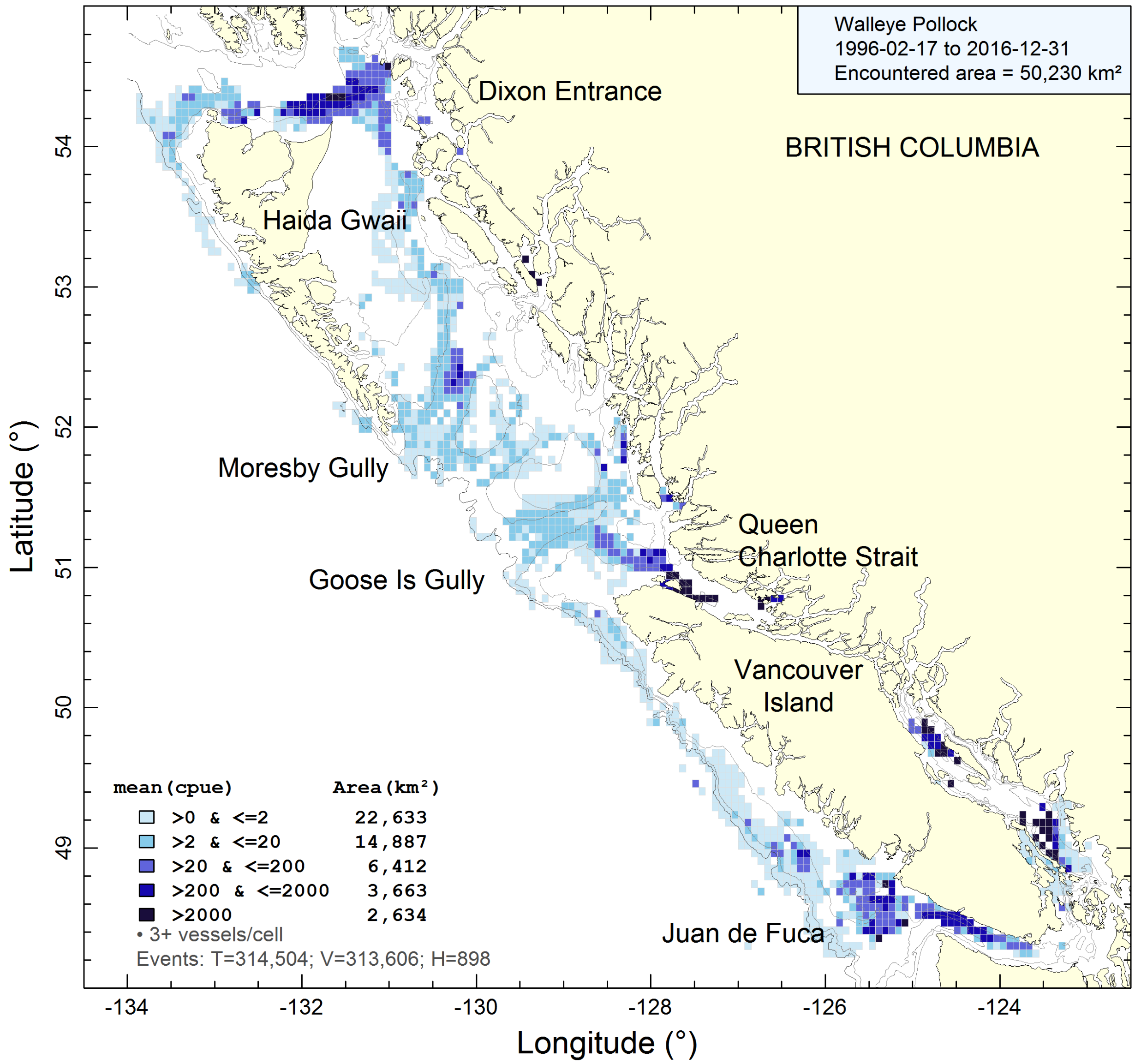


Figure ***Error! No text of specified style in document.****.3. Aerial distribution of Walleye Pollock mean trawl tow catch per unit effort (kg/hour) from Feb 17, 1996 to Dec 31, 2016. Isobaths show the 100, 200, and 500 m depth contours. Note that cells with <3 fishing vessels are not displayed. Each cell represents, on average, 32 km^2.*

Pacific whiting (hake)

8. Research

In British Columbia there are two commercially harvested and managed stocks of Pacific Hake. The offshore stock is the principle target of the commercial fishery comprising the bulk of landings year over year. A smaller and discrete stock residing within the Strait of Georgia is targeted episodically when market demand is sufficient and the available fish are larger enough for processing.

From 1995 – 2001, the offshore stock was been the target of triennial acoustic surveys. From 2001 onwards, the surveys have occurred biennially, covering the known extent of the offshore Pacific Hake stock, ranging from California to northern British Columbia. There was no survey in 2016, as it was an in-between year.

There has been a biennial acoustic survey for Pacific Hake in the Strait of Georgia since 2011. Methods are currently being developed to calculate a biomass estimate for these surveys, which will then be used as the primary index of abundance for the stock assessment. The 2017 survey was cancelled due to the decommissioning of the *C.C.G.S W.E. Ricker*, but there is a plan to continue the time series in 2018 with the new Offshore Fisheries Science Vessel.

Assessment

As in previous years, the 2016 assessment and the 2017 harvest advice was prepared jointly by Canadian and U.S. scientists working together as part of the Joint Technical Committee (JTC) of the Pacific Hake/Whiting Agreement between the Governments of the United States and Canada. The assessment model used was Stock Synthesis 3 (SS3). The 2017 model had the same model structure used in 2016, with updates to catch and age compositions. The 1995 survey index, which was not included in the 2016 assessment, was re-introduced in 2017, along with slight modifications to the 1998 and 2015 indices. These changes had little effect to model outcome.

An apparent very large cohort of age-2 hake was caught in the fishery, which caused the model to predict the highest biomass ever seen by a factor of nearly 2, but with very large uncertainty. This seemed implausible and was addressed by the JTC by allowing the time-varying selectivity parameters more freedom in the estimation. This reduced the predicted biomass but increased the differences in selectivity between years when compared to the 2016 model. However, the differences in selectivity are thought to be a real effect, due to targeting of cohorts by the fisheries.

There has not been an assessment of Pacific Hake in the Strait of Georgia, although the recent increases in catch may warrant one.

Management

Since 2011, management of Pacific Hake has been accomplished under a treaty between Canada and the United States known as the Pacific Hake/Whiting Agreement ("The Agreement"). The stock is managed by the Joint Management Committee (JMC) which is made up of fisheries managers and industry representatives from both the U.S. and Canada. These managers receive advice from the JTC and the Scientific Review Group (SRG), which is a committee responsible for the scientific review of the assessment.

The total Canadian TAC for 2016 was 129,947 t including a carryover of 15,020 t. The shoreside/freezer trawler sector was allocated 114,947 t of this and caught 69,741t (53.7% of total TAC). The Joint Venture (JV) fishery received a quota of 15,000 t in 2016, but did not choose to participate in the fishery. The majority of the Canadian

Pacific Hake catch for the 2016 season was taken from the west coast of Vancouver Island.

The final decision on catch advice for the 2017 fishing season was made at the meeting of the International Pacific Hake JMC in Lynwood, Washington on Feb. 28 – Mar. 2, 2017. A coastwide TAC of 597,500 t for 2017 was agreed upon. As laid out in the treaty, Canada will receive 26.12% of this, or 156,067 t. Managers will choose how to allocate this between the domestic and joint venture fisheries as the season progresses.

The final assessment document and other treaty-related documents are posted at: http://www.nwr.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html

Management of Strait of Georgia Pacific Hake has been implemented as ad-hoc quota allocation throughout the history of the fishery. Typical catch for the Strait has been approximately 10 - 40 metric tonnes for many years, but has seen a dramatic increase in the last few years. In 2014 the total catch was 2,774 t, in 2015 it was 4,962 t, and in 2016 it was 10,079 t. The TAC for 2016 was set at 7,000 t.

Grenadiers

9. Research

There is no directed work being conducted on Grenadiers but ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

Rockfish

10. Research

For research and assessment purposes, populations of rockfish (*Sebastes*) species are broadly grouped as “inshore” (shallow regions near shore that are accessible by many fisher groups) and “offshore,” with “offshore” further divided into “shelf” and “slope” (BC’s continental shelf and slope, often only accessible by the commercial industry). Ongoing data collection in support of directed work on rockfish continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

DFO tackles a variety of issues related to rockfish in addition to assessment needs: COSEWIC (Committee on the Status of Endangered Wildlife in Canada) listing requirements, oceanographic exploration, software development for the R statistical platform (https://github.com/pbs-software), and scientific research in marine ecological modelling. For stock assessment, DFO collaborates with outside contractors from agencies such as the Canadian Groundfish Research and Conservation Society and The School of Resource and Environmental Management at Simon Fraser University.

Inshore Rockfish Surveys on the Inside (PMFC Area 4B)

A DFO research longline survey was designed and initiated in 2003 to survey hard bottom (non-trawlable) areas over the Inside waters east of Vancouver Island (Strait of Georgia). Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records, and consultations with fishers. The hard bottom areas were overlain with a 2 km by 2 km grid and survey blocks were stratified by area and depth (41–70 m and 71 –100 m) and randomly selected for sampling (Lochead and Yamanaka 2004; 2006; 2007). The Inside waters are divided into two regions, Northern and Southern, and one region is surveyed each year. Twenty-three days of DFO ship time were allocated for the longline survey in the Northern region in August 2016. The Southern region is due to be surveyed over 25 days in July-August 2017. For complete details see Appendix 1.

Inshore Rockfish Surveys on the Outside (PMFC Areas 3CD, 5ABCDE)

Since 2003, the International Pacific Halibut Commission (IPHC) has allowed a third technician onboard charter vessels during the Area 2B setline survey to collect hook-by-hook catch data and conduct biological sampling of non-Halibut catch (e.g. Flemming et al. 2012). Funding for this third technician on the IPHC survey has evolved from industry sources to DFO National budgets through the survey series, with the exception of 2013 where no funding mechanism was available to fund the surveys. Since 2014, the survey program has been conducted under a “Use-of-Fish” DFO policy in conjunction with a Collaborative Agreement which outlines this project and includes responsibilities for the IPHC, the Pacific Halibut Management Association (PHMA) and DFO. For complete details see Appendix 1.

In collaboration with industry (PHMA), a research longline survey was designed and conducted in the outside BC coastal waters in 2006. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records, and fishermen consultations. The hard bottom survey areas were overlain with a 2 km by 2 km grid (matched with the adjacent trawl survey grid) and survey blocks were stratified by area and depth and chosen at random. 198 survey sets are targeted annually. The survey covers the coastwide outside waters over two years, alternating annually between the north and the south. Three chartered fishing vessels have conducted this survey annually between August 15 and September 15 with the exception of 2013. Similar to the IPHC survey, this survey program is conducted under a “Use-of-Fish” policy and Collaborative Agreement with the PHMA. For complete details see Appendix 1.

Both the IPHC and PHMA Collaborative Agreements are scheduled for renewal in 2017. The IPHC will conduct survey work over 170 fixed stations in BC. The PHMA will conduct surveys over the northern portion of B.C..

Inshore Rockfish: Assessment of Rockfish Conservation Areas (RCAs) using visual surveys

Late in 2014, competitive funding for three years was granted to continue the analysis of the visual data to assess inshore rockfishes within and adjacent to RCAs. A PhD thesis (Haggarty 2015) was completed in 2015, while documentation of survey methods and two additional papers were completed in 2016 (see Section VII Publications).

Slope Rockfish

In anticipation of upcoming assessments, ageing was initiated on 6,564 Redstripe Rockfish otoliths from commercial trips and/or research surveys for 1994, 1996, 1999-2015.

Genetic work on separating the Rougheye Rockfish complex (Rougheye Types I and II or the Rougheye/Blackspotted complex) was initiated in 2010 and is planned to continue in 2017. Tissues samples are processed annually; aging of specimen sampled for DNA was initiated in 2016 in anticipation of completing an assessment by 2020.

Literature Cited:

Flemming, R.G., Yamanaka, K.L., Cooke, K., and Dykstra C. 2012. Summary of non-Halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from June 3 to August 27, 2010. Can. Tech. Rep. Fish. Aquat. Sci. 2989: viii + 99 p.

Haggarty, Dana Rochelle. An evaluation of the effectiveness of rockfish conservation areas in British Columbia, Canada. Diss. University of British Columbia, 2015.

Lochead, J.K. and Yamanaka, K.L. 2007. Summary report for the inshore rockfish (Sebastes spp.) longline survey conducted in Statistical Areas 14 to 20, 28 and 29, August 11 – September 6, 2005. Can. Tech. Rep. Fish. Aquat. Sci. 2690: viii + 53 p.

Lochead, J.L. and Yamanaka, K.L. 2006. Summary report for the inshore rockfish (Sebastes spp.) longline survey conducted in Statistical Areas 12 and 13, August 24 – September 10, 2004. Can. Tech. Rep. Fish. Aquat. Sci. 2627: ix + 65 p.

Lochead, J.L. and Yamanaka, K.L. 2004. A New Longline Survey to Index Inshore Rockfish (Sebastes spp.): Summary Report on the Pilot Survey Conducted in Statistical Areas 12 and 13, August 17 – September 6, 2003. Can. Tech. Rep. Fish. Aquat. Sci. 2567: 59 p.

Assessment

a) Yelloweye Rockfish

A stock assessment for the Outside population of Yelloweye Rockfish in 2014 was reviewed by the Canadian Science Advisory Secretariat in September 2015. The Science Advisory Report from this process is available at: http://www.dfo-mpo.gc.ca/csas-sccs/publications/sar-as/2015/2015_060-eng.pdf. A synopsis of the assessment was presented in the 2016 TSC report, revisions to that research document have been finalized and publication on the CSAS website is anticipated during 2017.

The assessment suggests that the stock has continued to decline, despite more than a decade of rockfish conservation measures. Increases in Yelloweye Rockfish density have not yet been seen in Rockfish Conservation Areas, but given the low productivity of this species, benefits are not expected to be detected until at least 10 years after their closure.

Slope Rockfish

Work was started on an update assessment for Pacific Ocean Perch in PMFC area 5ABC. This stock was last assessed in 2010 and the assessment concluded that the spawning biomass at the start of 2011 had a probability of 0.96 or 0.82 of being above the limit reference point $0.4B_{\mathrm{MSY}}$, and of 0.68 or 0.24 of being above the upper stock reference point $0.8\ B_{\mathrm{MSY}}$, depending on the model (estimate M and h vs. fix M=0.06 and estimate h). The spawning biomass depletion was estimated to be 0.26 (0.12-0.43) or 0.14 (0.08-0.24), where amounts in parentheses represent the 5 to 95% credible intervals derived from Bayesian output. The 2010 assessment resulted in a reduction of TAC for 5ABCD from 4,188 t to 3,413 t over 3 years, starting in 2011. The 2016 assessment, due in June 2017, should see if this reduction made any difference to the stock status.
Rougheye Rockfish (types I and II) were designated “Special Concern” by COSEWIC in 2007. A pre-COSEWIC report has been requested and is currently being prepared and is scheduled for presentation through CSAP in 2017. A full assessment has been requested, but is on hold until more genetics and aging work has been completed, and pending the outcome of the COSEWIC review.

Management

b) Inshore Rockfish

Management, in consultation with the commercial industry, will step down the current Outside Yelloweye Rockfish Total Allowable Catch (TAC) over the next three years to bring harvests from 290 t to 100 t by the 2018/19 fishing year. An industry proposal for a more spatially explicit quota apportionment was adopted by management, which shifts the current apportionment slightly to better match higher TACs with areas of higher survey CPUE. Similarly, recreational bag limits have been reduced from 3 to 2 Yelloweye Rockfish in the north and from 2 to 1 in the south.

Yelloweye Rockfish was listed as Special Concern under the SARA in 2011 and DFO is currently developing a SARA management plan. Yelloweye Rockfish is up for reassessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2018.

Subsequent to public consultations in 2012, the Minister of Environment has not made a decision on whether to list Quillback Rockfish as *Threatened* under Canada’s *Species At Risk Act* (SARA). Quillback Rockfish remain unlisted in 2015. Quillback Rockfish is up for reassessment by the COSEWIC by November 2019.

Slope Rockfish

Pacific Ocean Perch is an IVQ (individual vessel quota) species with a 2016 trawl TAC (total allowable catch) of 5,192 t coastwide (750 t in 3CD, 1,687 t in 5AB, 1,544 t in 5C, and 1,200 t in 5DE). Commercial total allowable catch for various groundfish species were allocated between the different groundfish sectors; Pacific Ocean Perch was allocated 99.98% to the Trawl sector and 0.02% (1 t coastwide) to the ZN hook and line sector.

To support groundfish research and account for unavoidable mortality incurred during the 2016 Groundfish Trawl multi-species surveys planned for the west coast of Vancouver Island (WCVI, Groundfish Management Area or GMA 3C/D) and west coast of Haida Gwaii (WCHG, GMA 5E), 15.3 t and 41.8 t, respectively were accounted for before defining the Groundfish Trawl TACs.

An area called Tide Marks (near Goose Island Gully) was closed to all trawling from Feb 21, 2016 to May 31, 2016 and from Oct 1, 2016 to Mar 31, 2017 to reduce harvesting pressure on Pacific Ocean Perch stocks during the spawning period.

In 2016, an assessment for Silvergrey rockfish was finalized and published through the Canadian Science Advice Secretariat (CSAS). The working paper was prepared and reviewed in 2015.

Thornyheads

11. Research

In anticipation of upcoming assessments, ~500 Longspine Thornyhead otoliths were selected for ageing after stratifying by length bin from the combined Thornyhead surveys (2001-2003). The final otolith sample: 70 (5-10cm), 97 (10-15 cm), 97 (15-20 cm), 97 (20-25 cm), 97 (25-30 cm), and 43 (30-35 cm). These data will perhaps contribute to estimating growth parameters for a delay-difference model.

Assessment

No Thornyhead assessments were conducted in 2016. Longspine Thornyhead was designated “Special Concern” by COSEWIC in 2007. It is anticipated that an assessment may be requested in the near future.

Management

Longspine and Shortspine Thornyhead are both IVQ species with a 2016 coastwide TAC (total allowable catch) of 425 t and 769 t, respectively. Commercial TACs for various groundfish species were allocated between the different groundfish sectors; Longspine Thornyhead was allocated 95.35% to the Trawl sector, 2.29% to the ZN hook and line sector, and 2.36% to the Halibut sector; Shortspine Thornyhead was allocated 95.40% to the Trawl sector, 2.27% to the ZN hook and line sector, and 2.33% to the Halibut sector.

To support groundfish research and account for unavoidable mortality incurred during the 2016 Groundfish Trawl multi-species surveys planned for the WCVI and the WCHG, 0.8 t and 3.3 t, respectively were accounted for before defining the Groundfish Trawl TACs for Shortspine Thornyhead. The adjustment for Longspine Thornyhead was only 0.4 t for the WCHG survey.

Sablefish

12. Research

The Sablefish management system in British Columbia is an adaptive ecosystem-based approach in which three pillars of science – hypotheses, empirical data, and simulation - play a central role in defining management objectives and in assessing management performance relative to those objectives via Management Strategy Evaluation (MSE) processes. Objectives relate to outcomes for three categories of ecosystem resources: target species (TS), non-target species (NTS), and Sensitive Benthic Areas (SBAs). The MSE process is used to provide management advice each year that supplements the stock assessment process by providing a way to explicitly evaluate harvest strategies given a set of stock and fishery objectives and uncertainties/hypotheses about Sablefish fishery and resource dynamics. Fisheries and Oceans Canada (DFO) and Wild Canadian Sablefish Ltd. have collaborated for many years on fisheries management and scientific research with the aim of further supporting effective assessment and co-management of the Sablefish stock and the fishery in Canadian Pacific waters.

Fishery independent research includes the following activities:

c) A Stratified Random Survey using Longline Trap Gear (2003-2016)

This activity captures Sablefish for tagging and release following a depth and area stratified random survey design. Tag-recoveries are used for deriving estimates of gear selectivity and studying Sablefish movement. The catch rate data are used to derive an index of stock abundance. The survey also provides biological samples for determination of life history characteristics for Sablefish and non-target species (e.g., Blackspotted and Rougheye Rockfish.

d) An Inlets Survey using Longline Trap Gear (1995-2016)

This activity includes standardized sets at four (4) mainland inlet localities on coastal British Columbia (excludes Vancouver Island). Sablefish are tagged and released from inlet sets and are sampled for biological data.

Sablefish research surveys are planned for the fall of 2017 contingent on the availability of resources.

A new introduction to both surveys (a, b) in 2013-2016 was the deployment of (1) tri-axial accelerometers that produce measurements of quasi-continuous 3-axis motion and orientation of fishing traps, (2) deep-water autonomous cameras affixed to traps that produces motion-activated and fixed-interval high definition video of benthic substrate type, gear interaction with the substrate, and biological communities; and (3) standard oceanographic probes that measure in-situ depth and temperature data needed for gear mobility (depth) and habitat suitability modeling (both). This novel equipment will be deployed for the 2017 survey, and has been deployed on commercial trap gear fishing trips to SGaan Kinghlas-Bowie Seamount over the 2013-2016 period.

13. Assessment

The Sablefish operating model (OM) was revised in 2015/16 to account for potential structural model mis-specification and lack-of-fit to key observations recognized in previous models. Specific modifications include: (i) changing from an age-/growth-group operating model to a two-sex/age-structured model to account for differences in growth, mortality, and maturation of male and female Sablefish, (ii) adjusting model age-proportions via an ageing error matrix, (iii) testing time-varying selectivity models, and (iv) revising the multivariate-logistic age composition likelihood to reduce model sensitivity to small age proportions. Structural revisions to the operating model improved fits to age-composition and at-sea release data that were not well-fit by the previous operating model. Accounting for ageing errors improved the time-series estimates of age-1 Sablefish recruitment by reducing the unrealistic auto-correlation present in the previous model results. The resulting estimates clearly indicate strong year classes of Sablefish that are similar in timing and magnitude to estimates for the Gulf of Alaska. Two unanticipated results were that (i) time-varying selectivity parameters were not estimable (or necessarily helpful) despite informative prior information from tagging and (ii) improved recruitment estimates helped to explain the scale and temporal pattern of at-sea release in the trawl fishery. The latter finding represents a major improvement in the ability to assess regulations (e.g., size limits) and incentives aimed at reducing at-sea releases in all fisheries. Estimates of Sablefish stock status, productivity, and trends over the past several years are consistent with previous harvest strategy simulations.

In 2016/17 the updated operating model was used to generate simulated data to test the current and alternative management procedures (MPs). The joint posterior distribution of spawning biomass and stock-recruitment steepness was used to generate five scenarios that captured a range of hypotheses related to current spawning biomass and productivity. The effects of the new recruitment estimates and impacts of sub-legal mortality were much greater than estimated from the 2011 analyses (Cox et al. 2011), and estimated management parameters indicated a less productive stock. Estimates of fishing mortality on sub-legal fish were much higher than those based on the 2011 operating model (DFO 2016).

Simulations showed that the current MP (DFO 2014) may not be robust in the long-term under the revised operating model (DFO 2016) since productivity estimates from the revised OM are lower than previously estimated (Cox et al.[1]). As a result, a maximum harvest rate of 5.5%, which was typically less than stock assessment model estimates

---

[1] Cox, S., Holt, K., and Johnson, S. Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18. CSAP Working Paper 2014GRF08. *In revision*

of the harvest rate of at maximum sustainable yield, U_{MSY}, used in the current MP, was tested in the alternative MPs. Improving long-term conservation performance usually involves trade-offs between short-term and long-term yield; however, the TAC floor in the current MP limits the scope for adjusting performance in any time period. Alternatives to the current MP were derived based on combinations of TAC floors (0, 1,800, 1,992 t), phase-in periods over which new, lower maximum harvest rates are introduced (0, 3, 4, and 5 years), and sub-legal release regulations (all Sablefish < 55 cm fork length, full retention and accounting against TAC of all Sablefish caught, regardless of size). The alternative MPs also included a constraint on upward TAC changes in which TACs remain at a particular level until the recommended TAC increase is at least 200 t. This change was requested by industry to limit unnecessary upward movement in TACs. The alternative MPs also differed from the current MP in the level of tuning used to define prior distributions for U_{MSY} and MSY in the simulated stock assessment: they were given tighter and more precise prior distributions for these parameters to reflect the corresponding reductions in these values for the revised OM. The revised operating model continues to assume that the BC Sablefish stock is a closed population, despite evidence of movements among Sablefish stocks in Alaska and US waters south of BC. These movements may have implications for the assumptions made about Sablefish stock dynamics in BC (i.e., recruitment, productivity) that are not currently captured by the revised OM or reflected in MP performance evaluations.

Literature Cited:

Cox, S.P., Kronlund, A.R., Lacko, L. 2011. Management procedures for the multi-gear sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/063. viii + 45 p.

DFO. 2014. Performance of a revised management procedure for Sablefish in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/025.

DFO. 2016. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

14. Management

In 2013, fishing industry stakeholders proposed a TAC floor of 1,992 t, because lower quotas may increase economic risks. The management procedure first applied in 2010 was revised to implement this TAC floor and simulation analyses were conducted to determine whether the revised management procedure would continue to meet agreed conservation objectives. The revised procedure provides conservation performance that is comparable to the 2010 procedure. Applying the revised procedure to updated landings and biomass index data resulted in a harvest recommendation of 1,992 t for the 2016/17 fishing season. However, as a result of lower productivity estimates derived from the revised operating model and tested in 2016/17, the TAC floor could no longer be supported in the harvest control rule because long-term stock growth objectives could not be met in simulations. The current MP was replaced by a revised MP that does not include a TAC floor and phases in a reduction in the annual harvest rate from 9.5% to 5.5% over five years; the resulting TAC for the 2017/18 fishing year is 2,276 t. Although MPs with full retention Sablefish regardless of size showed superior performance against objectives, these alternatives could not be implemented for the 2017/18 fishing season and will be evaluated further in 2017/18. An update of the MSE simulation work is planned for 2019/20.

Lingcod

15. Research

Ongoing data collection continued in 2016 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

2. Assessment

In 2016, an assessment for Strait of Georgia lingcod was finalized and published through the Canadian Science Advice Secretariat (CSAS); the working paper was prepared and reviewed in 2014.

Atka mackerel

The distribution of Atka mackerel does not extend into the Canadian zone.

Flatfish

3. Research

Ongoing data collection in support of the flatfish research program continued in 2016 through the Groundfish Synoptic Surveys, port sampling, and at-sea observer sampling.

Assessment

In 2016, an assessment for Southern Rock sole was finalized and published through the Canadian Science Advice Secretariat (CSAS)

In anticipation of a request for an updated assessment aging of Dover sole otoliths was completed in 2016. Dover sole was last assessed in 1999.

Work initiated in 2015 to prepare an updated assessment for Petrale sole remains on hold until additional personnel resources can be assigned. In addition, the time series of ages needs to be updated.

Management

Arrowtooth Flounder, Sothern Rock Sole, English Sole and Petrale sole are all managed by annual coastwide or area specific TACs and harvested primarily by the IVQ multi-species bottom trawl fishery. Details of the current management plan are available at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.html#Groundfish.

Pacific halibut & IPHC activities

Pacific halibut caught incidentally by Canadian groundfish trawlers are measured and assessed for condition prior to being released. Summaries of these length data are supplied annually to the IPHC. In addition, summaries of live and dead releases (based on condition) are provided.

Other groundfish species

Ecosystem Studies

A. Development of a tiered approach to the provision of harvest advice for B.C.'s groundfish

Many species of groundfish in B.C. are data deficient, such that the available data are inadequate to support complex stock assessment models. However, DFO's Sustainable Fisheries Framework (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm) requires the provision of science advice on the status of, or risks to, species of groundfish affected by fishing activities.

Work was initiated on this project in 2015. In 2015 – 2016, a literature search and annotated bibliography was completed, looking at work on tiered approaches in other international jurisdictions. In May 2016, CSAP hosted a workshop focusing on the creation of a Tiered Approach framework for assessing groundfish stocks. The meeting included discussions on a proposed hierarchical system based on data (using a scorecard to assess data availability, quality, and reliability), candidate references points, and candidate performance metrics. Significant time was spent on the issue of data-limited species.

The workshop presented existing "Tiered Approaches" from four international jurisdictions, and compared the supporting data requirements and expected outputs (including advice types). Additionally, the federal Alaskan experience was presented by a NOAA representative. Lessons learned from other jurisdictions were reviewed and appreciated by RPR participants.

A candidate data scorecard was created for assessing data availability (quantity and quality) within four sectors – commercial, recreational, First Nations, and fishery-independent. The scorecard was presented and accepted as a means of classifying species as data-rich, datamoderate, or data-poor, and communicating this information.

A candidate five-tier system was presented as a tool to communicate data availability by species and determine the path forward for decision-making regarding stock assessment advice. Tier 1 (data-rich) would use statistical catch-age models and Tier 2 (data-moderate) would use statistical "delay-difference" and/or surplus production models. Tiers 3 (data-limited), 4 (data-poor), and 5 (data-less) would be amalgamated for analysis and use various datalimited methods, selected using closed-loop simulation methods. The most likely candidate for running the closed-loop simulations is DLMtool, which incorporates numerous peer-reviewed assessment methods. DFO Science staff agreed to conduct further scoping of DLMtool to determine its suitability in this context.

Candidate management objectives and performance metrics were presented using examples from Sablefish, Pacific Halibut, and those built into DLMtool. The RPR group were not able to select further performance metrics, and a recommendation was made to proceed with the examples from Sablefish as a starting point.

Participants endorsed the development of a technical working (advisory) group (TWG), and recommended that a work plan and timelines be developed to help determine the appropriate membership for the TWG. It is expected that the TWG will assist with the completion of the decision tree, management objectives, performance metrics, simulation exercises, and evaluation, all contributing to the second CSAS working paper to be reviewed in a subsequent CSAS regional peer review.

The workshop also established that the TA project would not be conducting a full management strategy evaluation (MSE) initially, but will apply closed-loop simulation testing of management procedures to test the robustness of various assessment methods against performance metrics. The RPR group acknowledged that stakeholders and First Nations make credible and valuable contributions to full MSE processes, but this procedure was beyond the scope of the current TA project. The RPR group also recognized that the TA project could not at this time incorporate important aspects such as the multispecies nature of the fisheries, ecosystem effects, or climate change effects.

Other related studies

B. Ecosystem Approach for single-species assessments

In November, 2016, DFO's TESA (Technical Expertise in Stock Assessment) sponsored a week-long working group on implementing an Ecosystem Approach in single-species stock assessment. DFO scientists from across Canada convened in Nanaimo to present some of their research and to form break-out groups to develop working examples for three models – data-poor, data-rich, and data-alternative. The data-poor group adopted DLMtool and used Darnley Bay Arctic Charr to explore how climate-change shifts in life history parameters would affect the stock. The data-rich group used a traditional catch-at-age model (Stock Synthesis 3) to explicitly model multivariate physical and biological factors on Atlantic Herring off western Newfoundland and time-varying natural mortality on Atlantic Cod in the Gulf of St. Lawrence. The data-alternative group adopted Empirical Dynamic Modelling (Ye at al. 2015) to explore ecosystem effects on a Snow Crab population.

Groundfish Data Unit

As part of the Pacific Region Science reorganization that occurred in June 2016, the Groundfish Data Unit, previously operated as part of the Groundfish "Statistics and Sampling" program, was pulled out of the new "Offshore" section and placed in the new Fishery and Assessment Data Section (FADS). FADS incorporates data units from shellfish and salmon, as well as groundfish. However, the Groundfish Data Unit remains strongly linked to the Offshore section.

Principal Groundfish Data Unit activities in 2016 included the ongoing population of the groundfish biological database (GFBio), scanning and archiving "rescued" data, and answering internal and external requests for groundfish data.

The GFBio database now includes 27,520 trips and approximately 10,972,000 specimens. Data entry activities concentrated on input of recent and historic research cruises, and current commercial biological data from at-sea and dockside observers as well as the from the groundfish port sampler and groundfish staff.

The groundfish trawl fishery continues to be covered by 100% dockside and virtually 100% observer coverage. In 2016, the at-sea observer program (ASOP) provided 498 length/sex/age samples and 264 length samples. A further 92 samples of hake and salmonids were collected from the hake fishery by the dockside monitoring program (DMP); 70 of the hake samples had aging structures. In addition, the Groundfish Port Sampler collected four samples from the domestic hake fishery, all with ageing structures (length/sex/age/weight). Groundfish program staff collected 15 samples from the Strait of Georgia (Gulf) hake fishery; all samples had aging structures and DNA. Pacific Halibut and Pacific Hake accounted for 75% of the approximately 96,000 specimens sampled from the trawl fishery.

Biological samples from the non-observed sablefish trap fishery are collected by an external contractor with assistance from the Groundfish Port Sampler. Fish designated for sampling are set aside in totes labelled to identify individual sets. In 2016, 23 length/sex/weight/age samples were collected.

Biological samples from the hagfish experimental trap fishery are collected by an external contractor. In 2016, 73 length samples from three hagfish trips were collected.

An extensive data rescue project has been ongoing from 2014. This project has involved searching manuscript reports and data files for research and commercial biological and other data of enduring value. The goal is to convert all paper data to digital format, load historical trips into GFBio, scan and verify the paper records, and destroy the originals or send to the DFO library for permanent archiving. In 2016, about 60 historical trips (1944 – 1963) were recovered and loaded into GFBio, as well as 25 observer trips from 1991 – 1992. To date, the data rescue scan archive comprises about 9,777 files or 88 GB.

The Groundfish Data unit responded to about 40 internal and external data requests in 2016. Work continues on a comprehensive "merged catch" table that will include commercial catch records from all the groundfish catch databases. At the same time, government-wide initiatives to make data publically available are underway, which may help address many external requests in future.

Publications

C. Primary Publications

Haggarty, Dana R., Steve JD Martell, and Jonathan B. Shurin. 2016. Lack of recreational fishing compliance may compromise effectiveness of Rockfish Conservation Areas in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 73(10): 1587-1598.

Haggarty, Dana R., Jonathan B. Shurin, and K. Lynne Yamanaka. 2016. Assessing population recovery inside British Columbia's Rockfish Conservation Areas with a remotely operated vehicle. Fisheries Research 183: 165-179.

King, Jackie R., and A. Maria Surry. 2016. First record of Pacific Angel Shark (*Squatina californica*) in Canadian Pacific waters. Canadian Field-Naturalist 130(4): 302–303.

Other Publications

Berger, A.M., Grandin, C.J., I.G. Taylor, A.M. Edwards, and S. Cox. 2017. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2017. Prepared by the Joint Technical Committee of the U.S. and Canada Pacific Hake/ Whiting Agreement; National Marine Fishery Service and Fisheries and Oceans Canada. 202 p.

DFO. 2016. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

DFO. 2016. Evaluation of Information Available to Support the Identification of Habitat Necessary for the Survival and Recovery of Basking Shark in Canadian Pacific Waters. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/046.

DFO. 2016. Stock assessment of the coastwide population of Shortspine Thornyhead (*Sebastolobus alascanus*) for British Columbia, Canada in 2015. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/016.

Haggarty, D.R., R. Flemming, K. Cooke, N. Deleys and K.L. Yamanaka. 2016. Remotely operated vehicle surveys of rockfish conservation areas in British Columbia, February 2009-July 2011. Can. Tech. Rep. Fish. Aquat. Sci. 3189: iv + 147 p.

Holt, K., King, J. R., and Krishka, B.A. 2016. Stock Assessment for Lingcod (*Ophiodon elongatus*) in the Strait of Georgia, British Columbia in 2014. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/013. xi + 186 p.

Holt, K.R., Starr, P.J., Haigh, R. and Krishka, B. 2016. Stock Assessment and Harvest Advice for Rock Sole (*Lepidopsetta* spp.) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/009. ix + 256 p.

Starr, P.J., Haigh, R., and Grandin, C. 2016. Stock assessment for Silvergray Rockfish (*Sebastes brevispinis*) along the Pacific coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/049. v + 170 p.

Appendix 1

Summary of Fisheries and Oceans, Canada Pacific Region Groundfish Survey Program in 2016

TABLE OF CONTENTS

Groundfish Surveys Program Overview

The Fisheries and Oceans, Canada (DFO) Offshore Assessment and Monitoring section of the Aquatic Resources Research and Assessment Division includes a surveys program. The cornerstone of the surveys program comprises a suite of randomized surveys using bottom trawl, longline hook, and longline trap gear to cover most of the BC coast. All surveys use random depth stratified designs and in aggregate provide good coverage for all offshore waters of Canada's Pacific Coast. They also have in common full enumeration of the catches (all catch sorted to the lowest taxon possible), size composition sampling for most species, and more detailed biological sampling of selected species. Most of the surveys are conducted in collaboration with the commercial fishing industry under the authorities of various Joint Project Agreements. In addition to the randomized surveys, we also conduct a hydroacoustic assessment of Pacific Hake as well as collecting additional information from a DFO Small-Mesh Bottom Trawl Survey and the International Pacific Halibut Commission (IPHC) setline survey.

Each year two or three area-specific randomized bottom trawl surveys are conducted in collaboration with the commercial fishing industry. We call these surveys the Multi-Species Synoptic Bottom Trawl Surveys. The commercial trawl industry provides the vessel for one survey a year while the other is conducted onboard a Canadian Coast Guard research trawler. Surveys are conducted with a combination of DFO staff and industry-hired sea-going technicians. The bottom trawl surveys provide coast-wide coverage of most of the trawlable habitat between 50 and 500 meters depth.

Each year two area-specific randomized longline hook surveys are conducted in collaboration with the commercial fishing industry. We call these surveys the Hard Bottom Longline Hook Surveys. The commercial longline hook industry contracts vessels and sea-going technicians for a survey of outside waters (not between Vancouver Island and the mainland) while a separate longline hook survey of inside waters (between Vancouver Island and the mainland) is conducted by DFO staff aboard a Canadian Coast Guard research vessel. The longline hook surveys provide coast-wide coverage of most of the non-trawlable habitat between 20 and 220 meters depth that is not covered by the bottom trawl surveys.

An annual, coast-wide longline trap survey targeting sablefish is conducted in collaboration with the commercial fishing industry. We call this survey the Sablefish Research and Assessment Survey. The commercial sablefish industry supplies the chartered commercial fishing vessel and the survey is conducted with a combination of DFO staff and industry-hired sea-going technicians. This survey covers the depth range of 150 m to 1500 m for the entire outer BC coast as well as a number of central coast inlets.

Each year an acoustic survey is conducted for Pacific Hake. We call this the Hake Acoustic Survey. The survey is conducted as part of the Pacific Whiting Treaty and typically alternates year to year between research and assessment activities. The survey is conducted aboard the Canadian Coast Guard research trawler by DFO staff.

Each year, DFO staff participates in a fixed-station survey of commercially important shrimp grounds onboard the Canadian Coast Guard research trawler. We call this survey the Multi-Species Small Mesh Bottom Trawl Survey. Groundfish program staff participates in the survey to provide assistance in enumerating the catch while also collecting biological samples from selected species.

During their survey, the IPHC only fully enumerates the catch for, and collects biological samples from Pacific Halibut. In an effort to acquire more data on hook and line groundfish species, particularly rockfish, the commercial fishing industry sponsors an additional technician aboard each of the IPHC chartered survey vessels. The extra technician fully enumerates the catch of all species and collects biological samples from all species of rockfish.

The following sections provide additional details as well as an annual summary of each survey.

Multi-Species Small Mesh Bottom Trawl Survey

An annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island was initiated in 1973. In 1998, areas in Eastern Queen Charlotte Sound were added to the survey. Given that the survey is conducted using a shrimp bottom trawl without an excluder device, groundfish can make up a significant portion of the catch in many of the tows. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Although catch rates are useful indicators of stock status, additional information such as the size and age composition of the catch improves the usefulness of the indices. Consequently, a program was initiated in 2003 to collect biological samples from all groundfish species caught during the survey. Groundfish staff provides assistance in catch sorting and species identification and also collect biological samples from selected species. From 2010 through 2013, the goal was to collect biological information from as many different species in each tow as possible - as opposed to detailed information from only a few species. As such, two groundfish program staff members were deployed and the biological sampling effort was focused on length by sex data in favour of collecting ageing structures. Starting in 2014, only one groundfish staff member participated in the survey and the biological sampling program was reduced so that a single person could accomplish all the work. In addition, the sampling program was rationalized to only include species where the survey is expected to provide a useful index of abundance.

Starting in 2013, the West Coast Vancouver Island portion of the survey also included locations in Barkley Sound that were surveyed by the CCGS Neocaligus in previous years. In 2014, the Queen Charlotte Sound portion of the survey was not conducted due to the limited number of vessel days available for the program. The Queen Charlotte Sound area was also not visited in 2015 due to staffing limitations. In 2016, both the West Coast Vancouver Island and Queen Charlotte Sound areas were surveyed.

The 2016 survey was conducted onboard the W.E. Ricker and ran from April 28 to May 22. A total of 190 usable tows were completed (Figure 4). The total catch weight of all species was 44,923 kg. The mean catch per tow was 233 kg, averaging 26 different species of fish and invertebrates in each. Over the entire survey, the most abundant fish species encountered were Arrowtooth Flounder (*Atheresthes stomias*), Flathead Sole (*Hippoglossoides elassodon*), Pacific Hake (*Merluccius productus*), and Rex Sole (*Glyptocephalus zachirus*). The number of tows where the species was captured, total catch weight, estimated biomass, and relative survey error for the top 25 fish species by weight are shown in Table 1 for the West Coast Vancouver Island tow locations and Table 2 for the Queen Charlotte Sound tow locations. Biomass indices have not been calculated for the Barkley Sound tow locations as these locations have not yet been used for any groundfish assessments.

Biological data were collected from a total of 14,943 individual fish from 20 different groundfish species (Table 3). Most biological samples included fish length and sex but age structures were also collected for Bocaccio (*Sebastes paucispsinis*) and both age structures and tissue samples for DNA analysis were collected from Rougheye/ Blackspotted Rockfish (*Sebastes aleutianus/ melanostictus*) and Yelloweye Rockfish (*Sebastes ruberrimus*). Almost half of all the individual fish measured during the survey were Eulachon (*Thaleichthys pacificus*). Although we include this species in these summaries, the groundfish program staff typically does not directly collect the biological data from this species or American Shad (*Alosa sapidissima*).

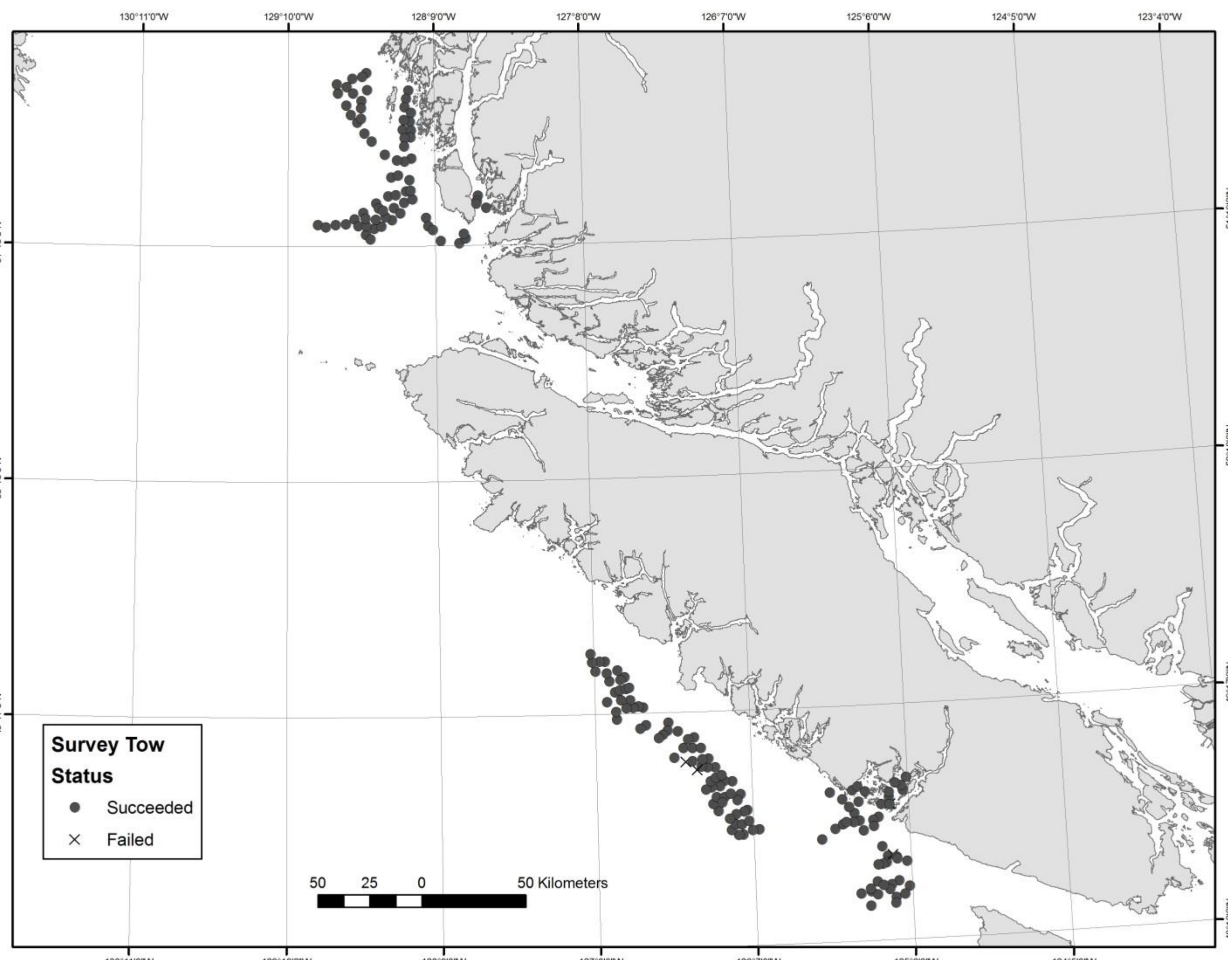


Figure 4. Tow locations of the 2016 Multi-species Small Mesh Bottom Trawl Survey.

Table 1. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the West Coast Vancouver Island tow locations of the 2016 Multi-species Small Mesh Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
Pacific Hake	*Merluccius productus*	62	2075	2058	0.28
Flathead Sole	*Hippoglossoides*	66	1779	1842	0.13
Arrowtooth Flounder	*Atheresthes stomias*	67	1500	1569	0.11
Eulachon	*Thaleichthys pacificus*	65	1354	1369	0.14
Rex Sole	*Glyptocephalus zachirus*	66	1301	1377	0.09
Pacific Herring	*Clupea pallasii*	60	1115	1144	0.56
Pacific Cod	*Gadus macrocephalus*	50	667	724	0.22
Slender Sole	*Lyopsetta exilis*	66	662	700	0.12
Pacific Sanddab	*Citharichthys sordidus*	37	602	592	0.19
Sablefish	*Anoplopoma fimbria*	60	566	580	0.22
Dover Sole	*Microstomus pacificus*	64	546	558	0.14
Walleye Pollock	*Gadus chalcogrammus*	52	378	410	0.29
Yellowtail Rockfish	*Sebastes flavidus*	33	276	283	0.34
North Pacific Spiny	*Squalus suckleyi*	17	187	201	0.4
Lingcod	*Ophiodon elongatus*	21	142	157	0.3
English Sole	*Parophrys vetulus*	54	141	145	0.17
Pacific Halibut	*Hippoglossus stenolepis*	22	132	150	0.18
Spotted Ratfish	*Hydrolagus colliei*	43	101	96	0.15
Blackbelly Eelpout	*Lycodes pacificus*	56	70	68	0.19
American Shad	*Alosa sapidissima*	32	53	48	0.26
Petrale Sole	*Eopsetta jordani*	21	38	38	0.29
Chinook Salmon	*Oncorhynchus*	24	36	38	0.22
Darkblotched Rockfish	*Sebastes crameri*	30	29	32	0.54
Longnose Skate	*Raja rhina*	15	27	25	0.27
Silvergray Rockfish	*Sebastes brevispinis*	2	14	17	0.8

Table 2. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the Queen Charlotte Sound tow locations of the 2016 Multi-species Small Mesh Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
Arrowtooth Flounder	*Atheresthes stomias*	67	6605	5124	0.24
Flathead Sole	*Hippoglossoides elassodon*	66	1297	956	0.1
Walleye Pollock	*Gadus chalcogrammus*	63	1293	885	0.26
Dover Sole	*Microstomus pacificus*	58	1120	938	0.29
Pacific Ocean Perch	*Sebastes alutus*	37	1070	757	0.35
Eulachon	*Thaleichthys pacificus*	49	612	428	0.2
Pacific Hake	*Merluccius productus*	54	465	344	0.2
Rex Sole	*Glyptocephalus zachirus*	66	446	326	0.14
Spotted Ratfish	*Hydrolagus colliei*	49	339	241	0.29
Sablefish	*Anoplopoma fimbria*	58	283	208	0.18
Blackbelly Eelpout	*Lycodes pacificus*	51	267	192	0.23
Slender Sole	*Lyopsetta exilis*	62	119	83	0.12
Redbanded Rockfish	*Sebastes babcocki*	16	83	67	0.33
Pacific Halibut	*Hippoglossus stenolepis*	11	79	59	0.4
Longnose Skate	*Raja rhina*	17	78	55	0.27
Pacific Cod	*Gadus macrocephalus*	25	74	59	0.25
Silvergray Rockfish	*Sebastes brevispinis*	14	37	28	0.36
Yellowmouth Rockfish	*Sebastes reedi*	5	32	16	0.61
Shortspine Thornyhead	*Sebastolobus alascanus*	13	28	20	0.33
Pacific Herring	*Clupea pallasii*	13	27	18	0.24
Darkblotched Rockfish	*Sebastes crameri*	23	27	19	0.41
English Sole	*Parophrys vetulus*	13	25	18	0.44
Rougheye/ Blackspotted Rockfish	*Sebastes aleutianus/ melanostictus*	24	25	18	0.25
Canary Rockfish	*Sebastes pinniger*	9	19	13	0.34
Yellowtail Rockfish	*Sebastes flavidus*	7	14	11	0.39

Table 3. Number of fish sampled for biological data during the 2016 Multi-species Small Mesh Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	**Scientific Name**	**Lengths**	**Age Structures**
North Pacific Spiny Dogfish	*Squalus suckleyi*	47	0
Big Skate	*Beringraja binoculata*	4	0
Sandpaper Skate	*Bathyraja interrupta*	29	0
Longnose Skate	*Raja rhina*	231	0
American Shad	*Alosa sapidissima*	440	0
Pacific Herring	*Clupea pallasii*	148	0
Eulachon	*Thaleichthys pacificus*	7123	0
Pacific Cod	*Gadus macrocephalus*	164	0
Walleye Pollock	*Gadus chalcogrammus*	1239	0
Rougheye/ Blackspotted	*Sebastes aleutianus/*	139	140
Bocaccio	*Sebastes paucispinis*	2	2
Yelloweye Rockfish	*Sebastes ruberrimus*	3	3
Sablefish	*Anoplopoma fimbria*	923	0
Lingcod	*Ophiodon elongatus*	15	0
Arrowtooth Flounder	*Atheresthes stomias*	1416	0
Petrale Sole	*Eopsetta jordani*	91	0
Rex Sole	*Glyptocephalus zachirus*	1857	0
Pacific Halibut	*Hippoglossus stenolepis*	58	0
Dover Sole	*Microstomus pacificus*	851	0
English Sole	*Parophrys vetulus*	163	0

Multi-Species Synoptic Bottom Trawl Surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive multi-species bottom trawl survey strategy that covers most of the BC Coast. The objectives of these surveys are to provide fishery independent abundance indices of as many benthic and near benthic fish species available to bottom trawling as is reasonable while obtaining supporting biological samples from selected species. The abundance indices and biological information are incorporated into stock assessments, status reports, and research publications.

All of the synoptic bottom trawl surveys along the British Columbia coast have followed the same random depth-stratified design. Each survey area is divided into 2 km by 2 km blocks and each block is assigned one of four depth strata based on the average bottom depth in the block. The four depth strata vary between areas. For each survey, blocks are randomly selected within each depth stratum. If a survey block is not fishable for any reason it will be abandoned and the vessel will proceed to the next block.

There are four core surveys, two of which are conducted each year. The Hecate Strait survey and the Queen Charlotte Sound survey are conducted in odd-numbered years while the West Coast Vancouver Island survey and the West Coast Haida Gwaii (formerly Queen Charlotte Islands) survey are conducted in even-numbered years.

In addition to the four core surveys, a Strait of Georgia survey was initiated in 2012 with the intention of repeating the survey every 3 years. The first scheduled repeat of the survey was in 2015 but it was not possible to conduct the survey during March. Nonetheless, research vessel time was available during May and it appeared that the time period would remain available in future years. Unfortunately, due to changing priorities, the May time period will not be available in future years. Research vessel time has been secured for March 2017 and the new plan is to move forward conducting the Strait of Georgia survey biennially, in odd numbered years.

The synoptic bottom trawl surveys are conducted on both chartered commercial vessels and government research vessels. The Hecate Strait survey, the West Coast Vancouver Island survey, and the Strait of Georgia survey are all conducted on a Canadian Coastguard research trawler while the Queen Charlotte Sound survey and the West Coast Haida Gwaii are conducted on chartered commercial fishing vessels.

The four core synoptic surveys (Hecate Strait, Queen Charlotte Sound, West Coast Vancouver Island, and West Coast Haida Gwaii) are all fished using an Atlantic Western bottom trawl. In contrast, the SOG survey is fished using a much smaller Yankee 36 bottom trawl. The decision to use the smaller trawl makes direct comparisons between the areas difficult but allowed us to conduct the survey in the available days. The use of the smaller trawl allows more blocks to be fished each day as the net is faster to deploy and retrieve and catches tend to be smaller.

In 2016 the West Coast of Vancouver Island and the West Coast of Haida Gwaii surveys were conducted.

West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey

The West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 24 and June 16, 2016. We assessed a total of 176 blocks (Table 4, Figure 5). Of the 147 total tows conducted, 140 were successful and 7 were failures due to hang ups or insufficient bottom time. Note that some blocks are only successfully fished following more than one attempt. The relatively large number of blocks that remained unassessed at the end of the survey (31) was due to days lost to a mechanical breakdown with four days remaining in the survey.

A total of 15 different DFO staff persons and four volunteer students participated in the survey.

The total catch weight of all species was 125,192 kg. The mean catch per tow was 857 kg, averaging 27 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (Atheresthes *stomias*), Splitnose Rockfish (*Sebastes diploproa*), Pacific Ocean Perch (*Sebastes alutus*), Redstripe Rockfish (*Sebastes proriger*), and Sablefish (*Anoplopoma fimbria*). The number of tows where the species was captured and total catch weight from usable tows as well as the estimated biomass and relative survey error for the 25 most abundant species are shown in Table 5. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 33,948 individual fish of 51 different species (Table 6). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 4. 2016 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master’s knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum	**Rejected Prior**	**Rejected Inspected**	**Failed**	**Success**	**Not Assessed**	**Total**
50m to 125 m	2	15	0	54	13	84
125m to 200 m	2	8	2	41	11	64
200m to 330 m	0	2	1	26	4	33
330m to 500 m	0	4	0	19	3	26
Total	**4**	**29**	**3**	**140**	**31**	**207**

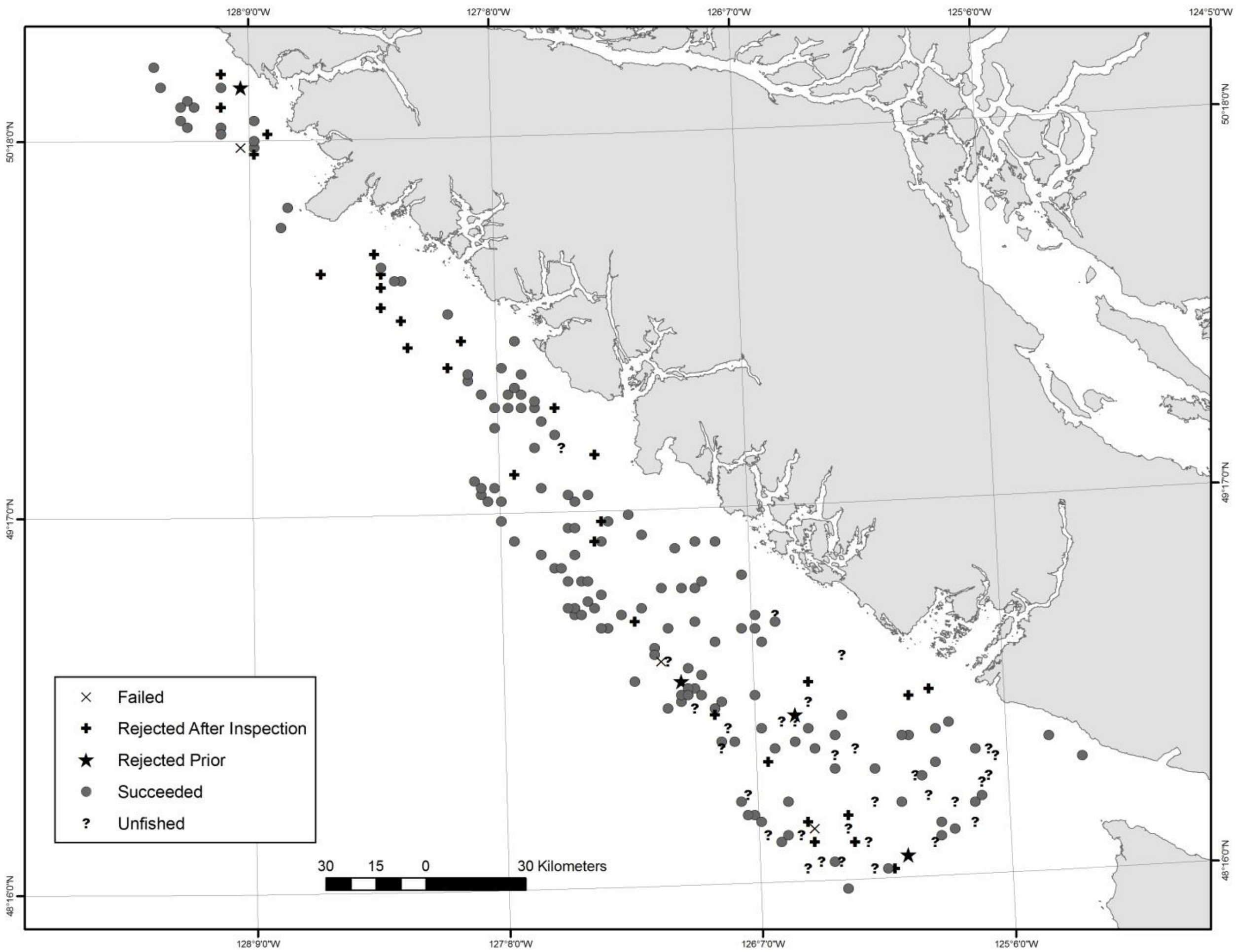


Figure 5. Final status of the allocated blocks for the 2016 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

Table 5. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2016 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Number of**	**Catch**	**Biomas**	**Relative**
Arrowtooth Flounder	*Atheresthes stomias*	126	19940	10282	0.24
Splitnose Rockfish	*Sebastes diploproa*	29	11493	2606	0.37
Pacific Ocean Perch	*Sebastes alutus*	57	10306	2399	0.19
Sablefish	*Anoplopoma fimbria*	103	8767	3536	0.23
Redstripe Rockfish	*Sebastes proriger*	42	7957	5513	0.41
Sharpchin Rockfish	*Sebastes zacentrus*	43	6518	2016	0.22
Rex Sole	*Glyptocephalus zachirus*	132	5929	3625	0.07
North Pacific Spiny Dogfish	*Squalus suckleyi*	102	5861	3474	0.24
Yellowtail Rockfish	*Sebastes flavidus*	68	4956	3293	0.49
Dover Sole	*Microstomus pacificus*	123	4040	2001	0.12
Pacific Hake	*Merluccius productus*	82	3476	2664	0.29
Pacific Cod	*Gadus macrocephalus*	99	2895	2047	0.19
Canary Rockfish	*Sebastes pinniger*	55	2860	1566	0.35
Spotted Ratfish	*Hydrolagus colliei*	128	2717	2194	0.39
English Sole	*Parophrys vetulus*	88	2270	2006	0.2
Greenstriped Rockfish	*Sebastes elongatus*	76	2028	995	0.18
Flathead Sole	*Hippoglossoides elassodon*	60	1847	1476	0.2
Rougheye/ Blackspotted Rockfish	*Sebastes aleutianus/ melanostictus*	35	1811	439	0.37
Lingcod	*Ophiodon elongatus*	80	1714	1292	0.24
Pacific Halibut	*Hippoglossus stenolepis*	94	1590	1094	0.18
Shortspine Thornyhead	*Sebastolobus alascanus*	41	1509	366	0.16
Petrale Sole	*Eopsetta jordani*	89	1442	1206	0.27
Pacific Sanddab	*Citharichthys sordidus*	50	1128	1056	0.23
Silvergray Rockfish	*Sebastes brevispinis*	45	1064	407	0.34
Longnose Skate	*Raja rhina*	61	638	308	0.15

Table 6. Number of fish sampled for biological data during the 2016 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Brown Cat Shark	*Apristurus brunneus*	41	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	1006	266
Big Skate	*Beringraja binoculata*	32	0
Sandpaper Skate	*Bathyraja interrupta*	27	0
Longnose Skate	*Raja rhina*	159	0
Alaska Skate	*Bathyraja parmifera*	1	0
Spotted Ratfish	*Hydrolagus colliei*	792	0
Green Sturgeon	*Acipenser medirostris*	1	0
Eulachon	*Thaleichthys pacificus*	1246	0
Pacific Cod	*Gadus macrocephalus*	971	839
Pacific Hake	*Merluccius productus*	1174	141
Pacific Tomcod	*Microgadus proximus*	176	0
Walleye Pollock	*Gadus chalcogrammus*	459	26
Wolf Eel	*Anarrhichthys ocellatus*	1	0
Rougheye/ Blackspotted Rockfish	*Sebastes aleutianus/ melanostictus*	379	379
Pacific Ocean Perch	*Sebastes alutus*	1236	846
Aurora Rockfish	*Sebastes aurora*	29	0
Redbanded Rockfish	*Sebastes babcocki*	484	484
Shortraker Rockfish	*Sebastes borealis*	11	11
Silvergray Rockfish	*Sebastes brevispinis*	302	137
Darkblotched Rockfish	*Sebastes crameri*	256	0
Splitnose Rockfish	*Sebastes diploproa*	598	301
Greenstriped Rockfish	*Sebastes elongatus*	1280	0
Puget Sound Rockfish	*Sebastes emphaeus*	50	50
Yellowtail Rockfish	*Sebastes flavidus*	674	218
Rosethorn Rockfish	*Sebastes helvomaculatus*	661	0
Shortbelly Rockfish	*Sebastes jordani*	75	0
Quillback Rockfish	*Sebastes maliger*	46	46
Bocaccio	*Sebastes paucispinis*	17	17
Canary Rockfish	*Sebastes pinniger*	531	422
Redstripe Rockfish	*Sebastes proriger*	765	393
Yellowmouth Rockfish	*Sebastes reedi*	20	0

Species	Scientific Name	Lengths Collected	Age Structures Collected
Yelloweye Rockfish	*Sebastes ruberrimus*	63	63
Stripetail Rockfish	*Sebastes saxicola*	27	0
Pygmy Rockfish	*Sebastes wilsoni*	327	0
Sharpchin Rockfish	*Sebastes zacentrus*	1058	0
Shortspine Thornyhead	*Sebastolobus alascanus*	1061	102
Sablefish	*Anoplopoma fimbria*	1705	2
Kelp Greenling	*Hexagrammos decagrammus*	39	0
Lingcod	*Ophiodon elongatus*	355	323
Pacific Sanddab	*Citharichthys sordidus*	1336	0
Arrowtooth Flounder	*Atheresthes stomias*	2491	411
Petrale Sole	*Eopsetta jordani*	747	615
Rex Sole	*Glyptocephalus zachirus*	3698	231
Flathead Sole	*Hippoglossoides elassodon*	1146	0
Pacific Halibut	*Hippoglossus stenolepis*	314	0
Southern Rock Sole	*Lepidopsetta bilineata*	528	271
Slender Sole	*Lyopsetta exilis*	1444	0
Dover Sole	*Microstomus pacificus*	2451	852
English Sole	*Parophrys vetulus*	1574	663
Curlfin Sole	*Pleuronichthys decurrens*	84	0

West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey was conducted on the F/V Frosti between August 25 and September 26, 2016. We assessed a total of 130 blocks (Table 7, Figure 6). Of the 120 total tows conducted, 112 were successful and 8 were failures due to hang ups or insufficient bottom time. Note that some blocks are only successfully fished following more than one attempt. Two blocks remained unassessed at the end of the survey.

A total of six different DFO staff persons and five contract science staff from Archipelago Marine Research participated in the survey.

The total catch weight of all species was 160,511 kg. The mean catch per tow was 1337 kg, averaging 22 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (*Sebastes alutus*), Rougheye/ Blackspotted Rockfish (*Sebastes aleutianus/ Sebastes melanostictus*), Sharpchin Rockfish (*Sebastes zacentrus*), Silvergray Rockfish (*Sebastes brevispinis*), and Redstripe Rockfish (*Sebastes proriger*). The number of tows where the species was captured and total catch weight from usable tows as well as the estimated biomass and relative survey error for the 25 most abundant species are shown in Table 8. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 28,686 individual fish of 46 different species (Table 9). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 7. 2016 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (m)	**Rejected Prior**	**Rejected Inspected**	**Failed**	**Success**	**Not Assessed**	**Total**
180 to 330 m	0	3	1	71	2	77
330 to 500 m	0	7	0	26	0	33
500 to 800 m	0	5	1	5	0	11
800 to 1300 m	0	1	0	10	0	11
Total	**0**	**16**	**2**	**112**	**2**	**132**

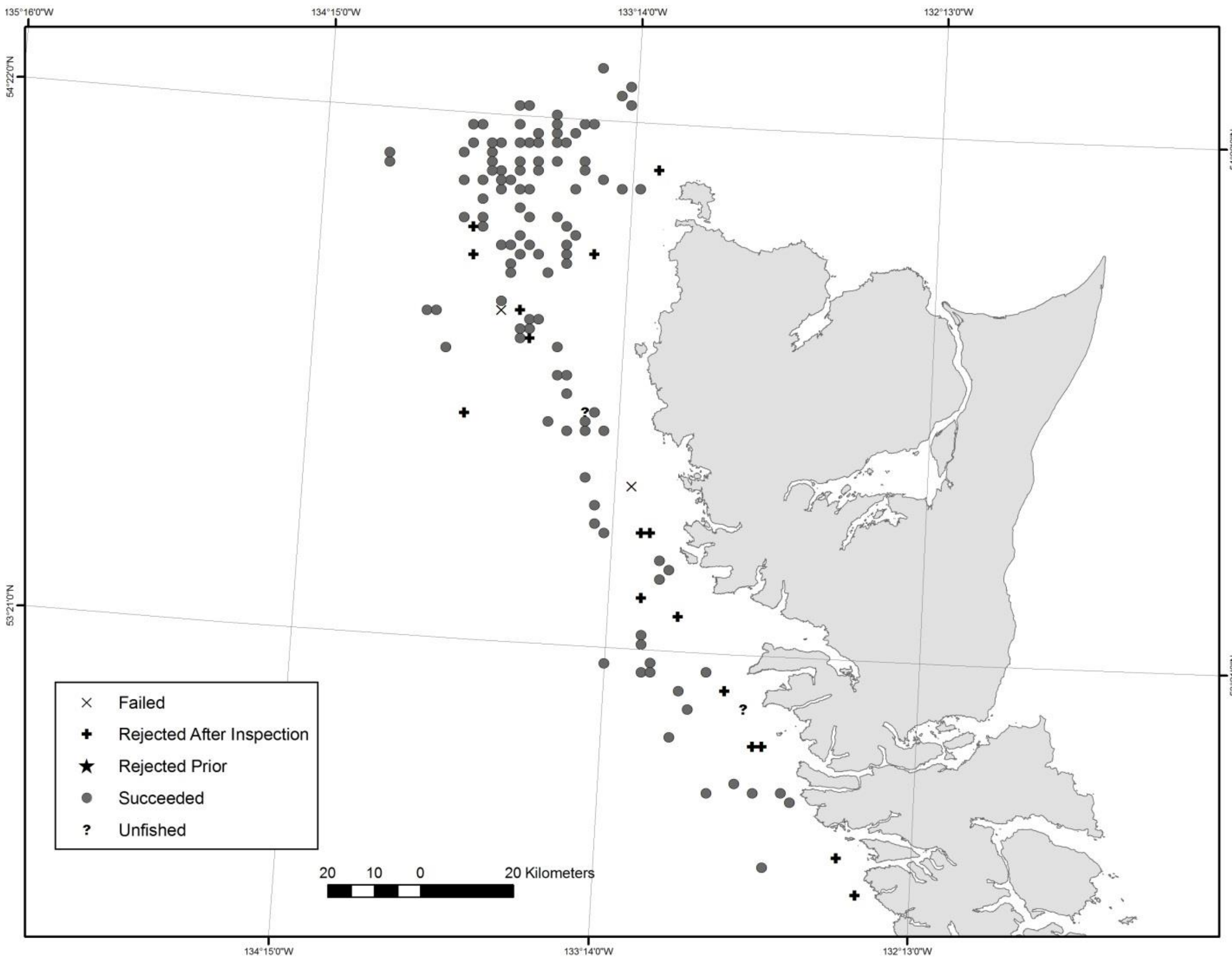


Figure 6. Final status of the allocated blocks for the 2016 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

Table 8. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2016 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
Pacific Ocean Perch	*Sebastes alutus*	90	79901	13925	0.19
Rougheye/ Blackspotted Rockfish	*Sebastes aleutianus/ melanostictus*	49	15754	6969	0.43
Sharpchin Rockfish	*Sebastes zacentrus*	59	13205	1734	0.23
Silvergray Rockfish	*Sebastes brevispinis*	74	9949	3748	0.52
Redstripe Rockfish	*Sebastes proriger*	55	7170	2052	0.4
Shortspine Thornyhead	*Sebastolobus alascanus*	100	6617	3912	0.13
Yellowmouth Rockfish	*Sebastes reedi*	40	6251	1712	0.68
Canary Rockfish	*Sebastes pinniger*	14	3245	777	0.51
Sablefish	*Anoplopoma fimbria*	55	1664	6371	0.18
Arrowtooth Flounder	*Atheresthes stomias*	75	1616	361	0.32
Redbanded Rockfish	*Sebastes babcocki*	72	864	120	0.19
Dover Sole	*Microstomus pacificus*	84	853	432	0.36
Pacific Hake	*Merluccius productus*	33	835	211	0.21
Rex Sole	*Glyptocephalus zachirus*	88	823	309	0.55
Rosethorn Rockfish	*Sebastes helvomaculatus*	70	745	111	0.19
Pacific Grenadier	*Coryphaenoides acrolepis*	14	701	11693	0.27
Splitnose Rockfish	*Sebastes diploproa*	13	642	80	0.61
Widow Rockfish	*Sebastes entomelas*	33	611	168	0.46
Giant Grenadier	*Albatrossia pectoralis*	15	569	8321	0.2
Longspine Thornyhead	*Sebastolobus altivelis*	15	521	7109	0.14
Walleye Pollock	*Gadus chalcogrammus*	41	493	121	0.48
Pacific Halibut	*Hippoglossus stenolepis*	25	446	451	0.77
Longnose Skate	*Raja rhina*	32	353	73	0.2
Shortraker Rockfish	*Sebastes borealis*	10	352	152	0.43
Spotted Ratfish	*Hydrolagus colliei*	60	320	58	0.27

Table 9. Number of fish sampled for biological data during the 2016 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**
Brown Cat Shark	*Apristurus brunneus*	5	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	11	8
Aleutian Skate	*Bathyraja aleutica*	9	0
Big Skate	*Beringraja binoculata*	2	0
Roughtail Skate	*Bathyraja trachura*	39	0
Sandpaper Skate	*Bathyraja interrupta*	21	0
Longnose Skate	*Raja rhina*	44	0
Spotted Ratfish	*Hydrolagus colliei*	133	0
Pacific Flatnose	*Antimora microlepis*	43	21
Pacific Cod	*Gadus macrocephalus*	51	0
Pacific Hake	*Merluccius productus*	273	48
Walleye Pollock	*Gadus chalcogrammus*	242	25
Popeye	*Coryphaenoides cinereus*	245	0
Pacific Grenadier	*Coryphaenoides acrolepis*	612	0
Giant Grenadier	*Albatrossia pectoralis*	446	50
Rougheye/ Blackspotted Rockfish	*Sebastes aleutianus/ melanostictus*	685	682
Pacific Ocean Perch	*Sebastes alutus*	2356	1564
Redbanded Rockfish	*Sebastes babcocki*	496	495
Shortraker Rockfish	*Sebastes borealis*	77	77
Silvergray Rockfish	*Sebastes brevispinis*	908	548
Splitnose Rockfish	*Sebastes diploproa*	131	85
Greenstriped Rockfish	*Sebastes elongatus*	174	0

Species	Scientific Name	Lengths Collected	Age Structures Collected
Widow Rockfish	*Sebastes entomelas*	72	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	1069	0
Bocaccio	*Sebastes paucispinis*	8	8
Canary Rockfish	*Sebastes pinniger*	185	185
Redstripe Rockfish	*Sebastes proriger*	834	475
Yellowmouth Rockfish	*Sebastes reedi*	419	350
Yelloweye Rockfish	*Sebastes ruberrimus*	16	16
Harlequin Rockfish	*Sebastes variegatus*	79	0
Sharpchin Rockfish	*Sebastes zacentrus*	1275	0
Shortspine Thornyhead	*Sebastolobus alascanus*	2383	685
Longspine Thornyhead	*Sebastolobus altivelis*	480	458
Sablefish	*Anoplopoma fimbria*	539	0
Lingcod	*Ophiodon elongatus*	28	0
Arrowtooth Flounder	*Atheresthes stomias*	239	87
Petrale Sole	*Eopsetta jordani*	32	25
Rex Sole	*Glyptocephalus zachirus*	1002	191
Pacific Halibut	*Hippoglossus stenolepis*	29	0
Dover Sole	*Microstomus pacificus*	570	405
English Sole	*Parophrys vetulus*	30	30

Hard Bottom Longline Hook Surveys

This Hard Bottom Longline Hook survey program is designed to provide hook by hook species composition and catch rates for all species available to longline hook gear from 20 to 260 m depth. The surveys are intended to cover areas that are not covered by the synoptic bottom trawl surveys. The goal of the surveys is to provide relative abundance indices for commonly caught species, distributional and occurrence data for all other species, and detailed biological data for inshore rockfish population studies. These data are incorporated into stock assessments, status reports, and research publications.

The program includes an industry-funded survey of outside waters and a DFO-funded survey of inside waters. Fisheries and Oceans Canada (DFO), together with the Pacific Halibut Management Association of BC (PHMA) have implemented an annual research longline hook survey of the "outside" area. The "outside" area covers the entire British Columbia coast excluding inlets and the protected waters east of Vancouver Island. The "inside" area includes waters east of Vancouver Island. Each year, approximately half of each survey area is covered and alternates between northern and southern portions year to year.

The northern portion of the outside survey area includes the mainland coast north of Milbanke Sound, Dixon Entrance, and both sides of Haida Gwaii while the southern portion includes the mainland coast south of Milbanke Sound, Queen Charlotte Sound, and the north and west coasts of Vancouver Island. The northern portion of the outside area was surveyed during even numbered years from 2006 to 2012 and the southern portion was surveyed in odd years from 2007 to 2011. The survey had a one year hiatus in 2013 but resumed in 2014 in the southern portion. The current schedule is to survey the northern portion in odd numbered years and the southern portion in even numbered years.

The northern portion of the inside area includes Johnstone Strait and the Broughton Archipelago while the southern portion includes the Desolation Sound, the Strait of Georgia and the southern Gulf Islands. The survey has been conducted annually since 2003 excluding 2006. Currently the northern portion is surveyed in even numbered years while the southern portion is surveyed in odd numbered years.

Both of the Hard Bottom Longline Hook surveys follow the same random depth-stratified design using standardized "snap and swivel" longline hook gear with prescribed fishing protocols including bait, soak time and set locations within the selected blocks. Hard bottom regions within each survey were identified through bathymetry analyses, inshore rockfish fishing records and fishermen consultations. Each survey area is divided into 2 km by 2 km blocks and each block within the hard bottom regions is assigned a depth stratum based on the average bottom depth within the block. The three depth strata for the outside area are 20 to 70 meters, 71 to 150 meters, and 151 to 260 meters. Suitable hard bottom regions in the Strait of Georgia and Johnstone Strait are more limited so the depth strata for the inside area are 20 to 70 meters and 71 to 100 meters.

In 2016 the southern portion of the outside area and the northern portion of the inside areas were surveyed.

Outside Area – Pacific Halibut Management Association Longline Survey

The Pacific Halibut Management Association (PHMA) Longline Survey was conducted in the southern portion of the outside area. Three commercial hook and line vessels where chartered in August and together completed a total of 197 blocks (Figure 7). The Pacific Ambition surveyed the area off the mainland coast and in Queen Charlotte Sound (Figure 7) and completed a total of 65 sets from August 7 to 23. The Borealis 1 surveyed the area off the north coast of Vancouver Island and north half of the west coast of Vancouver Island (Figure 7) and completed a total of 66 sets from August 1 to 18, 2017. The Banker II surveyed the area off the southern half of the west coast of Vancouver Island (Figure 7) and completed a total of 66 sets from August 7 to 25, 2016.

The most common species captured during the 2016 PHMA longline survey was Yelloweye Rockfish (*Sebastes ruberrimus*), followed by Pacific Halibut (*Hippoglossus stenolepis*), Quillback Rockfish (*Sebastes maliger*), and Pacific Cod (*Gadus macrocephalus*) (Table 10). Table 11 shows the breakdown by major area of the top 25 species in the survey catch while Table 12 through Table 14 show the catch of all species by each vessel. Table 15 provides an annual summary of the total catch of the PHMA Longline Survey in the southern region while Table 16 provides an annual summary of the catch landed from the PHMA longline survey in both northern and southern regions.

During the PHMA longline survey, detailed biological samples including ageing structures are collected from 50 rockfish in each set with a focus on Yelloweye Rockfish (*Sebastes ruberrimus*). If time permits additional rockfish will be sampled. Table 17 provides an annual summary by species of the number of fish that were sampled for biological data during the PHMA Longline Survey in the southern region. A total of 4506 individual fish were sampled for biological data in 2016. On the Banker II, biological data were collected from a total of 979 individual fish (Table 18), while on the Pacific Ambition biological data were collected from a total of 1427 individual fish (Table 19), and on the Borealis 1 biological data were collected from a total of 2100 individual fish (Table 20).

A temperature depth recorder was attached to most of the sets during the 2016 PHMA longline survey.

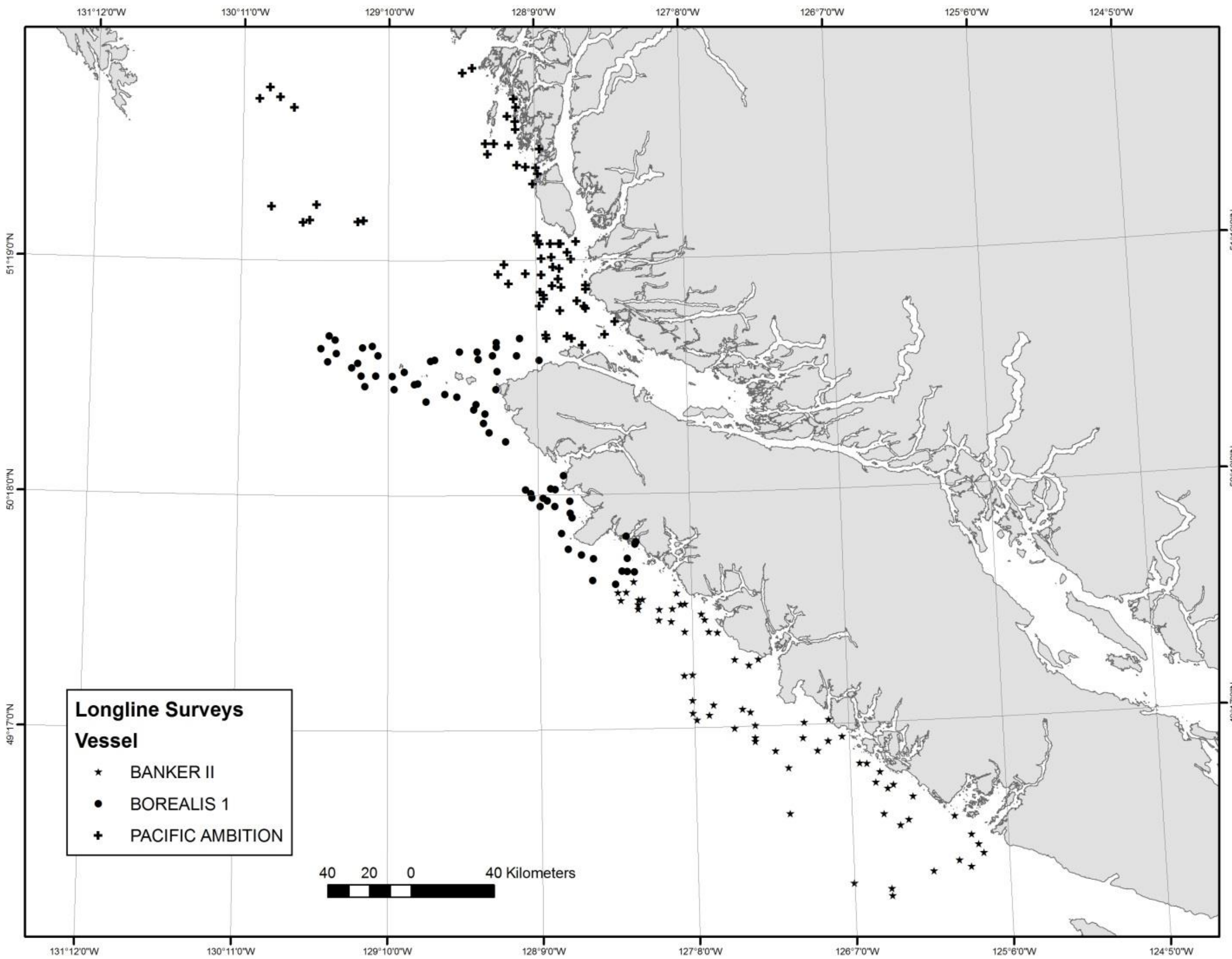


Figure 7. Longline set locations of the 2016 PHMA longline survey.

Table 10. Number of sets, catch (piece count), and proportion of the total fish caught catch of the top 25 fish species (by piece count) from the 2016 PHMA longline survey.

Species	**Scientific Name**	**Number of Sets**	**Catch (count)**	**Proportion of Total Catch (%)**
Yelloweye Rockfish	*Sebastes ruberrimus*	107	2444	16.67
Pacific Halibut	*Hippoglossus stenolepis*	183	2303	15.71
Quillback Rockfish	*Sebastes maliger*	99	1477	10.08
Pacific Cod	*Gadus macrocephalus*	84	1249	8.52
Sablefish	*Anoplopoma fimbria*	57	1128	7.69
Spotted Ratfish	*Hydrolagus colliei*	131	941	6.42
Canary Rockfish	*Sebastes pinniger*	93	820	5.59
North Pacific Spiny Dogfish	*Squalus suckleyi*	116	779	5.31
Arrowtooth Flounder	*Atheresthes stomias*	77	616	4.20
Redbanded Rockfish	*Sebastes babcocki*	30	529	3.61
Lingcod	*Ophiodon elongatus*	110	473	3.23
Longnose Skate	*Raja rhina*	93	429	2.93
China Rockfish	*Sebastes nebulosus*	30	277	1.89
Big Skate	*Beringraja binoculata*	66	209	1.43
Greenstriped Rockfish	*Sebastes elongatus*	47	176	1.20
Rosethorn Rockfish	*Sebastes helvomaculatus*	40	137	0.93
Silvergray Rockfish	*Sebastes brevispinis*	37	137	0.93
Copper Rockfish	*Sebastes caurinus*	29	127	0.87
Yellowmouth Rockfish	*Sebastes reedi*	9	85	0.58
Yellowtail Rockfish	*Sebastes flavidus*	23	58	0.40
Southern Rock Sole	*Lepidopsetta bilineata*	20	39	0.27
Vermilion Rockfish	*Sebastes miniatus*	14	32	0.22
Sandpaper Skate	*Bathyraja interrupta*	25	31	0.21
Petrale Sole	*Eopsetta jordani*	20	28	0.19

Tiger Rockfish	*Sebastes nigrocinctus*	15	23	0.16

Table 11. Catch (piece count) by major area for the top 25 fish species (by piece count) from the 2016 PHMA longline survey.

Species	Scientific Name	4B	3C	3D	5A	5B
Yelloweye Rockfish	*Sebastes ruberrimus*	23	20	783	1185	433
Pacific Halibut	*Hippoglossus stenolepis*	9	126	919	697	552
Quillback Rockfish	*Sebastes maliger*	27	225	261	524	440
Pacific Cod	*Gadus macrocephalus*	10	133	537	389	180
Sablefish	*Anoplopoma fimbria*	0	186	298	329	315
Spotted Ratfish	*Hydrolagus colliei*	46	73	144	351	327
Canary Rockfish	*Sebastes pinniger*	6	72	404	216	122
North Pacific Spiny Dogfish	*Squalus suckleyi*	20	392	266	56	45
Arrowtooth Flounder	*Atheresthes stomias*	2	23	287	182	122
Redbanded Rockfish	*Sebastes babcocki*	0	1	251	223	54
Lingcod	*Ophiodon elongatus*	4	71	220	144	34
Longnose Skate	*Raja rhina*	1	40	148	157	83
China Rockfish	*Sebastes nebulosus*	0	67	96	108	6
Big Skate	*Beringraja binoculata*	1	64	103	33	8
Greenstriped Rockfish	*Sebastes elongatus*	1	16	62	78	19
Rosethorn Rockfish	*Sebastes helvomaculatus*	0	8	40	62	27
Silvergray Rockfish	*Sebastes brevispinis*	1	0	27	90	19
Copper Rockfish	*Sebastes caurinus*	0	27	52	34	14
Yellowmouth Rockfish	*Sebastes reedi*	0	0	0	79	6
Yellowtail Rockfish	*Sebastes flavidus*	1	2	13	29	13
Southern Rock Sole	*Lepidopsetta bilineata*	0	4	8	15	12
Vermilion Rockfish	*Sebastes miniatus*	0	2	13	14	3
Sandpaper Skate	*Bathyraja interrupta*	0	11	7	8	5
Petrale Sole	*Eopsetta jordani*	0	5	8	10	5

Tiger Rockfish	*Sebastes nigrocinctus*	1	1	3	12	6

Table 12. Total catch (piece count) by species for the 2016 PHMA Longline Survey sets completed by the Pacific Ambition.

Species	**Scientific Name**	**Total Catch (count)**
Quillback Rockfish	*Sebastes maliger*	801
Pacific Halibut	*Hippoglossus stenolepis*	706
Yelloweye Rockfish	*Sebastes ruberrimus*	667
Spotted Ratfish	*Hydrolagus colliei*	649
Sablefish	*Anoplopoma fimbria*	404
Pacific Cod	*Gadus macrocephalus*	267
Canary Rockfish	*Sebastes pinniger*	175
Arrowtooth Flounder	*Atheresthes stomias*	160
Longnose Skate	*Raja rhina*	91
North Pacific Spiny Dogfish	*Squalus suckleyi*	89
Starfish	*Asteroidea*	79
China Rockfish	*Sebastes nebulosus*	63
Lingcod	*Ophiodon elongatus*	62
Redbanded Rockfish	*Sebastes babcocki*	57
Copper Rockfish	*Sebastes caurinus*	39
Rosethorn Rockfish	*Sebastes helvomaculatus*	38
Greenstriped Rockfish	*Sebastes elongatus*	30
Silvergray Rockfish	*Sebastes brevispinis*	29
Southern Rock Sole	*Lepidopsetta bilineata*	21
Big Skate	*Beringraja binoculata*	17
Yellowtail Rockfish	*Sebastes flavidus*	14
Tiger Rockfish	*Sebastes nigrocinctus*	12
Petrale Sole	*Eopsetta jordani*	12
Vermilion Rockfish	*Sebastes miniatus*	10

Species	Scientific Name	Total Catch (count)
	Solasteridae	9
Dover Sole	*Microstomus pacificus*	8
Yellowmouth Rockfish	*Sebastes reedi*	6
Sandpaper Skate	*Bathyraja interrupta*	6
Sponges	*Porifera*	5
Walleye Pollock	*Gadus chalcogrammus*	3
Darkblotched Rockfish	*Sebastes crameri*	2
Sea Pens	*Pennatulacea*	2
Red Irish Lord	*Hemilepidotus hemilepidotus*	2
Cabezon	*Scorpaenichthys marmoratus*	2
Shortspine Thornyhead	*Sebastolobus alascanus*	2
Greenlings	*Hexagrammidae*	1
Redstripe Rockfish	*Sebastes proriger*	1
Rougheye Rockfish	*Sebastes aleutianus*	1
Stony Corals	*Scleractinia*	1
Anemone	*Actiniaria*	1
C-o Sole	*Pleuronichthys coenosus*	1
	Echinoidea	1
Giant Pacific Octopus	*Enteroctopus dofleini*	1
Box Crabs	*Lopholithodes*	1

Table 13. Total catch (piece count) by species for the 2016 PHMA Longline Survey sets completed by the Borealis 1.

Species	Scientific name	Total Catch (count)
Yelloweye Rockfish	*Sebastes ruberrimus*	1583
Pacific Halibut	*Hippoglossus stenolepis*	783
Pacific Cod	*Gadus macrocephalus*	462
Canary Rockfish	*Sebastes pinniger*	437
Redbanded Rockfish	*Sebastes babcocki*	417
Quillback Rockfish	*Sebastes maliger*	304
Sablefish	*Anoplopoma fimbria*	256
Arrowtooth Flounder	*Atheresthes stomias*	255
Lingcod	*Ophiodon elongatus*	231
Longnose Skate	*Raja rhina*	226
North Pacific Spiny Dogfish	*Squalus suckleyi*	222
Spotted Ratfish	*Hydrolagus colliei*	156
China Rockfish	*Sebastes nebulosus*	115
Silvergray Rockfish	*Sebastes brevispinis*	107
Greenstriped Rockfish	*Sebastes elongatus*	99
Fish-Eating Star	*Stylasterias forreri*	91
Yellowmouth Rockfish	*Sebastes reedi*	79
Rosethorn Rockfish	*Sebastes helvomaculatus*	71
Big Skate	*Beringraja binoculata*	56
Copper Rockfish	*Sebastes caurinus*	50
Yellowtail Rockfish	*Sebastes flavidus*	41
Vermilion Rockfish	*Sebastes miniatus*	20
Deacon Rockfish	*Sebastes diaconus*	14
Sandpaper Skate	*Bathyraja interrupta*	9
Scallop	*Pectinidae*	9

Species	**Scientific name**	**Total Catch (count)**
Starfish	*Asteroidea*	8
Tiger Rockfish	*Sebastes nigrocinctus*	8
Leather Star	*Dermasterias imbricata*	7
	Metridium	7
Southern Rock Sole	*Lepidopsetta bilineata*	7
Red Irish Lord	*Hemilepidotus hemilepidotus*	6
Cabezon	*Scorpaenichthys marmoratus*	6
Anemone	*Actiniaria*	5
Sea Cucumbers	*Holothuroidea*	4
Petrale Sole	*Eopsetta jordani*	4
Sea Pens	*Pennatulacea*	3
Echinoderms	*Echinodermata*	3
Greenlings	*Hexagrammidae*	3
Bocaccio	*Sebastes paucispinis*	3
	Solasteridae	3
Redstripe Rockfish	*Sebastes proriger*	3
Shortspine Thornyhead	*Sebastolobus alascanus*	2
Skates	*Rajidae*	2
Alaska Skate	*Bathyraja parmifera*	2
Pacific Sanddab	*Citharichthys sordidus*	2
Speckled Sanddab	*Citharichthys stigmaeus*	2
	Primnoa	2
Dover Sole	*Microstomus pacificus*	2
Octopus	*Octopoda*	1
Chum Salmon	*Oncorhynchus keta*	1
Blue Shark	*Prionace glauca*	1

Species	**Scientific name**	**Total Catch (count)**
Oregontriton	*Fusitriton oregonensis*	1
Pacific Hake	*Merluccius productus*	1
Hydroid	*Hydrozoa*	1
Barnacles	*Cirripedia*	1
Kelp Greenling	*Hexagrammos decagrammus*	1
Sea Urchins	*Echinacea*	1

Table 14. Total catch (piece count) by species for the 2016 PHMA Longline Survey sets completed by the Banker II.

Species	Scientific Name	Total Catch (count)
Pacific Halibut	*Hippoglossus stenolepis*	814
Pacific Cod	*Gadus macrocephalus*	520
North Pacific Spiny Dogfish	*Squalus suckleyi*	468
Sablefish	*Anoplopoma fimbria*	468
Quillback Rockfish	*Sebastes maliger*	372
Canary Rockfish	*Sebastes pinniger*	208
Arrowtooth Flounder	*Atheresthes stomias*	201
Yelloweye Rockfish	*Sebastes ruberrimus*	194
Lingcod	*Ophiodon elongatus*	181
Big Skate	*Beringraja binoculata*	136
Spotted Ratfish	*Hydrolagus colliei*	136
Longnose Skate	*Raja rhina*	112
China Rockfish	*Sebastes nebulosus*	99
Redbanded Rockfish	*Sebastes babcocki*	55
Greenstriped Rockfish	*Sebastes elongatus*	47
Copper Rockfish	*Sebastes caurinus*	38
Rosethorn Rockfish	*Sebastes helvomaculatus*	28
Fish-eating Star	*Stylasterias forreri*	19
Sandpaper Skate	*Bathyraja interrupta*	16
Pacific Sanddab	*Citharichthys sordidus*	15
Petrale Sole	*Eopsetta jordani*	12
Southern Rock Sole	*Lepidopsetta bilineata*	11
Pacific Staghorn Sculpin	*Leptocottus armatus*	9
Anemone	*Actiniaria*	9
Great Sculpin	*Myoxocephalus polyacanthocephalus*	7

Species	Scientific Name	Total Catch (count)
Tiger Rockfish	*Sebastes nigrocinctus*	3
Starfish	*Asteroidea*	3
Yellowtail Rockfish	*Sebastes flavidus*	3
Vermilion Rockfish	*Sebastes miniatus*	2
Wolf Eel	*Anarrhichthys ocellatus*	2
Sunflower Starfish	*Pycnopodia helianthoides*	2
Dover Sole	*Microstomus pacificus*	2
Sea Cucumbers	*Holothuroidea*	2
Octopus	*Octopoda*	1
Sand Sole	*Psettichthys melanostictus*	1
Scallop	*Pectinidae*	1
Red Irish Lord	*Hemilepidotus hemilepidotus*	1
Sand Star	*Luidia foliolata*	1
	Tealia	1
Plainfin Midshipman	*Porichthys notatus*	1
Silvergray Rockfish	*Sebastes brevispinis*	1

Table 15. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the PHMA Longline Survey southern region.

Species	2007	2009	2011	2014	2016	Total
North Pacific Spiny Dogfish	8240	4896	5854	1457	779	21226
Yelloweye Rockfish	3784	3520	4079	2523	2444	16350
Pacific Halibut	2753	1760	1808	2881	2303	11505
Quillback Rockfish	1604	966	1718	1463	1477	7228
Sablefish	1257	1340	912	534	1128	5171
Longnose Skate	1498	645	698	621	429	3891
Spotted Ratfish	1029	263	1188	400	941	3821
Redbanded Rockfish	841	1125	647	507	529	3649
Lingcod	1188	610	493	767	473	3531
Pacific Cod	486	493	552	725	1249	3505
Arrowtooth Flounder	789	874	682	402	616	3363
Canary Rockfish	751	537	593	469	820	3170
Silvergray Rockfish	592	689	293	96	137	1807
China Rockfish	446	82	419	304	277	1528
Copper Rockfish	242	144	235	197	127	945
Greenstriped Rockfish	122	127	226	122	176	773
Rosethorn Rockfish	108	108	252	111	137	716
Big Skate	92	134	118	93	209	646
Yellowmouth Rockfish	115	84	28	37	85	349
Vermilion Rockfish	92	12	80	55	32	271
Yellowtail Rockfish	30	30	60	43	58	221
Cabezon	42	16	28	51	8	145
Petrale Sole	30	13	46	20	28	137
Tiger Rockfish	41	23	30	17	23	134
Southern Rock Sole	25	10	12	20	39	106

Table 16. Annual summary of the total landed weight (1000 kg) by species for the PHMA Longline Survey including both southern and northern regions.

Species	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
Pacific Halibut	16.24	8.53	16.4	6.37	14.58	7.05	19.64	9.38	22.91	7.5	128.6
Yelloweye Rockfish	12.95	11.82	13.55	11.19	12.16	12.63	14.22	8.58	16.43	7.86	121.38
Lingcod	6.34	6.42	6.88	2.68	3.17	2.6	4.21	3.46	3.25	2.09	41.11
Longnose Skate	4.6	8.16	4.22	3.18	3.23	3.65	3.69	1.82	0	0	32.55
Quillback Rockfish	2.32	1.79	2.5	1.01	2.65	1.84	3.09	1.63	3.14	1.65	21.62
Pacific Cod	2.02	0.84	1.85	0.75	2.33	1.1	2.99	0.98	1.71	2.32	16.87
Redbanded Rockfish	2.33	1.64	1.28	2.3	1.06	1.21	1.97	0.93	1.05	0.96	14.73
Silvergray Rockfish	2.56	1.24	2.24	1.43	1.59	0.54	2.31	0.19	1.22	0.26	13.58
Sablefish	1.41	2.14	1.01	2.46	0.5	0.83	0.97	1.14	0.53	1.11	12.09
Canary Rockfish	1.39	1.36	1.39	1.09	0.88	1.01	1.68	0.81	0.87	1.38	11.86
Big Skate	1.9	0.98	1.71	2.42	1.13	1.38	1.42	0.75	0	0	11.68
North Pacific Spiny Dogfish	0	2.16	0	0	0	0	0	0	0	0	2.16
Copper Rockfish	0.22	0.26	0.21	0.25	0.18	0.29	0.21	0.23	0.17	0.15	2.16
China Rockfish	0.05	0.35	0.13	0.06	0.14	0.32	0.14	0.23	0.11	0.22	1.75
Bocaccio	0.13	0.19	0.18	0.07	0.07	0.08	0.07	0	0.04	0.02	0.86
Sandpaper Skate	0.39	0.02	0.25	0.02	0.05	0	0.11	0	0	0	0.84
Vermilion Rockfish	0.04	0.19	0.03	0.03	0.01	0.21	0.05	0.13	0.07	0.08	0.84
Rosethorn Rockfish	0.05	0.05	0.07	0.04	0.06	0.1	0.1	0.04	0.07	0.06	0.64
Yellowtail Rockfish	0.06	0.04	0.04	0.05	0.03	0.09	0.12	0.05	0.05	0.09	0.63
Rougheye Rockfish	0.1	0.06	0.22	0.03	0.04	0	0.09	0.01	0.03	0	0.58

Species	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
Shortspine Thornyhead	0.12	0.01	0.27	0.01	0.05	0.01	0.05	0.02	0.04	0	0.58
Yellowmouth Rockfish	0	0.16	0.01	0.16	0	0.05	0.03	0.05	0	0.12	0.57
Tiger Rockfish	0.04	0.06	0.07	0.03	0.07	0.04	0.12	0.02	0.07	0.03	0.55
Greenstriped Rockfish	0.01	0.05	0.02	0.05	0.02	0.11	0.03	0.06	0.02	0.1	0.48
Black Rockfish	0.01	0.01	0.04	0	0.02	0.04	0.01	0.01	0.03	0	0.18
Petrale Sole	0.04	0.01	0.03	0	0	0.01	0.02	0.01	0	0	0.12
Dusky Rockfish	0	0	0.02	0	0	0	0.02	0	0.05	0	0.09
Widow Rockfish	0.03	0	0	0	0.02	0.01	0	0	0	0	0.06
Shortraker Rockfish	0.02	0	0.01	0	0	0	0	0.01	0	0	0.04
Southern Rock Sole	0.01	0	0	0	0	0	0	0	0	0	0.03
Pacific Ocean Perch	0	0.01	0	0	0.01	0	0	0	0	0	0.02
Redstripe Rockfish	0.01	0	0	0	0	0	0	0	0	0	0.02
Deacon Rockfish	0	0	0	0	0	0	0	0	0	0.02	0.02
Cabezon	0	0	0	0.02	0	0	0	0	0	0	0.02
Kelp Greenling	0	0	0	0	0	0	0	0	0	0	0.01
Walleye Pollock	0	0	0	0	0	0	0	0	0.01	0	0.01
Sharpchin Rockfish	0	0	0	0	0	0	0	0	0	0	0
Darkblotched Rockfish	0	0	0	0	0	0	0	0	0	0	0
Arrowtooth Flounder	0	0	0	0	0	0	0	0	0	0	0
Chilipepper	0	0	0	0	0	0	0	0	0	0	0

Table 17. Annual summary of the number of fish sampled for biological data during the PHMA Longline Survey in the southern region.

Species	2007	2009	2011	2014	2016	Total
Yelloweye Rockfish	2758	2579	3072	1939	1899	12247
Quillback Rockfish	1330	782	1296	1449	1107	5964
Redbanded Rockfish	468	603	265	355	413	2104
Canary Rockfish	238	332	192	445	426	1633
China Rockfish	224	69	228	308	266	1095
Copper Rockfish	221	144	221	192	130	908
Silvergray Rockfish	86	195	104	93	23	501
Greenstriped Rockfish	35	85	72	125	74	391
Rosethorn Rockfish	34	18	92	113	85	342
Vermilion Rockfish	27	4	16	54	32	133
Pacific Cod	0	0	0	119	0	119
Yellowtail Rockfish	4	15	22	41	11	93
Tiger Rockfish	23	7	22	17	23	92
Rougheye Rockfish	58	22	1	3	1	85
Yellowmouth Rockfish	0	5	2	36	2	45
Black Rockfish	4	1	26	8	0	39
Shortspine Thornyhead	6	6	8	16	0	36
Bocaccio	5	11	5	1	0	22
Deacon Rockfish	6	0	0	0	14	20
Redstripe Rockfish	0	1	5	0	0	6
Southern Rock Sole	0	0	5	0	0	5
Widow Rockfish	0	0	2	0	0	2
Pacific Ocean Perch	0	0	1	0	0	1
Sharpchin Rockfish	0	0	0	1	0	1
Shortraker Rockfish	0	0	0	1	0	1
Dusky Rockfish	0	1	0	0	0	1
Chilipepper	0	0	1	0	0	1

Table 18. Number of fish sampled for biological data during the 2016 PHMA Longline Survey on the Banker II showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Canary Rockfish	*Sebastes pinniger*	207	144
China Rockfish	*Sebastes nebulosus*	90	90
Copper Rockfish	*Sebastes caurinus*	41	41
Greenstriped Rockfish	*Sebastes elongatus*	45	41
Quillback Rockfish	*Sebastes maliger*	309	295
Redbanded Rockfish	*Sebastes babcocki*	54	54
Rosethorn Rockfish	*Sebastes helvomaculatus*	32	20
Tiger Rockfish	*Sebastes nigrocinctus*	3	3
Vermilion Rockfish	*Sebastes miniatus*	3	3
Yelloweye Rockfish	*Sebastes ruberrimus*	192	192
Yellowtail Rockfish	*Sebastes flavidus*	3	3

Table 19. Number of fish sampled for biological data during the 2016 PHMA Longline Survey on the Pacific Ambition showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Canary Rockfish	*Sebastes pinniger*	100	100
China Rockfish	*Sebastes nebulosus*	61	61
Copper Rockfish	*Sebastes caurinus*	40	40
Greenstriped Rockfish	*Sebastes elongatus*	14	14
Quillback Rockfish	*Sebastes maliger*	500	500
Redbanded Rockfish	*Sebastes babcocki*	56	56
Rosethorn Rockfish	*Sebastes helvomaculatus*	34	34
Rougheye Rockfish	*Sebastes aleutianus*	1	1
Silvergray Rockfish	*Sebastes brevispinis*	18	18
Tiger Rockfish	*Sebastes nigrocinctus*	12	12
Vermilion Rockfish	*Sebastes miniatus*	9	9
Yelloweye Rockfish	*Sebastes ruberrimus*	579	526
Yellowtail Rockfish	*Sebastes flavidus*	3	3

Table 20. Number of fish sampled for biological data during the 2016 PHMA Longline Survey on the Borealis 1 showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Canary Rockfish	*Sebastes pinniger*	119	119
China Rockfish	*Sebastes nebulosus*	115	115
Copper Rockfish	*Sebastes caurinus*	49	49
Deacon Rockfish	*Sebastes diaconus*	14	14
Greenstriped Rockfish	*Sebastes elongatus*	15	15
Quillback Rockfish	*Sebastes maliger*	298	300
Redbanded Rockfish	*Sebastes babcocki*	303	303
Rosethorn Rockfish	*Sebastes helvomaculatus*	19	19
Silvergray Rockfish	*Sebastes brevispinis*	5	5
Tiger Rockfish	*Sebastes nigrocinctus*	8	8
Vermilion Rockfish	*Sebastes miniatus*	20	20
Yelloweye Rockfish	*Sebastes ruberrimus*	1128	1128
Yellowmouth Rockfish	*Sebastes reedi*	2	2
Yellowtail Rockfish	*Sebastes flavidus*	5	5

Inside Area – DFO Hard Bottom Longline Hook

The DFO Hard Bottom Longline Hook Survey was conducted in the northern portion of the inside area on board the Canadian Coast Guard Ship Neocaligus from August 1 to 23, 2016. A total of 71 sets were completed (Figure 8). Six different DFO science staff and one volunteer student participated in the survey. The total catch of the survey was 6281 kg (Table 21). The average catch per set was 88 kg, averaging five different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (*Squalus suckleyi*), followed by Quillback Rockfish (*Sebastes maliger*), Yelloweye Rockfish (*Sebastes ruberrimus*), and Spotted Ratfish (*Hydrolagus colliei*). The number of sets where the species was captured as well as the total catch count and proportion of the total catch for the 25 most abundant species are shown in

Table 22. An annual summary of catch by species in the southern area is shown in Table 23. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 3719 individual fish of 20 different species (Table 24). An annual summary of the number of fish sampled for biological data in the southern area is shown in Table 25.

One vertical CTD (conductivity, temperature, and depth recorder) cast was made at each selected block during the 2016 DFO Hard Bottom Longline Hook Survey. The CTD also included a dissolved oxygen sensor. In addition, a temperature depth recorder were deployed at the start, middle, and end of every fishing set.

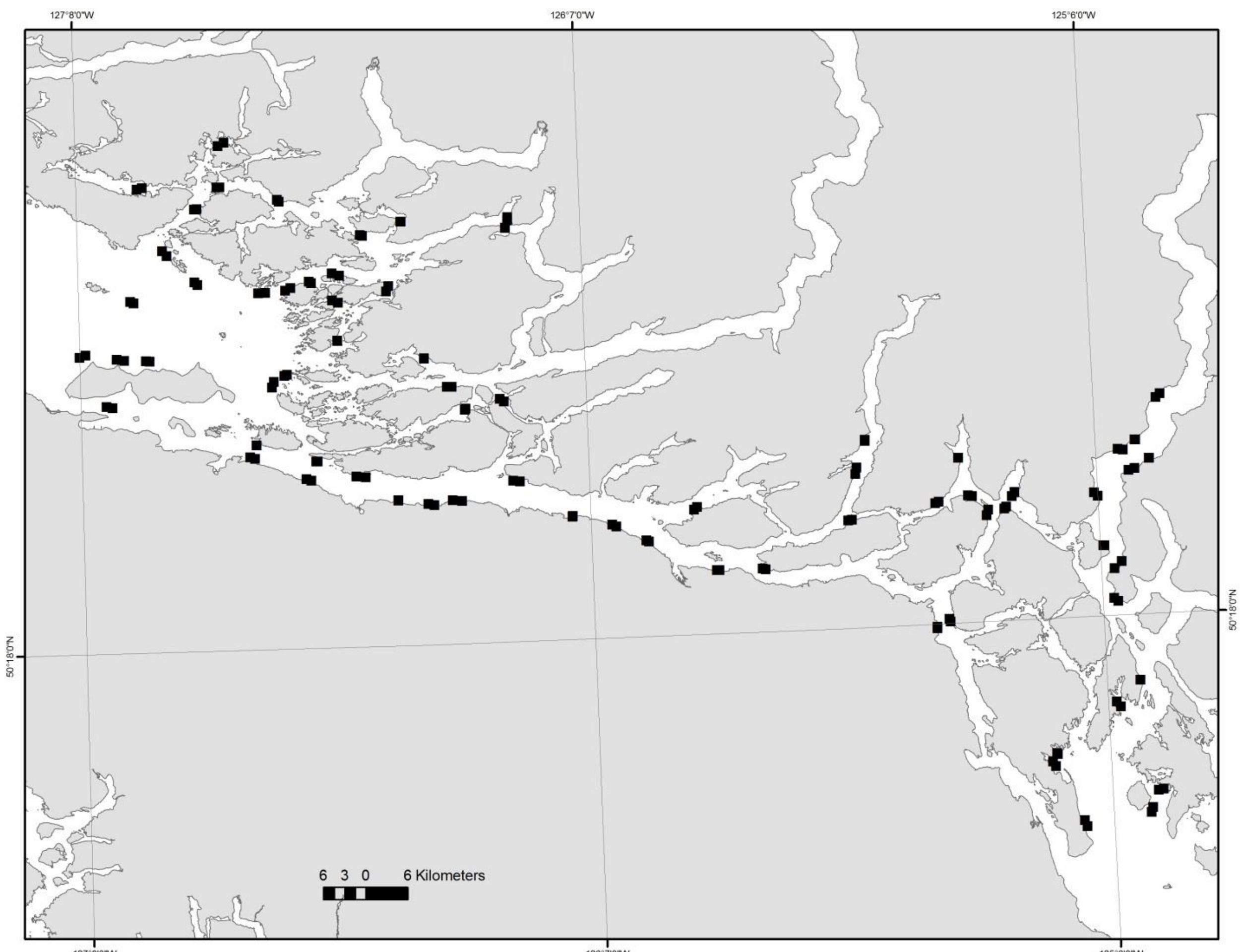


Figure 8. Longline set locations of the 2016 DFO Hard Bottom Longline Hook Survey.

Table 21. Total catch, showing both piece count and weight by species for the 2016 DFO Hard Bottom Longline Hook Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
North Pacific Spiny Dogfish	*Squalus suckleyi*	2290	3550
Quillback Rockfish	*Sebastes maliger*	570	507
Yelloweye Rockfish	*Sebastes ruberrimus*	246	575
Spotted Ratfish	*Hydrolagus colliei*	242	293
Sablefish	*Anoplopoma fimbria*	137	91
Lingcod	*Ophiodon elongatus*	90	578
Pacific Halibut	*Hippoglossus stenolepis*	41	465
Sponges	*Porifera*	28	7
Longnose Skate	*Raja rhina*	19	55
Copper Rockfish	*Sebastes caurinus*	16	20
Pink Scallop	*Chlamys rubida*	15	
Sunflower Starfish	*Pycnopodia helianthoides*	13	13
Greenstriped Rockfish	*Sebastes elongatus*	13	5
Pacific Cod	*Gadus macrocephalus*	11	12
Gastropods	*Gastropoda*	9	
Big Skate	*Beringraja binoculata*	7	65
	Bryozoa	7	
Canary Rockfish	*Sebastes pinniger*	7	16
Kelp Greenling	*Hexagrammos decagrammus*	6	5
Sea Pens	*Pennatulacea*	5	0
Oregontriton	*Fusitriton oregonensis*	5	0
Yellowtail Rockfish	*Sebastes flavidus*	3	2
Lampshells	*Brachiopoda*	3	0
Anemone	*Actiniaria*	2	0

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Tiger Rockfish	*Sebastes nigrocinctus*	2	1
Starfish	*Asteroidea*	2	1
Mottled Star	*Evasterias troschelii*	2	0
Great Sculpin	*Myoxocephalus polyacanthocephalus*	2	1
Barnacles	*Cirripedia*	2	2
Red Rock Crab	*Cancer productus*	2	0
Bivalve Molluscs	*Bivalvia*	2	
Inshore Tanner Crab	*Chionoecetes bairdi*	1	0
Box Crabs	*Lopholithodes*	1	0
Brown Box Crab	*Lopholithodes foraminatus*	1	1
Squat Lobster	*Munida quadrispina*	1	
Pacific Sanddab	*Citharichthys sordidus*	1	0
Pacific Staghorn Sculpin	*Leptocottus armatus*	1	0
	Tunicata	1	
Southern Rock Sole	*Lepidopsetta bilineata*	1	0
	Antedonidae	1	
	Coralliidae	1	
Sea Whip	*Balticina septentrionalis*	1	0
Glass Sponges	*Hexactinellida*		0

Table 22. Number of sets, catch (piece count), and proportion of the total fish caught catch of the top 25 fish species (by piece count) from the 2016 DFO Hard Bottom Longline Hook Survey.

Species	Number of Sets	Catch (count)	Proportion of Total Catch (%)
North Pacific Spiny Dogfish	58	2290	61.81
Quillback Rockfish	62	570	15.38
Yelloweye Rockfish	41	246	6.64
Spotted Ratfish	42	242	6.53
Sablefish	6	137	3.70
Lingcod	31	90	2.43
Pacific Halibut	21	41	1.11
Longnose Skate	11	19	0.51
Copper Rockfish	10	16	0.43
Greenstriped Rockfish	8	13	0.35
Pacific Cod	8	11	0.30
Canary Rockfish	2	7	0.19
Big Skate	3	7	0.19
Kelp Greenling	5	6	0.16
Yellowtail Rockfish	3	3	0.08
Great Sculpin	2	2	0.05
Tiger Rockfish	2	2	0.05
Southern Rock Sole	1	1	0.03
Pacific Staghorn Sculpin	1	1	0.03
Pacific Sanddab	1	1	0.03

Table 23. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the DFO Hard Bottom Longline Survey southern region.

Species	2007	2008	2010	2012	2014	2016	Total
North Pacific Spiny Dogfish	3035	5082	2716	2749	3004	2290	28194
Quillback Rockfish	745	158	441	757	526	570	4157
Spotted Ratfish	640	18	267	353	142	242	2776
Yelloweye Rockfish	116	202	156	170	156	246	1392
Pacific Halibut	168	3	27	62	79	41	475
Lingcod	38	38	65	75	45	90	411
Pacific Cod	96	15	26	32	22	11	379
Sablefish	23	0	26	47	14	137	366
Longnose Skate	42	15	33	17	8	19	221
Greenstriped Rockfish	48	4	10	23	7	13	184
Red Irish Lord	75	2	7	25	3	0	160
Copper Rockfish	4	38	11	25	10	16	126
Pacific Sanddab	7	5	9	21	3	1	86
Yellowtail Rockfish	21	1	3	1	5	3	65
Canary Rockfish	4	3	0	8	17	7	56
Tiger Rockfish	15	3	2	11	1	2	53
Arrowtooth Flounder	6	0	7	8	13	0	44
Big Skate	3	1	3	0	1	7	33
Buffalo Sculpin	0	0	25	7	0	0	32
Southern Rock Sole	0	5	7	10	1	1	28
Kelp Greenling	4	1	3	4	0	6	24
Cabezon	0	3	2	5	7	0	19
Brown Irish Lord	2	0	0	0	0	0	18
Great Sculpin	0	0	4	6	3	2	16
Silvergray Rockfish	1	2	8	3	0	0	15

Table 24. Number of fish sampled for biological data during the 2016 DFO Hard Bottom Longline Hook survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Big Skate	*Beringraja binoculata*	7	0
Canary Rockfish	*Sebastes pinniger*	7	0
Copper Rockfish	*Sebastes caurinus*	16	16
Great Sculpin	*Myoxocephalus polyacanthocephalus*	2	0
Greenstriped Rockfish	*Sebastes elongatus*	13	0
Kelp Greenling	*Hexagrammos decagrammus*	6	0
Lingcod	*Ophiodon elongatus*	89	0
Longnose Skate	*Raja rhina*	18	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	2289	0
Pacific Cod	*Gadus macrocephalus*	9	0
Pacific Halibut	*Hippoglossus stenolepis*	37	0
Pacific Sanddab	*Citharichthys sordidus*	1	0
Pacific Staghorn Sculpin	*Leptocottus armatus*	1	0
Quillback Rockfish	*Sebastes maliger*	568	569
Sablefish	*Anoplopoma fimbria*	133	118
Southern Rock Sole	*Lepidopsetta bilineata*	1	0
Spotted Ratfish	*Hydrolagus colliei*	283	0
Tiger Rockfish	*Sebastes nigrocinctus*	2	2
Yelloweye Rockfish	*Sebastes ruberrimus*	235	235
Yellowtail Rockfish	*Sebastes flavidus*	2	0

Table 25. Annual summary of the number of fish sampled for biological data during the DFO Hard Bottom Longline Survey in the northern region.

Species	2007	2008	2010	2012	2014	2016	Total
North Pacific Spiny Dogfish	2952	5061	2701	2747	3195	2289	26002
Quillback Rockfish	637	152	438	744	520	568	3991
Spotted Ratfish	553	11	255	339	135	283	2511
Yelloweye Rockfish	115	201	153	169	156	235	1372
Lingcod	36	36	64	75	45	89	402
Sablefish	24	0	24	47	13	133	354
Pacific Cod	72	9	25	27	18	9	310
Pacific Halibut	3	2	26	62	79	37	294
Greenstriped Rockfish	43	3	9	18	7	13	164
Longnose Skate	12	0	33	15	8	18	160
Copper Rockfish	4	36	11	25	10	16	121
Red Irish Lord	0	1	1	21	3	0	74
Pacific Sanddab	0	0	8	20	1	1	61
Canary Rockfish	3	3	0	8	17	7	55
Yellowtail Rockfish	13	1	3	1	5	2	54
Tiger Rockfish	14	3	2	11	1	2	51
Arrowtooth Flounder	1	0	8	8	13	0	35
Big Skate	2	0	3	0	1	7	30
Southern Rock Sole	0	3	6	10	1	1	24
Kelp Greenling	2	1	3	4	0	6	22
Silvergray Rockfish	2	2	8	3	0	0	16
Brown Irish Lord	0	0	0	0	0	0	14
Great Sculpin	0	0	3	6	3	2	14
Black Rockfish	0	0	0	0	0	0	12
Cabezon	0	0	2	2	7	0	11

Species	2007	2008	2010	2012	2014	2016	Total
China Rockfish	1	0	0	0	0	0	10
Redstripe Rockfish	5	0	0	0	0	0	9
Rosethorn Rockfish	3	0	0	0	0	0	6
Pacific Staghorn Sculpin	0	0	1	2	1	1	5
Sandpaper Skate	0	0	0	0	0	0	5
Buffalo Sculpin	0	0	0	5	0	0	5
Harlequin Rockfish	1	0	0	0	0	0	2
Sharpchin Rockfish	1	0	0	0	0	0	2
Widow Rockfish	0	0	0	0	0	0	1
Petrale Sole	0	0	0	1	0	0	1
Northern Ronquil	0	0	0	1	0	0	1
Deacon Rockfish	0	0	0	0	0	0	1
Flathead Sole	0	0	1	0	0	0	1

International Pacific Halibut Commission Standardized Stock Assessment Survey

The International Pacific Halibut Commission's (IPHC) Standardized Stock Assessment (SSA) survey is a fixed-station longline survey that extends from southern Oregon to the Bering Sea. This survey serves to index Pacific Halibut (*Hippoglossus stenolepis*) abundance and provide accompanying biological samples to assess the Pacific Halibut stock. The British Columbia (regulatory area 2B) portion of this survey has been conducted annually in various configurations from 1963 to the present (www.iphc.washington.edu).

Since 2003, the IPHC has provided the opportunity to deploy an additional technician during the survey to identify the catch to species level on a hook-by-hook basis and to collect biological samples from rockfish. This information was been collected every year since 2003 except for a one-year hiatus in 2013. This program is designed to fully enumerate the non-halibut catch in the survey and collect biological samples from inshore rockfish species.

The IPHC Longline Survey was conducted by two chartered commercial hook and line vessels and together completed a total of 170 sets (Figure 9). The Pender Isle completed a total of 86 sets at the IPHC Charlotte and James stations from June 16 to July 25, 2016. The Free to Wander completed a total of 84 sets in the IPHC Goose Island, James, and Vancouver stations from July 7 to August 13, 2016.

The most common species captured during the 2016 IPHC survey was Pacific Halibut (*Hippoglossus stenolepis*), followed by North Pacific Spiny Dogfish (Squalus suckleyi), Sablefish (Anoplopoma fimbria), and Yelloweye Rockfish (Sebastes ruberrimus) (Table 26). Table 27 shows the breakdown by major area of the top 25 species in the survey catch while Table 28 and Table 29 show the catch of all species by each vessel. Table 30 provides an annual summary of the total catch of the IPHC survey. Table 31 provides an annual summary of the catch landed from the IPHC survey.

During the IPHC longline survey, detailed biological samples including ageing structures are collected from rockfish in each set with a focus on inshore species. Table 32 provides an annual summary by species of the number of fish that were sampled for biological data during the IPHC Survey. A total of 2184 individual fish were sampled for biological data in 2016. On the Pender Isle, biological data were collected from a total of 896 individual fish (Table 33), while on the Free to Wander biological data were collected from a total of 1288 individual fish (Table 34).

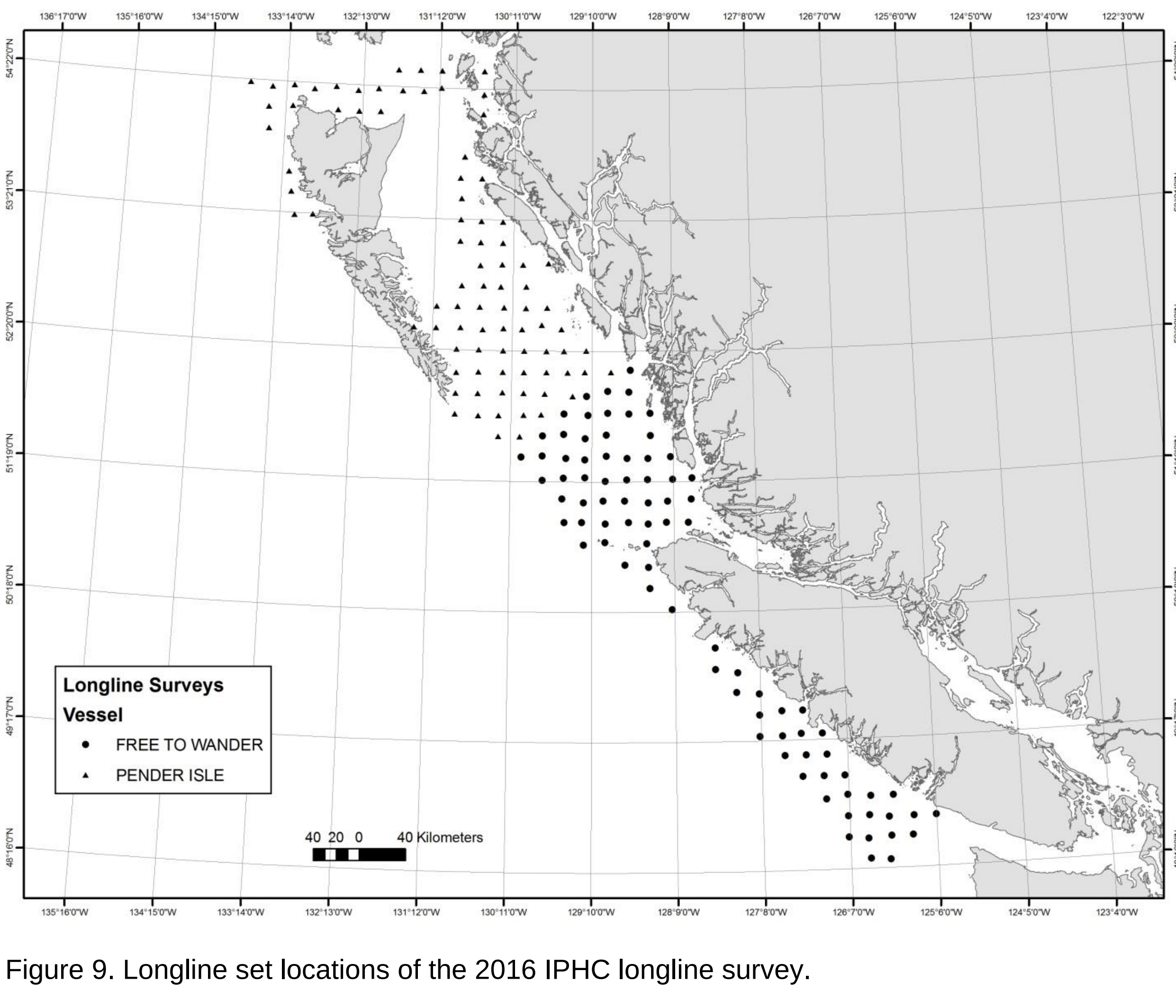


Figure 9. Longline set locations of the 2016 IPHC longline survey.

Table 26. Number of sets, catch (piece count), and proportion of the total fish caught catch of the top 25 fish species (by piece count) from the 2016 IPHC survey.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)
Pacific Halibut	*Hippoglossus stenolepis*	166	8135	39.02
North Pacific Spiny Dogfish	*Squalus suckleyi*	162	5563	26.69
Sablefish	*Anoplopoma fimbria*	106	2404	11.53
Yelloweye Rockfish	*Sebastes ruberrimus*	61	926	4.44
Redbanded Rockfish	*Sebastes babcocki*	73	871	4.18
Arrowtooth Flounder	*Atheresthes stomias*	97	830	3.98
Longnose Skate	*Raja rhina*	134	740	3.55
Lingcod	*Ophiodon elongatus*	54	243	1.17
Rougheye Rockfish	*Sebastes aleutianus*	17	178	0.85
Big Skate	*Beringraja binoculata*	56	141	0.68
Quillback Rockfish	*Sebastes maliger*	25	139	0.67
Shortspine Thornyhead	*Sebastolobus alascanus*	23	130	0.62
Pacific Cod	*Gadus macrocephalus*	46	113	0.54
Tope Shark	*Galeorhinus galeus*	13	67	0.32
Blue Shark	*Prionace glauca*	37	66	0.32
Silvergray Rockfish	*Sebastes brevispinis*	25	60	0.29
Spotted Ratfish	*Hydrolagus colliei*	23	43	0.21
Petrale Sole	*Eopsetta jordani*	20	39	0.19
Aleutian Skate	*Bathyraja aleutica*	15	36	0.17
Shortraker Rockfish	*Sebastes borealis*	5	31	0.15
Canary Rockfish	*Sebastes pinniger*	16	24	0.12
Yellowmouth Rockfish	*Sebastes reedi*	4	9	0.04
Flatfishes	*Pleuronectiformes*	5	8	0.04
Bocaccio	*Sebastes paucispinis*	4	8	0.04

China Rockfish	*Sebastes nebulosus*	2	7	0.03

Table 27. Catch (piece count) by major area for the top 25 fish species (by piece count) from the 2016 IPHC survey.

Species	**Scientific Name**	**3C**	**3D**	**5A**	**5B**	**5C**	**5D**	**5E**
Pacific Halibut	*Hippoglossus stenolepis*	429	866	920	2365	1436	1248	871
North Pacific Spiny Dogfish	*Squalus suckleyi*	2328	254	101	1398	949	373	160
Sablefish	*Anoplopoma fimbria*	345	298	183	626	462	223	267
Yelloweye Rockfish	*Sebastes ruberrimus*	21	58	72	524	127	5	119
Redbanded Rockfish	*Sebastes babcocki*	10	102	54	281	274	66	84
Arrowtooth Flounder	*Atheresthes stomias*	55	101	122	105	256	180	11
Longnose Skate	*Raja rhina*	83	80	60	203	100	133	81
Lingcod	*Ophiodon elongatus*	17	99	37	24	33	2	31
Rougheye Rockfish	*Sebastes aleutianus*	2	1	3	54	0	17	101
Big Skate	*Beringraja binoculata*	26	13	7	28	20	38	9
Quillback Rockfish	*Sebastes maliger*	49	12	10	16	32	2	18
Shortspine Thornyhead	*Sebastolobus alascanus*	8	2	0	56	9	24	31
Pacific Cod	*Gadus macrocephalus*	15	14	5	12	24	35	8
Tope Shark	*Galeorhinus galeus*	53	11	0	3	0	0	0
Blue Shark	*Prionace glauca*	11	19	7	20	9	0	0
Silvergray Rockfish	*Sebastes brevispinis*	0	5	2	22	5	6	20
Spotted Ratfish	*Hydrolagus colliei*	10	0	3	7	11	5	7
Petrale Sole	*Eopsetta jordani*	2	4	15	5	11	2	0
Aleutian Skate	*Bathyraja aleutica*	0	0	0	0	12	13	11
Shortraker Rockfish	*Sebastes borealis*	0	5	0	7	1	0	18
Canary Rockfish	*Sebastes pinniger*	1	6	0	3	8	2	4
Yellowmouth Rockfish	*Sebastes reedi*	0	0	4	4	0	0	1
Flatfishes	*Pleuronectiformes*	0	0	1	0	0	1	6
Bocaccio	*Sebastes paucispinis*	0	1	1	6	0	0	0
China Rockfish	*Sebastes nebulosus*	6	1	0	0	0	0	0

Table 28. Total catch (piece count) by species for the 2016 IPHC survey sets completed by the Pender Isle.

Species	Scientific Name	Total Catch (count)
Pacific Halibut	*Hippoglossus stenolepis*	4510
North Pacific Spiny Dogfish	*Squalus suckleyi*	1853
Sablefish	*Anoplopoma fimbria*	1185
Yelloweye Rockfish	*Sebastes ruberrimus*	552
Redbanded Rockfish	*Sebastes babcocki*	480
Arrowtooth Flounder	*Atheresthes stomias*	468
Longnose Skate	*Raja rhina*	389
Rougheye Rockfish	*Sebastes aleutianus*	142
Shortspine Thornyhead	*Sebastolobus alascanus*	95
Lingcod	*Ophiodon elongatus*	77
Pacific Cod	*Gadus macrocephalus*	73
Big Skate	*Beringraja binoculata*	71
Quillback Rockfish	*Sebastes maliger*	52
Silvergray Rockfish	*Sebastes brevispinis*	49
Aleutian Skate	*Bathyraja aleutica*	36
Spotted Ratfish	*Hydrolagus colliei*	26
	Anthozoa	25
Fish-eating Star	*Stylasterias forreri*	24
Shortraker Rockfish	*Sebastes borealis*	19
Blue Shark	*Prionace glauca*	17
Canary Rockfish	*Sebastes pinniger*	14
Petrale Sole	*Eopsetta jordani*	13
Scallop	*Pectinidae*	11
Starfish	*Asteroidea*	11
Sunflower Starfish	*Pycnopodia helianthoides*	11

Species	Scientific Name	Total Catch (count)
Anemone	*Actiniaria*	11
Basket Stars	*Euryalina*	8
Flatfishes	*Pleuronectiformes*	7
Sponges	*Porifera*	7
Bocaccio	*Sebastes paucispinis*	6
Yellowmouth Rockfish	*Sebastes reedi*	4
	Radiata	4
Pacific Sleeper Shark	*Somniosus pacificus*	4
Sandpaper Skate	*Bathyraja interrupta*	3
Sea Urchins	*Echinacea*	3
Octopus	*Octopoda*	3
Giant Wrymouth	*Cryptacanthodes giganteus*	2
Bluntnose Sixgill Shark	*Hexanchus griseus*	2
Sea Pens	*Pennatulacea*	2
Copper Rockfish	*Sebastes caurinus*	2
Skates	*Rajidae*	1
Inanimate Object(s)	*Inanimate object(s)*	1
Pacific Hagfish	*Eptatretus stoutii*	1
Glass Sponges	*Hexactinellida*	1
Walleye Pollock	*Gadus chalcogrammus*	1
Sleeper Sharks	*Somniosidae*	1

Table 29. Total catch (piece count) by species for the 2016 IPHC Survey sets completed by the Free to Wander.

Species	Scientific Name	Total Catch (count)
North Pacific Spiny Dogfish	*Squalus suckleyi*	3710
Pacific Halibut	*Hippoglossus stenolepis*	3625
Sablefish	*Anoplopoma fimbria*	1219
Redbanded Rockfish	*Sebastes babcocki*	391
Yelloweye Rockfish	*Sebastes ruberrimus*	374
Arrowtooth Flounder	*Atheresthes stomias*	362
Longnose Skate	*Raja rhina*	351
Lingcod	*Ophiodon elongatus*	166
Quillback Rockfish	*Sebastes maliger*	87
Big Skate	*Beringraja binoculata*	70
Tope Shark	*Galeorhinus galeus*	67
Blue Shark	*Prionace glauca*	49
Pacific Cod	*Gadus macrocephalus*	40
Rougheye Rockfish	*Sebastes aleutianus*	36
Shortspine Thornyhead	*Sebastolobus alascanus*	35
Petrale Sole	*Eopsetta jordani*	26
Fish-eating Star	*Stylasterias forreri*	24
Spotted Ratfish	*Hydrolagus colliei*	17
Shortraker Rockfish	*Sebastes borealis*	12
Silvergray Rockfish	*Sebastes brevispinis*	11
Canary Rockfish	*Sebastes pinniger*	10
Anemone	*Actiniaria*	10
Inanimate Object(s)	*Inanimate object(s)*	8
China Rockfish	*Sebastes nebulosus*	7
Octopus	*Octopoda*	6

Species	Scientific Name	Total Catch (count)
Basket Stars	*Euryalina*	5
Yellowmouth Rockfish	*Sebastes reedi*	5
	Radiata	4
Sea Urchins	*Echinacea*	4
Thornyheads	*Sebastolobinae*	3
Starfish	*Asteroidea*	3
Bocaccio	*Sebastes paucispinis*	2
Wolf Eel	*Anarrhichthys ocellatus*	2
	Anthozoa	2
Copper Rockfish	*Sebastes caurinus*	2
Southern Rock Sole	*Lepidopsetta bilineata*	2
Dover Sole	*Microstomus pacificus*	1
Scallop	*Pectinidae*	1
Greenstriped Rockfish	*Sebastes elongatus*	1
	Bryozoa	1
Walleye Pollock	*Gadus chalcogrammus*	1
Sponges	*Porifera*	1
Bluntnose Sixgill Shark	*Hexanchus griseus*	1
Pacific Sleeper Shark	*Somniosus pacificus*	1
Sandpaper Skate	*Bathyraja interrupta*	1
Vermilion Rockfish	*Sebastes miniatus*	1
Tiger Rockfish	*Sebastes nigrocinctus*	1
Pacific Sanddab	*Citharichthys sordidus*	1
Flatfishes	*Pleuronectiformes*	1

Table 30. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the IPHC Survey.

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
North Pacific Spiny Dogfish	14166	11814	15114	13984	12952	8854	19112	17562	12847	7985	8938	6617	5563	155508
Pacific Halibut	7101	8570	7075	5567	4912	6901	9308	10784	6487	8480	9642	10268	8135	103230
Sablefish	4169	5610	5033	3000	2020	2360	3342	4077	2648	1933	1716	2444	2404	40756
Arrowtooth Flounder	1381	2135	1671	1060	724	1109	1910	2014	1238	981	910	896	830	16859
Redbanded Rockfish	1309	2013	1597	1285	739	1157	1946	1625	973	848	939	597	871	15899
Yelloweye Rockfish	1225	1545	1174	1005	693	840	1371	1744	955	877	716	708	926	13779
Longnose Skate	926	1147	1011	795	645	781	1243	1385	922	1008	1161	1086	740	12850
Lingcod	263	308	201	375	335	411	504	324	237	311	321	324	243	4157
Rougheye Rockfish	287	474	541	216	121	279	346	159	229	156	190	139	178	3315
Quillback Rockfish	156	144	300	198	122	88	182	251	182	114	155	188	139	2219
Big Skate	222	256	236	159	102	95	116	221	202	150	201	109	141	2210
Pacific Cod	80	333	253	162	62	52	98	149	269	117	248	260	113	2196
Shortspine Thornyhead	202	190	216	152	59	92	157	171	13	61	52	14	130	1509
Silvergray Rockfish	62	68	109	155	65	140	78	87	118	63	70	35	60	1110
Spotted Ratfish	58	47	98	100	32	46	36	34	77	52	71	57	43	751
Canary Rockfish	19	25	69	63	21	43	70	35	34	19	36	34	24	492
Shortraker Rockfish	33	27	30	17	44	18	152	17	16	12	42	19	31	458
Unknown Fish	2	0	0	420	0	0	0	1	2	0	0	0	0	425
Blue Shark	19	125	12	0	3	1	8	15	0	14	24	57	66	344

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
Thornyheads	0	0	0	0	15	17	0	1	108	30	60	91	3	325
Tope Shark	5	30	17	2	2	11	16	25	9	3	18	87	67	292
Petrale Sole	10	27	18	16	14	14	16	19	35	19	25	29	39	281
Bocaccio	19	32	16	37	15	32	24	15	23	14	13	10	8	258
Aleutian Skate	0	0	0	12	16	19	8	19	14	20	34	22	36	200
Pacific Sleeper Shark	8	21	5	7	9	5	9	5	3	2	3	3	5	85

Table 31. Annual summary of the total landed weight (1000 kg) by species for the IPHC Survey. Data from 2003 are not included as the landings records are not available in the FOS database.

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Pacific Halibut	34.04	37.62	24.7	18.22	32.59	45.09	55.19	36.3	49.44	0	48.12	48.01	40.84	488.4
Yelloweye Rockfish	5.55	4.04	3.3	1.89	2.8	4.54	5.93	3.14	3.06	0	2.41	2.52	3.31	45.53
Redbanded Rockfish	4.92	3.84	3.07	1.47	2.77	4.49	3.7	2.23	2.01	0	2.16	1.36	2	36.68
Sablefish	6.74	0	1.14	0	2.28	0	0	1.85	2.13	0	2.28	0	0	16.92
Rougheye Rockfish	0.97	1.16	0.47	0.23	0.61	1	0.34	0.46	0.31	0	0.4	0.27	0.39	7.1
Pacific Cod	0.63	0.45	0.09	0.17	0.09	0.1	0.3	0.46	0.2	0	0.2	0.11	0.16	3.08
Quillback Rockfish	0.17	0.36	0.24	0.15	0.11	0.22	0.29	0.23	0.14	0	0.19	0.21	0.16	2.56
Silvergray Rockfish	0.17	0.24	0.35	0.1	0.3	0.17	0.19	0.25	0.13	0	0.15	0.07	0.13	2.35
Shortraker Rockfish	0.18	0.16	0.06	0.16	0.06	0.26	0.09	0.08	0.1	0	0.25	0.15	0.22	2.05
Shortspine Thornyhead	0.23	0.32	0.2	0.09	0.17	0.25	0.25	0.24	0	0	0	0	0	2.04
Bocaccio	0.11	0.07	0.16	0.04	0.11	0.1	0.06	0.09	0.06	0	0.05	0.04	0.03	1
Canary Rockfish	0.05	0.12	0.12	0.04	0.08	0.13	0.07	0.06	0.04	0	0.07	0.06	0.05	0.89
Lingcod	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Yellowmouth Rockfish	0.01	0.02	0	0	0.01	0.01	0	0.01	0.01	0	0	0.01	0.01	0.1
China Rockfish	0	0.01	0	0.01	0.01	0.01	0	0.01	0	0	0	0	0.01	0.05
Copper Rockfish	0.01	0	0	0	0.01	0	0	0	0.01	0	0	0	0	0.04
Yellowtail Rockfish	0.01	0.01	0	0	0	0	0	0	0	0	0	0.01	0	0.03
Vermilion Rockfish	0	0	0.01	0	0	0.01	0	0	0	0	0	0.01	0	0.02
Greenstriped Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Black Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Tiger Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Rosethorn Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Pacific Ocean Perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Darkblotched Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 32. Annual summary of the number of fish sampled for biological data during the IPHC Survey.

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
Redbanded Rockfish	866	1312	1379	1201	712	1130	1889	1598	971	843	927	582	823	14233
Yelloweye Rockfish	838	1240	1065	958	682	832	1349	1727	950	878	711	699	926	12855
Sablefish	2216	2917	0	0	0	0	0	0	0	0	0	0	0	5133
Rougheye Rockfish	102	292	525	210	112	277	368	149	230	154	179	131	164	2893
Quillback Rockfish	115	133	234	186	119	86	177	246	179	112	150	177	128	2042
Silvergray Rockfish	21	24	47	141	60	136	77	87	114	57	67	32	56	919
North Pacific Spiny Dogfish	0	0	0	0	0	0	0	0	485	0	0	0	0	485
Shortspine Thornyhead	0	120	151	136	0	0	0	75	0	0	0	0	0	482
Canary Rockfish	5	19	39	60	15	43	65	33	32	17	35	32	22	417
Shortraker Rockfish	15	10	29	16	44	16	116	19	15	12	40	18	30	380
Bocaccio	4	14	7	33	13	31	24	14	23	14	11	10	8	206
Yellowmouth Rockfish	0	2	2	3	9	6	12	4	5	3	4	5	9	64
China Rockfish	1	5	6	0	8	9	6	1	5	2	2	3	7	55
Copper Rockfish	0	5	2	0	0	6	2	4	4	12	0	1	4	40
Greenstriped Rockfish	0	8	2	2	2	2	2	2	5	2	2	1	1	31
Blackspotted Rockfish	0	0	0	0	0	0	24	0	0	0	0	0	0	24
Yellowtail Rockfish	0	5	4	4	1	0	0	1	2	0	1	2	0	20
Rosethorn Rockfish	0	0	0	0	1	3	1	1	2	3	4	2	0	17
Vermilion Rockfish	0	0	0	2	0	0	0	0	0	0	1	2	1	6
Tiger Rockfish	0	0	0	1	1	0	0	0	1	0	0	0	1	4
Black Rockfish	0	0	0	2	0	0	0	0	0	0	2	0	0	4

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	Total
Darkblotched Rockfish	0	0	0	0	2	0	0	0	1	0	0	0	0	3
Blue Shark	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Sleeper Sharks	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Redstripe Rockfish	0	1	0	0	0	0	0	0	0	0	0	0	0	1

Table 33. Number of fish sampled for biological data during the 2016 IPHC Survey on the Pender Isle showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Blue Shark	*Prionace glauca*	2	0
Bocaccio	*Sebastes paucispinis*	6	6
Canary Rockfish	*Sebastes pinniger*	13	13
Copper Rockfish	*Sebastes caurinus*	2	2
Quillback Rockfish	*Sebastes maliger*	47	47
Redbanded Rockfish	*Sebastes babcocki*	469	468
Rougheye Rockfish	*Sebastes aleutianus*	135	111
Shortraker Rockfish	*Sebastes borealis*	18	1
Silvergray Rockfish	*Sebastes brevispinis*	48	47
Sleeper Sharks	*Somniosidae*	2	0
Yelloweye Rockfish	*Sebastes ruberrimus*	542	544
Yellowmouth Rockfish	*Sebastes reedi*	4	4

Table 34. Number of fish sampled for biological data during the 2016 IPHC Survey on the Free to Wander showing the number of lengths and age structures that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**
Bocaccio	*Sebastes paucispinis*	2	2
Canary Rockfish	*Sebastes pinniger*	9	9
China Rockfish	*Sebastes nebulosus*	7	7
Copper Rockfish	*Sebastes caurinus*	2	2
Greenstriped Rockfish	*Sebastes elongatus*	1	1
Quillback Rockfish	*Sebastes maliger*	81	80
Redbanded Rockfish	*Sebastes babcocki*	354	353
Rougheye Rockfish	*Sebastes aleutianus*	29	29
Shortraker Rockfish	*Sebastes borealis*	12	12
Silvergray Rockfish	*Sebastes brevispinis*	8	8
Tiger Rockfish	*Sebastes nigrocinctus*	1	1
Vermilion Rockfish	*Sebastes miniatus*	1	1
Yelloweye Rockfish	*Sebastes ruberrimus*	384	328
Yellowmouth Rockfish	*Sebastes reedi*	5	5

Sablefish Research and Assessment Survey

Fisheries and Oceans Canada, in collaboration with the commercial sablefish industry, initiated an annual research and assessment survey of British Columbia Sablefish in 1988. Each year, fishing is conducted at selected localities using trap gear consistent with the commercial fishery. The fishing protocol was refined over the first few years of the survey and was standardized beginning in 1990. These standardized sets were intended to track trends in abundance and biological characteristics at the survey localities. We refer to these sets as the Traditional Standardized Program. Sablefish from standardized sets were tagged and released beginning in 1991. Then, in 1994, sets with the sole purpose of capturing Sablefish for tag and release were added at the existing localities. We refer to these sets as the Traditional Tagging Program. Also in 1994, sets were made in selected mainland inlet localities. In 1995, additional offshore localities were added specifically for tagging sets. The Traditional Tagging Program has not been conducted since 2007 and the Traditional Standardized Program has not been conducted since 2010.

A pilot stratified random design was introduced for the 2003 survey with the dual purposes of random release of tagged fish and development of a second stock abundance index. The offshore survey area was divided into five spatial strata (Figure 10). Each spatial stratum was further divided into 2 km by 2 km blocks and each block was assigned to one three depth strata. Each year, blocks are randomly selected within each combination of spatial and depth strata. From 2003 through 2010, the selected blocks were allocated equally among the strata. An analysis was conducted for the 2011 survey to estimate the optimal allocation of blocks and that allocation was used in both 2011 and 2012. In 2013 the number of blocks in the survey was reduced in an effort to reduce the overall cost of the survey. The allocation from 2013 has been used for all subsequent surveys and will be used again in 2016.

The 2016 Sablefish research and assessment survey was comprised of two main components:

A **Randomized Tagging Program** that releases tagged Sablefish at randomly selected fishing locations in offshore waters. Theses sets also produce a time series of catch rate and biological data that can be used for assessing changes in stock abundance.

An **Inlets Program** that releases tagged Sablefish from fixed-stations at four mainland inlet localities (Figure 11). These sets also provide a time series of catch rate and biological data that can be used for assessing changes in stock abundance.

In addition to the main survey programs, the Sablefish Research and Assessment Survey included a Bottom Contact Research Project to investigate gear interaction with the substrate. Autonomous, trap-mounted cameras captured high definition video of benthic substrate type, gear interaction with the substrate, and biological communities. In addition, trap-mounted accelerometers recorded motion and orientation of the traps. Oceanographic data from trap-mounted recorders including temperature, depth, salinity and dissolved oxygen were also recorded.

The 2016 Sablefish Research and Assessment Survey was conducted on the Ocean Pearl from October 7 to November 22, 2016. A total of 111 sets were completed (**Error! Reference source not found.**) including 91 Randomized Tagging Program sets (Table 35) and 20 Inlets Program sets (Table 36).

A total of six different DFO staff persons and four contract science staff from Archipelago Marine Research participated in the survey. The total catch of the survey was 67,166 kg (Table 37) and the average catch per set was 605 kg. The most abundant fish species encountered by weight were Sablefish (*Anoplopoma fimbria*), followed by Pacific Halibut (*Hippoglossus stenolepis*), North Pacific Spiny Dogfish (*Squalus suckleyi*), and Lingcod (*Ophiodon elongatus*). The number of sets where the species was captured as well as the total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species are shown in Table 38. An annual summary of catch for common species are shown for the Randomized Tagging Program in Table 39 and in Table 40 for the Inlet Program. Biological data, including individual length, weight, sex, maturity and age structure were collected from a total of 13,583 individual fish of 7 different species.

Table 41). An annual summary of the number of fish sampled for biological data during the Randomized Tagging Program is shown in Table 42 and in Table 42 for the Inlets Program.

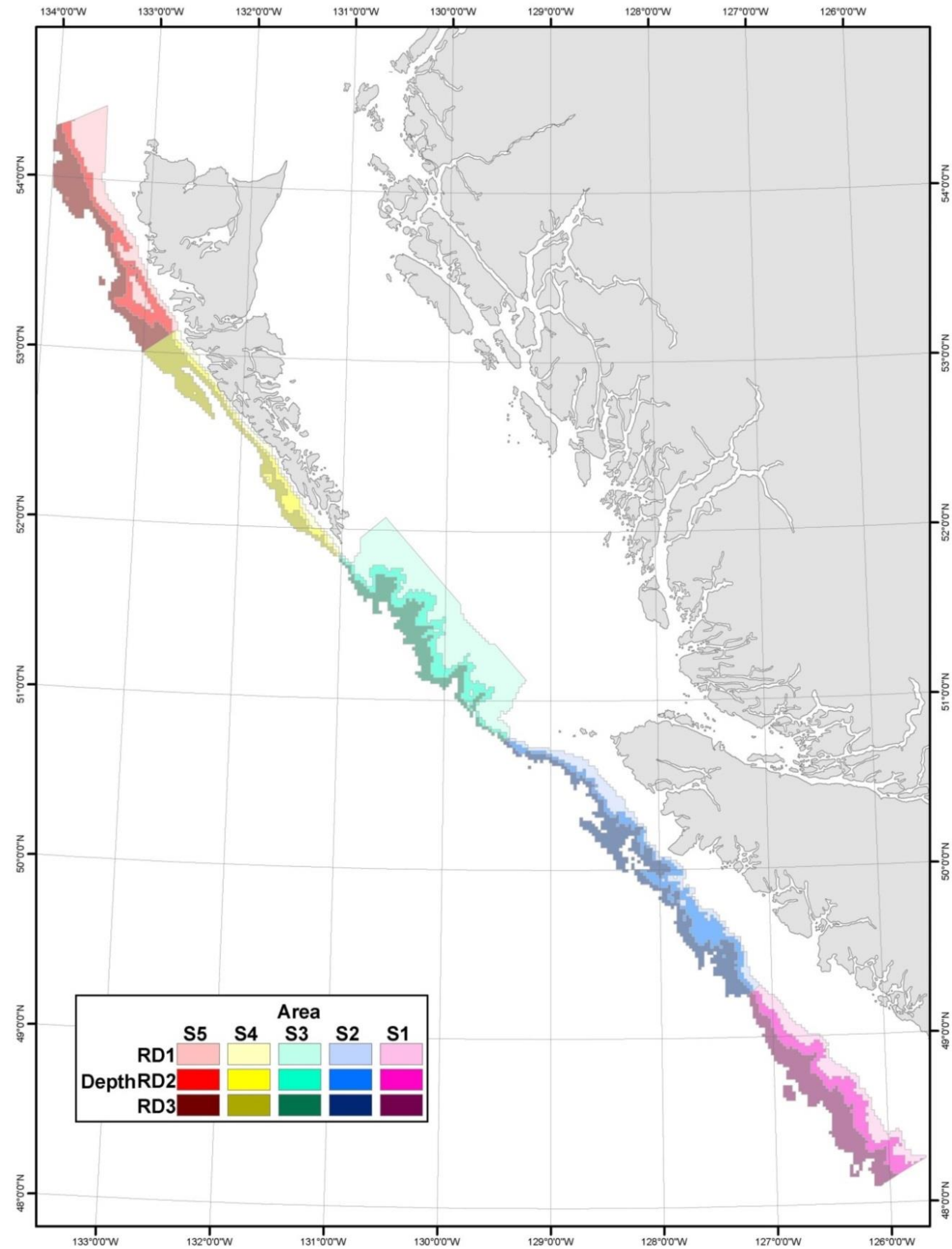


Figure 10. Sablefish Research and Assessment Survey randomized tagging program design showing the boundaries of each of the spatial and depth strata.

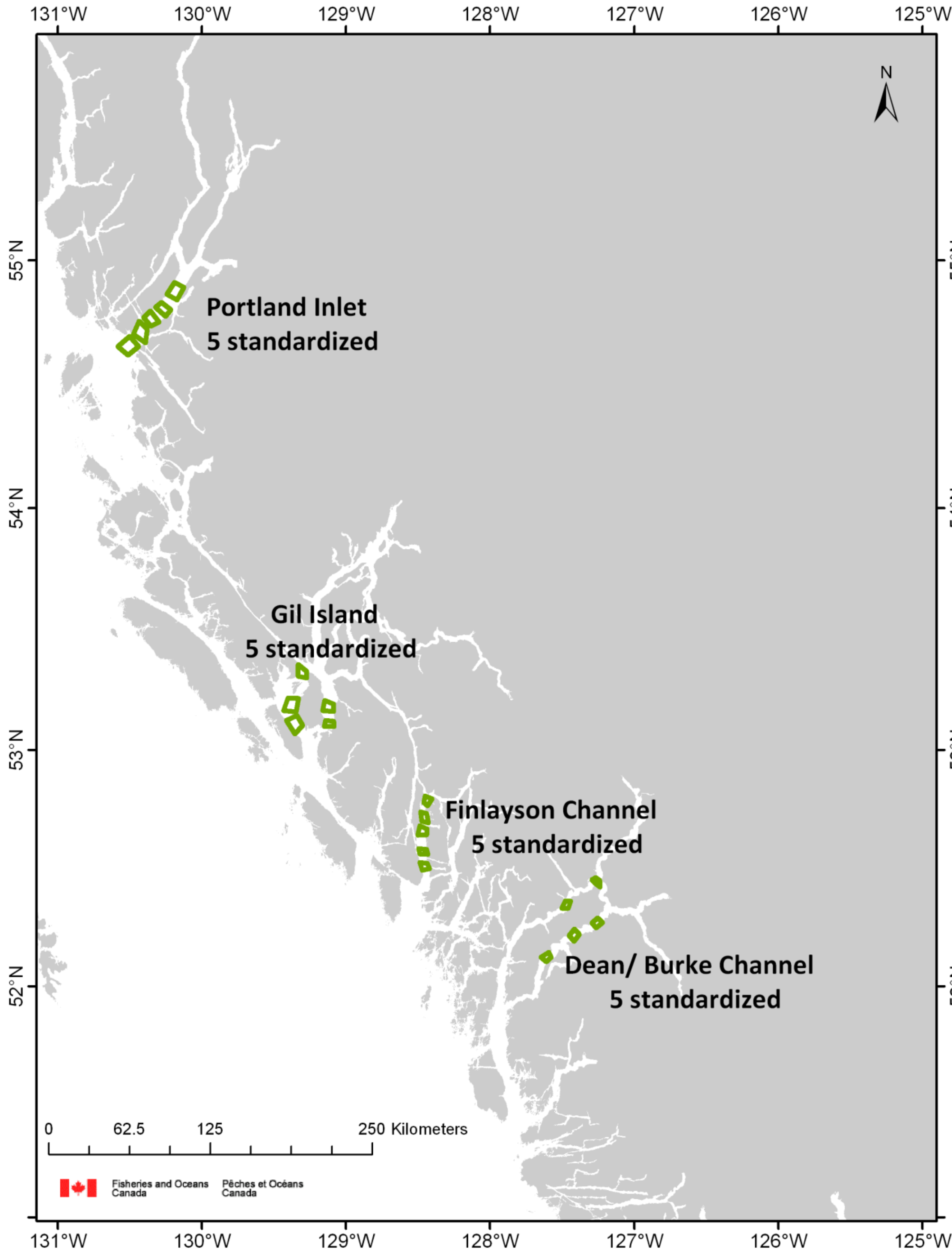


Figure 11. Sablefish Research and Assessment Survey Inlets program locations.

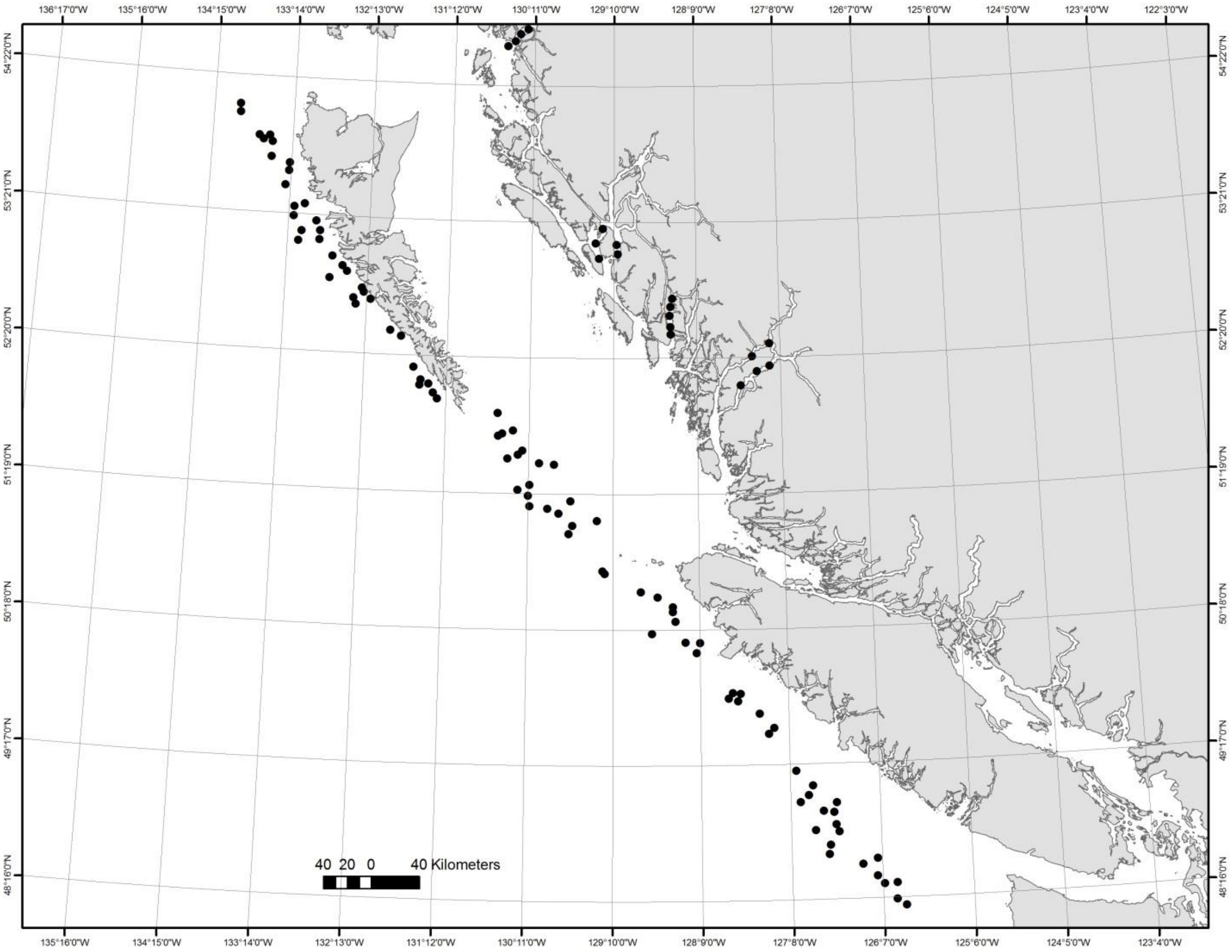


Figure 12. Set locations of the 2016 Sablefish Research and Assessment Survey.

Table 35. Summary of sets made during the 2016 Sablefish Randomized Tagging Program showing the number of sets in each combination of spatial and depth strata.

Spatial Strata	**Depth Strata**			
	RD1 (100-250 fm)	RD2 (250-450 fm)	RD3 (450-750)	**Total**
S1 (South West Coast Vancouver Island or SWCVI)	6	8	5	19
S2 (North West Coast Vancouver Island or NWCVI)	6	7	5	18
S3 (Queen Charlotte Sound or QCS)	8	6	5	19
S4 (South West Coast Haida Gwaii or SWCHG)	6	6	5	17
S5 (North West Coast Haida Gwaii or NWCHG)	6	7	5	18
Total	**32**	**34**	**25**	**91**

Table 36. Summary of sets made during the 2016 Sablefish Inlets Program.

Location	**Number of sets**
Dean/Burke Channel	5
Finlayson Channel	5
Gil Island	5
Portland Inlet	5

Table 37. Total catch for the top 35 species (by weight) captured during the 2016 Sablefish Research and Assessment Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Sablefish	*Anoplopoma fimbria*	23123	55575
Pacific Halibut	*Hippoglossus stenolepis*	526	3870
North Pacific Spiny Dogfish	*Squalus suckleyi*	713	2014
Lingcod	*Ophiodon elongatus*	154	1558
Arrowtooth Flounder	*Atheresthes stomias*	451	899
Rougheye Rockfish	*Sebastes aleutianus*	387	659
Pacific Grenadier	*Coryphaenoides acrolepis*	627	575
Yelloweye Rockfish	*Sebastes ruberrimus*	97	346
Redbanded Rockfish	*Sebastes babcocki*	217	345
Giant Grenadier	*Albatrossia pectoralis*	72	288
Shortraker Rockfish	*Sebastes borealis*	59	276
Grooved Tanner Crab	*Chionoecetes tanneri*	539	260
Pacific Sleeper Shark	*Somniosus pacificus*	2	225
Shortspine Thornyhead	*Sebastolobus alascanus*	60	85
NULL	*Paralomis multispina*	65	31
Dover Sole	*Microstomus pacificus*	24	29
NULL	*Lithodes couesi*	45	26
Yellowmouth Rockfish	*Sebastes reedi*	9	12
Fragile Urchin	*Allocentrotus fragilis*	93	12
Pacific Flatnose	*Antimora microlepis*	10	12
Bocaccio	*Sebastes paucispinis*	1	7
Canary Rockfish	*Sebastes pinniger*	2	5
Jellyfish	*Scyphozoa*		5
Rosethorn Rockfish	*Sebastes helvomaculatus*	15	5
Pink Snailfish	*Paraliparis rosaceus*	9	4
Rockfishes	*Sebastes*	3	3
Anemone	*Actiniaria*	3	3
Longspine Thornyhead	*Sebastolobus altivelis*	17	3
Golden King Crab	*Lithodes aequispinus*	4	3
Giant Pacific Octopus	*Enteroctopus dofleini*	3	2

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Oregontriton	*Fusitriton oregonensis*	44	2
Walleye Pollock	*Gadus chalcogrammus*	2	2
Brown Box Crab	*Lopholithodes foraminatus*	2	2
Pacific Cod	*Gadus macrocephalus*	1	1
Spotted Ratfish	*Hydrolagus colliei*	1	1

Table 38. Number of sets where the species was captured, total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species (by weight) captured during the 2016 Sablefish Research and Assessment Survey.

Species	**Number of Sets**	**Catch (count)**	**Proportion of Total Catch (%)**	**4B**	**3C**	**3D**	**5A**	**5B**	**5C**	**5D**	**5E**
Sablefish	110	23123	86.97	0	5022	3652	2463	4300	2137	2210	3339
North Pacific Spiny Dogfish	34	713	2.68	0	24	122	51	199	14	0	303
Pacific Grenadier	17	627	2.36	0	102	98	68	63	0	0	296
Pacific Halibut	59	526	1.98	0	28	99	17	33	68	160	121
Arrowtooth Flounder	56	451	1.70	0	92	76	27	65	15	3	173
Rougheye Rockfish	29	387	1.46	0	40	4	51	29	0	0	263
Redbanded Rockfish	31	217	0.82	0	13	93	22	48	0	0	41
Lingcod	18	154	0.58	0	2	52	45	6	0	0	49
Yelloweye Rockfish	7	97	0.36	0	1	6	64	20	0	0	6
Giant Grenadier	21	72	0.27	0	19	9	1	3	0	0	40
Shortspine Thornyhead	32	60	0.23	0	7	14	7	3	0	1	28
Shortraker Rockfish	21	59	0.22	0	3	4	3	6	0	0	43
Dover Sole	11	24	0.09	0	13	0	0	3	0	0	8
Longspine Thornyhead	10	17	0.06	0	0	11	1	0	0	0	5
Rosethorn Rockfish	8	15	0.06	0	2	2	2	5	0	0	4
Pacific Flatnose	6	10	0.04	0	7	1	0	0	0	0	2

Species	Number of Sets	Catch (count)	Proportion of Total Catch (%)	4B	3C	3D	5A	5B	5C	5D	5E
Pink Snailfish	3	9	0.03	0	5	4	0	0	0	0	0
Yellowmouth Rockfish	3	9	0.03	0	0	0	3	6	0	0	0
Rockfishes	3	3	0.01	0	2	1	0	0	0	0	0
Canary Rockfish	2	2	0.01	0	0	2	0	0	0	0	0
Greenstriped Rockfish	2	2	0.01	0	0	1	0	1	0	0	0
Pacific Sleeper Shark	2	2	0.01	0	0	0	0	0	2	0	0
Walleye Pollock	1	2	0.01	0	0	0	0	0	0	2	0
Pacific Hake	1	1	0.00	0	0	0	0	0	0	1	0
Pacific Cod	1	1	0.00	0	0	1	0	0	0	0	0

Table 39. Annual summary of the total catch (piece count) for the top 10 species (by total piece count over all years) for the Sablefish Research and Assessment Survey Randomized Tagging Program sets.

Species	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Sablefish	22055	16348	17730	24105	18833	20326	15529	17375	22568	16845	18095	14266	25428	18073	267576
Arrowtooth Flounder	352	665	598	763	1655	1163	1787	553	1037	921	414	864	610	427	11809
Pacific Grenadier	338	644	399	313	880	608	829	676	742	715	254	534	686	627	8245
North Pacific Spiny Dogfish	800	532	465	317	437	162	565	414	868	966	386	287	365	699	7263
Rougheye Rockfish	187	398	166	355	558	513	418	406	266	941	223	488	320	386	5625
Pacific Halibut	76	71	114	163	185	125	224	172	256	342	99	447	444	283	3001
Redbanded Rockfish	111	101	113	93	154	257	150	131	244	208	127	241	295	217	2442
Giant Grenadier	29	132	97	67	162	146	179	118	105	195	80	87	206	72	1675
Lingcod	89	76	128	108	201	109	93	97	165	71	88	92	121	154	1592
Yelloweye Rockfish	18	41	33	22	71	58	60	21	106	34	13	17	81	97	672

Table 40. Annual summary of the total catch (piece count) for the top 10 species (by total piece count over all years) for the Sablefish Research and Assessment Survey Inlet Program sets.

Species	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Sablefish	9964	9933	7066	5062	3453	2498	4339	7507	11034	6213	3271	3341	2708	5050	127899
Pacific Halibut	39	63	72	104	111	99	78	109	108	113	88	265	333	243	2112
Arrowtooth Flounder	10	14	23	46	101	108	49	25	11	20	11	49	30	24	762
North Pacific Spiny Dogfish	0	6	6	6	8	1	2	15	18	12	4	5	44	14	180
Pacific Sleeper Shark	1	6	1	5	5	4	2	0	1	0	0	2	0	2	67
Dover Sole	1	0	4	4	4	23	1	0	0	1	2	5	1	1	64
Walleye Pollock	2	0	7	1	6	3	3	3	3	4	1	4	2	2	44
Shortraker Rockfish	0	0	0	4	4	5	4	1	3	2	0	0	3	0	37
Pacific Cod	0	0	0	0	0	8	1	5	0	1	1	2	1	0	25
Rougheye Rockfish	0	2	0	1	2	1	1	1	0	2	0	2	0	1	25

Table 41. Number of fish sampled for biological data during the 2016 Sablefish Research and Assessment Survey showing the number of tag releases, lengths and age structures that were collected by species.

Species	Scientific Name	Tags	Lengths Collected	Age Structures Collected
Bocaccio	*Sebastes paucispinis*	0	1	1
Pacific Flatnose	*Antimora microlepis*	0	10	10
Pacific Sleeper Shark	*Somniosus pacificus*	0	2	0
Rougheye Rockfish	*Sebastes aleutianus*	0	271	271
Sablefish	*Anoplopoma fimbria*	8460	13205	4675
Shortraker Rockfish	*Sebastes borealis*	0	59	59
Yelloweye Rockfish	*Sebastes ruberrimus*	0	58	58

Table 42. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Tagging Program sets.

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Sablefish	21017	8837	8999	12210	10385	11059	9331	10270	12463	10486	10118	8204	12094	9910	155383
Rougheye Rockfish	0	0	0	56	0	282	289	266	240	393	179	373	270	270	2618
Pacific Grenadier	0	0	0	0	0	461	562	378	471	380	188	0	0	0	2440
Arrowtooth Flounder	0	0	0	0	0	441	379	245	400	656	140	0	0	0	2261
North Pacific Spiny Dogfish	0	0	0	0	0	0	219	326	440	674	207	0	0	0	1866
Redbanded Rockfish	0	0	0	0	0	224	145	131	243	204	113	0	0	0	1060
Giant Grenadier	0	0	0	0	0	129	141	111	99	195	79	0	0	0	754
Yelloweye Rockfish	0	0	0	0	0	55	60	21	106	32	12	0	75	58	419
Shortraker Rockfish	8	0	0	0	0	53	65	73	18	59	18	13	10	59	376
Pacific Flatnose	0	0	0	0	0	18	39	27	17	24	11	0	0	10	146

Shortspine Thornyhead	0	0	0	0	0	1	9	26	22	53	34	0	0	0	145
Pacific Halibut	0	0	0	0	0	0	2	60	5	15	0	0	0	0	82
Lingcod	0	0	0	0	0	0	27	36	1	3	1	0	0	0	68
Rosethorn Rockfish	0	0	0	0	0	8	6	2	23	7	3	0	0	0	49
Dover Sole	0	0	0	0	0	3	1	3	13	18	3	0	0	0	41
Emarginate Snailfish	0	0	0	0	0	30	0	0	1	0	0	0	0	0	31

Table 43. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Inlet Program sets.

Species	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Sablefish	5497	6022	4394	3506	2554	1993	3070	5064	5984	3900	2503	2379	2234	3272	98410
North Pacific Spiny Dogfish	0	0	6	0	0	0	0	0	8	11	0	0	0	0	25
Arrowtooth Flounder	0	0	0	0	0	0	0	0	3	18	0	0	0	0	21
Shortraker Rockfish	0	0	0	0	0	0	3	1	2	2	0	0	3	0	12
Walleye Pollock	0	0	7	0	0	0	0	0	1	1	0	0	0	0	9
Pacific Sleeper Shark	1	0	0	0	0	0	0	0	0	0	0	0	0	2	6
Rougheye Rockfish	0	0	0	0	0	0	0	1	0	2	0	2	0	1	6

TSC Agency Reports – IPHC 2017

Contents

Agency Overview

Management of the Pacific halibut resource and fishery has been the responsibility of the International Pacific Halibut Commission (IPHC) since its creation in 1923. Assessing, forecasting, and managing the resource and fishery requires accurate assessments, continuous monitoring, and research responsive to the needs of managers and stakeholders. The fishery for Pacific halibut (*Hippoglossus stenolepis*) is one of the most valuable and geographically largest in the northeast Pacific Ocean. Industry participants from Canada and the United States have prosecuted the modern fishery and have depended upon the resource since the 1880s. Annual removals have been as high as 100 million pounds, and the long-term average of removals is 64 million pounds.

Staffing Updates: In addition to some standard turnover seen in both the port and sea sampling seasonal positions, the following transitions occurred in 2016 and early 2017:

Name	Position	Start Date	End Date
Dr. Josep Planas	Biological and Ecosystem Science Program Manager	January 2016	
Dr. Allan Hicks	Quantitative Scientist	April 2016	
Heather Gilroy	Fisheries Statistics Program Manager		April 2016
Keith Jernigan	Database and IT Program Manager	May 2016	
Jamie Goen	Fisheries Statistics Program Manager	June 2016	
Dr. Bruce Leaman	Executive Director		August 2016
Dr. David Wilson	Executive Director	August 2016	
Anna Henry	Survey Manager		September 2016

Name	Position	Start Date	End Date
Tracee Geernaert	Survey Manager	December 2016	
Kirsten MacTavish	1 Commercial Fisheries Data Manager *		June 2016
Lara Erickson	2 Commercial Fisheries Data Manager	July 2016	
Aregash Tesfatsion	3 US Port Sampler Supervisor	September 2016	
Huyen Tran	4 Lead Data Transcriber	September 2016	
Kelly McElligott	5 Data Transcriber	January 2017	
Melissa Knapp	1 Administrative Coordinator *		January 2017
Tamara Briggie	2 Administrative Coordinator	January 2017	
Stephanie Hart	3 Administrative Assistant	January 2017	
Kelly Chapman	4 Front Office Administrative Assistant	January 2017	

* Note that the numbering in the subsequent lines reflects the sequence of position changes starting with this opening. In each of these sequences, only the last person is new to IPHC.

Surveys

In 2016, fourteen commercial longline vessels, four Canadian and ten U.S., were chartered by the IPHC for survey operations. During a combined 77 trips and 698 charter days, these vessels fished 29 charter regions, covering habitat from southern Oregon to the island of Attu in the Aleutian Islands, and north along and including the Bering Sea continental shelf.

The 2016 survey design encompassed nearshore and offshore waters of southern Oregon, Washington, British Columbia, southeast Alaska, the central and western Gulf of Alaska, Aleutian Islands, and northern Bering Sea. Stations were located at the intersections of a 10 nmi by 10 nmi square grid within the depth range occupied by Pacific halibut during summer months (20-275 fm [37-503 m] in most areas).

As the next stage of a multi-year coastwide effort to expand our survey coverage and depth profile, an additional 83 stations were added to Regulatory Area 4D for 2016, including stations as shallow as 50 fathoms (91 m) and as deep as 400 fathoms (732 m).

Figure 1 depicts the survey station positions, charter region divisions, and regulatory areas surveyed.

All 1,366 survey stations planned for the 2016 survey season were either scouted or completed. Of these stations, 1,359 (99.5%) were considered successful for stock assessment analysis. A total of 14 special projects were facilitated and completed, and 15,505 otoliths were collected coastwide. Approximately 681,553 pounds (309 mt) of Pacific halibut, 43,374 pounds (20 mt) of Pacific cod, and 42,152 pounds (19 mt) of rockfish were landed from the setline survey stations.

Compared to the 2015 survey, weight per unit effort (WPUE) increased in Regulatory Areas 3A, 3B, 4A, and, 4C, and decreased in areas 2A, 2C, and 4D. WPUE in Regulatory Areas 2B and 4B remained the same as in 2015.

In 2017, the IPHC survey will include expansion stations in Regulatory Areas 2A and 4B. Expansion in Regulatory Areas 2B and 2C is planned for 2018, and in areas 3A and 3B in 2019.

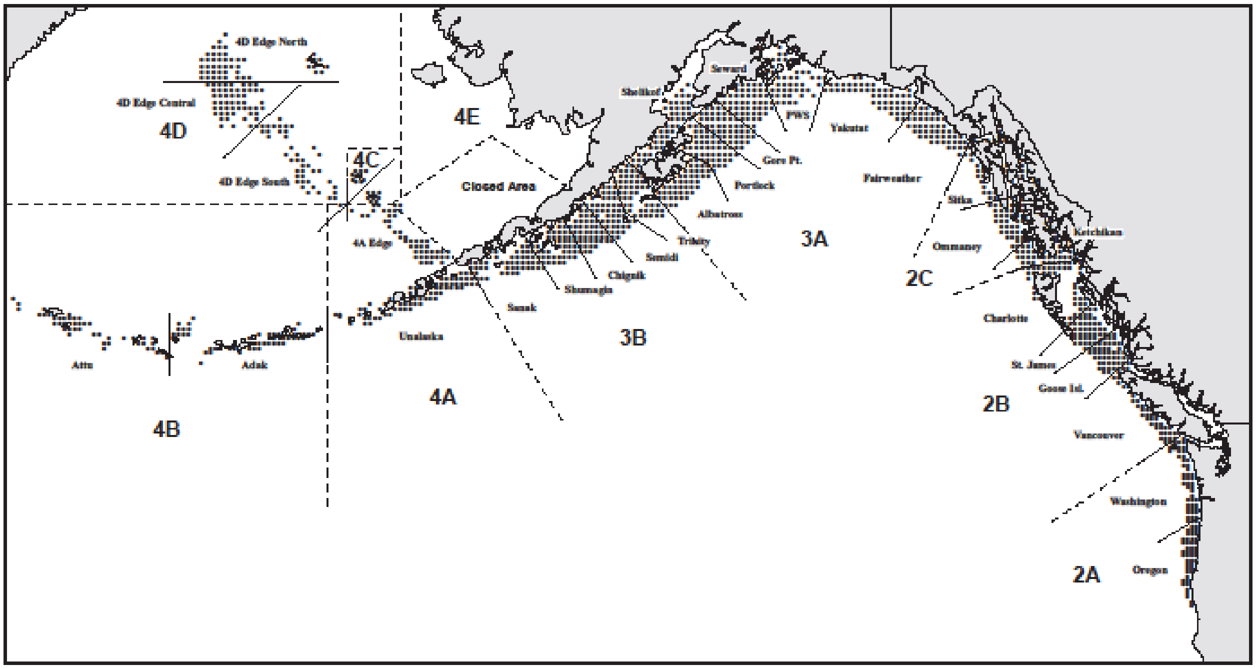


Figure 1. 2016 IPHC fishery-independent survey stations with regulatory area (two-character codes) and charter region (formal names) divisions.

Reserves – N/A

Review of Agency Groundfish Research, Assessment, and Management

Pacific halibut and IPHC activities

Research

Abstract

Since its inception, the IPHC has had a long history of research activities devoted to describe and understand the biology of the Pacific halibut (*Hippoglossus stenolepis*). Currently, the main objectives of the Biological and Ecosystem Science Research Program at IPHC are to:

1) To identify and assess critical knowledge gaps in the biology of the Pacific halibut;
2) To understand the influence of environmental conditions; and
3) To apply the resulting knowledge to reduce uncertainty in current stock assessment models.

Traditionally, IPHC staff annually propose new projects designed to address key biological questions as well as the continuation of certain projects initiated the previous year, based on their own input as well as input from the Commissioners, stakeholders, and the IPHC Scientific Review Board (SRB) and the Research Advisory Board (RAB). Proposed research projects are evaluated internally by IPHC staff and presented to the Commission for feedback and subsequent approval. Importantly, biological research activities at IPHC are guided by a Five-Year Research Plan that identifies key research areas that follow Commission objectives. In this document, we present an outline of a new proposed Five-Year Research Plan for the period 2017-21 and an overview of the research projects proposed by IPHC staff for 2017.

IPHC Five-Year Research Plan

The new proposed Five-Year Research Plan for the period 2017-21 includes extensive studies covering five major research areas:

1) Reproduction (i.e., sex identification, maturity estimates),
2) Growth (i.e., decrease in size-at-age, temperature effects),
3) Discard mortality rates (i.e., physiological condition and survival post-release of bycatch),
4) Migration (i.e., larval dispersal, adult and reproductive migrations) and
5) Genetics and Genomics (i.e., genetic population structure, genome characterization).

These studies are intended to provide information on factors that influence the biomass of the Pacific halibut population (e.g., distribution and movement of fish among regulatory areas, growth patterns and environmental influences on growth in larval, juvenile and adult fish) and, specifically, of the spawning (female) population (e.g., reproductive maturity, skipped spawning, reproductive migrations). Furthermore, these studies are also intended to provide information on the survival of bycatch and wastage fish and eventually refine current estimates of discard mortality rates. An overarching objective of the Five-Year Research Plan is to promote integration and synergies among the various research activities led by IPHC in order to significantly improve our knowledge of key biological inputs that are introduced into the stock assessment.

Overview of research projects for 2017

For 2017, seven new projects are proposed that cover specific research needs related to reproduction (Projects 2017-01, 2017-02), migration (Projects 2017-02, 2017-03, 2017-04), growth (Project 2017-05), viability assessment and survival post-capture (Projects 2017-04, 2017-06) and genetics (Project 2017-07).

Project 2017-01 ("Full characterization of the annual reproductive cycle in adult female Pacific halibut") proposes to study the annual reproductive cycle of Pacific halibut females in order to further our understanding of sexual maturation in this species and to improve maturity assessments and maturity-at-age estimates.

Project 2017-02 ("Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting [PAT] tags") proposes to study the migratory behavior of females prior to the spawning season in order to identify potential spawning areas in Regulatory Area 4B.

Project 2017-03 ("Tail pattern recognition analysis in Pacific halibut") is a pilot study that proposes to identify individual fish by ways of photographic recognition of tail patterns to complement migratory studies.

Project 2017-04 ("Condition Factors for Tagged U32 Fish") proposes to study the relationship between the physiological condition of fish and migratory performance as assessed by tagging U32 fish in order to better understand the potential use of quantitative physiological indicators in predicting migratory (as well as other types of) performance.

Project 2017-05 ("Identification and validation of markers for growth in Pacific halibut") proposes to identify and validate molecular and biochemical profiles that are characteristic of specific growth patterns and that will be instrumental to describe different growth trajectories in the Pacific halibut population and evaluate potential effects of environmental influences.

Project 2017-06 ("Discard mortality rates and injury classification profile by release method") proposes to study the relationship between hook release methods in the longline fishery and associated injuries with the physiological condition of fish in order to improve our understanding of factors influencing post-release survival in the directed fishery.

Project 2017-07 ("Sequencing of the Pacific halibut genome") proposes to characterize for the first time the genome of the Pacific halibut and provide genomic resolution to genetic markers for sex, reproduction, and growth that are currently being investigated.

In addition to the new projects, eight continuing projects are proposed, including two projects dealing with sex identification (621.15, 621.16), two projects monitoring the Pacific halibut population for mercury and *Ichthyophonus* contamination (642.00, 661.11), three projects continuing migration-related research with the use of wire and satellite tagging (650.18, 650.20, 670.11) and one project finalizing work conducted on the reevaluation of the weight-length relationship (669.11).

Summaries of each of the new and continuing projects are included in the following sections with indication of the principal investigator(s) (PIs). Figure 2 presents a schematic diagram of new and continuing research projects, their interactions, and their relationship to the major research areas identified in the IPHC Five-Year Research Plan.

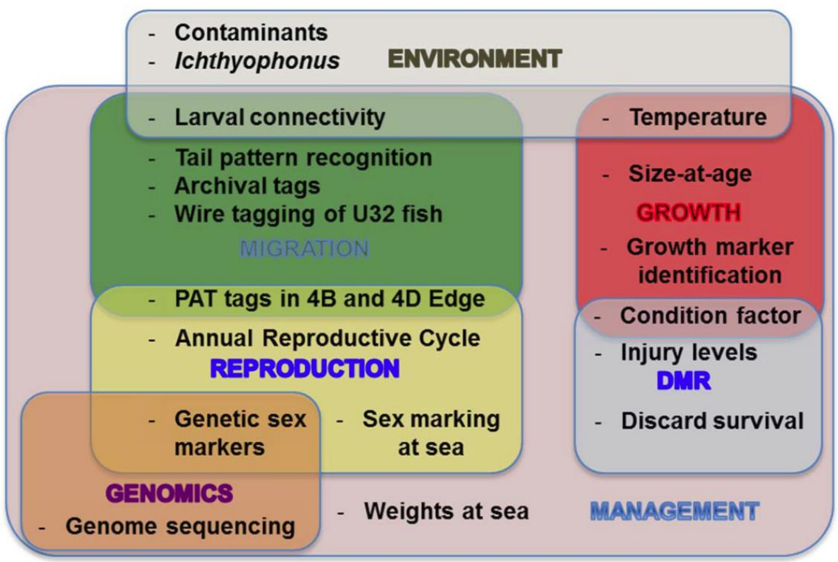


Figure 2. Schematic diagram of new and continuing IPHC research projects and their interactions

Following the discussion of new and continuing projects is a short description of other ongoing IPHC data collection projects that take place as part of the fishery-independent setline survey or as part of the commercial fishery data collection program.

<u>New research projects for 2017</u>

2017-01 Full characterization of the annual reproductive cycle in adult male and female Pacific halibut

PI: Josep Planas

In fisheries, understanding the reproductive biology of a species is important for estimating the reproductive potential and spawning biomass of the stock and, consequently, for optimizing the management of the species. The main purpose of this study is to improve our knowledge on basic aspects of the reproductive physiology of the Pacific halibut and to provide an updated and more comprehensive description of maturity in this species. The Pacific halibut is generally believed to reproduce following an annual cycle with spawning typically occurring in the winter. However, skipped spawning and biennial maturation cycles are not uncommon in temperate and subarctic species. Very large yet putatively immature female Pacific halibut are often observed in the setline survey and analyses of PAT tag data are consistent with the hypothesis that skipped spawning is common in Pacific halibut. Regional and temporal variation in maturation and spawning schedules can affect the relationship between estimates of mature biomass and effective female spawning stock. Additionally, seasonal changes in fish condition can affect stock productivity and the relative impact of any given volume of harvest over time. Given that reproduction is under the control of the endocrine system, knowledge on the reproductive hormones involved and their temporal pattern of production is essential for understanding the temporal progression of gonadal maturation. In Pacific halibut, a comprehensive characterization of the reproductive cycle has not been performed to date and no information on how reproductive hormones may control gonadal maturation is available. In the present study, we propose to describe the temporal changes in gonadal morphological characteristics as well as in the levels of reproductive hormones and physiological condition throughout an entire annual reproductive cycle in order to improve and update our estimation of maturity in this species.

2017-02 Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting (PAT) tags.

PI: Tim Loher

The IPHC has a history of conducting PAT tagging in the Bering Sea and Aleutian Islands (BSAI) in order to investigate both seasonal (2002-2007, 2016; Projects 622, 622.11.84, 622.14) and inter-annual (2008-2010, 2016; Projects 622.12, 622.14) dispersal. In total, (152) satellite tags have been deployed in the course of those experiments, covering the historically surveyed range of this stock component throughout Areas 4A, 4B, 4C, and the 4D Edge. These studies have been aimed at gaining greater understanding of the timing of movements within this stock component, identifying winter spawning locations, and investigating mixing among regulatory areas in a fishery-independent manner. The results of these experiments have complemented large-scale Passive Integrated Transponder (PIT) tagging and have jointly resulted in an understanding of population function that is generally consistent with the structure of the IPHC's current Area-as-Fleets stock assessment model. However, notable gaps in spatial coverage of these tag deployments, relative to areas fished by BSAI fleet components, still exist: 1) Bowers Ridge (in 4B); 2) all of Area 4E. In 2016, The IPHC extended its fishery-independent setline survey northward along the eastern Bering Sea continental shelf edge, providing for the first time demographic data and an opportunity to tag fish in southern Navarin Canyon, quite possibly the northern-most major spawning ground for this species. In 2017, the IPHC intends to extend its Area 4B survey northward along Bowers Ridge, presenting a unique opportunity to fill another gap in our understanding of Bering Sea stock structure. In particular, recent genetic analyses have indicated that Pacific halibut in western 4B are genetically distinct from the remainder of the stock, raising questions regarding the relationship between Pacific halibut found along Bowers Ridge and the remainder of the Aleutian Islands region.

2017-03 Tail pattern recognition analysis in Pacific halibut

PIs: Claude Dykstra, Tracee Geernaert

The purpose of the study is to collect high resolution images of Pacific halibut tail patterns with the hypothesis that these patterns are unique to individual fish. Images will be combined with the 2017 U32 tagged fish allowing us to track growth/migration and re-image individuals when they are recaptured. By comparing images at tagging and recapture we can test the hypothesis that the tail morphology is unique and stable through growth. If a natural tag is discovered it could allow for large scale tracking of movement and as a potential control for other tagging experiments with the added benefit of shedding light on discard mortality rates. The first step would be to determine if the patterns are unique and then the next step to determine if they are static or stable with growth.

2017-04 Condition Factors for Tagged U32 Fish

PI: Claude Dykstra

In this study we propose to collect condition factor information opportunistically on all fish under 32 inches in length (U32) that are tagged and released. This would need to be on a boat that was already carrying the scale for use in the weight-at-age project. In addition to the round weight of the tagged fish, this project would capture information on fat levels (utilizing the FatMeter device), and blood stress hormones. Over future years this would develop a deeper data set that could be related to some of the underlying physiology for tag recovery rates associated with different release injuries and subsequent tag recoveries.

2017-05 Identification and validation of markers for growth in Pacific halibut

PI: Josep Planas

Growth is a physiological process that takes place throughout the lifetime of Pacific halibut and that results from the complex interaction among dietary or trophic influences, environmental conditions, genetic background, energy expenditure requirements, etc. Growth is intimately linked to fitness and performance, adaptive capabilities and reproductive potential and, therefore, is a key process in determining the species' success in the ecosystem. From a fisheries perspective, growth at an individual and, ultimately, at a population level influences the amount of available biomass. In Pacific halibut, a significant decrease in size at age has been recorded over the last three decades. One of the various possible causes that have been attributed to this pattern, in addition to size-selective fishing, harvest pressure or size-dependent migration, is a decrease in somatic growth. Unfortunately, little is known regarding the factors that influence growth in this species. In order to begin to understand how growth in Pacific halibut can be modulated under specific (biotic or abiotic) conditions, it is necessary to develop appropriate tools to monitor growth. In this study, we propose to identify and validate appropriate molecular markers for growth that can be used to identify the presence of distinct growth patterns in the Pacific halibut population and evaluate the influence of environmental conditions on somatic growth in this species.

2017-06 Discard mortality rates and injury classification profile by release method

PI: Claude Dykstra

Discard mortality rates (DMR) in the longline fishery are currently estimated from Pacific halibut injury or vitality data obtained on observed trips. The small vessel longline fleet (<57') is currently developing electronic monitoring (EM) capabilities to collect data normally collected by the observer program. Determining vitality codes requires handling of the animal (which includes looking at both sides of the fish, testing muscle tone and opercular responses), which is something that cannot be achieved with cameras. EM data analysts are able to collect information on Pacific halibut release techniques for close to 95% of events; however, the suite of injuries incurred by each release technique is unknown. This study proposes to begin developing an injury profile for different release techniques with associated physiological condition measures, which could then be used to calculate DMRs on vessels carrying EM systems rather than observers. Additionally, this project could be a platform to tag and release Pacific halibut to further refine DMRs by each release category. DMRs calculated based on this sort of effort would need to be understood to be in pristine condition as fisher would likely still try to release fish with minimal injury regardless of what treatment they would be randomly assigned.

2017-07 Sequencing the Pacific halibut genome

PI: Josep Planas

The genome of an organism is the collection of genes that are organized in chromosomes and that contain the genetic material necessary for its development, growth, and maintenance. The genome sequence therefore contains information on all the genes present in the genome, namely their DNA sequence and location in the genome. The purpose of this project is to generate a first draft of the genome of the Pacific halibut. Through the sequencing of the Pacific halibut's genome we will be able to identify genomic regions and genes that are responsible for temporal and spatial adaptive and phenotypic characteristics and better understand genetic and evolutionary changes that occur in response to environmental and fisheries-related influences. Therefore, the genome sequence will be essential for understanding possible changes in the genetic constitution of the Pacific halibut population. Importantly, the genome sequence will also allow us to understand the genetic basis of growth, reproductive performance, migratory behavior, etc. in this species. In the short term, the genome sequence will allow us to effectively map and capitalize information derived from all the identified single nucleotide polymorphisms (SNPs) associated with sex that are being derived through restriction-site associated DNA sequencing (RADseq) as well as the transcripts generated from our current RNA sequencing efforts.

<u>Continuing research projects for 2017</u>

621.15 Voluntary at-sea sex marking and portside sampling of commercial longline vessels

PIs: Tim Loher, Ian Stewart, Claude Dykstra, Lara Erikson – and relevant port samplers; Collaborators: Lorenz Hauser and Dan Drinan (UW)

The current IPHC stock assessment is sex-structured, but it is not based upon direct observations of sex in the landed catch. Historically, fishery sex ratio at age has been estimated on the basis of the sex ratios at size and age observed in IPHC survey catches, according to regulatory area. While this is statistically robust for some combinations of age and size (e.g., large young and small old fish), this procedure can be sensitive to small sample sizes and it ultimately provides an estimator of the properties of the survey catch, not fishery landings. In particular, the survey spans only ~40% of the commercial fishing period, and seasonal migration and the fishery's ability to target specific stock components and geographic areas have the potential to generate unknown degrees of variance between survey and fishery landings composition. In the absence of derived fishery sex-ratio data, the 2013 stock assessment was found to be very sensitive to the assumption that the relative selectivity at age of males and females is equivalent in the survey and fishery: a 20% range in fishery selectivity sex ratio translated into an ~50 million pound range in female spawning biomass estimates (i.e., ~25% of the total estimated value). Without direct observations of fishery sex ratio at age there is no way to determine the magnitude of the uncertainty and/or bias from this source that would be included in assessment results. The current study represents one component of a suite of integrated studies that are ultimately designed to obtain reliable sex data from eviscerated commercial landings.

621.16 Development of production-scale genetic sexing techniques for routine catch sampling of Pacific halibut

PI: Tim Loher. Collaborators: Dr. Lorenz Hauser, Dan Drinan (UW).

Declines in size at age of Pacific halibut, in concert with sexually dimorphic growth and a constant minimum commercial size limit, have led to the expectation that the sex composition of commercial catches should be increasingly female-biased. Given this likelihood, it is important to correctly estimate sex-specific fishing mortality rates in order to accurately predict stock trajectories for long-term policy analyses. Recent sensitivity analyses have indicated that uncertainty regarding sex ratios within commercial harvest may be the most influential factor affecting our understanding of female spawning stock biomass (SSB_f), with 10% variance in estimated sex ratios translating into a roughly 50 million pound range in estimates of SSB_f. Such uncertainty may be exacerbated if age-specific sex compositions vary in space and time, as recent studies have suggested that they do. However, there is no reliable way to determine sex at landing because all Pacific halibut are eviscerated at sea. The current work will develop genetic assays that will allow for the rapid and cost-effective sex identification of large samples from the commercial Pacific halibut fishery at relatively low cost.

642.00 Assessment of Mercury and other contaminants in Pacific Halibut

PI: Claude Dykstra; Collaborator: Bob Gerlach (ADEC)

Ongoing public concern over contaminants in seafood requires a better understanding of these levels in wild caught fish in different areas and by size of animal. We have been working with the Alaska Department of Environmental Conservation (ADEC) since 2002 to better characterize the levels of contaminants found in Alaska-caught Pacific halibut. The project is ongoing to further characterize, update and expand our understanding, and provide monitoring of contaminants encountered in wild-caught Pacific halibut from all regions of Alaska.

650.18 Archival tags: tag attachment protocols

PI: Tim Loher

Recovery rates of archival tags affixed to Pacific halibut using four different external mounting protocols (three dart-and-tether configurations; wired to the operculum) are being tested in a field release of "dummy" archival tags. During the summer of 2013, 900 fish were tagged off northern Kodiak Island (Area 3A), with an equal number of fish tagged with each tag attachment type. Fish carrying a dart-and-tether tag were also tagged with a bright pink cheek tag, and rewards of $100 are being given for all tags recovered. Total tags recovered in FY2015 were 4); there were 32 in FY2016. We expect approximately 25 recoveries in FY2017.

650.20 Investigation of Pacific halibut dispersal on the far northern 4D Shelf Edge via Pop-up Archival Transmitting (PAT) tags

PI: Tim Loher

During the summer of 2016, 35 Pacific halibut were tagged with Lotek PSATs on northern Area 4D Edge survey stations. Of these tags, 32 were programmed to detach from their host fish and report to the Argos system during FY2017 (n=20 during January; 12 during June). The remaining three tags were scheduled to report in September 2016.

661.11 Ichthyophonus Incidence Monitoring

PI: Claude Dykstra

Ichthyophonus is an internal histozoic parasite that can be found in all visceral organs and the musculature of infected hosts. Over a six-year period, infections in Pacific halibut were detected at a relatively high prevalence compared to other host species. Between 2011 and 2016, the infection prevalence was 10.8 to 37.3% in the Bering Sea, 16.7 to 50% off the coast of Oregon, and with significantly higher infection prevalence ranging from 58.3 to 76.7% in Prince William Sound. Inter-annual infection prevalence has been relatively stable within geographic locations. While prevalence has been high for a marine species, infection intensity (i.e. number of schizonts in the liver or heart) has been extremely low to not detectable. Effects of infection vary greatly among individuals and host species, and can include reduced swimming performance, retarded growth, and acute mortality in other hosts; however, effects on Pacific halibut remain uninvestigated. The ongoing nature of the study is to monitor changes in infection prevalence at the three base sites (Bering Sea, inside Prince William Sound, Oregon) and more specifically in infection intensity. Sudden increases in infection intensity have been followed by large die off events in other species, and could then warrant a more intensive grow-out study.

669.11 At-sea Collection of Pacific Halibut Weight to Reevaluate Conversion Factors

PI: Eric Soderlund

Net weight is a fundamental concept that the IPHC uses for stock assessment, apportionment, and all facets of Pacific halibut management. However, individual net weight is not a strictly biological quantity; instead it is the result of natural variation as well as of one to several processing steps. The purpose of this study is to collect data on IPHC's fishery-independent setline survey for use in estimating the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight, as well as estimation of shrinkage (potentially occurring in both length and weight) from time of capture to time of offload. This project will complement an ongoing project (665.11), in which portions of commercial deliveries are measured and weighed at the dock, by providing length-to-weight data that is not available at commercial offloads: from U32 fish, round fish, and freshly killed and dressed fish, as well as measurements of shrinkage from the time of capture to final weighing at the offload. The current length to net weight relationship was estimated in 1926. Using 1989 data, Clark re-estimated the relationship's parameters and found good agreement with the earlier curve. However, when Courcelles estimated the relationship data collected in 2011, she found significant differences between her estimated curve and that derived from the 1989 data, although inference was limited to a relatively small part of Area 3A and to the time of the setline survey. IPHC staff has also raised the issue of the relationship varying both regionally and seasonally. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or weight per unit effort (WPUE) derived from length measurements. The current relationship between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime. As a secondary goal, we also plan to collect data to provide direct estimates of adjustment factors to compare with the currently assumed values, and to assess variability in the weight of heads and ice and slime.

670.11 Wire tagging of Pacific halibut on NMFS trawl and setline surveys

PIs: Joan Forsberg, Lauri Sadorus

In response to bycatch-related requests at the 2015 Annual Meeting to learn more about juvenile Pacific halibut distribution and movement, IPHC staff launched a pilot project during the 2015 survey season to test the practicality of wire tagging Pacific halibut aboard the NMFS trawl surveys. IPHC routinely participates in the NMFS groundfish trawl surveys in the Bering Sea (annual), Gulf of Alaska (biennial) and Aleutian Islands (biennial, alternate years from the GOA survey). Pacific halibut caught on the trawl survey range in size from about 20-100 cm fork length with most of the catch under 82 cm. The tagging effort was successful and the decision was made to continue the project into the foreseeable future on NMFS trawl surveys and to expand the tagging effort to small Pacific halibut captured on the IPHC setline survey. The IPHC setline survey tagging effort conducted in 2016 was limited to one regulatory area (4D) and to Pacific halibut less than 82 cm fork length that were not part of the otolith sample. In 2016, a total of 424 and 170 Pacific halibut were tagged and released on the Bering Sea and Aleutian Islands surveys, respectively. As of 31 August 2016, a total of eight tags from the NMFS trawl releases have been recovered and returned to IPHC: four tags from the 2015 Bering Sea and four tags from the 2015 Gulf of Alaska releases. A total of 169 Pacific halibut were tagged on the IPHC setline survey in Area 4D. No tags from the 2016 releases had been recovered as of 31 August. In 2017, a broader tagging project will take place on our setline surveys. U32 halibut not sampled for their otoliths will be wire tagged. None will be tagged on the Area 2A and 4D Edge surveys where the otolith sampling rate is 100%. The goal is 500 tags per charter area.

<u>Other ongoing data collection projects</u>

In addition to specific research projects, the IPHC collects data each year through ongoing data collection projects that are funded separately, either as part of the fishery-independent setline survey or as part of the commercial fishery data collection program. Ongoing data collections projects that are continuing in 2017 include the following:

IPHC fishery-independent setline survey

IPHC Survey Team – Tracee Geernaert, survey manager

The IPHC fishery-independent setline survey provides catch information and biological data on Pacific halibut that are independent of the commercial fishery. These data, which are collected using standardized methods, bait, and gear during the summer of each year, provide an important comparison with data collected from the commercial fishery.

Biological data collected on the surveys (e.g., the size, age, and sex composition of Pacific halibut) are used to monitor changes in biomass, growth, and mortality in adult and sub-adult components of the Pacific halibut population. In addition, records of non-target species caught during survey operations provide insight into bait competition, rate of bait attacks, and serve as an index of abundance over time, making them valuable to the assessment, management, and avoidance of non-target species.

The Commission has conducted fishery-independent setline surveys in selected areas during most years since 1963. The majority of the current survey station design and sampling protocols have been consistent since 1998.

Environmental data collection aboard the IPHC setline survey using water column profilers

PIs: Lauri Sadorus, Jay Walker

The IPHC collects oceanographic data using water column profilers during the IPHC fishery-independent setline survey. The profilers collect a suite of oceanographic data, including pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll concentration). The IPHC has operated profilers since 2000 on a limited basis, and coastwide since 2009.

IPHC aboard National Marine Fisheries Service groundfish trawl surveys in the Gulf of Alaska, Bering Sea, and Aleutian Islands

PI: Lauri Sadorus

The National Marine Fisheries Service (NMFS) has conducted annual bottom trawl surveys on the eastern Bering Sea continental shelf since 1979 and the IPHC has participated in the survey on an annual basis since 1998 by directly sampling Pacific halibut from survey catches. The IPHC has participated in the NMFS Aleutian Islands trawl survey, which takes place every two years, since 2012. Alternating year by year with the Aleutian Islands trawl survey is the NMFS Gulf of Alaska trawl survey, which IPHC has participated in since 1996. The IPHC uses the NMFS trawl surveys to collect information on Pacific halibut that are not yet vulnerable to the gear used for the IPHC fishery-independent setline survey or commercial fishery, and as an additional data source and verification tool for stock analysis. In addition, trawl survey information is useful as a forecasting tool for cohorts approaching recruitment into the commercial fishery.

Commercial fishery port sampling program

IPHC Port Team – Lara Erikson, port manager

The IPHC positions field staff to sample the commercial catch for Pacific halibut in Alaska, British Columbia, Washington, and Oregon. Commercial catch sampling involves collecting Pacific halibut otoliths, fork lengths, logbook information, and final landing weights.

The collected data are used in the stock assessment and other research and the collected otoliths provide age composition data. Lengths of sampled Pacific halibut provide the basis for estimates of mean weight and, in combination with age data, size-at-age analyses. Mean weights are combined with final landing weights to estimate catch in numbers. Logbook information provides weight per unit effort data, fishing location for the landed weight, and data for research projects. Finally, tags are collected to provide information on migration, exploitation rates, and natural mortality.

In addition to sampling the catch, other objectives include collecting recovered tags, and copying information from fishing logs along with the respective landed weights, for as many Pacific halibut trips as possible throughout the entire season.

Assessment

The stock assessment reports the status of the Pacific halibut (*Hippoglossus stenolepis*) resource in the Convention Area, including the Exclusive Economic Zones of the United States of America and Canada. Commercial fishery landings in 2016 were approximately 25.0 million pounds (~11,400 t, all weights in this document are reported as 'net' weights, head and guts removed; this is approximately 75% of the round weight), up from a low of 23.7 million pounds (~10,700 t) in 2014. Bycatch mortality was estimated to be 7.1 million pounds (~3,200 t), the lowest level in the estimated time series. The 2016 IPHC fishery-independent setline survey estimates of coastwide aggregate legal sized Pacific halibut (O32; over 32 inches (81.3 cm) in length) WPUE were 6% higher than the value observed in 2015, representing the fifth year of stable WPUE rates. Age distributions in 2016 from both the survey and fishery remained similar to those observed in 2011-15, indicating a relatively stable stock, but not showing clear evidence of strong coastwide recent recruitment events. At the coastwide level, individual size-at-age continues to be very low relative to the rest of the time-series, although there has been little change over the last several years.

This stock assessment consists of an ensemble of four equally-weighted models, two long time-series models, and two short time-series models either using data sets by geographical region, or aggregating all data series into coastwide summaries. As has been the case since 2012, this stock assessment is based on the approximate probability distributions derived from the ensemble of models, thereby incorporating the uncertainty within each model as well as the uncertainty among models. The results at the end of 2016 indicate that the Pacific halibut stock declined continuously from the late 1990s to around 2010, as a result of decreasing size-at-age, as well as somewhat weaker recruitment strengths than those observed during the 1980s. Since the estimated female spawning biomass (SB) stabilized near 200 million pounds (~90,100 t) in 2010, the stock is estimated to have been increasing gradually. The SB at the beginning of 2017 is estimated to be 212 million pounds (~96,200 t), with an approximate 95% confidence interval ranging from 153 to 286 million pounds (~69,400-129,700 t). Recruitment estimates show the largest recent cohorts in 1999 and 2005, and there is little information on the relative strength of subsequent cohorts, which will be the most important for stock productivity over the next decade.

A comparison of the median current ensemble SB to reference levels specified by the current harvest policy suggests that the stock is currently at 41% of equilibrium unfished levels; however, the probability distribution indicates considerable uncertainty, with a 5/100 (5%) probability the stock is below the $SB_{30\%}$ level. Stock projections for a range of alternative management actions were conducted using the integrated results from the stock assessment ensemble, summaries of the 2016 fishery, and other sources of mortality, as well as the results of apportionment calculations and the target harvest rates from the current IPHC harvest policy. The results for 2017 show somewhat more risk than those from last year's assessment: the stock is projected to increase gradually over 2018-20 in the absence of any removals, and for removals of up to around 40 million pounds (~18,100 t). For removals around 40 million pounds (~18,100 t), projections are slightly decreasing. The risk of stock declines begins to increase rapidly for levels of harvest above 40 million pounds (~18,100 t) of total mortality, becoming more pronounced by 2020. The current IPHC Harvest Policy (the Blue Line) suggests that 37.9 million pounds, ~17,200 t, total removals, corresponds to a 56/100 (56%) chance of stock decline in

2018 and the *status quo* SPR line (41.6 million pounds, ~18,900 t) corresponds to a 68/100 (68%) chance of stock decline in 2018.

An executive summary of the 2016 stock assessment is posted on the IPHC website at: http://iphc.int/meetings-and-events/interim-meeting/im2016-documents.html.

The complete report of the 2016 stock assessment is available on the IPHC website at: http://www.iphc.int/publications/rara/2016/IPHC-2016-RARA-26-R-4.2_Assessment_of_the_Pacific_halibut_stock.pdf.

Management

The International Pacific Halibut Commission (IPHC) completed its 93rd Annual Meeting (AM093) in Victoria, British Columbia, Canada, on 27 January 2017, with Mr. Paul Ryall of Canada presiding as Chairperson. More than 330 Pacific halibut industry stakeholders attended the meeting, with over 160 more participating via the web. All of the Commission's public and administrative sessions during the meeting were open to the public and broadcast on the web.

The Commission recommended to the governments of Canada and the United States of America catch limits for 2017 totaling 31.4 million pounds. The Commission also addressed other regulatory issues and took actions regarding the IPHC fishery-independent setline survey expansion and its harvest policy. A news release issued on 27 January 2017 announced the catch limits and fishing seasons for 2017. Documents and presentations from the Annual Meeting can be found on the Annual Meeting page on the IPHC website: http://www.iphc.int/meetings-and-events/annual-meeting.html.

Catch Limits

The Commission received harvest advice for 2017 from the IPHC Secretariat, Canadian and United States harvesters and processors, and recommended the following catch limits for 2017, to the two governments:

IPHC Regulatory Area	**Catch Limit (pounds)**
Area 2A (California, Oregon, and Washington)	**1,330,000**
Non-treaty directed commercial (south of Pt. Chehalis)	225,591
Non-treaty incidental catch in salmon troll fishery	39,810
Non-treaty incidental catch in sablefish fishery (north of Pt. Chehalis)	70,000
Treaty Indian commercial	435,900
Treaty Indian ceremonial and subsistence (year-round)	29,600
Sport – Washington	237,762
Sport – Oregon	256,757
Sport – California	34,580
Area 2B (British Columbia) (includes sport catch allocation)	**7,450,000**
Area 2C (southeastern Alaska) (combined commercial/guided sport[1])	**5,250,000**
Commercial fishery (4,212,000 catch and 123,000 incidental mortality)	4,335,000

Guided sport fishery	915,000
Area 3A (central Gulf of Alaska) (combined commercial/guided sport[1])	**10,000,000**
Commercial fishery (7,739,000 catch and 371,000 incidental mortality)	8,110,000
Guided sport fishery	1,890,000
Area 3B (western Gulf of Alaska)	**3,140,000**
Area 4A (eastern Aleutians)	**1,390,000**
Area 4B (central/western Aleutians)	**1,140,000**
Areas 4CDE	**1,700,000**
Area 4C (Pribilof Islands)	752,000
Area 4D (northwestern Bering Sea)	752,000
Area 4E (Bering Sea flats)	196,000
Total	**31,400,000**

[1]The combined total includes estimated mortality from regulatory discards of sublegal Pacific halibut and lost gear in the commercial fishery, plus discard mortality in the guided sport fishery, as mandated in the U.S. Catch Sharing Plan.

Fishing Periods (Season dates)

The Commission approved a season of 11 March to 7 November 2017, for the U.S. and Canadian quota fisheries. Seasons will commence at noon local time on 11 March and terminate at noon local time on 7 November 2017 for the following fisheries and areas: the Canadian Individual Vessel Quota (IVQ) fishery in Area 2B, and the United States IFQ and CDQ fisheries in Areas 2C, 3A, 3B, 4A, 4B, 4C, 4D, and 4E. All Area 2A commercial fishing, including the treaty Indian commercial fishery, will take place between 11 March and 7 November 2017. The Saturday opening date was chosen to facilitate marketing.

In Area 2A, seven 10-hour fishing periods for the non-treaty directed commercial fishery south of Point Chehalis, Washington, are recommended: 28 June, 12 July, 26 July, 9 August, 23 August, 6 September, and 20 September 2017. All fishing periods will begin at 8 a.m. and end at 6 p.m. local time, and will be further restricted by fishing period limits announced at a later date.

Area 2A fishing dates for incidental commercial Pacific halibut fisheries concurrent with the limited-entry sablefish fishery north of Point Chehalis and the salmon troll fishing seasons will be established under U.S. domestic regulations by the National Marine Fisheries Service (NMFS). The remainder of the Area 2A CSP, including sport fishing seasons and depth restrictions, will be determined under regulations promulgated by NMFS. Further information regarding the depth restrictions in the commercial directed Pacific halibut fishery, and details for the sport fisheries, is available at the NMFS hotline (1-800-662-9825). The Area 2A IPHC licensing procedures did not change.

Regulatory Changes

Charter Pacific Halibut Sector Management Measures for IPHC Regulatory Areas 2C and 3A

The Commission received a request from NPFMC to adopt charter Pacific halibut sector management measures in accordance with the NMFS CSP for Areas 2C and 3A. The NPFMC proposal is designed to keep removals by the charter fishery within the limits of the CSP. The Commission approved the following measures:

In Area 2C: 1) a one-fish daily bag limit, and 2) a "reverse slot" size limit restriction (≤ 44 inches or ≥ 80 inches).

In Area 3A: 1) a two-fish daily bag limit, 2) a maximum size limit for the second fish of 28 inches, 3) a four-fish annual limit, with a recording requirement, 3) a vessel limit of one trip per calendar day, 4) a limit of one trip per charter permit per calendar day, 5) a one-day-per-week closure of Pacific halibut charter fishing on Wednesdays throughout the year, and 6) Tuesday closures on 18 July, 25 July, and 1 August.

Head-on Pacific Halibut Landing Requirement

The Commission adopted a proposal aimed at eliminating a recently identified bias in Pacific halibut removal estimates (net weight), by requiring all commercial Pacific halibut to be landed and weighed with their heads attached for data reporting purposes and to only be subject to a 32-inch minimum size limit. An exemption was agreed upon whereby vessels that freeze Pacific halibut at sea may land their frozen fish with the head removed and remain subject to a 24-inch minimum size limit only.

Harmonize IPHC and NMFS Regulations Regarding Fishing in Multiple Regulatory Areas

The Commission adopted a proposal aimed at harmonizing IPHC and NMFS regulations regarding fishing in multiple IPHC Regulatory Areas in Alaska, specifically to clarify that retention of Pacific halibut on a vessel in excess of the total amount of unharvested IFQ or CDQ that is currently held by all IFQ or CDQ permit holders aboard the vessel for the area in which the vessel is fishing is prohibited unless the vessel has a NMFS-certified observer on board and maintains a daily fishing log only.

Use of the eLog in British Columbia

The Commission directed the IPHC Secretariat to work with DFO to incorporate the use of the electronic version of the DFO British Columbia Integrated Groundfish Fishing Log into IPHC Regulations as an acceptable logbook for use in the Area 2B commercial Pacific halibut fishery.

<u>Other Actions</u>

Harvest Policy Analysis

The Commission agreed that the current IPHC harvest policy is outdated and that there is a need to remove the current "blue line" reference in the harvest decision table, which reflects this outdated harvest policy. The Commission will use the "status quo SPR" (F46%) fishing intensity as the reference line for this and future years' catch limit discussions, and will use its

Management Strategy Evaluation (MSE) process to evaluate options for a modified harvest policy that separates the decisions regarding scale of the coastwide fishing intensity and the distribution of the removals among Regulatory Areas, and accounts for all sizes and sources of Pacific halibut mortality.

The Commission also requested that the IPHC Secretariat initiate a process to develop alternative, biologically based stock distribution strategies for consideration by the Commission and its subsidiary bodies. This should also be incorporated into the MSE Program of Work.

The Commission recommended that the IPHC MSE process be accelerated so that more of the elements contained within the current Program of Work are delivered at the 94th Annual Meeting of the Commission in 2018.

Expanded Survey

The Commission approved the next in a series of expansions to its annual fishery-independent setline survey. The purpose of the expansion series is to provide more accurate and precise estimates among regulatory areas and to encompass all depths over which the stock is distributed. In 2017, the Commission's survey in Areas 2A and 4B will be expanded.

Meeting Report

The Report of the 93rd Session of the IPHC Annual Meeting (AM093) has been published and posted at the Annual Meeting page of the IPHC website: http://www.iphc.int/meetings-and-events/annual-meeting.html . The Report includes details on all the decisions, recommendations, and requests made by the Commission during the Annual Meeting.

Ecosystem Studies

[See the description of "Environmental data collection aboard the IPHC setline survey using water column profilers" in the Research section on ongoing IPHC data collection projects above.]

Publications

International Pacific Halibut Commission. 2017. Report of Assessment and Research Activities 2016. http://iphc.int/library/raras/485-rara2016.html

Northwest Fisheries Science Center

National Marine Fisheries Service

NOAA Fisheries

Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2017

Table of Contents

I. Agency Overview

The Northwest Fisheries Science Center (NWFSC) provides scientific and technical support to the National Marine Fisheries Service (NMFS) for management and conservation of the Northwest region's marine and anadromous resources. The Center conducts research in cooperation with other federal and state agencies and academic institutions. Four divisions, Conservation Biology, Environmental and Fisheries Sciences, Fish Ecology, and Fishery Resource Analysis and Monitoring, conduct applied research to resolve problems that threaten marine resources or that deter their use. The Center's main facility and laboratories are located in Seattle. Other Center research facilities are located in Pasco, Big Beef Creek, Mukilteo, and Manchester, Washington; Newport, Hammond, and Clatskanie, Oregon; and Charleston, North Carolina.

The Fishery Resource Analysis and Monitoring Division (FRAMD) is the source for most of the research reported by the NWFSC to the Technical Subcommittee of the Canada-US Groundfish Committee. The FRAMD works in partnership with state and federal resource agencies, universities, and the groundfish industry to achieve a coordinated groundfish program for the West Coast.

FRAMD consists of a multi-disciplinary team with expertise in fishery biology, stock assessment, economics, mathematical modeling, statistics, computer science, and field sampling techniques. Members of this program are stationed at the NWFSC facilities in Seattle and in Newport, Oregon, with some Observer Program staff located in California. Together, they work to develop and provide scientific information necessary for managing West Coast marine fisheries and strive to provide useful and reliable stock assessment data with which fishery managers can set ecologically safe and economically valuable harvest levels. FRAM researchers develop models for managing multi-species fisheries; design programs to provide information on the extent and characteristics of bycatch in commercial fisheries as they look at methods to reduce fisheries bycatch; characterize essential habitats for key groundfish species; and employ advanced technologies for new assessments.

During 2016, FRAMD continued to: implement a West Coast observer program; conduct a coast wide survey program that includes West Coast groundfish acoustic, hook and line, and trawl surveys; develop new technologies for surveying fish populations; and expand its stock assessment, economics, and habitat research. Significant progress continues in all programs.

For more information on FRAMD and groundfish investigations, contact the Division Director, Dr. Michelle McClure at Michelle.McClure@noaa.gov, (206) 860-3381.

Other Divisions at the NWFSC are:

The Conservation Biology Division is responsible for characterizing the major components of biodiversity in living marine resources, using the latest genetic and quantitative methods. It also has responsibility for identifying factors that pose risks to these components and the mechanisms that limit natural productivity. The Division's multi-disciplinary approach draws on expertise in the fields of population genetics, population dynamics, and ecology.

The Environmental and Fisheries Sciences Division conducts research to assess and reduce natural and human-caused impacts on environmental and human health, and to improve methods for fisheries restoration and production in conservation hatcheries and in aquaculture. Environmental health and conservation research examines environmental conditions and the impacts of chemical contaminants, marine biotoxins, and pathogens on fishery resources, protected species, habitat quality, seafood safety, and human health. Fisheries restoration and aquaculture includes research on the challenges associated with captive rearing, nutrition, reproduction, behavior, disease control, engineering, hatchery technology and larval/juvenile quality for protected, depleted and commercially valuable species.

The Fish Ecology Division's role is to understand the complex ecological linkages among important marine and anadromous fishery resources in the Pacific Northwest and their habitats. The Division particularly places emphasis on investigating the myriad biotic and abiotic factors that control growth, distribution, and survival of important species and on the processes driving population fluctuations.

For more information on Northwest Fisheries Science Center programs, contact the Center Director, Dr. Kevin Werner at 6795Kevin.Werner@noaa.gov, (206) 860-6795.

II. Surveys

A. U.S. West Coast Groundfish Bottom Trawl Survey

The NWFSC conducted its nineteenth annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2016 survey was to provide information on the distribution and relative abundance of demersal species within this region at depths from 30 to 700 fathoms. Other biological information necessary to assess the status of groundfish stocks (e.g. length, weight, sex and age structures) was collected throughout the survey period.

The NWFSC chartered commercial fishing vessels to conduct independent, replicate surveys using standardized trawl gear. Fishing vessels *Last Straw, Noah's Ark, Ms. Julie,* and *Excalibur* were contracted to survey the area from Cape Flattery, WA to the Mexican border in Southern California, beginning in the later part of May and continuing through October. Each charter was for a period of 11-12 weeks with the *Last Straw* and *Excalibur* surveying the coast during the initial survey period from May to July. The *Noah's Ark* and *Ms. Julie* operating in tandem, surveyed the coast during a second pass from mid-August to late October. The survey area was partitioned into ~12,000 adjacent cells of equal area (1.5 nm long. by 2.0 nm lat., Albers Equal Area projection) with each vessel assigned a primary subset of 188 randomly selected cells to sample. An Aberdeen-style net with a small mesh (1 1/2" stretch) liner in the codend was used for sampling. The survey followed a stratified random sampling scheme with 15-minute tows within 2 geographic strata (80% N of Pt. Conception, CA and 20% S) and 3 depth strata. The depth strata were: shallow (30-100 fms), middle (100-300 fms), and deep (300-700 fms). The sample design consisted of 752 sampling locations, with a minimum of 30 tows per strata.

In 2016, we utilized a new backdeck data collection system with updated software applications, and wireless networking. We initiated use of a ruggedized printer for labeling specimens in 2016, as well as updating the power supply for backdeck equipment. Established NOAA national bottom trawl protocols were used throughout the survey. As in prior years, a series of special research projects were undertaken in cooperation with other NOAA groups and various Universities.

Additional data were collected during the trawl survey for collaborative research projects with several NMFS/academic colleagues:
1) Assessing sublethal effects of hypoxia on greenstriped rockfish (*Sebastes elongatus*) – NWFSC, Conservation Biology Division, Environmental and Fisheries Sciences Division;
2) Collection of voucher specimens for multiple fish species – Northwest Fisheries Science Center;
3) Lingcod aging study – collect otolith and fin ray from one lingcod in any tow where they are collect – NWFSC Aging Laboratory;
4) collection of DNA and/or whole specimens of rougheye rockfish (S*ebastes aleutianus*), blackspotted rockfish (S*ebastes melanostictus*), darkblotched rockfish (S*ebastes crameri*) and blackgill rockfish (S*ebastes melanostomus*) to reduce uncertainty in the assessment of morphologically-similar west coast rockfish – Northwest Fisheries Science Center;
5) Collect fin slips from all Pacific sleeper sharks (*Somniosus pacificus*) to examine genetics – NOAA, NWFSC – Cindy Tribuzio
6) Does Puget Sound represent a distinct population segment for yelloweye and canary rockfish? - collection of fin clips for yelloweye and canary rockfishes – NWFSC, Conservation Biology Division;
7) Request for photographs of lamprey scars and specimens for Pacific lamprey (*Lampetra tridentata*) and river lamprey (*Lampetra ayresii* – NWFSC, Conservation Division, Newport;
8) Lingcod study – whole specimens for stomachs, tissue, fecundity, DNA sampling – NWFSC, Conservation Biology Division;
9) Record all sightings of basking sharks – Moss Landing Marine Laboratories;
10) Collection of all thornback rays, *Platyrhinoidis triseriata* – Moss Landing Marine Laboratories;
11) Collection of 25 big skate (*Raja binoculata*) egg cases containing embryos– Moss Landing Marine Laboratories
12) Collection of all biological data and specimens of deepsea skate (*Bathyraja abyssicola)* and broad skate ((*Amblyraja badia*) - Moss Landing Marine Laboratories;
13) Collection of all longnose catsharks *(Apristurus kampae)* – Moss Landing Marine Laboratories;
14) Collection of all specimens of Pacific black dogfish, *Centroscyllium nigrum* – Moss Landing Marine Laboratories;
15) Collection of all unusual or unidentifiable skates, Pacific white skate, *Bathyraja spinossisima*, fine-spined skate, *Bathyraja microtrachys*, and Aleutian skate, *Bathyraja aleutica* – Moss Landing Marine Laboratories;
16) Collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* and velvet dog shark (*Zameus squamulosus*) – Moss Landing Marine Laboratories;

17) Collection of any chimaera that is not a spotted ratfish (*Hydrolagus colliei)*, including: *Harriotta raleighana*, *Hydrolagus* spp. and *Hydrolagus trolli* – Moss Landing Marine Laboratories;
18) Collection of voucher specimens for multiple fish species – Oregon State University;
Several other research initiatives were undertaken by the Survey Team including: 1) Use of stable isotopes and feeding habits to examine the feeding ecology of rockfish (genus *Sebastes*) and other species; 2) Fin clip collection for various shelf rockfish species; 3) Collection of stomachs for various rockfish species (darkblotched rockfish, splitnose rockfisk, blackgill rockfish, blackspotted/rougheye rockfish, yelloweye rockfish, and cowcod; 4) Collection and identification of cold water corals; 5) Fish distribution in relation to near-bottom dissolved oxygen concentration; 6) Composition and abundance of benthic marine debris collected during the 2016 West Coast Groundfish Trawl Survey; and 8) Collection of ovaries and finclips from copper rockfish, cowcod, bank rockfish, blackspotted/rougheye rockfish, vermilion/sunset rockfish, yelloweye rockfish, and Pacific hake; 9) Collection of ovaries from aurora rockfish, yellowtail rockfish, shortspine thornyheads, lingcod and petrale sole to assess maturity; 10) Collection of whole ovary from petrale sole to assess fecundity; 10) Collection of stomachs for non-rockfish species (arrowtooth flounder, sablefish, and lingcod; 11) Collection of voucher specimens for teaching purpose; 12) Collection of all specimens identified as sharpnose sculpin (*Clinocottus acuticeps*); 13) Photograph, tag, bag and freeze deep water species such as arbiter snailfish *Careproctus kamikawi*) and other rare or unidentified deep water species.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

B. Southern California shelf rockfish hook-and-line survey

In early Fall 2016, FRAM personnel conducted the 13th hook and line survey for shelf rockfish in the Southern California Bight (SCB). This project is a cooperative effort with Pacific States Marine Fisheries Commission (PSMFC) and the southern California sportfishing industry aimed at developing an annual index of relative abundance and time series of other biological information for structure-associated species of groundfish including bocaccio (*Sebastes paucispinis*), greenspotted rockfish (*S. chlorostictus*), cowcod (*S. levis*) blue rockfish (*S. mystinus*), the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) and lingcod (*Ophiodon elongatus*) within the SCB.

The F/V *Aggressor* (Newport Beach, CA), F/V *Mirage* (Port Hueneme, CA), and F/V *Toronado* (Long Beach, CA) were each chartered for 14 days of at-sea research, with 14 biologists participating during the course of the survey. The three vessels sampled a total of 185 sites ranging from Point Arguello in the north to the US-Mexico EEZ boundary in the south. For the first nine field seasons, sampling was conducted aboard two chartered vessels, however a third vessel was added to the survey in 2013 in response to internal and external peer reviews recommending additional research into the role the vessel platform plays in abundance modeling. In response to research needs identified by the PFMC and stock assessment scientists, the survey began adding sites within the Cowcod Conservation Areas (CCAs). During the period 2014-16, the survey added 79 sites within the CCAs bringing the total number of sites in the sampling frame to 200. It is anticipated that monitoring at these sites will continue during subsequent surveys.

Final data are not yet available for the 2016 survey, but should be similar to results from the 2015 survey where approximately 6,822 sexed lengths and weights, 5,480 fin clips, and 5,371 otolith pairs were taken during the course of the entire survey representing 39 different species of fish. Several ancillary projects were also conducted during the course of the survey. Approximately 779 ovaries were collected from 17 different species to support the development of maturity curves. Several dozen individual fish were retained for use in species identification training for west coast groundfish observers and for a genetic voucher program conducted by the University of Washington. Researchers also deployed an underwater video sled to capture visual observations for habitat analysis, species composition, and fish behavior studies. In addition, the 2016 survey collected rockfish specimens to generate species-specific fatty acid profiles to support research into increased mortality of juvenile California sea lions along the West Coast and conducted a pilot environmental DNA (eDNA) project aimed at comparing presence/absence of species-specific genetic sequences in water samples with species positively observed on survey hooks or video observations.

For more information, please contact John Harms at John.Harms@noaa.gov

C. 2016 Investigations of hake ecology, survey methods, and the California Current ecosystem.

The NOAA/ NMFS/ Fisheries Engineering and Acoustic Technologies Team (FEAT) conducted two Pacific Hake research cruise during the past year. The 2016 Investigations of hake ecology, survey methods, and the California Current ecosystem was conducted on the NOAA Ship *Bell M. Shimada* from July 30, 2016 to August 14, 2016. The data collected during the research cruise were processed to provide improved understanding of Pacific Hake biology and ecology as related to the California Current Large Marine Ecosystem. Additionally, we conducted experimental trawls comparing our standard AWT to an AWT with a MMED added. The survey range was from 41 07.03N to 41 07.03N. A total of 73 trawls were attempted with 65 completed successfully and 8 aborted. Acoustic data were collected on the *Shimada* with a Simrad EK60 echosounder operating at frequencies of 18, 38, and 120, and 200 kHz. We also began testing and comparison to EK60 of the new wideband EK80 sytems at the 45-90 kHz and 160-260 kHz ranges. The EK80 system is the replacement system for the Midwater trawls equipped with a camera system were conducted to verify species composition of observed backscatter layers and to obtain biological information (e.g., species identification, size, time and position encountered).

For more information, please contact Larry Hufnagle at lawrence.c.hufnagle@noaa.gov.

D. 2017 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Winter Research Cruise

We conducted our second Integrated Ecosystem and Pacific Hake Acoustic-Trawl Winter Research Cruise from January 11, 2017 to February 12, 2017. The purpose of this research cruise is to learn more about Pacific Hake spawning, distribution in winter and migration. The survey range was 45 30.58N and down to 30 47.02N and a total of 11 trawls using our standard AWT were conducted. This research cruise was impacted by weather and vessel issues so the number of transects and trawls were reduced from our research plan. EK60 and EK80 systems were used as described above.

For more information, please contact Larry Hufnagle at lawrence.c.hufnagle@noaa.gov.

III. Reserves

A. How does the definition of 'home range' affect predictions of the efficacy of marine reserves?

Investigators: N. Tolimieri, K.S. Andrews and P.S. Levin.

Understanding how animals use space is fundamental to the employment of spatial management tools like marine protected areas (MPAs). A commonly used metric of space use is home range—defined as the area in which an individual spends 95% of its time and often calculated as 95% of the utilization distribution (UD), which is a probabilistic map describing space use. Since home range represents only 95% of an animal's time, it is important to understand whether the other 5% matters to the design of MPAs. We developed an MPA-population model for lingcod *Ophiodon elongatus* that examined the population recovery under six characterizations of space use ranging from one mean home range to nine real lingcod UDs. Mean home range and similar estimates (based on the area in which a fish spent 95% of its time) predicted higher biomass and numbers relative to the more complete analysis of space use like the UD (which represented 99.99% of a fish's time) and underestimated the size of reserves necessary to achieve the same level of recovery of biomass. Our results suggest failing to account for the full extent of a fish's time overestimates the effectiveness of marine reserves.

For more information please contact Dr. Nick Tolimieri at NOAA's Northwest Fisheries Science Center, Nick.Tolimieri@noaa.gov.

IV. Review of Agency Groundfish Research, Assessments, and Management

A. Hagfish: No research or assessments in 2016

B. Dogfish and other sharks: No assessments in 2016

1. Research

a) If the tag fits.....finding the glass slipper of tags for spiny dogfish (*Squalus suckleyi*).

Investigators: C. Tribuzio and K.S. Andrews

There are a multitude of technologies available for tagging and tracking fish species, however, not all tags are appropriate for all species or situations. The spiny dogfish (Squalus suckleyi) is a small species of shark, common in coastal waters of the eastern North Pacific Ocean. Fishery dependent tags, those requiring recapture of the fish to recover data, are less appropriate for this species because of the likely biased response rate. The purpose of this study was to examine fishery independent tag technology for spiny dogfish. There are two main types of fishery independent tags: satellite transmitting (relatively high resolution archived data) and acoustic transmitting (low resolution data, only when tags are in range of receiver). The satellite tags have historically been too large to apply to small species, but miniaturization of the technology has dramatically reduced tag size. These tags are limited to a short battery life and greater potential for failure. Acoustic tags have a longer battery life and less of a potential for failure, but data is limited to the spatial extent of the receivers. In this study we double tagged six spiny dogfish in Puget Sound, Washington with both satellite and acoustic tags. Results suggest that either tag type would work well for the species, but both have benefits and drawbacks. In general, the satellite tags perform better for large scale movements, and provide high resolution depth and temperature (i.e., habitat) data, while the acoustic tags provide better fine scale movement information with lower resolution depth data.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

b) Sibling rivalry: do sixgill sharks (*Hexanchus griseus*) co-occur in kin-structured pairs within nursery habitat of an inland estuary?

Investigators: K.S. Andrews and S. Larson

The association of individuals in the animal kingdom is based on several life-history, reproductive and behavioral processes. Some taxa, such as mammals, have relatively small litters, care for their young and form close-knit family units that remain together for several years and in some instances for their entire lives. However, many fishes broadcast spawn millions of eggs or release thousands of larvae into the water column, provide no subsequent parental care and never come in contact with offspring or siblings. In order to determine whether sixgill sharks move in kin-structured groups, we monitored the movement of 24 individuals from 2006 to 2009 in Puget Sound, WA. Using tissue samples from each shark, we were able to calculate the relatedness of all sharks collected. Using kinship coefficient values, pairs of sharks that were more closely related to each other were more likely to be detected at the same location during the same week than pairs of sharks that were not closely related to each other.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

C. Skates: No research or assessments in 2016
D. Pacific cod: No research or assessments in 2016
E. Walleye Pollock: No research or assessments in 2016
F. Pacific whiting (hake)
1. Assessment

a) Status of the Pacific (whiting) stock in U.S. and Canadian waters in 2017

Authors: A. Berger, C. Grandin, I. Taylor, A. Edwards, S. Cox

This stock assessment reported the collaborative efforts of the official U.S. and Canadian JTC members in accordance with the Agreement between the government of the United States and the government of Canada on Pacific hake/whiting. The assessment reported the status of the coastal

Pacific Hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the United States and Canada for 2017. Coast-wide fishery landings of Pacific hake averaged 226 thousand mt from 1966 to 2016, with a low of 90 thousand mt in 1980 and a peak of 363 thousand mt in 2005. Prior to 1966 the total removals were negligible relative to the modern fishery. Recent coast-wide landings from 2007–2016 have been above the long term average, at 262 thousand mt. Landings between 2013 and 2013 were predominantly comprised of fish from the very large 2010-year class, comprising around 70% of the total removals. In 2016, U.S. fisheries caught mostly 2- and 6-year old fish from the 2010 and 2014 year classes, while the Canadian fisheries encountered mostly 6-year old fish from the 2010 year-class. The Agreement between the United States and Canada establishes U.S. and Canadian shares of the coast-wide TAC at 73.88% and 26.12%.

Data were updated for the 2017 assessment with the addition of fishery catch and age compositions from 2016, reanalyzed acoustic survey biomass and age compositions for 1995 (completing the reanalyzed acoustic survey time series initiated in the 2016 model), and other minor refinements such as catch estimates from earlier years. The assessment used Bayesian methods to incorporate prior information on two key parameters (natural mortality, *M*, and steepness of the stock-recruit relationship, *h*) and integrated over parameter uncertainty to provide results that can be probabilistically interpreted. The exploration of uncertainty was not limited to parameter uncertainty as structural uncertainty was investigated through sensitivity analyses. Pacific Hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts resulting in time-varying selectivity, and little data to inform incoming recruitment until the cohort is age-2 or greater, will, in most circumstances, continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Uncertainty in this assessment is largely a function of the potentially large 2014 year-class, which has been observed twice by the fishery but has yet to be observed by the acoustic survey, and uncertain selectivity. However, with recruitment being a main source of uncertainty in the projections and the survey not able to monitor the 2014 year-class until they are 3 years old (i.e., summer 2017), short term forecasts are very uncertain.

The base model estimates indicate that since the 1960s, Pacific hake female spawning biomass has ranged from well below to near unfished equilibrium biomass. The model estimates that the stock was below the unfished equilibrium in the 1960s and 1970s, increased toward the unfished equilibrium after two or more large recruitments occurred in the early 1980s, and then declined steadily through the 1990s to a low in 2000. This long period of decline was followed by a brief peak in 2003 as the large 1999-year class matured and subsequently supported the fishery for several years. Estimated female spawning biomass declined to an all-time low of 0.565 million mt in 2009 because of low recruitment between 2000 and 2007, along with a declining 1999-year class. Spawning biomass estimates have increased since 2009 on the strength of large 2010 and 2014 cohorts and an above average 2008 cohort. The 2017 female spawning biomass is estimated to be 89.2% of the unfished equilibrium level (B_0) with a 95% posterior credibility interval ranging from 37% to 271%. The median estimated 2017 female spawning biomass is 2.13 million mt.

Estimates of historical Pacific hake recruitment indicate very large year classes in 1980, 1984, 1999, and 2010. The U.S. fishery shows that the 2014 year-class comprised a very large proportion of the observations in 2016. Uncertainty in estimated recruitments is substantial, especially for

2014, as indicated by broad posterior intervals. The fishing intensity on the Pacific Hake stock is estimated to have been below the $F_{40\%}$ target except for 1999 when the median estimated fishing intensity was slightly above target. Fishing intensity has been substantially below the $F_{40\%}$ target since 2012. Although the official catch targets adopted by the U.S. and Canada have been exceeded only once in the last decade (2002), fishing intensity is estimated to have not exceeded the target rate in the last 10 years. Recent catch and levels of depletion are presented in Figure 1.

Management strategy evaluation tools will be further developed to evaluate major sources of uncertainty relating to data, model structure and the harvest policy for this fishery and compare potential methods to address them. A spatially explicit operating model is needed, so forthcoming research will focus on how best to model these dynamics, including the possible incorporation of seasonal effects and potential climate forcing influences in the simulations.

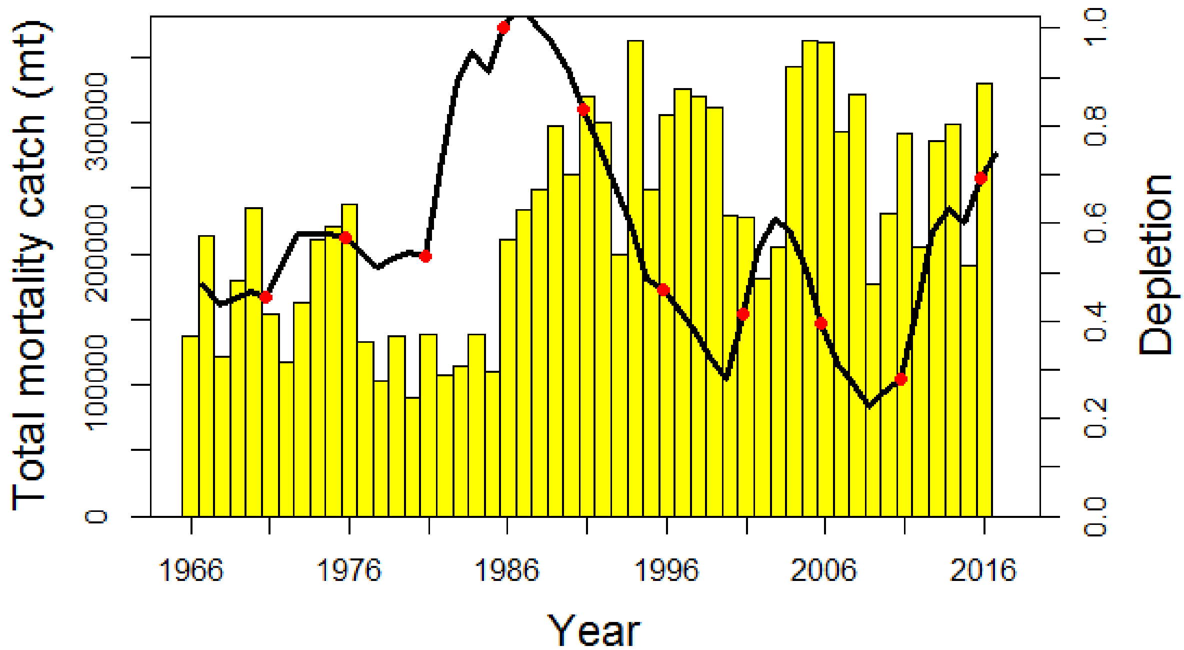


Figure 1. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2016.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov.

G. Grenadiers: No research or assessments in 2016

H. Rockfish: No assessments in 2016

1. Research

a) Survival and movement behavior of yelloweye rockfish in a relatively closed fjord system exposed to low dissolved oxygen levels

Investigators: K.S. Andrews, N. Tolimieri, C.J. Harvey

We have tagged 15 yelloweye rockfish *Sebastes ruberrimus* at three locations in Hood Canal with acoustic transmitters to monitor their survival and movement patterns for a period of one year. Three arrays of 5 acoustic receivers were deployed at the locations we captured individuals. These receivers will detect the presence/absence, depth and acceleration of each individual. Each tag emits a unique id code with each transmission of depth and acceleration so that we can monitor the movements of each individual fish. This research has two main objectives. First, we will determine the rate of survival for yelloweye rockfish captured with hook-and-line fishing methods and subsequently returned to the bottom using descending devices. Movement characteristics will determine whether individuals survived the capture event and whether mortality occurred over the following year. Second, we will calculate vertical and horizontal movement characteristics of yelloweye rockfish among these three sites in Hood Canal. This will provide evidence for or against the hypothesis that yelloweye rockfish have very small home ranges and that they do not migrate vertically in the water column like many marine species. Hood Canal is known to experience periods during the year (primarily in autumn months) of very low dissolved oxygen levels and we will use the calculated movement characteristics to investigate whether yelloweye rockfish behave differently under varying levels of dissolved oxygen. Understanding how this species responds to varying environmental conditions will provide necessary information to evaluate potential threats to the recovery of this population and to satisfy criteria for delisting this population from the endangered species list.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

b) Assessing the magnitude of rockfish bycatch among bait types while targeting lingcod

Investigators: K.S. Andrews and D. Tonnes

Rockfish in Puget Sound have declined > 70% over the last ~50 years and three species have been listed on the endangered species list. Most commercial fisheries have been ended in Puget Sound and several regulations restricting recreational fishing for bottomfish have been implemented over the last two decades. However, rockfish inhabit similar habitats as other recreationally-targeted species, such as lingcod and halibut and bycatch of rockfish during these fisheries is still a concern for managers trying to recover rockfish populations in the Puget Sound region. Thus, understanding whether there are specific types of bait and/or lures that reduce rockfish bycatch during these fisheries, while retaining similar catch rates for the target species, may provide protection to recovering rockfish populations and additional fishing opportunities. Anecdotal reports from the fishing community suggest that rockfish bycatch is low to non-existent in the lingcod fishery when large flatfish bait is used when compared to small, live baits or artificial lures/jigs. This project has been funded by NOAA’s Western Regional Office in order to test whether this hypothesis is true. Preliminary catch data from recreational fishing guides collected in 2014 and 2015 revealed that rockfish bycatch is small when using flounder/sandab as live bait, but due to confounding variables associated with this data set, the true extent of rockfish bycatch among bait types is difficult to determine. In this project, we will partner with charter boat captains to assess rockfish bycatch in local lingcod fisheries by fishing with different bait types in a controlled experimental design among fishing locations in Central Puget Sound and the San Juan Islands in 2017 and 2018.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

c) Effects of release timing and location of release on potential larval dispersal for yelloweye and canary rockfish in the Salish Sea.

Investigators: B. Bartos, K.S. Andrews, C.J. Harvey P. MacReady and D. Tonnes

Genetic evidence has shown that yelloweye rockfish in Puget Sound/Georgia Basin (PSGB) are distinct from populations on the outer coast of the United States and Canada, while canary rockfish show no broad-scale population structure among these regions. Adult canary rockfish have been characterized as transient with wide-ranging spatial movements that may cover hundreds of kilometers over the span of multiple years. Adult yelloweye rockfish are characterized by low rates of migration with little month-to-month variability in horizontal and vertical movements. The genetic information is consistent with these characteristics and suggest adult movement is a likely mechanism for population connectivity in canary rockfish and for population differentiation in yelloweye rockfish. However, numerous marine populations are connected via the dispersal of individuals at very young ages (e.g., larvae and pelagic juveniles). This project will begin to investigate whether differences in the timing of release and location of release of larvae may provide a second mechanism for the connectivity of canary rockfish and the population differentiation observed in yelloweye rockfish. Canary rockfish have peaks in larvae release in February-March, while yelloweye rockfish peak in May-June. Horizontal and vertical volume transport varies seasonally in the PSGB region. Horizontal advection is greatest in summer and early autumn, while vertical advection is more negative (waters moving from surface to deep) in May/June as compared to relatively no net vertical advection in February/March. We are using ocean circulation models to simulate larval dispersal of canary and yelloweye rockfish throughout this region. "Larvae" will be released at different times of year, respective of each species, from different locations and tracked for a period of 4 months, which is an approximate period that they spend in the plankton. We will then calculate the proportion of larvae that are transported into or out of PSGB and coastal locations and the proportion retained within each region. This should provide preliminary information to test whether interactions between larval release timing, larval behavior and swimming ability, and oceanographic conditions provide a mechanism for differential larval dispersal that might explain the observed genetic differences for these species in the PSGB region.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

d) Cooperative research sheds light on population structure and listing status of threatened and endangered rockfish species

Investigators: K.S. Andrews, K.M. Nichols, A. Elz, C.J. Harvey, N. Tolimieri, D. Tonnes, D. Lowry, R. Pacunski, and K.L. Yamanaka

In 2010, the National Marine Fisheries Service listed yelloweye (*Sebastes ruberrimus)* and canary rockfish (*S. pinniger*) as threatened and bocaccio (*S. paucispinis*) as endangered in Puget Sound (PS), WA, USA under the federal Endangered Species Act (ESA). However, this decision was made despite a lack of data to directly answer the first criterion of an ESA listing – Is the population segment "discrete" and "significant" from the remainder of the taxon? Indirect evidence from other species or *Sebastes* spp. in other geographic regions was the primary basis of the listing decision. To answer the first criterion directly, we collaborated with recreational fishing communities to collect tissue samples from these rare species in PS. We used population genetics analyses to determine whether samples from PS were genetically "discrete" from samples collected from the outer coast. Thousands of genetic markers for each species were surveyed using restriction-site associated DNA sequencing (RAD-seq). Multiple analyses showed that yelloweye rockfish collected in inland waters of PS and British Columbia, Canada were genetically different from coastal populations, whereas we found no evidence of population structure for canary rockfish. The sample size for bocaccio was insufficient to test the hypothesis. These data support the ESA designation status for yelloweye rockfish, but suggest canary rockfish in PS are not a "discrete" population and do not meet the first criterion of the ESA. Collaboration among agencies and fishing communities and technological advances in genetic sequencing provided the framework for the first de-listing of a marine fish species under the ESA.

For more information, please contact Mr. Kelly Andrews at Kelly.Andrews@noaa.gov.

e) Assessing sublethal effects of hypoxia on West Coast groundfish: do growth rates of greenstriped rockfish *Sebastes elongatus* vary with levels of dissolved oxygen?

Investigators: C.J. Harvey, K.S. Andrews, B.R. Beckman, V. Simon, P. Frey and D. Draper

In this project, we examine variation in the levels of insulin-like growth factor (IGF) in the blood plasma of greenstriped rockfish (*Sebastes elongatus*) in the northern portion of the U.S. West Coast as sampled by the FRAM groundfish trawl survey (legs 1, 2 and 3 to Cape Mendocino). We will collect IGF samples on the first and second passes of the 2015 survey. IGF is an indicator of feeding and somatic growth in fishes. Our objective is to determine if IGF levels of greenstriped rockfish, a model groundfish species, are correlated with physical parameters of the environment, with an emphasis on temperature and dissolved oxygen (DO). We propose to collect samples from the smallest size-frequency bins of greenstripe rockfish on the first pass, i.e., likely before hypoxia has developed, and on the second pass, i.e., likely after hypoxia has become established. We also hope to collect these samples over a broad spatial range of the northern portion of the survey domain, so that there are individuals both inside and outside but adjacent to the region most affected by hypoxic conditions. In addition to collecting blood, scientists will be collecting and analyzing stomach contents for comparison with IGF levels. Samples are being processed in the spring of 2016 and we plan to collect samples again during the FRAM groundfish trawl survey in 2016 and 2017.

For more information, please contact Dr. Chris Harvey at Chris.Harvey@noaa.gov.

f) MARSS models for estimating population status for data-poor species: three ESA listed rockfishes in Puget Sound

Investigators: N. Tolimieri, E.E. Holmes and G.D. Williams

Time-series analysis is a fundamental tool for evaluating the status of species thought to be potentially at risk of extinction. We show how multivariate autoregressive state-space models (MARSS) can combine gappy data from disparate gear types and multiple survey areas to estimate the regional population trajectory over time, the population growth rate, and the uncertainty in these estimates. MARSS can also test hypotheses about the spatial structure of subpopulations. We illustrate our approach with an analysis of population status for three, rockfishes listed in Puget Sound WA under the Endangered Species Act: bocaccio (endangered), yelloweye (threatened) and canary rockfishes (threatened). Data were available from three sources: 1) Washington Department of Fish and Wildlife (WDFW) recreational fishery survey, 2) REEF scuba surveys, and a WDFW trawl survey. The surveys use different gear and sample different depths likely providing information on different rockfish assemblages. Changes in bag limits reduced catch by recreational fishers through time, and all three data sets have data gaps. Because there were few observations of the listed species, we estimate the population trajectory and growth for 'total rockfish'. We then make inferences about the listed species by evaluating evidence that they have increased or decreased as a proportion of the assemblage. Our analysis indicates that total rockfish declined ~3.1 – 3.8% per year from 1977-2014 with similar rates of decline north and sound of Admiralty Inlet. The listed species all declined as a proportion of the local assemblage suggesting stronger rates of negative population growth for the listed species than for total rockfish. Although rates of decline were similar in north and south of Admiralty Inlet, there was evidence of temporal independence in these two regions as evidenced by higher and more variable catch north of Admiralty Inlet and data support for unique trajectories (year to year abundances).

For more information, please contact Dr. Nick Tolimieri at Nick.Tolimieri@noaa.gov.

g) Genetic analysis to reduce uncertainty in the assessment of morphologically-similar west coast rockfish

Investigators: A. Keller, J. Cope, A. Elz, P. Frey, J. Harms, A. Hicks, J. Orr, L. Park, and V. Tuttle

Cryptic and incipient speciation within rockfishes (genus Sebastes) abounds on the U.S. West Coast. Investigation into morphological, life history, and genetic differences between similar species continues to reveal important distinctions among known species as well as within currently recognized species. Ambiguity in the taxonomy and biology of such species may result in historical data being pooled inappropriately, potentially obscuring important life history differences and adding uncertainty to stock assessments. We identify differences in the depth, spatial distribution, and growth for the rougheye (S. aleutianus)/blackspotted (S. melanostictus) complex while also offering preliminary results into newly discovered genetic variability within darkblotched rockfish (S. crameri). The West Coast Groundfish Bottom Trawl Survey, At-Sea Hake Observer Program, and Oregon Department of Fish and Wildlife provided over 900 tissue samples for the rougheye/blackspotted genetic analysis. The process employed a diagnostic Taqman assay of the ND3 mitochondrial region developed for this species pair. Morphometrics and meristics confirm these species are challenging to distinguish via visual diagnostics, but are definitively identifiable using genetic techniques. Results indicate over 15% of the catch previously considered as nominal rougheye rockfish may be blackspotted. These results have implications for long-term data sets including commercial landings and historical survey data. Color variability in darkblotched rockfish has elicited a similar investigation into stock structure. Preliminary analysis suggests consistent genetic variation among samples at multiple loci. However, voucher specimens examined to date have thus far not revealed a connection between observed genetic differences and various morphometric and meristic characteristics. Further investigations are underway.

For more information, please contact Peter Frey at Peter.Frey@noaa.gov

h) Developing an index of abundance for yelloweye rockfish (*Sebastes ruberrimus*) off the Washington coast.

Investigators: T. –S. Tsou, J.M. Cope and B.W. Speidel

Yelloweye rockfish (Sebastes ruberrimus) was declared overfished in 2002 and since has been a “choke species” limiting groundfish fishing opportunities along the US west coast. One of the many challenges in monitoring and managing this stock is the lack of adequate fisheries-independent surveys. The conventional bottom trawl survey does not consistently sample Yelloweye rockfish habitat; and the only survey used in the past assessments was the International Pacific Halibut Commission’s fixed-station setline survey. For Yelloweye caught by the IPHC survey off Washington coast, more than 90% was from one single station off Cape Alava and the minimum size was 40 cm (older than 10 years old). The abundance trend derived from the IPHC survey is uninformative for the population in Washington waters, thus the need for another survey. Beginning in 2006, the Washington Department of Fish and Wildlife has been conducting pilot projects to identify the best location, season, and hook-size for constructing a representative Yelloweye rockfish abundance index trend. In this presentation, we summarize findings from these pilot projects, compare abundance trends, and recommend future research.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

I. Thornyheads: No research or assessments in 2016

J. Sablefish: No assessments in 2016

1. Research

a) Oceanographic drivers of sablefish recruitment in the California Current

Investigators: N. Tolimieri, M.A. Haltuch, Q. Lee, M.G. Jacox and S.J. Bograd

Oceanographic processes and ecological interactions can strongly influence recruitment success in marine fishes. Here, we develop an environmental index of sablefish recruitment with the goal of elucidating recruitment-environment relationships and informing stock assessment. We start with a conceptual life-history model for sablefish *Anoplopoma fimbria* on the US west coast to generate stage- and spatio-temporally-specific hypotheses regarding the oceanographic and biological variables likely influencing sablefish recruitment. Our model includes seven stages from pre-spawn female condition through benthic recruitment (age-0 fish) for the northern portion of the U.S. sablefish stock (40-50 °N). We then fit linear models and use model comparison to select predictors. We use residuals from the asserted sablefish stock-recruitment relationship in the 2015 assessment as the dependent variable (thus removing the effect of spawning stock biomass). Predictor variables were drawn primarily from ROMS model outputs for the California Current Ecosystem. We also include indices of prey and predator abundance and freshwater input. Five variables explained 57% of the variation in recruitment not accounted for by the stock-recruitment relationship asserted in the sablefish assessment. Recruitment deviations were positively correlated with (1) colder conditions during the spawner preconditioning period, (2) warmer water temperatures during the egg stage, (3) stronger cross shelf transport to near-shore nursery habitats during the egg stage, (4) stronger long-shore transport to the north during early development, and (5) cold surface water temperatures during the larval stage. This result suggests that multiple mechanisms likely affect sablefish recruitment at different points in their life-history.

For more information, please contact Dr. Nick Tolimieri at nick.tolimieri@noaa.gov.

K. Lingcod: No assessments in 2016

1. Research

a) Landscape genomics & life history diversity in lingcod on the US West Coast

Investigators: J.F. Samhouri, K.S. Andrews, B. Brown, J. Cope, S. Hamilton, L. Lam, G. Longo, K. Nichols and G. Williams

Demographic rates, life history traits, and genetic structure are the foundations of stock assessment models. Mounting evidence suggests that genetic stock structure and geographic variation in demographic rates and life history traits (hereafter, regional stock structure) may be much more common than previously assumed, in some cases due to natural gradients in environmental factors such as temperature, habitat, prey availability, and predation pressure. More recently, the field of landscape genomics has begun to reveal the extent to which such gradients in environmental factors lead to predictable genotypic variation. This possibility is especially likely for reef-associated nearshore stocks, as they occupy spatially-fractured habitats likely to produce localized demographic, life history, and genetic differences.

Despite universal recognition of the potential for regional stock structure, most stock assessment models currently in use along the US West Coast have assumed (often due to data limitations) homogeneous stock structure across broad regions. Thus, most commercial and recreational fisheries are managed with a single set of regulations (e.g., catch limits) tuned to biological parameters that are fixed over large spatial scales. Inappropriate assumptions of spatial homogeneity can produce inefficiencies in fisheries yields and revenues, and thus there is a great need to use information on spatial heterogeneity in demographic, life history, and genetic variability to guide future stock assessment efforts.

Using lingcod, *Ophiodon elongatus*, as a focal stock, this project aims to develop a general approach for determining if there are regional differences in demographic rates, life history traits, and genetic composition along the US West Coast. Lingcod are one of the stocks determined to be a high priority for habitat science following regional Habitat Assessment Prioritization, and they are listed under the Fish Stock Sustainability Index. On the US West Coast, the lingcod stock has been rebuilt recently from a depleted state, and in some places is now considered underutilized (e.g., Central and Northern CA Coast). These large, piscivorous, temperate fish occur from Baja California to Alaska in relatively shallow (common to 200 m), rocky habitats, and can show substantial spatial variability in life history-related traits (e.g., lingcod body length can be two-fold greater in WA than in CA). Combined with the fact that lingcod have relatively small home ranges, geographic variability in body size creates huge potential for regional differences in demographic rates and life history traits. Previous work examining lingcod genetic structure using allozymes, mtDNA, and microsatellites has proven equivocal, and no analyses have been conducted on lingcod collected after 2000, since the stock rebuilt. The most recent stock assessment considered separate Northern (WA and OR) and Southern (CA) stocks, but stressed major uncertainty with respect to (i) the proper break points for stocks and sub-stocks and (ii) stock-specific length-at-age data.

We have collected lingcod from all regions of the U.S. West Coast and, in 2017, are sampling Puget Sound, WA, and southeast Alaska. In addition, the FRAM trawl survey team has collected lingcod for us as part of a Special Project in 2015-2016, and plans to sample gill tissues for us in 2017. When collections from all regions are complete, we will evaluate the extent to which demographic rates and life history traits vary spatially, and whether there is a genetic basis for such variation using cost-effective sampling techniques and state-of-the-art approaches in genetics.

For more information please contact Dr. Jameal Samhouri at Jameal.Samhouri@noaa.gov.

L. Atka mackerel: No research or assessments in 2016

M. Flatfish: No research or assessments in 2016

N. Pacific halibut & IPHC activities: No research or assessments in 2016

O. Other groundfish species: No assessments in 2016

1. Research

a) Size at maturity for grooved Tanner crab (*Chionoecetes tanneri*) along the U.S. west coast (Washington to California)

Investigators: A. Keller, J.C. Buchanan, E. Steiner, D. Draper, A. Chappell, P.H. Frey and M.A. Head

We conducted a multiyear study to examine interannual variability in mean size (carapace width, mm), maturity size (mm), and depth (m) for grooved Tanner crab (Chionoecetes tanneri Rathbun, 1893) along the U.S. west coast. An additional goal was to provide updated, estimates of carapace width (mm) at 50% maturity (W50) for male and female grooved Tanner crab and assess changes over time. Randomly selected samples came from trawl surveys undertaken annually by the Northwest Fisheries Science Center at depths of 55 to 1280 m. We used allometric relationships between carapace width and either abdominal width (females) or chela length (males) to determine functional maturity by sex. We evaluated maturity by fitting logistic regression models to proportion mature. W50 varied significantly between males (125.2 mm) and females (89.1 mm) but interannual differences were slight. Annual mean carapace widths (CW) were greater for mature males (139.9 – 143.4 mm) relative to females (98.8 – 100.4 mm). Average sizes of immature grooved Tanner crab varied between sexes with males (75.7 – 84.6 mm) larger than females (66.7 – 71.9 mm). Size frequency distributions indicated little overlap in size of mature male and female grooved Tanner crab but considerable overlap between immature grooved Tanner crab. The best model expressing complexity in growth incorporated width, sex, and maturity stage. Depth ranged from 195 – 1254 m with the average depth of mature grooved Tanner crab (females, 737 m; males, 767 m) significantly shallower than immature (females, 949 m; males, 918 m) grooved Tanner crab.

For more information, please contact John Buchanan at John.Buchanan@noaa.gov

b) Dynamic population trends observed in the deep-living Pacific flatnose, *Antimora microlepis*, on the U.S. West Coast

Investigators: P.H. Frey, A.A. Keller and V. Simon

As fisheries managers attempt to incorporate ecosystem-based considerations into decision making, it is important to understand the role that non-target species play in the ecosystems that support commercial fisheries. For some deep-water groundfishes, basic information on biology and population dynamics is extremely limited. This study presents findings on the spatial distribution, growth trends, and relative abundance of the Pacific flatnose, *Antimora microlepis*, using data collected from 2003 to 2015 by the Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey (WCGBTS). We observed a 67% increase in mean fork-length over the study period reflecting the advancement of strong year-classes from the early 2000s that currently dominate the population as a whole. Catch-weighted depth increased significantly as these cohorts migrated to deeper waters of the continental slope. Although catch per unit effort remained relatively constant, this demographic shift suggests that episodic recruitment may affect the resilience of this stock to fishing mortality over time. A notable decrease in the percentage of females observed after 2012 seemed to indicate the movement of large, older females to depths beyond the 1280 m limit of the survey. Otolith weight provided a useful proxy for age in growth models for this species.

For more information, please contact Peter Frey at Peter.Frey@noaa.gov

VII. Ecosystem Studies

A. Assessment Science

1. Modeling

a) Accounting for Spatial Complexities in the Calculation of Biological Reference Points: Effects of Misdiagnosing Population Structure for Stock Status Indicators

Investigators: D. Goethel and A. Berger

Misidentifying spatial population structure may result in harvest levels that are unable to achieve management goals. We developed a spatially-explicit simulation model to determine how biological reference points (BRPs) differ among common population structures, and to investigate the performance of management quantities that were calculated assuming incorrect spatial population dynamics. Simulated reference points were compared across a range of population structures and connectivity scenarios demonstrating the influence of spatial assumptions on management benchmarks. Simulations also illustrated that applying a harvest level based on misdiagnosed spatial structure leads to biased stock status indicators, overharvesting or foregone yield. Across the scenarios examined, incorrectly specifying the connectivity dynamics (particularly misdiagnosing source-sink dynamics) was often more detrimental than ignoring spatial structure altogether. However, when the true dynamics exhibited spatial structure, incorrectly assuming panmictic structure resulted in severe depletion if harvesting concentrated on more productive population units (instead of being homogenously distributed). Incorporating spatially-generalized operating models, such as the one developed here, into management strategy evaluations (MSEs) will help develop management procedures that are more robust to spatial complexities.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov

b) Space Oddity: the Mission for Spatial Integration

Investigators: A. Berger, D. Goethel, P. Lynch, T. Quinn II, S. Mormede, J. McKenzie and A. Dunn

Fishery management decisions are commonly informed by stock assessment models that aggregate outputs across the spatial domain of the species. However, refined understanding of spatial population structure has emphasized the need to address how spatiotemporal variation in ecological processes influences the validity of data collection programs and, ultimately, the determination of regional quotas. Recently, a surge of research activity has been dedicated toward developing and evaluating spatial modeling techniques to improve fisheries assessment and management. We overview the historical context and evolution of fisheries spatial models, highlight recent advances (focusing on research presented at a 2015 American Fisheries Society symposium on spatial modelling), and discuss incorporation of spatial models into the management process using symposium themes and lessons learned from several case studies. Continued investment in fine-scale data collection and associated spatial analyses will improve integration of spatial dynamics and ecosystem-level interactions across the stock assessment and fishery management interface. Despite the current shortage of examples where spatial assessment models are used as the basis for fisheries management, we believe that spatiotemporal modeling will soon be ubiquitous in fisheries science.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov

c) A framework for modelling spatial processes in stock assessments

Investigators: K. Bosley, A. Berger, D. Goethel, D. Hanselman, A. Schueller, J. Deroba and B. Langseth

We review approaches for incorporating spatial dynamics into stock assessments with a focus on data requirements, technical aspects, and performance of spatial harvest control rules. Results of the review will guide the development of a spatially-explicit simulation-estimation framework. A spatially-explicit operating model will be implemented to test the robustness of spatially-explicit and spatially-aggregated stock assessment models to estimation of stock status. The operating model will also be used to simulate spatially-explicit BRPs to evaluate the performance of commonly implemented harvest control rules assuming both correct and incorrect spatial structure. These simulations will provide an indication of how important assumed population structure is for the reliable determination of stock status and catch advice. We consider case studies of Atlantic menhaden, sablefish, Atlantic herring, Pacific hake/whiting, and Gulf of Mexico red snapper, which cover common population structures for marine fish populations (e.g., patchily distributed unit populations, natal homing, ontogenetic movement, and metapopulations). Several of these stocks have tag-recapture data sets to inform movement patterns or larval individual-based models to identify larval connectivity, which can inform the operating models.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov

d) Shifts in stock productivity: on the use of dynamic management metrics

Investigators: A. Berger, I. Taylor, Z. A'mar and M.A. Haltuch

The concept of "Dynamic B_0" was developed 30 years ago by a team of scientist on the US west coast (MacCall *et al*., 1985), but since that time it has not been widely explored in this region. Dynamic B_0 involves projecting fish populations using a time series of recruitment deviations and other parameters estimated in a stock assessment, but with the impact of fishing removed. It can be used as an alternative to the static equilibrium unfished spawning biomass (B_0) as a basis for harvest control rules that takes into account changes in productivity attributed to external factors such as climate or shifting predator-prey interactions. We present dynamic B_0 time series relative to the fished population biomass time series for 18 recent west coast groundfish stock assessments and discuss differences in stock status as calculated from dynamic vs. static B_0. In general, many species do not show strong differences between the two measures. However, a few notable exceptions include Sablefish, Bocaccio, Pacific Hake, and Widow Rockfish which were all estimated to have experienced above average recruitments in the 1960s or 1970s resulting in a subsequent period of 30 years or longer where the dynamic B_0 was above the static B_0. These results are related to other stock assessment examples where dynamic B_0 trajectories warrant examination. We also highlight results from a management strategy evaluation that compares 40-

10 harvest control rules for sablefish using static B_0 and dynamic B_0 based reference points to show how control rule performance can differ depending on the history of population productivity. We conclude by describing some advantages and complexities of using dynamic B_0 time series at the assessment-management interface (e.g., assessment diagnostic, determining future reproductive potential of the stock, or as reference points for adaptive management).

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov

e) Evaluating geostatistical tools for assessment model using spatial environmental and habitat-related covariates

Investigators: A. Berger, J. Thorson and C. Whitmire

Geostatistical models for survey data have shown improvements in terms of estimand (e.g., population density) bias and precision over traditional stratified design-based approaches. These models use random fields to approximate a function-valued variable representing population density within a given area, and can also incorporate covariates representing environmental and biological factors across the landscape. We applied random fields within a delta generalized linear mixed modeling framework to model three density-related processes: the probability of encountering a species at any particular sampling site, the probability distribution of the size of catch (biomass) at the sampling site given an encounter, and the relationship among discrete sampling sites and spatially continuous environmental and habitat-related covariates. We applied this model to data from the U.S. west coast groundfish bottom trawl survey to estimate changes in population density spatially across the survey time series. Several alternative spatially-continuous environmental and habitat-related covariates were evaluated (i.e., temperature, salinity, and distance to rocky habitat) to help explain spatial variation in density for several groundfish species. Abundance indices from the geostatistical delta general linear mixed model were compared with and without auxiliary habitat information for each species. Incorporating spatially-continuous covariate information improved prediction of relative abundance by facilitating a relational approach for spatial imputation of density across unsampled areas.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov

f) A synoptic approach to reconstructing west coast groundfish historical removals

Investigator: J.M. Cope

Quantifying the removal time series of a stock is an essential input to a variety of stock assessment methods and catch-based management. But estimating removals is REALLY hard. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are just some of the complications that vary across time and space. Given that most groundfish stocks are distributed coastwide and a complete time series of removals is needed, this project aims to coordinate approaches across the states of Washington, Oregon and California to confront removal reconstruction challenges and establish common practices. Both California and Oregon have attempted historical removal reconstructions, while Washington is just beginning the process. We use the Washington effort to focus on six groundfish species that vary in the difficulty of estimating removal histories: black (*Sebastes melanops*), canary (*S. pinniger*) and rougheye (*S. aleutianus*) rockfishes, petrale sole (*Eopsetta jordani*), sablefish (*Anoplopoma fimbria*), and lingcod (*Ophiodon elongatus*). The Washington reconstruction is compared to the approaches taken for the same species in Oregon and California with the goal of matching reconstruction protocols across states to the extent possible. Lastly, uncertainty levels across periods, species and states are established. This is a new feature of all three removal reconstructions which will improve treatment of uncertainty in future stock assessments.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

g) Mixed-species management in the U.S. west coast groundfish fishery

Investigator: J.M. Cope

The US west coast groundfish fishery is comprised of 90+ fish stocks of varied life histories, most of which do not have formal stock assessments, but all of which require catch limits. Most major fisheries are mixed-stock, and management has often focused on the weak stock when implementing catch limits. While stocks with assessments have individual catch limits, the remaining species have been managed in stock complexes. This presentation offers an overview of those stock complexes and offers an analysis of how they could be restructured to better account for ecology, life history and technical interactions. The use of data-limited approaches to estimate catches for stock complexes are described, as well as the treatment of uncertainty and application of the precautionary principle when setting catch limits.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

h) Extending integrated stock assessments models to use non-depensatory three-parameter stock-recruitment relationships

Investigators: A.E. Punt and J.M. Cope

Stock assessments based on the integrated paradigm often include an underlying stock-recruitment relationship, which allows the biomass and fishing mortality associated with Maximum Sustainable Yield (BMSY and FMSY respectively) to be calculated. However, the estimates of these quantities may differ from the proxies used in the harvest control rules used to provide management advice. Moreover, the estimated values for BMSY and FMSY are related functionally in population dynamics models based on 2-parameter stock-recruitment relationships such as Beverton-Holt and Ricker. Use of 2-parameter stock-recruitments hence restricts the ability to fully quantify the uncertainty associated with estimating BMSY and FMSY because the use of 2-parameter SRRs restricts the potential range of values for BMSY/B0. In principle, BMSY and FMSY can be set independently if the stock-recruitment relationship is more general than the Beverton-Holt and Ricker relationships. This paper outlines eleven potential 3-parameter stock-recruitment relationships and evaluates them in terms of whether they are able to match a wide range of specifications for BMSY (expressed relative to unfished spawning stock biomass, B0) and FMSY (expressed relative to natural mortality, M). Of the eleven 3-parameter stock-recruitment relationships considered, the Ricker-Power stock-recruitment relationship is found to best satisfy the characteristics of (a) being able to mimic a wide range of BMSY/B0 and FMSY/M values, (b) not to lead to negative recruitment for biomasses between 0 and B0, and (c) not to lead to increasing recruitment in the limit of zero population size. Bayesian assessments of three example species off the US west coast groundfish (aurora rockfish, petrale sole, and cabezon) are conducted using Simple Stock Synthesis based on the Beverton-Holt and Ricker-Power stock-recruitment relationships to illustrate some of the impacts of moving to a 3-parameter stock-recruitment relationship.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

i) A review of stock assessment packages in the United States.

Investigators: C.M. Dichmont, R.A. Deng, A.E. Punt, J. Brodziak, Y. Chang, J.M. Cope, J.N. Ianelli, C.M. Legault, R.D. Methot Jr., C.E. Porch, M.H. Prager and K.W. Shertzer

Stock assessments provide scientific advice in support of fisheries decision making. Ideally, assessments involve fitting population dynamics models to fishery and monitoring data to provide estimates of time trajectories of biomass and fishing mortality in absolute terms and relative to biological reference points such as BMSY and FMSY, along with measures of uncertainty. Some stock assessments are conducted sing software developed for a specific stock or group of stocks. However, increasingly, stock assessments are being conducted using packages developed for application to several taxa and across multiple regions. We review the range of packages used to conduct assessments of fish and invertebrate stocks in the United States because these assessments tend to have common goals, and need to provide similar outputs for decision making. Sixteen packages are considered, five based on surplus production models, one based on a delay-difference model, and the remainder based on age-structured models. Most of the packages are freely available for use by analysts in the US and around the world, have been evaluated using simulations, and can form the basis for forecasts. The packages differ in their ease of use and the types of data inputs they can use. This paper highlights the benefits of stock assessment packages in terms of allowing analysts to explore many assessment configurations and facilitating the peer-review of assessments. It also highlights the disadvantages associated with the use of packages for conducting assessments. Packages with the most options and greatest flexibility are the most difficult to use, and see the greatest development of auxiliary tools to facilitate their use.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

j) Developing partnerships for enhanced data collections of West Coast Groundfish

Investigators: J. Field, S. Sogard, S. Beyer, S. Rienecke, M. Gleason and M.A. Haltuch

Accurate information on basic life history traits such as age at maturity, growth rates, and fecundity are vital to assessing population health and productivity. These traits are rarely static over space and time, and understanding the importance of geographic (as well as temporal) variability in life history traits is a frequent research priority in stock assessments. Moreover, in California waters, age data for most species are increasingly less available for assessment purposes. Similarly, collection of reproductive ecology data (maturity, fecundity, condition) and genetic data (fin clips) has traditionally not been a component of port samplers data collection, due to the reluctance of most processors to cut fish (a voluntary, not mandatory, requirement in California) and the time consuming nature of sampling reproductive tissues (particularly subsamples of eggs or larvae) for such studies. In this study, we propose to develop a pilot study with a key fisheries stakeholder, The Nature Conservancy (TNC), and the fishermen partners they work with as part of the California Groundfish Collective (CGC), that will enable a localized data collection effort to complement existing port sampling efforts run by the Pacific States Marine Fisheries Commission (PSMFC). Samples have been collected for Petrale Sole, Chilipepper rockfish and Bocaccio rockfish and analysis is ongoing.

For more information, please contact John Field at John.Field@noaa.gov

k) Identifying partial regulation in community dynamics using spatio-temporal models.

Investigators: J. Thorson, S. Munch, and D. Swain

Niche-based approaches to community analysis often involve estimating a matrix of pairwise interactions among species (the “community matrix”), but this task becomes infeasible using observational data as the number of modeled species increases. As an alternative, neutral theories achieve parsimony by assuming that species within a trophic level are exchangeable, but generally cannot incorporate stabilizing interactions even when they are evident in field data. Finally, both regulated (niche) and unregulated (neutral) approaches have rarely been fitted directly to survey data using spatio-temporal statistical methods. We therefore propose a spatio-temporal and model-based approach to estimate community dynamics that are partially regulated. Specifically, we start with a neutral spatio-temporal model where all species follow ecological drift, which precludes estimating pairwise interactions. We then add regulatory relations until model selection favors stopping, where the “rank” of the interaction matrix may range from zero to the number of species. A simulation experiment shows that model selection can accurately identify the rank of the interaction matrix, and that the identified spatio-temporal model can estimate the magnitude of species interactions. A forty-year case study for the Gulf of St. Lawrence marine community shows that recovering grey seals have an unregulated and negative relation with demersal fishes. We therefore conclude that partial regulation is a plausible approximation to community dynamics using field data, and hypothesize that estimating partial regulation will be expedient in future analyses of spatio-temporal community dynamics given limited field data. We conclude by recommending ongoing research to add explicit models for movement, so that meta-community theory can be confronted with data in a spatio-temporal statistical framework.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

l) Improving estimates of population status and trajectory with superensemble models.

Investigators: S. Anderson, A. Cooper, O. Jensen, C. Minto, J. Thorson, J. Walsh, J. Afflerbach, M. Dickey-Collas, K. Kleisner, C. Longo, G. Osio, D. Ovando, A. Rosenberg and E. Selig

Fishery managers must often reconcile conflicting estimates of population status and trend. Superensemble models, commonly used in climate and weather forecasting, may provide an effective solution. This approach uses predictions from multiple models as covariates in an additional "superensemble" model fitted to known data. We evaluated the potential for ensemble averages and superensemble models (ensemble methods) to improve estimates of population status and trend for fisheries. We fit four widely applicable data-limited models that estimate stock biomass relative to equilibrium biomass at maximum sustainable yield (B/BMSY). We combined these estimates of recent fishery status and trends in B/BMSY with four ensemble methods: an ensemble average and three superensembles (a linear model, a random forest and a boosted regression tree). We trained our superensembles on 5,760 simulated stocks and tested them with cross-validation and against a global database of 249 stock assessments. Ensemble methods substantially improved estimates of population status and trend. Random forest and boosted regression trees performed the best at estimating population status: inaccuracy (median absolute proportional error) decreased from 0.42 – 0.56 to 0.32 – 0.33, rank-order correlation between predicted and true status improved from 0.02 – 0.32 to 0.44 – 0.48 and bias (median proportional error) declined from −0.22 – 0.31 to −0.12 – 0.03. We found similar improvements when predicting trend and when applying the simulation-trained superensembles to catch data for global fish stocks. Superensembles can optimally leverage multiple model predictions; however, they must be tested, formed from a diverse set of accurate models and built on a data set representative of the populations to which they are applied.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

m) Comparing estimates of abundance trends and distribution shifts using single- and multispecies models of fishes and biogenic habitat.

Investigators: J. Thorson and L. Barnett, L.

Several approaches have been developed over the last decade to simultaneously estimate distribution or density for multiple species (e.g. "joint species distribution" or "multispecies occupancy" models). However, there has been little research comparing estimates of abundance trends or distribution shifts from these multispecies models with similar single-species estimates. We seek to determine whether a model including correlations among species (and particularly species that may affect habitat quality, termed "biogenic habitat") improves predictive performance or decreases standard errors for estimates of total biomass and distribution shift relative to similar single-species models. To accomplish this objective, we apply a vector-autoregressive spatio-temporal (VAST) model that simultaneously estimates spatio-temporal variation in density for multiple species, and present an application of this model using data for eight US Pacific Coast rockfishes (Sebastes spp.), thornyheads (Sebastolobus spp.), and structure-forming invertebrates (SFIs). We identified three fish groups having similar spatial distribution (northern Sebastes, coastwide Sebastes, and Sebastolobus species), and estimated differences among groups in their association with SFI. The multispecies model was more parsimonious and had better predictive performance than fitting a single-species model to each taxon individually, and estimated fine-scale variation in density even for species with relatively few encounters (which the single-species model was unable to do). However, the single-species models showed similar abundance trends and distribution shifts to those of the multispecies model, with slightly smaller standard errors. Therefore, we conclude that spatial variation in density (and annual variation in these patterns) is correlated among fishes and SFI, with congeneric fishes more correlated than species from different genera. However, explicitly modelling correlations among fishes and biogenic habitat does not seem to improve precision for estimates of abundance trends or distribution shifts for these fishes.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

n) Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo.

Investigators: C.C. Monnahan, J. Thorson and T.A. Branch

Bayesian inference is a powerful tool to better understand ecological processes across varied subfields in ecology, and is often implemented in generic and flexible software packages such as the widely used BUGS family (BUGS, WinBUGS, OpenBUGS and JAGS). However, some models have prohibitively long run times when implemented in BUGS. A relatively new software platform called Stan uses Hamiltonian Monte Carlo (HMC), a family of Markov chain Monte Carlo (MCMC) algorithms which promise improved efficiency and faster inference relative to those used by BUGS. Stan is gaining traction in many fields as an alternative to BUGS, but adoption has been slow in ecology, likely due in part to the complex nature of HMC.

Here, we provide an intuitive illustration of the principles of HMC on a set of simple models. We then compared the relative efficiency of BUGS and Stan using population ecology models that vary in size and complexity. For hierarchical models, we also investigated the effect of an alternative parameterization of random effects, known as non-centering.

For small, simple models there is little practical difference between the two platforms, but Stan outperforms BUGS as model size and complexity grows. Stan also performs well for hierarchical models, but is more sensitive to model parameterization than BUGS. Stan may also be more robust to biased inference caused by pathologies, because it produces diagnostic warnings where BUGS provides none. Disadvantages of Stan include an inability to use discrete parameters, more complex diagnostics and a greater requirement for hands-on tuning.

Given these results, Stan is a valuable tool for many ecologists utilizing Bayesian inference, particularly for problems where BUGS is prohibitively slow. As such, Stan can extend the boundaries of feasible models for applied problems, leading to better understanding of ecological processes. Fields that would likely benefit include estimation of individual and population growth rates, meta-analyses and cross-system comparisons and spatiotemporal models.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

o) Model-based estimates of effective sample size in Stock Synthesis using the Dirichlet-multinomial distribution.

Investigators: J. Thorson, K. Johnson, R. Methot and I. Taylor

Theoretical considerations and applied examples suggest that stock assessments are highly sensitive to the weighting of different data sources whenever data sources conflict regarding parameter estimates. Previous iterative reweighting approaches to weighting compositional data are generally ad hoc, do not propagate uncertainty about data-weighting when calculating uncertainty intervals, and often are not re-adjusted when conducting sensitivity or retrospective analyses. We therefore incorporate the Dirichlet-multinomial distribution into Stock Synthesis, and propose it as a model-based method for estimating effective sample size. This distribution incorporates one additional parameter per fleet (with the option of mirroring its value among fleets), and we show that this parameter governs the ratio of nominal ("input") and effective ("output") sample size. We demonstrate this approach using data for Pacific hake, where the Dirichlet-multinomial distribution and an iterative reweighting approach previously developed by McAllister and Ianelli (1997) give similar results. We also use simulation testing to explore the estimation properties of this new estimator, and show that it provides approximately unbiased estimates of variance inflation when compositional samples capture clusters of individuals with similar ages/lengths. We conclude by recommending further research to develop computationally efficient estimators of effective sample size that are based on alternative, a priori consideration of sampling theory and population biology.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

p) Accounting for spatiotemporal variation and fisher targeting when estimating abundance from multispecies fishery data.

Investigators: J. Thorson, R. Fonner, M. Haltuch, K. Ono and H. Winker

Estimating trends in abundance from fishery catch rates is one of the oldest endeavors in fisheries science. However, many jurisdictions do not analyze fishery catch rates due to concerns that these data confound changes in fishing behavior (adjustments in fishing location or gear operation) with trends in abundance. In response, we developed a spatial dynamic factor analysis (SDFA) model that decomposes covariation in multispecies catch rates into components representing spatial variation and fishing behavior. SDFA estimates spatiotemporal variation in fish density for multiple species and accounts for fisher behavior at large spatial scales (i.e., choice of fishing location) while controlling for fisher behavior at fine spatial scales (e.g., daily timing of fishing activity). We first use a multispecies simulation experiment to show that SDFA decreases bias in abundance indices relative to ignoring spatial adjustments and fishing tactics. We then present results for a case study involving petrale sole (Eopsetta jordani) in the California Current, for which SDFA estimates initially stable and then increasing abundance for the period 1986–2003, in accordance with fishery-independent survey and stock assessment estimates.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

q) Using spatio-temporal models of population growth and movement to monitor overlap between human impacts and fish populations.

Investigators: J. Thorson, J. Jannot and K. Somers

Protected and managed species, including harvested fishes, exhibit spatial and temporal variation in their distribution and productivity. Spatio-temporal variation can arise from differences in habitat quality, human impacts (including harvest), density-dependent changes in per capita productivity, as well as individual movement. Human impacts (e.g. direct harvest) also vary

spatially and over time, and monitoring the overlap between impacts and population distribution is necessary to ensure that human impacts are sustainable and to prioritize research and management for populations that are heavily impacted. However, estimating spatio-temporal variation in human impacts and population dynamics while accounting for individual movement has remained computationally challenging for decades.
We developed a spatial population growth (also known as ‘surplus production’) model that is inspired by finite element analysis, which estimates spatio-temporal population dynamics given density-dependent population regulation, individual movement and spatially explicit harvest. We demonstrate the method using data for big skate Raja binoculata in the California Current from 2003 to 2013 and demonstrate that results can be processed to estimate an upper limit on sustainable harvest (an ‘overfishing limit’). We also conduct a simulation experiment to explore the small-sample properties of parameter estimates.
A simulation experiment confirms that real-world sample sizes are sufficient to estimate the sustainable harvest level within 20% of its actual value. However, sample sizes are likely insufficient to reliably estimate movement rates.
The spatial population growth model estimates an overfishing limit of 740–890 metric tonnes for big skate from 2010 to 2013, compared with annual harvest <100 tonnes. This suggests that recent harvest of big skate is likely sustainable, and sensitivity analysis confirms that this conclusion is robust to different potential rates for individual movement.
Synthesis and applications. We recommend that spatio-temporal population models be used across systems and taxa to monitor the spatial overlap between species distribution and human impacts. For big skate, we recommend management rules triggering additional data collection and assessment effort if harvest rates substantially increase. We also recommend future research regarding spatial management regulations for emerging fisheries.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

r) Density-dependent changes in effective area occupied for sea-bottom associated marine fishes.

Investigators: J. Thorson, A. Rindorf, J. Gao, D. Hanselman and H. Winker

The spatial distribution of marine fishes can change for many reasons, including density-dependent distributional shifts. Previous studies show mixed support for either the proportional-density model (PDM; no relationship between abundance and area occupied, supported by ideal-free distribution theory) or the basin model (BM; positive abundance–area relationship, supported by density-dependent habitat selection theory). The BM implies that fishes move towards preferred habitat as the population declines. We estimate the average relationship using bottom trawl data for 92 fish species from six marine regions, to determine whether the BM or PDM provides a better description for sea-bottom-associated fishes. We fit a spatio-temporal model and estimate changes in effective area occupied and abundance, and combine results to estimate the average abundance–area relationship as well as variability among taxa and regions. The average relationship is weak but significant (0.6% increase in area for a 10% increase in abundance), whereas only a small proportion of species–region combinations show a negative relationship (i.e. shrinking area when abundance increases). Approximately one-third of combinations (34.6%) are predicted to increase in area more than 1% for every 10% increase in abundance. We therefore infer that population density generally changes faster than effective area occupied during abundance changes. Gadiformes have the strongest estimated relationship (average 1.0% area increase for every 10% abundance increase) followed by Pleuronectiformes and Scorpaeniformes, and the Eastern Bering Sea shows a strong relationship between abundance and area occupied relative to other regions. We conclude that the BM explains a small but important portion of spatial dynamics for sea-bottom-associated fishes, and that many individual populations merit cautious management during population declines, because a compressed range may increase the efficiency of harvest.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

s) Joint dynamic species distribution models: a tool for community ordination and spatiotemporal monitoring.

Investigators: J. Thorson, M. Scheuerell, C. Szuwalski, E. Zipkin, L. Ries and J. Ianelli

Spatial analysis of the distribution and density of species is of continuing interest within theoretical and applied ecology. Species distribution models (SDMs) are being increasingly used to analyse count, presence–absence and presence-only data sets. There is a growing literature on dynamic SDMs (which incorporate temporal variation in species distribution), joint SDMs (which simultaneously analyse the correlated distribution of multiple species) and geostatistical models (which account for similarity between nearby sites caused by unobserved covariates). However, no previous study has combined all three attributes within a single framework.

We develop spatial dynamic factor analysis for use as a 'joint, dynamic SDM' (JDSDM), which uses geostatistical methods to account for spatial similarity when estimating one or more 'factors'. Each factor evolves over time following a density-dependent (Gompertz) process, and the log-density of each species is approximated as a linear combination of different factors. We demonstrate a JDSDM using two multispecies case studies (an annual survey of bottom-associated species in the Bering Sea and a seasonal survey of butterfly density in the continental USA), and also provide our code publicly as an R package.

Case study applications show that that JDSDMs can be used for species ordination, i.e. showing that dynamics for butterfly species within the same genus are significantly more correlated than for species from different genera. We also demonstrate how JDSDMs can rapidly identify dominant patterns in community dynamics, including the decline and recovery of several Bering Sea fishes since 2008, and the 'flight curves' typical of early or late-emerging butterflies. We conclude by suggesting future research that could incorporate phylogenetic relatedness or functional similarity, and propose that our approach could be used to monitor community dynamics at large spatial and temporal scales.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

t) Hierarchical analysis of phylogenetic variation in intraspecific competition across fish species.

Investigators: A. Foss-Grant, E. Zipkin, J. Thorson, O. Jensen and W. Fagan

The nature and intensity of intraspecific competition can vary greatly among taxa, yet similarities in these interactions can lead to similar population dynamics among related organisms. Variation along the spectrum of intraspecific competition, with contest and scramble competition as endpoints, leads to vastly different responses to population density. Here we investigated the diversity of intraspecific competition among fish species, predicting that functional forms of density-dependent reproduction would be conserved in related taxa. Using a hierarchical model that links stock–recruitment parameters among populations, species, and orders, we found that the strength of overcompensation, and therefore the type of intraspecific competition, is tightly clustered within taxonomic groupings, as species within an order share similar degrees of compensation. Specifically, species within the orders Salmoniformes and Pleuronectiformes exhibited density dependence indicative of scramble competition (overcompensation) while the orders Clupeiformes, Gadiformes, Perciformes, and Scorpaeniformes exhibited dynamics consistent with contest competition (compensation). Maximum potential recruitment also varied among orders, but with less clustering across species. We also tested whether stock–recruitment parameters correlated with maximum body length among species, but found no strong relationship. Our results suggest that much of the variation in the form of density-dependent reproduction among fish species may be predicted taxonomically due to evolved life history traits and reproductive behaviors.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

u) Model-based inference for estimating shifts in species distribution, area occupied, and center of gravity.

Investigators: J. Thorson, M. Pinsky and E. Ward

Changing climate is already impacting the spatial distribution of many taxa, including bees, plants, birds, butterflies and fishes. A common goal is to detect range shifts in response to climate change, including changes in the centre of the population's distribution (the centre of gravity, COG), population boundaries and area occupied. Conventional estimators, such as the abundance-weighted average (AWA) estimator for COG, confound range shifts with changes in the spatial distribution of available survey data and may be biased when the distribution of survey data shifts over time. AWA also does not estimate the standard error of COG in individual years and cannot incorporate data from multiple survey designs.

To explicitly account for changes in the spatial distribution of survey effort, we propose an alternative species distribution function (SDF) estimator. The SDF approach involves calculating distribution metrics, including COG, population boundary and area occupied, directly from the predicted species distribution or density function. We illustrate the SDF approach using a spatiotemporal model that is available as an r package. Using simulated data, we confirm that the SDF substantially decreases bias in COG estimates relative to the AWA estimator. We then illustrate the method by analysing data from two data sets spanning 1977–2013 for 18 marine fishes along the U.S. West Coast.

In our case study, the SDF estimator shows significant northward shifts for six of 18 species (with southward shifts for only 2), where two species (darkblotched and greenstriped rockfishes) have

both a northward shift and a decreased area occupied. Pelagic species (e.g. Pacific hake and spiny dogfish) have more variable distribution than bottom-associated species. We also find substantial differences between AWA and SDF estimates of COG that are likely caused by shifts in sampling distribution (which affect the AWA but not the SDF estimator).
We caution that common estimators for range shift can yield inappropriate inference whenever sampling designs have shifted over time. We conclude by suggesting further improvements in model-based approaches to analysing climate impacts, including methods addressing the impact of local and regional temperature changes on species distribution.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

v) Can autocorrelated recruitment be estimated using integrated assessment models and how does it affect population forecasts?

Investigators: K. Johnson, E. Councill, J. Thorson, L. Brooks, R. Methot and A. Punt

The addition of juveniles to marine populations (termed "recruitment") is highly variable due to variability in the survival of fish through larval and juvenile stages. Recruitment estimates are often large or small for several years in a row (termed "autocorrelated" recruitment). Autocorrelated recruitment can be due to numerous factors, but typically is attributed to multi-year environmental drivers affecting early life survival rates. Estimating the magnitude of recruitment autocorrelation within a stock assessment model and examinations on its effect on the quality of forecasts of spawning biomass within stock assessments is uncommon. We used a simulation experiment to evaluate the estimability of autocorrelation within a stock assessment model over a range of levels of autocorrelation in recruitment deviations. The precision and accuracy of estimated autocorrelation, and the ability of an integrated age-structured stock assessment framework to forecast the dynamics of the system, were compared for scenarios where the autocorrelation parameter within the assessment was fixed at zero, fixed at its true value, internally estimated within the integrated model, or input as a fixed value determined using an external estimation procedure that computed the sample autocorrelation of estimated recruitment deviations. Internal estimates of autocorrelation were biased toward extreme values (i.e., towards 1.0 when true autocorrelation was positive and −1.0 when true autocorrelation was negative). Estimates of autocorrelation obtained from the external estimation procedure were nearly unbiased. Forecast performance was poor (i.e., true biomass outside the predictive interval for the forecasted biomass) when autocorrelation was ignored, but was non-zero in the simulation. Applying the external estimation procedure generally improved forecast performance by decreasing forecast error and improving forecast interval coverage. However, estimates of autocorrelation were shown to degrade when fewer than 40 years of recruitment estimates were available.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

w) Relative magnitude of cohort, age, and year-effects on growth of marine fishes.

Investigators: J. Thorson and C. Minte-Vera

Variation in individual growth rates contributes to changes over time in compensatory population growth and surplus production for marine fishes. However, there is little evidence regarding the prevalence and magnitude of time-varying growth for exploited marine fishes in general, whether it is best approximated using changes in length-at-age or weight-at-length parameters, or how it can be represented parsimoniously. We therefore use a database of average weight in each year and age for 91 marine fish stocks from 25 species, and fit models with random variation in length and weight parameters by year, age, or cohort (birth-year). Results show that year effects are more parsimonious than age or cohort effects and that variation in length and weight parameters provide roughly similar fit to average weight-at-age data, although length parameters show a greater magnitude of variability than weight parameters. Finally, the saturated model can explain nearly 2/3 of total variability, while a single time-varying factor can explain nearly 1/2 of variability in weight-at-age data. We conclude that time-varying growth can often be estimated parsimoniously using a single time-varying factor, either internally or prior to including 'empirical' weight at age in population dynamics models.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

x) Space-time investigation of the effects of fishing on fish populations.

Investigators: K. Ono, A.O. Shelton, E.J. Ward, J. Thorson, B.E. Feist and R. Hilborn

Species distribution models (SDMs) are important statistical tools for obtaining ecological insight into species-habitat relationships and providing advice for natural resource management. Many SDMs have been developed over the past decades, with a focus on space- and more recently, time-dependence. However, most of these studies have been on terrestrial species and applications to marine species have been limited. In this study, we used three large spatio-temporal data sources (habitat maps, survey-based fish density estimates, and fishery catch data) and a novel space-time model to study how the distribution of fishing may affect the seasonal dynamics of a commercially important fish species (Pacific Dover sole, Microstomus pacificus) off the west coast of the USA. Dover sole showed a large scale change in seasonal and annual distribution of biomass, and its distribution shifted from mid-depth zones to inshore or deeper waters during late summer/early fall. In many cases, the scale of fishery removal was small compared to these broader changes in biomass, suggesting that seasonal dynamics were primarily driven by movement and not by fishing. The increasing availability of appropriate data and space-time modeling software should facilitate extending this work to many other species, particularly those in marine ecosystems, and help tease apart the role of growth, natural mortality, recruitment, movement, and fishing on spatial patterns of species distribution in marine systems.

For more information, please contact Dr. Kot Ono at kotarono@uw.edu

y) A generic approach to bias correction in population models using random effects, with spatial and age-structured examples.

Investigators: J. Thorson and K. Kristensen

Statistical models play an important role in fisheries science when reconciling ecological theory with available data for wild populations or experimental studies. Ecological models increasingly include both fixed and random effects, and are often estimated using maximum likelihood techniques. Quantities of biological or management interest ("derived quantities") are then often calculated as nonlinear functions of fixed and random effect estimates. However, the conventional "plug-in" estimator for a derived quantity in a maximum likelihood mixed-effects model will be biased whenever the estimator is calculated as a nonlinear function of random effects. We therefore describe and evaluate a new "epsilon" estimator as a generic bias-correction estimator for derived quantities. We use simulated data to compare the epsilon-method with an existing bias-correction algorithm for estimating recruitment in four configurations of an age-structured population dynamics model. This simulation experiment shows that the epsilon-method and the existing bias-correction method perform equally well in data-rich contexts, but the epsilon-method is slightly less biased in data-poor contexts. We then apply the epsilon-method to a spatial regression model when estimating an index of population abundance, and compare results with an alternative bias-correction algorithm that involves Markov-chain Monte Carlo sampling. This example shows that the epsilon-method leads to a biologically significant difference in estimates of average abundance relative to the conventional plug-in estimator, and also gives essentially identical estimates to a sample-based bias-correction estimator. The epsilon-method has been implemented by us as a generic option in the open-source Template Model Builder software, and could be adapted within other mixed-effects modeling tools such as Automatic Differentiation Model Builder for random effects. It therefore has potential to improve estimation performance for mixed-effects models throughout fisheries science.

For more information, please contact Jim Thorson at james.thorson@noaa.gov

z) Software: Shiny DLMtool. Shiny application of the DLMtool.
https://shcaba.shinyapps.io/Shiny_DLMtool/

Application developed to improve utility of the DLMtool for data-limited method application and management strategy.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

aa) Software: Natural Mortality Tool
https://github.com/shcaba/Natural-Mortality-Tool ; http://barefootecologist.com.au/shiny_m

Application developed to allow multiple calculation of natural mortality.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

2. Survey and Observer Science

a) Resolving the issues of hook saturation, hook competition, and fixed-site design in the Southern California hook-and-line survey

Investigators: P. Kuriyama, A.C. Hicks, J.H. Harms and T.A. Branch

The Southern California hook-and-line survey has been conducted by the Northwest Fisheries Science Center since 2004 to monitor the untrawlable habitat of the Southern California Bight. Data from the survey have been used in stock assessments and supporting research for a number of shelf rockfish species, such as bocaccio (*Sebastes paucispinis*) and vermilion rockfish (*S. miniatus*). However, an index of abundance estimated from hook-and-line data may be biased due to the fixed-site design of the survey, hook saturation, and hook competition. We are using empirical results from the hook-and-line data and to inform a simulation study exploring the biases associated with aspects of the survey. Bocaccio are the most sampled species in the survey, and sites with low catch rates of bocaccio may also have high catch rates of vermilion rockfish suggesting possible bias associated with interspecific competition for hooks. Preliminary results from the simulations indicate that hook saturation causes estimates of abundance to be negatively biased at large population sizes, hook competition leads to positively biased indices of abundance, and weighting catch rates by site leads to the least biased index of abundance. Results are aimed at identifying methods of incorporating hook-and-line data from untrawlable habitat into stock assessments and identify ways of correcting biases common to all hook-and-line surveys.

For more information, please contact John Harms at John.Harms@noaa.gov

b) The Northwest Fisheries Science Center's (NWFSC) wireless back deck and data logging system

Investigators: V. Simon, T. Hay and A.A. Keller

The NWFSC's West Coast Groundfish Bottom Trawl Survey (WCGBTS) annually samples approximately 750 stations at depths from 55 to 1280 meters off the continental United States using four chartered commercial fishing vessels. To improve data capture efficiency, the FRAM division uses a sophisticated wireless network (802.11 protocols) to input data into several in-house applications. We demonstrated the use of all WCGBTS wireless back-deck data gathering instruments in concert with our new back deck data logging software at the 2016 TSC electronic data capture methods workshop held in Newport OR as part of the 2016 Western Groundfish Conference. We demonstrated the incorporation of the NWFSC's communication box that provides power, networking, and printing resources in the extremely harsh conditions of an open and small backdeck work environment. Electronic sampling components include scales, fish measuring boards, barcode wand, barcode gun, calipers, and label printers. We demonstrated a new Python language data-based logging program including refined and practical real-time validations which limit data input errors, expedite resolution of data errors and facilitate data dissemination.

For more information, please contact Victor Simon at Victor.Simon@noaa.gov

c) The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey: Survey History, Design, and Description

Investigators: A. Keller, J. Wallace and R. Methot

Scientists from the Northwest Fisheries Science Center (NWFSC) Fisheries Resources Analysis and Monitoring (FRAM) division annually conduct a bottom trawl survey of groundfish resources. The purpose of the West Coast Groundfish Bottom Trawl Survey (WCGBTS) is to provide fisheries-independent indices of stock abundance to support stock assessment models for commercially and recreationally harvested groundfish species. The survey produces annual biomass estimates that are calculated using the area swept by the trawl to estimate fish density. These estimates are expanded to the full survey area to produce species-specific biomass indices. The WCGBTS collects data on 90+ species contained in the Fisheries Management Plan (FMP) to fulfill the mandates of the Magnuson-Stevens Sustainable Fisheries Act. Fishery managers on the West Coast of the United States rely on fishery stock assessments to provide information on the status of groundfish stocks. Stock status determinations directly influence decisions regarding harvest levels. Here we provided a detailed description of the groundfish survey's history, design and current description.

Prior to 1998, surveys conducted by the Alaska Fisheries Science Center (AFSC) were the principal source for fishery-independent data about groundfish resources along the upper continental slope and shelf of the U.S. west coast. The AFSC triennial shelf surveys used chartered Alaska fishing vessels (19.8–52.1 m) while slope surveys were conducted with the NOAA R/V Miller Freeman during most years (1988 and 1990–2001). A review of the earlier surveys reveals that both the AFSC's west coast shelf and slope surveys varied considerably among years both in the timing of the surveys and the geographical extent (longitudinally and by depth). Survey timing varied between years as the focus of the surveys shifted among different groundfish species. Spatial coverage varied between years due to constraints imposed by annual budget levels and/or availability of NOAA ship time. The various configurations of these surveys are described since they provide insights into the design of the current NWFSC's annual groundfish survey. The NWFSC survey has utilized a consistent survey extent and design since 2003 except for the changes to geographic strata and station allocations in 2004.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

d) National Marine Fisheries Service, Untrawlable Habitat Strategic Initiative (UHSI)

The NMFS Untrawlable Habitat Strategic Initiative (UHSI) was started in 2013 to identify and quantify biases associated with mobile survey vehicles (i.e., remotely operated vehicle (ROV), autonomous underwater vehicle (AUV), human-occupied submersible (HOV), and towed camera) used to count fishes in complex habitats that preclude the use of bottom trawls. Following on a two-year Gulf of Mexico study focused on a snapper / grouper complex, the UHSI moved to the West Coast to address a critical need to quantify the response of West Coast rockfishes (genus Sebastes) to mobile survey vehicles. In 2016, a pilot testbed experiment was initiated on a deep-water rocky bank (100-150m) in the Southern California Bight – a site characterized by diverse and abundant assemblages of rockfishes and a long history of HOV, AUV, and ROV surveys. MOUSS stereo cameras and orthogonal DIDSON imaging sonars were integrated into two instrumented and novel autonomous fixed platforms, which were deployed and positioned daily by an HOV along a high-relief rocky section of the bank. These optical and acoustical imaging surveillance systems were used to quantify changes in fish density and behavior in response to two representative survey vehicles, a Seabed AUV and the DeepWorker HOV.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

e) West Coast Observer Program

The FRAM West Coast Groundfish Observer Program (WCGOP) continued collecting fishery-dependent data during 2016 on groundfish fleets along the entire U.S. west coast. The groundfish fishery is broken down into two main categories the catch share fisheries and the non-catch share fisheries. The catch share fishery can be further broken down into the shorebased fleet and the at sea fleet. The at sea fleet includes catcher-processors (CPs) and motherships. The catch share fisheries require 100% observer and shore side monitoring. The non-catch share fisheries require observer coverage upon request and coverage is randomly assigned by fishery and port group.

Table 1. Number of observers deployed by the WCGOP in 2016

2016	
Number of catch share observers	**49**
Number of non-catch share observers	**44**
Number of A-SHOP Observers	**44**

Catch Shares

There are three sectors in the catch share program: shorebased, motherships (includes motherships and mother ship catcher-vessels), and catcher-processors. All vessels participating in the shorebased sector or acting as mother ship catcher-vessels (MSCV's) must carry one observer on all trips. Motherships and catcher-processors carry two observers each trip. The shorebased sector is managed through Individual Fishing Quotas (IFQ's) and includes all vessels that land catch at shore side processors. Catch shares regulations allow the shorebased sector to use trawl, longline, or pots to harvest IFQ species. The mother ship and catcher-processor sectors target Pacific hake using trawl gear and process it entirely at-sea. Motherships and catcher-processors have formed cooperatives to ensure sectors can attain Pacific hake quota without exceeding bycatch caps for overfished species or salmon. Table 3 below provides information on observer activities in the catch share fishery.

Catch Share observers are deployed in the following catch share fisheries:

- All vessels participating in the Shore-based Individual Fishing Quota (IFQ) program including hake and non-hake groundfish trawl and fixed gear vessels
- All motherships participating in the at-sea hake fishery
- All mother ship catcher-vessels participating in the at-sea hake fishery
- All catcher-processors participating in the at-sea hake fishery

Table 2. Summary of observer coverage and sea days in the catch share fisheries

DESCRIPTION	SS IFQ Trawl	SS IFQ Fixed Gear	SS Hake	MSCV	A-SHOP
Number of vessels	58	13	3	2	15
Number of trips*	806	91	99	6	82
Number of Sea days*	3,019		245	91	2180
Number of Observers	49				44

*Includes trips and/or sea days where no fishing activity occurred.

SS IFQ trawl: vessels targeting non-hake groundfish with trawl gear and landing at shore based processors.
SS IFQ Fixed Gear: vessels targeting non-hake groundfish using longlines or pots and landing at shore based processors.
SS Hake: vessels targeting hake using trawl gear and landing at shore based processors.
MSCV: mother ship catcher-vessel targeting hake with trawl gear
CPs and Motherships: mother ships and catcher-processors targeting hake using trawl gear

Non-catch shares

The observer program collects data in other west coast fisheries that are not part of the catch share program. The program had 2,606 sea days in the non-catch share fisheries in 2016 aboard vessels ranging in size from skiffs to larger fixed gear vessels and depths ranging from less than 20 ft. to more than 300 ft.

Table 3. Non-Catch Share sea day summary by fisheries/sectors:

NCS Sea Days	
FISHERY DESCRIPTION	SEA DAYS*
CA Emley-Platt EFP	3
CA Halibut	150
CA Nearshore	144
CA Pink Shrimp	104
Electronic Monitoring EFP	185
Limited Entry Sablefish	528
Limited Entry Trawl	2
Limited Entry Zero Tier	68
OR Blue/Black Rockfish	95
OR Blue/Black Rockfish Nearshore	132
OR Pink Shrimp	732
PSMFC Discard Handling Research	33

WA Pink Shrimp	301
WC Open Access Fixed Gear	129

*Includes sea days where no fishing activity occurred.

Due to its unique data collection circumstances in both the catch shares and non-catch shares fisheries, the program continues to stress safety and data quality.

Data and analytical reports

The data collected by observers is used to improve total catch estimates, primarily for fish discarded at-sea. The data are used in assessing a variety of groundfish species, by fisheries managers, and by other fishery, protected resource, and other scientists.

Summaries of data collected on observed trips are routinely published on the NWFSC web site.

All WCGOP reports can be obtained at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm.

For more information, please contact Jon McVeigh at Jon.McVeigh@noaa.gov

f) Community Participation in U.S. Catch Share Programs

Investigators: K. Norman, L.L. Colburn, M. Jepson, A. Himes-Cornell, S. Kasperski, C. Weng and P.M. Clay

A guiding principle of the NOAA Catch Share Policy is to track the performance of programs to monitor whether they are achieving their goals and objectives. This report focuses on assessing changes in fisheries participation for communities involved in each of the U.S. catch share programs, including the shore-based trawl-caught groundfish fishery on the U.S. West Coast. The indicators included in this communities research effort were chosen to better elucidate catch share performance by providing a comparison between pre and post implementation community participation in a particular catch share program. Trends in community participation in 13 of the 16 federally managed catch share programs in the U.S. were measured using a standard set of indicators. These indicators were calculated for each catch share program and reported by region. A community level pre-implementation Baseline was established and compared to each year post-implementation through 2013 for each indicator. Indicators of community-level social well-being are included to provide a context for understanding community involvement in catch share programs.

For more information, please contact Dr. Karma Norman at karma.norman@noaa.gov.

g) Development of the Pacific Groundfish Trawl IFQ Market

Investigators: D. Holland

In-season transferability of quota plays an important role in multispecies individual fishing quota (IFQ) systems since fishermen often need to acquire quota to balance incidental catch. The optimal utilization of quotas is thus dependent on development of an efficient quota market, but markets in multispecies IFQ fisheries develop slowly and may fail to perform efficiently even after several years. In 2011 an IFQ system was implemented for the Pacific groundfish trawl fishery in the US. After four years, the quota market does not appear to be yielding efficient prices for many species or distributing quota efficiently. I explore the structure and performance of the QP market and discuss the impediments to market efficiency. Drawing from theory and experience in other multispecies IFQ systems, I discuss other quota distribution and catch-balancing mechanisms that can supplement and perhaps improve inefficient markets and enable higher quota utilization rates

For more information, please contact Dr. Dan Holland at dan.holland@noaa.gov.

h) The Impact of Access Restrictions on Fishery Income Diversification of US West Coast Fishermen

Investigators: D. Holland and S. Kasperski

Access to most fisheries on the US West Coast was essentially open prior to the mid-1970s when state licenses were first limited for salmon fisheries. Subsequently, licenses to most fisheries on the West Coast have been limited, and the numbers of licenses in many fisheries have been reduced with buyback programs. More recently, catch share programs, which dedicate exclusive shares of catch to individuals or cooperatives, have been introduced in several sectors of the federally managed Pacific groundfish fishery. As access to fisheries has become more restricted, revenue diversification of West Coast fishing vessels has generally declined. This is a source of concern, since diversification has been shown to reduce year-to-year variation in revenue and thus financial risk. However, catch share programs may create more security and stability in vessels' landings which may offset effects of less diversification. Nevertheless, there may be a tradeoff between the efficiency gains enabled by restricting access and risk reduction benefits associated with greater diversification.

For more information please contact Dr. Dan Holland at dan.holland@noaa.gov.

i) The Pacific Coast Groundfish Fishery Social Study

Investigators: S. Russell, M.V. Oostenburg, A. Vizek and B. Carter

The Pacific Coast Groundfish Fishery Social Study is a multi-year study designed to measure social changes in affected fishing communities resulting from the implementation of a catch shares program in January 2011. Extensive data collection include efforts in 2010, 2012, and 2015/2016. Data was collected using a survey tool and semi-structured interviews, primarily in person. Additional data collection will be pursued on a 5-year cycle. Study participants include anyone with a connection to the trawl fishery. Additional participation by others outside the trawl fishery were welcomed. Data is analyzed and compared across all study years. Common themes in the data include Graying of the Fleet, Changing Women's Roles, Impacts on Small Vessels, Changing Fishery Participation, New Entry, and other emerging themes. Data is provided to management entities to inform the 5-year review of the catch shares program, as well as other management needs. Results will be distributed through agency reports and other publications.

For more information, please contact Suzanne Russell at suzanne.russell@noaa.gov.

j) West Coast Communities and Catch Shares: The Early Years of Social Change

Investigators: S. Russell, A. Arias-Arthur, K. Sparks and A. Varney

The Pacific Coast Groundfish Trawl Fishery transitioned to a catch shares program in January 2011. The Pacific Coast Groundfish Fishery Social Study was designed to measure associated social changes and impacts to individuals and communities. Selected survey and interview data from the baseline data collection in 2010 and the first supplemental data collection effort in 2012 are aggregated at the community level and analyzed for initial signs of social change. Communities are sorted into top, mid, and low tier communities based on the percentage of quota share (QS) permit owners that live in each community. A higher number of QS permit owners in a place is expected to result in relatively greater benefits to those communities. Questions analyzed include percent of income from fishing, multiple jobs worked, job stability, job satisfaction, standard of living, and how individuals were personally affected. Significant results include improvements in job satisfaction and increases in multiple jobs worked for TOP tier communities, and improved standard of living in LOW tier communities. MID tier communities appear to be in the middle, with no significant changes. Interview data indicate variation between owners, where some can fish their allocations and others need to lease more to fish.

For more information, please contact Suzanne Russell at suzanne.russell@noaa.gov.

3. Age and Life History

a) Cooperative Ageing Unit

The Cooperative Ageing Project (CAP) operates under a grant from the Northwest Fisheries Science Center to Pacific States Marine Fisheries Commission, and provides direct support for U.S. West Coast groundfish stock assessments by providing fish ages derived primarily from otoliths. In 2016, CAP production aged 26,975 otoliths and completed over 970 training reads. Production ages will support the upcoming 2017 assessments on arrowtooth flounder, California scorpionfish, darkblotched rockfish, lingcod, Pacific hake, Pacific Ocean perch and yellowtail rockfish. California scorpionfish, lingcod and yellowtail rockfish are species that had previously never been aged by the lab before. The lab cored 31 black rockfish otoliths for C14 analysis at NOSAMS. Over 295 black rockfish otoliths were double read in order to make the coring selection.

CAP continued the practice of recording otolith weights prior to breaking and burning, in support of research into alternative methods of age determination. Two age readers travelled to Olympia, WA to learn how to age lingcod from WDFW personnel.

For more information, please contact Jim Hastie at Jim.Hastie@noaa.gov

b) Bomb radiocarbon age validation for California Current (CC) rockfish

Investigators: M.A. Haltuch, O. Hamel, P. McDonald, J. Field and C. Kastelle

Otolith-derived ages provide an informative piece of data in fisheries stock assessment in regard to estimating recruitments, growth, and exploitation rates (e.g. Haltuch, Ono, Valero 2013). The research and data needs sections of NWFSC stock assessments routinely identify the need for age-determination and age-validation studies (e.g. Gertseva et al. 2011). Historical otolith collections that include fish caught by commercial vessels fishing out of northern California ports during the 1960's until present are available at the SWFSC. These historical samples are ideal for the application of bomb radiocarbon age validation methods that require fish with birth years during the late 1950s through the 1970s (e.g. Haltuch et al. 2013).

Rockfish are the focus of the proposed bomb radiocarbon analyses due to longevity, and thus the likelihood of large ageing bias and variability at older ages. Archived samples are available for splitnose, canary, black, copper, and brown rockfish. Ongoing radiocarbon age validation work is focusing on black and canary rockfish with the aim of producing more reliable ageing error matrices that will improve stock assessment's ability to model age imprecision and bias, reducing assessment uncertainty. Canary rockfish have a complimentary bomb radiocarbon age validation study in the north (Piner at al. 2005) but this age validation used the northeast Pacific halibut reference chronology, which came from a much different environment than the reference chronology developed for the west coast of the US (Haltuch et al, 2013). CC petrale sole radiocarbon data suggests that it may be necessary to revisit the canary rockfish age validation using a species specific CC reference chronology (Haltuch et al. 2013). If species specific reference chronologies are not able to be developed for the above rockfish species, the petrale sole reference chronology, which is more environmentally representative of the canary rockfish distribution, will be used for age validation. The first batch of radiocarbon ages have been processed for canary and black rockfish, focusing on producing both test and reference curves. Aging of a second set of samples for both species is underway in an effort to fill in gaps in both reference and test curves. The second set of bomb radiocarbon analyses are expected to be run during 2017.

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

c) FRAM's reproductive maturity program and its application for fisheries management

Investigator: Melissa A. Head

Since the initiation of the NWFSC's reproductive maturity program (FRAM Division) in 2009, we collected over 10,000 ovaries from 32 groundfish species. We identified several key factors essential for understanding reproductive biology of west coast groundfishes: (1) spatial and temporal patterns, (2) oceanographic conditions related to skip spawning and abortive maturation, and (3) estimating biological (sexual) versus functional (potential spawner) maturity. FRAM is currently obtaining reproductive samples for multiple groundfish species via multiple sampling platforms, (west coast groundfish trawl survey, Southern California hook and line survey, hake acoustics survey), observers (at sea hake observers), and collaboration with Washington and Oregon state departments (WDFW and ODFW). Samples are histologically assessed for maturity using a binocular microscope and imaging software. In the past, many stock assessments relied on outdated or incomplete life-history information from opportunistic or geographically/temporally limited data sources. Our goal is to provide updated, coast wide maturity information on an annual basis to reduce uncertainty in parameters used to estimate spawning biomass and recruitment. Ecosystem variables, such as habitat, predator-prey interactions, food availability, upwelling, and oceanographic patterns may also have an outsized influence on the reproductive behavior of groundfish stocks in a given year. We are investigating how these variables affect skip-spawning and abortive maturation patterns and how spatial/temporal relationships are associated with maturity schedules.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

d) Techniques for improving estimates of maturity ogives in groundfish using double-reads and measurement error models

Investigators: M.A. Head, G.L. Stokes, J.T. Thorson and A.A. Keller

The reproductive output of a population depends upon physiological factors, including maturation rates and fecundity at size and age, as well as the rate at which post-maturation females fail to spawn (i.e. skipped spawning). These rates are increasingly included in stock assessment models, and are thought to change over time due to harvest and environmental factors. Thus, it is important to accurately estimate maturation and skipped spawning rates while including information on imprecision. For this task, we developed a new double-read and measurement-error modeling protocol for estimating maturity that is based on the use of multiple histological reads of ovaries to account for reader error caused by poorly prepared slides, nuclear smear, and early yolk development. Application to three U.S. West Coast groundfishes (Pacific hake *Merluccius productus*, darkblotched rockfish *Sebastes crameri*, and canary rockfish *Sebastes pinniger*) indicates that reader uncertainty is strongly predictive of reader error rates. Results also show differences in rates of skipped spawning among species, and should be further investigated. We recommend that future maturity studies record reader certainty, use models that incorporate covariates into the analysis, and conduct an initial double reader analysis. If readers exhibit little variation, then double reads may not be necessary. In addition, slide quality should also be recorded, so that future studies do not confuse this with reader imprecision. This improved protocol will assist in estimating life history, as well as environmental, and anthropogenic effects on maturity.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

e) Challenges associated with assessing maturity, skipped spawning, and abortive maturation rates for fisheries managers: a case study of *Sebastes pinniger*

Investigator: M.A. Head, P.H. Frey, J.M. Cope and A.A. Keller

Incorporating accurate estimates of life history parameters into population models can increase the reliability of biomass estimates used to manage fish stocks. In addition, understanding the reproductive biology and life history strategies of these fish provides support for sustainable management. However, seasonal data collections create challenges for gaining a full understanding of their reproductive biology. Many groundfish species on the U.S. West Coast spawn between November – March, when opportunities to collect biological data on surveys or from fisheries landings are limited. We examined the reproductive biology of canary rockfish, *Sebastes pinniger*, using ovaries collected by the West Coast groundfish bottom trawl survey (WCGBT) from 2009 – 2015 (n = 533) and Oregon Department of Fish and Wildlife (ODFW) port biologists from 2014 – 2016 (n = 308). This allowed for comparisons of length and age at maturity estimates based on the histological examination of ovaries collected within and outside the spawning season. We identified several key factors essential for understanding reproductive biology of west coast groundfishes: (1) spatial and temporal patterns, (2) oceanographic conditions effect on reproductive patterns related to skip spawning and abortive maturation, and (3) estimating biological (sexual) versus functional (potential spawner) maturity for fisheries management models. Ecosystem variables, such as habitat, food availability, upwelling, and oceanographic patterns may also have an outsized influence on the reproductive behavior of groundfish stocks. Understanding how these variables influence reproductive behavior can provide useful information for predicting shifting oceanographic conditions influence on the spawning output of groundfish stocks.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

f) A new approach to reproductive analysis for fisheries management.

Investigators: M. Head, J. M. Cope, P. Frey and A. Keller

As part of the NWFSC's reproductive maturity program (FRAM Division), we have identified several key factors to study in assessing West Coast groundfish reproductive biology. To date, these include: (1) spatial and temporal patterns, (2) oceanographic conditions effect on maturity schedules and reproductive patterns related to skip spawning and abortive maturation, and (3) estimating biological (sexual) versus functional (potential spawner) maturity. Based on ongoing analyses, our goal is to provide updated, coast wide maturity information, at annual intervals to alleviate the need for fish managers to make assumptions about life history strategies in models used for biomass estimates. Prior to the initiation of our research, data were often lacking or if available outdated and/or from localized rather than widespread sources. Ecosystem variables, such as habitat, predator-prey interactions, food availability, upwelling, and oceanographic changes influence reproductive behavior of groundfishes. If we can understand how these variables affect skip-spawning and abortive maturation patterns in fish, and how spatial/temporal relationships are associated with maturity schedules, we can make fewer assumptions in current biomass estimates and have more reliable data for climate model forecasts. Using up to-date information may be critical to accurately estimating future rebuilding patterns. In addition, modelling maturity data accurately to reflect current biological patterns may reduce uncertainty and change spawning biomass estimates.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

B. Ecosystem Research

1. Habitat

a) Relating groundfish diversity and biomass to structure-forming invertebrates in the Northeast Pacific Ocean: an exploration of catch data from a fishery-independent trawl survey

Investigators: K.L. Bosley, K.M. Bosley, A.A. Keller and C.E. Whitmire

Some cold-water corals and sponges occur in such dense aggregations that they provide structurally complex habitats which support a diverse assemblage of associated invertebrates and fish. For this study we investigated the relationship between structure-forming invertebrates (SFIs), specifically corals, sea pens and sponges, and their associations with demersal fish using trawl survey data from 2003-2015, covering continental shelf and slope waters from Cape Flattery, Wash., to the Mexican border. Survey data were divided into one of four groups by haul location and tow depth: north vs. south of Cape Mendocino (Calif.) and shallow (<=300m) vs. deep (>300m). General linear models (GLMs) and generalized additive models (GAMs) were used to correlate species richness and fish biomass with SFI densities. GLMs showed that average species richness was slightly lower and finfish biomass slightly higher in hauls with no SFIs. GAMs indicated a weak, non-linear relationship between species richness and sponge density (<1% of deviance explained) and slightly higher fish biomass in hauls with low or zero densities of sea pens or sponges. Multivariate analyses were used to relate fish community structure in each group to SFI densities, and to environmental parameters including depth, latitude and bottom temperature. Bottom temperature and depth were the primary drivers of community composition, but there were no strong correlations with SFI densities. Indicator species analysis identified species that were associated with three levels of SFI densities (high, low and none). Some flatfishes (Pacific sanddab, petrale sole, arrowtooth flounder and curlfin sole) were associated with high and low densities of corals and sea pens while others (Dover, Rex and slender soles) were associated with the absence of sponge. Short- and longspine thornyheads, greenstriped rockfish and chilipepper rockfish were associated with low (thornyheads) or zero (rockfishes) coral and sea pen densities and high sponge density, suggesting a preference for sponges. Sablefish were the opposite and were associated with hauls containing either no sponge or high levels of corals and sea pens. These results provide information about broad-scale associations between SFIs and demersal fish that may be useful for developing studies that are specifically focused on the function of SFIs as habitats for fish, and the role they may play in their life-histories.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

b) Fine-scale benthic habitat classification as part of the Northwest Fisheries Science Center's (NWFSC) Southern California Hook and Line Survey

Investigators: A.C. Chappell, C. Whitmire, J. Harms, J. Benante and A.A. Keller

The NWFSC's Southern California Shelf Rockfish Hook and Line Survey samples hard bottom habitats within the Southern California Bight via rod and reel to provide management information for multiple demersal rockfishes (*Sebastes* spp.). To compliment the fishing component of the survey, a towed camera-sled equipped with a low-light analog camera and mini-DV recording system is deployed opportunistically to collect video data on fish presence and benthic habitat. Through 2013, we have analyzed 6,982 benthic habitat observations collected during 69 dives at 59 unique sites.

Benthic habitat observations were categorized both by major strata (primary, ≥50% of habitat in the field of view (FOV); secondary, ≥20% of the next most abundant habitat in the FOV; and, all other habitats in the FOV), and by eight previously-defined substrata categories: mud, sand, pebble, cobble, boulder, continuous flat rock, diagonal ridge and vertical rock-pinnacle top.

When compared with existing National Oceanic and Atmospheric Administration's Essential Fish Habitat (EFH) maps in these areas, we found significantly different habitat classification values, especially for hard habitats. Our analysis found significantly more hard bottom substrata from the reviewed camera-sled video, when compared to EFH designations in the same areas. This suggests hard-bottom habitat features, especially smaller reefs, rock outcrops and boulder patches are not fully resolved within available habitat maps. Incorporating habitat designation from EFH charts into the development of abundance indices for groundfish stock assessments may misrepresent the total available hard-bottomed habitats available to many species that use them, resulting in biased results.

For more information, please contact Aaron Chappell at Aaron.Chappell@noaa.gov

c) Getting to the Bottom of Fishery Interactions with Living Habitats: Spatiotemporal Trends in Disturbance of Corals and Sponges on the US West Coast

Investigators: L. Barnett, S. Hennessey, T. Essington, A. Shelton, B Feist, T. Branch and M. McClure

Physical seafloor damage by mobile bottom fishing gear is a conservation concern because of potential direct impacts on habitat-forming organisms, and indirect effects on fishes supported by these habitats. Despite this concern, it has not been common practice to systematically quantify changes over time in the extent and intensity of fishery impacts on seafloor habitat, making it difficult to determine the effect of fisheries management actions on habitat. Here, we estimate spatiotemporal trends in bottom trawl activity in areas containing such biogenic habitat (sponges and corals) on the US west coast to evaluate the effect of policies such as spatial closures, catch shares and vessel buybacks. Biogenic habitat exposure to trawl gear was greatest at moderate to deep depths of the outer continental shelf and upper slope, primarily north of Cape Mendocino and off Southern California. However, given the location of commercial trawling, the interaction frequency between biogenic habitat and trawl gear is likely highest in deep waters off Oregon and Washington. Temporal trends in total biogenic habitat contacts tracked changes in fishing effort, but the relative frequency of contacts in areas open to fishing actually increased after spatial closures were implemented—likely due to effort displacement and shifts in the spatial distribution of fishing—and was only slightly reduced by implementation of catch shares. Thus although spatial closures may protect habitat within reserves, without complimentary policies, spatial closures may increase gear-habitat interactions in adjacent areas due to changes in fisher behavior and fishing effort displacement.

For more information, please contact Dr. Lewis Barnett at UW SAFS, lewisakbarnett@gmail.com

d) Species-specific responses of demersal fishes to near-bottom oxygen levels within the California Current large marine ecosystem

Investigators: A. A. Keller, L. Ciannelli, W. Waldo Wakefield, V. Simon, J.A. Barth and S. D. Pierce

Long-term environmental sampling provided information on catch and near-bottom oxygen levels across a range of depths and conditions from the upper to the lower limit of the oxygen minimum zone and shoreward across the continental shelf of the U.S. west coast (U.S. – Canada to U.S. – Mexico). During 2008 – 2014, near-bottom dissolved oxygen concentrations (DO) ranged from 0.02 to 5.5 mL L^{-1} with 63.2% of sites experiencing hypoxia (DO<1.43 mL L^{-1}). The relationship between catch per unit effort (CPUE) and DO was estimated for 34 demersal fish species in five subgroups by life history category (roundfishes, flatfishes, shelf rockfishes, slope rockfishes and thornyheads) using Generalized Additive Models. Models included terms for position, time, near-bottom environmental measurements (salinity, temperature, oxygen) and bottom depth. Significant positive relationships between CPUE and DO occurred for 19 of 34 groundfish species within hypoxic bottom waters. Community effects (total CPUE and species richness for demersal fishes) also exhibited significant and positive relationships with low near-bottom oxygen levels. GAM analysis revealed an apparent threshold effect at lower oxygen levels, where small changes in oxygen produced large changes in catch for several species, as well as total catch and species richness. An additional seven species displayed negative trends. Based on AIC-values, near-bottom oxygen played a major role in the distribution of flatfishes, roundfishes and thornyheads. By examining similarities and differences in the response of various subgroups of commercially important groundfish species to low DO levels, we uncovered ecological inferences of potential value to future ecosystem-based management.
Investigators: A.A. Keller, L. Ciannelli, W. Waldo Wakefield, V. Simon, J.A. Barth, S.D. Pierce

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

e) A Taxonomic Guide to Deep-Sea Corals of the U.S. Pacific Coast: Washington, Oregon and California

Investigators: C.E. Whitmire, M.V. Everett, R.P. Stone, J.C. Buchanan, T. Mitchell and E.A. Berntson

Deep-sea corals are invertebrates in the Phylum Cnidaria. Cnidarians are distinguished from other invertebrates in that they possess specialized cells, called cnidocytes, which have several functions including prey capture, defense, and transfer of gametes/larvae. In contrast to their tropical cousins, deep-sea corals live in either the mesophotic or aphotic zones of the ocean. Because they lack the symbiotic relationship with photosynthetic algae, they must sustain themselves by passively capturing particulate organic matter and plankton. Whitmire et al. (2017) inventoried 134 unique taxa of corals within the Pacific Coast region, representing two classes, three subclasses, five orders, eight suborders and 33 families. Octocorals, including gorgonians, sea pens and soft corals are the most speciose (100 taxa), followed by stony corals (19), black corals (9) and lace corals (6).

We describe the distinctive morphological characteristics of taxonomic groups, highlighting species that are known to occur off the U.S. West Coast. The taxonomic hierarchy used here follows that of the World Register of Marine Species (WoRMS). In addition, this guide will be used to improve field identification of deep-sea corals and sponges in the Pacific Council Region by enhancing the pictorial field guides used by fishery observers and field survey biologists.

For more information, please contact John Buchanan at John.Buchanan@noaa.gov

f) Deep-sea octocoral *Swiftia simplex* (Nutting 1909) on the United States West coast

Investigators: M.V. Everett, L.K. Park, E.A. Berntson, A.E. Elz, C.E. Whitmire, A. A. Keller, M.E. Clarke

Deep-sea corals are a critical component of habitat in the deep-sea, existing as regional hotspots for biodiversity, and are associated with increased assemblages of fish, including commercially important species. Because sampling these species is so difficult, little is known about the connectivity and life history of deep-sea octocoral populations. This study evaluates the genetic connectivity among 23 individuals of the deep-sea octocoral *Swiftia simple*x collected from Eastern Pacific waters along the west coast of the United States. We utilized high-throughput restriction-site associated DNA (RAD)-tag sequencing to develop the first molecular genetic resource for the deep-sea octocoral, *Swiftia simplex*. Using this technique, we discovered thousands of putative genome-wide SNPs in this species, and after quality control, successfully genotyped 1,145 SNPs across individuals sampled from California to Washington. These SNPs were used to assess putative population structure across the region. A STRUCTURE analysis as well as a principal coordinates analysis both failed to detect any population differentiation across all geographic areas in these collections. Additionally, after assigning individuals to putative population groups geographically, no significant FST values could be detected (FST for the full data set 0.0056), and no significant isolation by distance could be detected ($p = 0.999$). Taken together, these results indicate a high degree of connectivity and potential panmixia in *S. simplex* along this portion of the continental shelf.

For more information, please contact Meredith Everet at meredith.everet@noaa.gov

2. Ecosystems

B. Ecosystem Research

1. Ecosystems

a) Integrated Ecosystem Assessment of the California Current

Investigators: C.J. Harvey, N. Garfield, E.L. Hazen and G.D. Williams

An integrated ecosystem assessment (IEA) is a science support element for ecosystem-based management (EBM); the IEA process involves synthesizing and analyzing information through steps that include scoping, indicator development, risk analysis, and evaluating management strategies. The primary goal of the California Current IEA is to inform the implementation of EBM by melding diverse ecosystem components into a single, dynamic fabric that allows for coordinated evaluations of the status of the California Current ecosystem. We also aim to involve and inform a wide variety of stakeholders and agencies that rely on science support for EBM, and to integrate information collected by NOAA and other federal agencies, states, non-governmental organizations, and academic institutions. The essence of IEAs is to inform the management of diverse, potentially conflicting ocean-use sectors. As such, a successful California Current IEA must encompass a variety of management objectives, consider a wide-range of natural drivers and human activities, and forecast the delivery of ecosystem goods and services under a multiplicity of scenarios. This massive undertaking will evolve over time.

We are well into the Phase IV iteration of the California Current IEA, which builds on earlier reports by focusing on integrative products, particularly: in-depth quantitative analysis of ecosystem indicators; assessing the risk posed by natural and anthropogenic stressors to key ecosystem resources and human wellbeing; and evaluating potential management strategies to determine which strategies are most effective in moving the ecosystem toward management goals and objectives, and to identify potential management tradeoffs. Many of these efforts involve analyses related to groundfish and will be fleshed out further between now and 2017.

The project includes regular reporting of ecosystem status and trends to the Pacific Fishery Management Council. These reports and other California Current IEA documents can be found at https://www.integratedecosystemassessment.noaa.gov/regions/california-current-region/index.html.

For more information, please contact Dr. Chris Harvey at Chris.Harvey@noaa.gov.

b) Feeding ecology of select groundfish species captured in the NWFSC bottom trawl survey, from gut contents and stable isotopes

Investigators: K.L. Bosley, J.C. Buchanan, A.C. Chappell, D. Draper and K.M. Bosley

We are examining the diets of multiple groundfish species as an ongoing component of the NMFS West Coast Bottom Trawl Survey. Stomachs and tissue samples were collected at sea and preserved for gut content and stable-isotope analyses. We focused on several species of Sebastes and now have stomach content and stable-isotope data covering multiple years. Yellowtail, darkblotched, canary, sharpchin and stripetail rockfishes prey largely on zooplankton, with euphausiids composing a majority of their diet. Shrimp also contribute significantly to the diets of darkblotched and canary rockfishes, whereas bocaccio, yelloweye and chilipepper rockfishes all share a highly piscivorous diet. Greenstriped and rosethorn rockfishes show a strong preference for benthic prey, greenstriped preferring various shrimp species, and rosethorn preferring a mix of shrimp and galatheid crabs. Finally, widow rockfish and Pacific ocean perch exhibit a more omnivorous feeding strategy, eating a variety of zooplankton, including euphausiids, amphipods, shrimp and gelatinous organisms. Stable isotope values averaged by year indicate that bocaccio and yelloweye rockfish feed approximately one trophic level above Pacific ocean perch and above darkblotched, greenstriped, sharpchin, stripetail and widow rockfishes. All other species in this study feed at mixed trophic levels. Multivariate analyses of diet data show significant differences in diet among species but strong overlap among benthic and bentho-pelagic species. Stable-isotope data also show significant differences among species and years. These results demonstrate the groundfishes in this study are significant consumers in both benthic and pelagic habitats, feeding across multiple trophic levels.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

c) Potential effects of ocean acidification on the California Current food web and fisheries: ecosystem model projections

Investigators: K.N. Marshall, I.C. Kaplan, E.E. Hodgson, A. Hermann, S. Busch, P. McElhany, T.E. Essington, C.J. Harvey, E.A. Fulton

Humans rely heavily on ocean ecosystems and the services they provide. Global climate change manifests in the ocean through a number of pathways, one of which is ocean acidification. In this project and associated manuscripts we describe the effects of ocean acidification on an upwelling system that is particularly prone to low pH conditions, the California Current. We used an end-to-end ecosystem model (Atlantis), forced by downscaled global climate models and informed by a meta-analysis of the pH sensitivities of local taxa, to investigate the direct and indirect effects of future pH on biomass and fisheries revenues. Our model projects wide ranging magnitudes of effects across guilds and functional groups, although with more "losers" than "winners". The most dramatic effects of future pH may be expected on demersal fish, sharks, and epibenthic invertebrates. State-managed fisheries such as those that harvest Dungeness crab were particularly vulnerable in our projections, with revenues declining by almost 30%. The model's pelagic species, marine mammals, and seabirds were much less influenced by future pH. Our results provide a set of projections that generally support and build upon previous findings and set the stage for hypotheses to guide future modeling and experimental analysis on the effects of OA on marine ecosystems and fisheries.

For more information, please contact Dr. Isaac Kaplan at Isaac.Kaplan@noaa.gov

d) The impacts of climate variability on the distribution of groundfish along the Northeast Pacific coastal shelf.

Investigators: L. Li, A. Hollowed, S. Barbeaux, J. Boldt, E. Cokelet, T. Garfield, S. Gauthier, D. Jones, A. Keller, J. King, M. McClure, O. Ormseth, W. Palsso1, P. Ressler, D. Sweetnam, P. Stabeno and C. Wilson.

Global warming has impacted marine organisms in many different ways, including changes in species distribution. In addition to higher latitude and deeper waters, many species have been observed to move to a wide range of directions. However, to date, ontogenetic changes have rarely been accounted for. Due to different habitats across their life stages, changes in the species composition likely play an important role in the distributional shifts reported for the species as a whole in many studies. Here we present distributional responses of groundfish, across all size ranges of their lives, to climate variability in the Northeast Pacific with an emphasis on the unusual warm event “the Blob”. We analyzed survey data from bottom trawl and acoustic surveys, along the west coast of US, the west coast of Canada and the Gulf of Alaska 1984 - 2016. A group of commercially exploited fish species of gadids, sablefish, rockfish, and flatfish were selected as representatives for the three regions and length bins were chosen through expert opinion to capture ontogenetic differences in distribution for each species. We computed the centroids (bottom depth and bottom temperature) and the leading edges of the distribution for each species each size bin and link their distributions with environmental changes. We applied different predictors including absolute value of temperature, temperature anomalies, and climate velocities. In the end, we summarized the sensitive and resilient species and size bins to environmental changes and discussed the different mechanisms.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

e) The West Coast Ocean Acidification and Hypoxia Science Panel

Investigators: W. Wakefield and R. Feely

Global carbon dioxide (CO_2) emissions over the past two centuries have altered the chemistry of the world’s oceans, threatening the health of coastal ecosystems and industries that depend on the marine environment. This fundamental chemical alteration is known as ocean acidification (OA), a phenomenon driven by the oceans absorbing CO_2 generated through human activities. Although OA is a global phenomenon, emerging research indicates that, among coastal zones around the world, the West Coast of North America will face some of the earliest, most severe changes in ocean carbon chemistry. The threats posed by OA’s progression will be further compounded by other dimensions of global climate change, such as the intensification and expansion of low dissolved oxygen – or hypoxic – zones. In the coming decades, the impacts of ocean acidification and hypoxia (OAH), which are already being felt across West Coast systems, are projected to grow rapidly in intensity and extent. Even if atmospheric CO_2 emissions are stabilized today, many of the ongoing chemical changes to the ocean are already “locked in” and will continue to occur for the next several decades. In an effort to develop the scientific foundation necessary for West Coast managers to take informed action, the California Ocean

Protection Council in 2013 asked the California Ocean Science Trust to establish and coordinate a scientific advisory panel in collaboration with California's ocean management counterparts in Oregon, Washington and British Columbia. The resulting West Coast Ocean Acidification and Hypoxia Science Panel, was comprised of 20 scientific experts, including from NOAA, Richard Feely (Pacific Marine Environmental Laboratory) and Waldo Wakefield (Northwest Fisheries Science Center). The panel was charged with summarizing the current state of knowledge and developing scientific consensus about available management options to address OAH on the West Coast. A report of the major findings, recommendations and actions is was released in April 2016 and available through the panel's website (http://westcoastoah.org/). The website also provides access to an array of panel products and supporting appendices.

For more information, please contact Waldo Wakefield at Waldo.Wakefield@noaa.gov, other panelists (http://westcoastoah.org/panelists/) or staff members at the California Ocean Science Trust (www.oceansciencetrust.org/)

C. Bycatch Reduction Research

Investigators: W. Wakefield and M. Lomeli

Recent Conservation Engineering Work in US West Coast Groundfish Fisheries

Beginning in 2004, the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) initiated a fisheries conservation engineering program within its Fisheries Resource Analysis and Monitoring Division. Through key regional collaborations with the Pacific States Marine Fisheries Commission, Oregon Department of Fish and Wildlife, Alaska Fisheries Science Center, and the fishing industry, the NWFSC has been able to pursue a wide-ranging array of conservation engineering projects relevant to reducing bycatch in the west coast groundfish and ocean shrimp trawl fisheries. In the past several years, these projects included: 1) Reducing Chinook salmon, eulachon, rockfish, and Pacific halibut bycatch in midwater and bottom trawl fisheries using BRDs, 2) Providing loaner video camera systems to the fishing industry, and 3) Examining selectivity characteristics of codends that differ in mesh size and configuration in the bottom trawl fishery, 4) Developing and testing selective flatfish sorting grid bycatch reduction devices in the bottom trawl fisheries, 5) Evaluating how illuminating fishing gear in situ can influence selectivity and reduce bycatch. Much of our current work has been in response to the fishing industries concerns over catches of overfished rockfishes and Pacific halibut IBQ (Individual Bycatch Quota) allocated in the Pacific coast Groundfish Trawl Rationalization Catch Share Program. The trawl rationalization program, starting in January 2011, established formal Annual Catch Limits (ACLs) and individual catch share quotas. In addition to ACLs, fishing opportunities may also be limited by hard caps or IBQs for non-groundfish species (e.g., Chinook salmon, and Pacific halibut). Bycatch of overfished, rebuilding, and prohibited species in the West Coast groundfish trawl fishery has the potential to constrain the fishery such that a substantial portion of available harvest may be left in the ocean. Several recently completed conservation engineering projects are highlighted below.

1. Artificial light: Its influence on Chinook salmon escapement out a bycatch reduction device in a Pacific whiting midwater trawl

The Pacific whiting (*Merluccius productus*) midwater trawl fishery represents the largest groundfish fishery by volume along the U.S. west coast. While landed catches consist of mostly Pacific whiting, bycatch of Chinook salmon (*Oncorhynchus tshawytscha*) is an issue affecting the fishery. Although the catch ratio of Chinook salmon caught in the fishery is typically <0.03 fish per metric ton of Pacific whiting, bycatch is a concern because of the high volume of the fishery and the incidental capture of Endangered Species Act listed salmon. In this study, we examined the use of artificial light as a technique to reduce Chinook salmon bycatch. Specifically, we tested if Chinook salmon can be attracted towards and out of specific escape windows/openings of a bycatch reduction device (BRD) using artificial light. Data on fish behavior and escapement was collected using underwater video camera systems. During sea trials, video observations were made on 437 Chinook salmon with escapement occurring in 298 individual (68.2% of fish). At trawl depths, 266 Chinook salmon escaped with 230 individuals (86.5% of fish) exiting out a window that was illuminated. This result was highly significant ($P<0.00001$). These data show that light can influence where Chinook salmon exit a BRD, but also suggest that light could be used to enhance their escapement overall. In 2017, the PSMFC / NWFSC – MHE group will continue this line of research switching from the use of underwater video to the use of a recapture net to compare escapement rates between tows conducted with and without the use of artificial light.

2. Illuminating the headrope of a selective flatfish trawl: Effect on catches of groundfishes and Pacific halibut

This study evaluated how illuminating the headrope of a selective flatfish trawl could affect catches of groundfishes and Pacific Halibut in the U.S. West Coast limited entry groundfish bottom trawl fishery. Lindgren-Pitman LED Electralume® fishing lights (color = green) were used to illuminate the headrope. Lights were grouped into clusters of three, with each cluster attached ca. 1.35 m apart along the 40.3 m long headrope. Using an alternate tow randomized block design, catch comparisons and ratios were compared between tows conducted with (treatment) and without (control) LED lights attached along the trawl headrope. Catches of rex sole, Arrowtooth Flounder, Greenstriped Rockfish, and Lingcod were fewer in the treatment compared to the control trawl, however, not at a significant level. Bycatch of Pacific halibut was substantially different between the two trawls, with the treatment trawl catching an average of 57% less Pacific halibut. As for Dover Sole and Sablefish, significantly fewer fish were caught in the treatment than the control trawl. Compared to the control, the treatment trawl on average caught more rockfishes (with the exception of Greenstriped Rockfish), English Sole, and Petrale Sole, but not at a significant level. Findings show that illuminating the headrope of the selective flatfish trawl can affect the catch comparisons and ratios of several groundfish species and Pacific Halibut and depending on the target or avoidance species, the effect can be positive or negative.

3. Testing of two selective flatfish sorting grid bycatch reduction devices in the U.S. West Coast groundfish bottom trawl fishery

In the U.S. West Coast limited entry (LE) groundfish bottom trawl fishery, catches of constraining species (e.g., rockfishes, sablefish, Pacific halibut) continue to hinder some fishermen's ability to maximize catches of more abundant flatfish stocks (e.g., Dover Sole, Petrale Sole). In this study, the size-selection characteristics of two flexible sorting grid bycatch reduction devices (BRDs), termed BRD-1 (6.4 x 25.4 cm grid size) and BRD-2 (6.4 x 30.5 cm grid size), designed to retain flatfishes while reducing catches of rockfishes, other roundfishes, and Pacific halibut were evaluated using a recapture net. The size selectivity parameters for rockfishes, other roundfishes, and Pacific Halibut did not differ significantly between the two designs. The size-selection characteristics between BRD-1 and -2 did not differ significantly for English Sole or Rex Sole. However, for Arrowtooth Flounder 53-58 cm in total (TL), Dover Sole 39-53 cm TL, and Petrale Sole 36-49 cm TL, BRD-1 retained significantly more fish of these length classes than BRD-2. Combined, the mean flatfish retention (not including Pacific halibut) was 89.3% for BRD-1 and 81.7% for BRD-2. Compared to previous flatfish sorting grid selectivity work conducted in the LE groundfish bottom trawl fishery, BRD-1 enhanced the retention of flatfishes while substantially reducing catches of non-target species.

4. Improving catch utilization in the U.S. West Coast groundfish bottom trawl fishery: an evaluation of T90-mesh and diamond-mesh cod ends

The limited-entry bottom trawl fishery for groundfish along the U.S. West Coast operates under a catch share program, which is implemented with the intention of improving the economic efficiency of the fishery, maximizing fishing opportunities, and minimizing bycatch. However, stocks with low harvest guidelines have limited the ability of fishermen to maximize their catch of more abundant stocks. Size-selection characteristics of 114-mm and 140-mm T90-mesh cod ends and the traditional 114-mm diamond-mesh cod end were examined by using the covered cod end method. Selection curves and mean L50 values (length at which fish had a 50% probability of being retained) were estimated for two flatfish species (Rex Sole and Dover Sole) and two roundfish species (Shortspine Thornyhead and Sablefish). Mean L50 values were smaller for flatfishes but larger for roundfishes in the 114-mm T90 cod end compared to the diamond-mesh cod end. For Rex Sole, Dover Sole, and Shortspine Thornyheads, selectivities of the 140-mm T90 cod end were significantly different from those of the other cod ends; the 140-mm T90 cod end was most effective at reducing the catch of smaller-sized fishes but with a considerable loss of larger-sized marketable fishes. Findings suggest that T90 cod ends have potential to improve catch utilization in this multispecies fishery.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Mark Lomeli at MLomeli@psmfc.org or visit http://www.nwfsc.noaa.gov/research/divisions/fram/habitat.cfm

VIII. Publications

Anderson, S.C., Cooper, A.B., Jensen, O.P., Minto, C., Thorson, J.T., Walsh, J.C., Afflerbach, J., Dickey-Collas, M., Kleisner, K.M., Longo, C., Osio, G.C. 2017. Improving estimates of population status and trend with superensemble models. Fish and Fisheries.

Andrews, K.S., Nichols, K.M., Elz, A., Harvey, C.J., Tolimieri, N., Tonnes, D., Lowry, D., Pacunski, R., Yamanaka, K.L. Submitted. Cooperative research sheds light on population structure and listing status of threatened and endangered rockfish species. Conservation Genetics.

Barnett, L.A.K., Hennessey, S.M., Essington, T.E., Shelton, A.O., Feist, B.E., Branch, T.A., McClure, M.M. In revision. Getting to the bottom of fishery interactions with living habitats: spatiotemporal trends in disturbance of corals and sponges on the US west coast. Marine Ecology Progress Series.

Benaka, L., Sharpe, L., Abrams, K., Campbell, M., Cope, J., Darby, F., Dick, E.J., Hyde, J., Linton, B., Lunsford, C., Rioux, D. 2016. Action Plan for Fish Release Mortality Science.

Bizzarro, J.J., Yoklavich, M.M., Wakefield, W.W. 2016. Diet composition and foraging ecology of U.S. Pacific Coast groundfishes with applications for fisheries management. Environmental Biology of Fishes. Environ Biol Fish DOI 10.1007/s10641-016-0529-2.

Bosley, K.L., Bosley, K.M., Keller, A.A., Whitmire, C.E. In prep. Relating groundfish diversity and biomass to structure-forming invertebrates in the Northeast Pacific Ocean: an exploration of catch data from a fishery-independent trawl survey. Mar. Ecol. Prog. Ser.

Bosley, K.L., Buchanan, J.C., Chappell, A.C., D. Draper, D., Bosley, K.M. In prep. A comparative analysis of food habits for several Northeast Pacific rockfishes (*Sebastes* sp.), using gut contents and stable isotopes. Can. J. Fish. Aquat. Sci.

Colburn, L., Norman, K., Jepson, M., Himes-Cornell, A., Kasperski, S., Weng, C., Clay, P.M. 2017. Community Participation in U.S. Catch Share Programs. NOAA Technical Memorandum.

Everett, M., Park, L., Berntson, E., Elz, A., Whitmire, C., Keller, A.A., Clarke, E. 2016. Large-scale genotyping-by-sequencing reveals lack of structure in the deep-sea octocoral Swiftia simplex (Nutting 1909) on the west coast of the United States. PLoS ONE 11(10): e0165279. doi:10.1371/journal.pone.0165279

Foss-Grant, A.P., Zipkin, E.F., Thorson, J.T., Jensen, O.P., Fagan, W.F. 2016. Hierarchical analysis of taxonomic variation in intraspecific competition across fish species. Ecology 97(7), pp.1724-1734. DOI: 10.1890/15-0733.1

Frey, P.H., Keller, A.A., Simon, V. 2017. Dynamic population trends observed in the deep-living Pacific flatnose, *Antimora microlepis*, on the US West Coast. Deep Sea Research Part I: Oceanographic Research Papers.

Head, M.A., Frey, P.H., Cope, J.M., Keller, A.A. 2016. Challenges associated with assessing maturity, skipped spawning, and abortive maturation rates for fisheries managers: a case study of *Sebastes pinniger*. Presentation at the North Pacific Marine Science Organization (PICES), San Diego, CA, Nov 2 - 13.

Head, M.A., Haltuch, M.A., Frey, P.H., Cope, J.M., Keller, A.A. 2016. Spatio-temporal variability in canary rockfish (*Sebastes pinniger*) maturity. Presentation, NWFSC Ecosystem Science Review, July 12 – 14.

Head, M.A., Stokes, G.L., Thorson, J.T., Keller, A.A. 2016. Techniques for improving estimates of maturity ogives in groundfish using double-reads and measurement error models. Fisheries Research 179, pp.251-258.

Holland, D.S. 2016. Development of the Pacific Groundfish Trawl IFQ Market. Marine Resource Economics 31(4):453-464. DOI: 10.1086/687829

Holland, D.S., S. Kasperski. 2016. The Impact of Access Restrictions on Fishery Income Diversification of US West Coast Fishermen. Coastal Management 44:452-463.

Johnson, K.F., Councill, E., Thorson, J.T., Brooks, E., Methot, R.D., Punt, A.E. 2016. Can autocorrelated recruitment be estimated using integrated assessment models and how does it affect population forecasts? Fisheries Research 183, pp.222-232. DOI: 10.1016/j.fishres.2016.06.004

Keller, A., Buchanan, J.C., Steiner, E., Draper, D., Chappell, A., Frey, P.H., Head, M.A. 2016. Size at maturity for grooved Tanner crab (*Chionoecetes tanneri*) along the U.S. west coast (Washington to California). Fisheries Oceanography 25(3):292-305.

Keller, A.A., Ciannelli, L., Wakefield, W.W., Simon, V., Barth, J., Pierce, S.D. 2017. Species-specific responses of demersal fishes to near-bottom oxygen levels within the California Current large marine ecosystem. Mar. Ecol. Prog. Ser. 568:151-173

Keller, A.A., Wallace, J.R., Methot, R.D. 2017. The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey: Survey History, Design, and Description. NOAA Technical Memorandum NMFS-NWFSC-136, 47pp.

Lomeli, M.J.M., Hamel, O.S., Wakefield, W.W., Erickson, D.L. 2017. Improving catch utilization in the U.S. West Coast groundfish bottom trawl fishery: an evaluation of T90-Mesh and diamond-mesh cod ends, Marine and Coastal Fisheries 9:149-160, DOI: 10.1080/19425120.2016.1274697.

Lomeli, M.J.M., Wakefield, W.W. 2016. Evaluation of a selective flatfish sorting grid bycatch reduction device in a U.S. west coast bottom trawl fishery. Fisheries Research 183:294–303.

Marshall, K.N., Kaplan, I.C., Hodgson, E.E., Hermann, A., Busch, D.S., McElhany, P., Essington, T.E., Harvey, C.J., Fulton, E.A. 2017. Risks of ocean acidification in the California Current food web and fisheries: ecosystem model projections. Global Change Biology.

Monnahan, C.C., Thorson, J.T., Branch, T.A. 2016. Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo. Methods in Ecology and Evolution.

Ono, K., Shelton, A.O., Ward, E.J., Thorson, J.T., Feist, B.E., Hilborn, R. 2016. Space-time investigation of the effects of fishing on fish populations. Ecological Applications 26(2), pp.392-406.

Ono, K., Shelton, O.A., Ward, E.J., Thorson, J.T., Feist, B.E., Hilborn, R. 2016. Space-time investigation of the effects of fishing on fish populations. Ecological Applications 26(2): 392-406. DOI: 10.1890/14-1874.1

Russell, S.M., Arias-Arthur, A., Sparks, K., Varney, A. 2016. West Coast Communities and Catch Shares: The Early Years of Social Change. 2016. Coastal Management 44 441-451.

Thorson, J.T., Barnett, L.A. 2017. Comparing estimates of abundance trends and distribution shifts using single-and multispecies models of fishes and biogenic habitat. ICES Journal of Marine Science.

Thorson, J.T., Fonner, R., Haltuch, M.A., Ono, K., Winker, H. 2016. Accounting for spatiotemporal variation and fisher targeting when estimating abundance from multispecies fishery data 1. Canadian Journal of Fisheries and Aquatic Sciences 73(999), pp.1-14. DOI: 10.1139/cjfas-2015-0598

Thorson, J.T., Ianelli, J.N., Larsen, E.A., Ries, L., Scheuerell, M.D., Szuwalski, C., Zipkin, E.F. 2016. Joint dynamic species distribution models: a tool for community ordination and spatio-temporal monitoring. Global Ecology and Biogeography 25(9), pp.1144-1158. DOI: 10.1111/geb.12464

Thorson, J.T., Jannot, J., Somers, K. 2016. Using spatio-temporal models of population growth and movement to monitor overlap between human impacts and fish populations. Journal of Applied Ecology. DOI: 10.1111/1365-2664.12664

Thorson, J.T., Johnson, K.F., Methot, R.D., Taylor, I.G. 2016. Model-based estimates of effective sample size in stock assessment models using the Dirichlet-multinomial distribution. Fisheries Research. DOI: 10.1016/j.fishres.2016.06.005

Thorson, J.T., Kristensen, K. 2016. Implementing a generic method for bias correction in statistical models using random effects, with spatial and population dynamics examples. Fisheries Research 175, pp.66-74.

Thorson, J.T., Minte-Vera, C.V. 2016. Relative magnitude of cohort, age, and year effects on size at age of exploited marine fishes. Fisheries Research 180, pp.45-53.

Thorson, J.T., Munch, S.B., Swain, D.P. 2017. Estimating partial regulation in spatio-temporal models of community dynamics. Ecology.

Thorson, J.T., Pinsky, M.L., Ward, E.J. 2016. Model-based inference for estimating shifts in species distribution, area occupied and centre of gravity. Methods in Ecology and Evolution 7(8), pp.990-1002. DOI: 10.1111/2041-210X.12567

Thorson, J.T., Rindorf, A., Gao, J., Hanselman, D.H., Winker, H. 2016. Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes. In Proc. R. Soc. B (Vol. 283, No. 1840, p. 20161853). The Royal Society. DOI: 10.1098/rspb.2016.1853

Tolimieri, N., Holmes, E.E., Williams, G.D., Pacunski R., Lowry D. 2017. Population assessment using multivariate time-series analysis: A case study of rockfishes in Puget Sound. Ecology and Evolution 00:1–15. https://doi.org/10.1002/ece3.2901

Tribuzio, C.A., Andrews, K.S. 2016. If the tag fits.....finding the glass slipper of tags for spiny dogfish (*Squalus suckleyi*). Poster presentation, Western Groundfish Conference, Newport, OR. February 2016.

West Coast Groundfish Observer Program Data Reports. Available at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm.

Whitmire, C.E., Everett, M.V., Stone, R.P., Buchanan, J.C., Mitchell, T., Berntson, E.A. In prep. A Taxonomic Guide to Deep-Sea Corals of the U.S. Pacific Coast: Washington, Oregon and California. Deep Sea Coral Research & Technology Program 2016-17.

NMFS Southwest Fisheries Science Center

Agency Report to the Technical Subcommittee of

the Canada-U.S. Groundfish Committee

April 2017

Edited by Xi He and John Field

With contributions from Aaron Mamula
Susan Sogard, Andrew Thompson, Nick Wegner and Mary Yoklavich

A. AGENCY OVERVIEW

The Southwest Fisheries Science Center (SWFSC) conducts fisheries and marine mammal research at three laboratories in California. Activities are primarily in support of the Pacific Fishery Management Council, the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), as well as a number of international fisheries commissions and conventions. The Acting Director is Kristen Koch and the Acting Deputy Director is Dr. Toby Garfield. All SWFSC divisions have supported the essential needs of the NMFS and the Pacific Fishery Management Council (PFMC) for groundfish, including as active members of the PFMC's Scientific and Statistical Committee (SSC), the Groundfish Management Team, and other management teams and advisory bodies.

The Center is headquartered in La Jolla, which hosts three divisions that conduct research on a wide range of Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats; the Antarctic Ecosystem Research Division (led by Dr. George Watters), the Marine Mammal and Turtle Division (led by Dr. Lisa Ballance), and the Fisheries Resources Division (led by Dr. Gerard DiNardo). The Fisheries Resources Division (FRD) conducts research on groundfish, large pelagic fishes (tunas, billfish and sharks), and small coastal pelagic fishes (anchovy, sardine and mackerel), and is the only source of groundfish research at the La Jolla facility. The Fisheries Research Division is also the primary source of federal support for the California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys that have taken place along much of the California coast since 1951. Researchers at FRD have primary responsibility for ichthyoplankton collections, studies of species abundance and distribution (including responses to climate variability), systematics, and the application of early life history information to stock assessments.

The Fisheries Ecology Division (FED), located in Santa Cruz and directed by Dr. Steve Lindley, comprises two research branches. The Fisheries Branch (led by Michael Mohr) conducts research and stock assessments in salmon population analysis, economics, groundfish, and fishery oceanography of salmonids and groundfish. The Ecology branch (led by Dr. Susan Sogard) conducts research on the early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. Specific objectives of the FED groundfish programs include: (1) collecting and developing information useful in assessing and managing groundfish stocks; (2) conducting stock assessments and improving upon stock assessment methods to provide a basis for harvest management decisions at the PFMC; (3) characterizing and mapping biotic and abiotic components of groundfish habitats, including structure-forming invertebrates; (4) disseminating information, research findings and advice to the fishery management and scientific communities; and (5) providing professional services (many of which fall into the above categories) at all levels, including inter-agency, state, national and international working groups. An FED economist represents the SWFSC on the Pacific Council's Groundfish Management Team.

The Environmental Research Division (ERD) is led by Dr. Toby Garfield and has researchers located in both Monterey and Santa Cruz. The ERD is a primary source of environmental information to fisheries researchers and managers along the west coast, and provides science-based analyses, products, and information on environmental variability to meet the agency's research and management needs. The objectives of ERD are to: (1) provide appropriate science-based environmental analyses, products, and knowledge to the SWFSC and its fishery scientists and managers; (2) enhance the stewardship of marine populations in the California Current ecosystem, and other relevant marine ecosystems, by understanding and describing environmental variability, the processes driving this variability, and its effects on the production of living marine resources, ecosystem structure, and ecosystem function; and (3) provide science-based environmental data and products for fisheries research and management to a diverse customer base of researchers, decision-makers, and the public. The ERD also contributes oceanographic expertise to the groundfish programs within the SWFSC, including planning surveys and sampling strategies, conducting analyses of oceanographic data, and cooperating in the development and testing of environmental and biological indices that can be useful in preparing stock assessments.

B. MULTISPECIES STUDIES

B1. Sablefish movement, growth, and survival off Oregon

Contact: Susan Sogard (susan.sogard@noaa.gov)
Investigator: Susan Sogard (FED, SWFSC)

Demersal fish inhabiting continental slopes experience colder temperatures, increasing hydrostatic pressure, decreasing oxygen saturation, and decreasing productivity with increased depth. We examined depth-related patterns in small- and large-scale movement, growth, and relative survival of sablefish (*Anoplopoma fimbria*) tagged during 1996–2004 in Oregon waters at depths of 141–1225 m (Figure 1); 2614 of 17,400 fish were recaptured as of December 2016 (Sogard et al. 2017). Recapture rates indicated significant size-dependent mortality. Discard mortality was affected by surface temperature for small fish (<55 cm in fork length) from upper slope depths (<400 m). Depth effects on recapture rates reflected differences in fishing effort. Most recaptures were near the initial capture depth. Although 91% of the recaptures were within 200 km of the tagging location, some individuals migrated thousands of kilometers, reaching the western Aleutian Islands. Growth rates were faster for females than for males and decreased with depth (Figure 2). Sablefish in the deepest depths sampled had extremely slow growth rates (<2 cm FL/year), low dispersal (2.4%), and were largely female (81%). Prior studies of age distribution indicate that deep slope habitats also support greater longevity, potentially providing a refuge for older fish and a buffering effect to longevity overfishing, depending on spatial differences in exploitation rates.

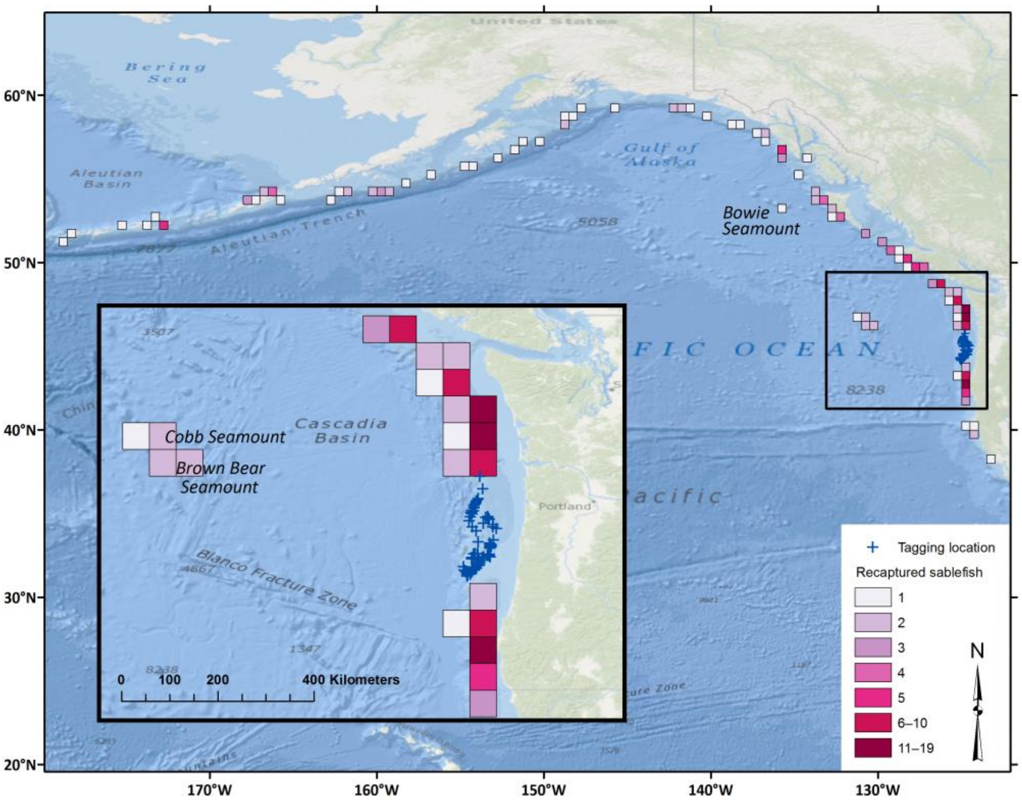


Figure 1. Location of all initial captures of sablefish off Newport, Oregon, (blue crosses, inset map) and recapture locations of dispersers (fish that moved at least 200 km from their initial capture location) for the period 1996–2016. Recapture locations of fish categorized as residents, fish that moved <200 km from their tagging location, are not shown.

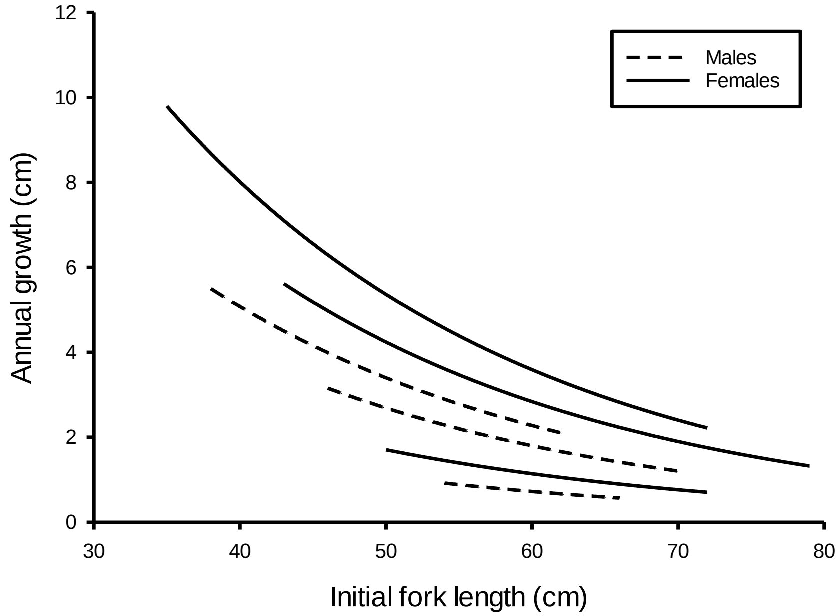


Figure 2. Estimated annual growth for male (dashed lines) and female (solid lines) sablefish residing in 3 depth zones (Z1=141–302 m, Z2=327–649 m, Z3=1112–1225 m) off Newport, Oregon. Growth estimates were derived from a nonlinear regression model incorporating factors of sex, FL, time at large, depth at tagging, depth at recapture, and recapture gear. For each depth zone, the range of fish sizes was restricted to that observed for recaptured fish with known sex.

B2. Effects of climate change induced ocean acidification and hypoxia on reproduction of rockfishes

Contact: Susan Sogard (susan.sogard@noaa.gov)

Investigators: Susan Sogard (FED, SWFSC), Neosha Kashef (UCSC), David Stafford (UCSC), Scott Hamilton (MLML), Cheryl Logan (CSUMB), Giacomo Bernardi (UCSC)

This study seeks to determine the effects of ocean acidification and hypoxia on reproduction and larval performance in multiple species of commercially and ecologically important West Coast rockfish. Since early life stages have not yet acquired full physiological capacity, developing embryos and larvae are expected to be most sensitive to shifts in ocean chemistry. In turn, survival of early life stages is critical for population dynamics of marine fisheries, due to the importance of small changes in early survival in modifying recruitment success. Thus, exposure of early life stages to low oxygen levels and low pH (i.e., high CO_2) waters, alone or in combination, may have a disproportionate effect on population dynamics if such exposure increases mortality rates or impairs physiological performance during critical periods of development.

We conducted experiments with brown rockfish testing how predicted changes in ocean chemistry in the next 50-100 years (by manipulating pH and dissolved oxygen levels in the laboratory) will affect embryo development and condition, starvation resistance and larval mortality, larval metabolic physiology and swimming performance, patterns of gene expression, and enzyme activity. Preliminary results indicate that low oxygen conditions (i.e., hypoxia) will be detrimental to the reproductive success of brown rockfish by negatively affecting embryo development and subsequent larval performance, and that hypoxia is likely to have a greater impact on rockfish reproduction than ocean acidification (Figure 3). In the lowest DO treatment (2 mg/L), mothers did not bring their larvae to full term and released dead larvae about 3 days pre-parturition, indicating strong effects of hypoxic conditions on embryo development and reproductive success. Deformities, including eye abnormalities, enlarged body cavities, enlarged hearts, and runt larvae were observed in both low DO and low pH treatments. Larvae that completed development under normoxic conditions but were transferred to low DO or low pH at parturition tended to have comparable survival rates. Enzyme analyses indicated a significant shift towards anaerobic metabolism (higher LDH:CS ratios) in larvae from hypoxia-exposed mothers compared with larvae from control mothers, but no change was evident in larvae from OA challenged mothers.

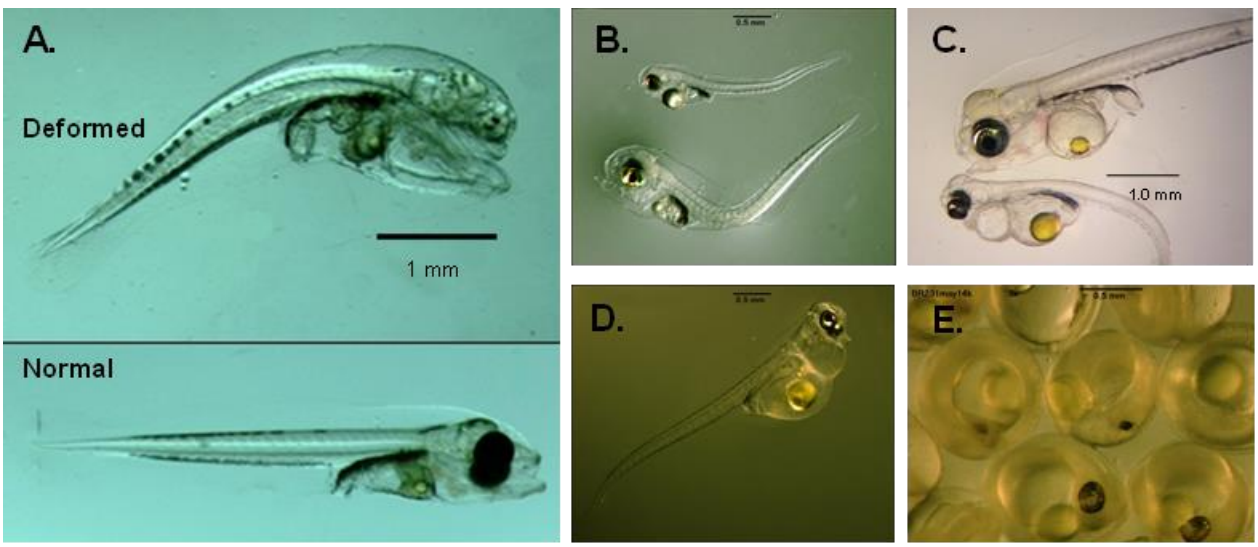


Figure 3. (A) Brown rockfish larva with enlarged body cavity and malformed eyes (above), potentially caused by hypoxia exposure, compared with a normally developing larva (below). Runt larval deformities observed in blue rockfish (B) and brown rockfish (C), reared at DO of 4 mg L^{-1}. Jaw (D) and eye deformities (E) of brown rockfish at DO of 2 mg L^{-1}.

B3. Ecosystem indicators for the Central California Coast, April-June 2016

Contact: Keith Sakuma (Keith.Sakuma@noaa.gov

Investigators: John Field and Keith Sakuma, Fisheries Ecology Division, SWFSC

The Fisheries Ecology Division of the SWFSC has conducted a late spring midwater trawl survey for pelagic juvenile (young-of-the-year, YOY) rockfish (*Sebastes* spp.) and other groundfish off Central California (approximately 36 to 38°N) since 1983, and has enumerated most other epipelagic micronekton encountered in this survey since 1990 (Sakuma et al. 2016). The survey expanded the spatial coverage to include waters from the U.S./Mexico border north to Cape Mendocino in 2004. The results here include time series of anomalies of some of the key species or groups of interest in this region since 1990 (core area) or 2004 (expanded survey area,. based on the mean of the log transformed catch rates for YOY rockfish, YOY Pacific hake (*Merluccius productus*), krill, and YOY Pacific sanddab (*Citharichthys sordidus*) (Figure 4). The survey area is broken into four large regions for this analysis, south (Point Conception south to the U.S./Mexico Border), south central (Point Sur to Point Conception), core (immediately north of Point Reyes through Monterey Bay), north central (Cape Mendocino to Fort Ross). The 2016 data represent a continuation of the very high catches of YOY rockfish in the central California areas (core and south central regions) observed over the past four years, although catches in the north central and southern regions were very low, and catches of juvenile Pacific sanddabs also declined to lower levels relative to previous years. Catches of YOY Pacific hake were spatially variable, but among the highest observed in the core area. Catches of krill were close to mean levels following several years of high productivity. The unusual ocean conditions associated with the marine heatwave between 2013 and 2016 were contributing factors in observed record high catches of other taxa, such as gelatinous zooplankton (particularly salps and pyrosomes) and and typically warm-water associated species such as pelagic red crabs (*Pleuroncodes planipes*) and California lizardfish (*Synodus luciocepsis*). Sakuma et al. (2016) document additional unusual catch rates and observations for this period, and also demonstrate that for the shorter duration of the survey over the broader survey area, the trends among the community indices (including YOY groundfish as well as krill, market squid, coastal pelagic and mesopelagic species) covary rather strongly among the four regions described above for this survey.

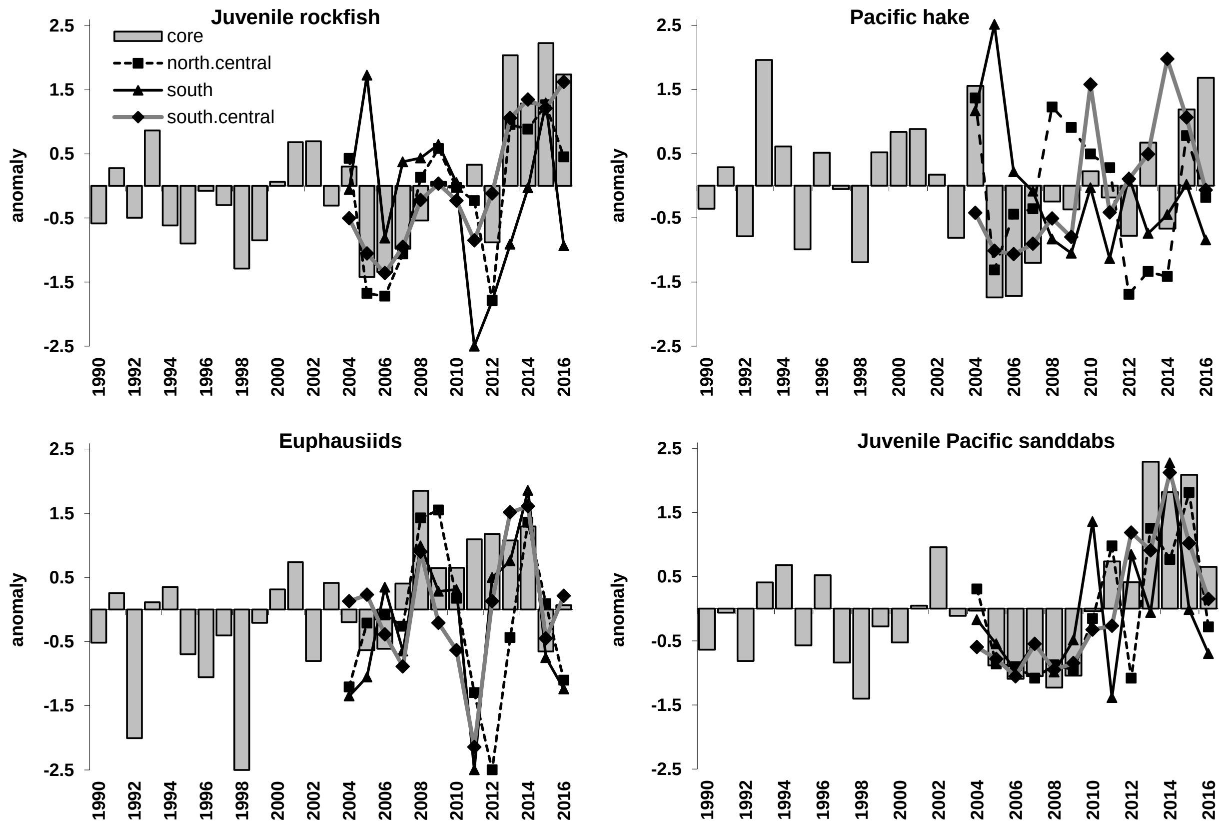


Figure 4. Long-term standardized anomalies of frequently encountered pelagic forage species from rockfish recruitment survey in the core (Central California) region (1990-2016).

B4. Research on larval rockfish at the SWFSC

Contact: Andrew Thompson (Andrew.Thompson@noaa.gov)

Over the past year (2016-2017) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla completed molecular identification of larval rockfishes collected from winter core CalCOFI stations between 1998 and 2013. The overall aim of this research is to develop a species-specific larval rockfish time-series and then use this data to evaluate how spawning patterns of different rockfishes responded to environmental factors and the presence of rockfish conservation areas in Southern California between 1997 and the present. Methodologically, the project involved sorting rockfishes (which can mostly only be identified to the genus level based on morphology) from ethanol-preserved plankton samples, sequencing mitochondrial DNA from individual larvae and matching larval sequences to those from adults that have previously been identified to the species level.

In total, we identified 39 species from the CalCOFI samples. Fifteen of these species were abundant enough to conduct time-series analyses, and 8 species were targeted by fishing while 7 were not targeted. Mean abundances of 6/8 targeted and 3/7 non-targeted species increased significantly between 1998 and 2013 throughout southern California. We also tested whether the Cowcod Conservation Area (CCA) affected larval abundance dynamics. Seventy-five percent of targeted species increased at a greater rate within the CCA than at locations with similar environmental conditions outside of the reserves. By contrast, there was no difference in rate of change for the untargeted species within or outside the CCA. Results from this study are now documented in a master thesis from a student at University of San Diego and we have submitted a manuscript to Proceedings of the Royal Society, Series B.

We were awarded a FATE grant to extract otoliths from the genetically-identified larva to test whether larval condition correlates with recruitment success. We use these funds to hire a post-doctoral researcher who will measure core and outer edge otolith width to evaluate maternal investment and recent growth rate, respectively. We will then test the hypothesis that higher maternal investment and recent growth correlate positively with recruitment success between 1998 and 2013 in southern California.

We initiated a project seeking to use next generation sequencing techniques to bulk-identify rockfish (and other fish) species presence absence from plankton samples. The goal here is to homogenize ethanol-preserved plankton samples, extract DNA and use an Illumina Mi-seq platform to sequence DNA from all fish species in the sample. We will then match these sequences to a library of known fish sequences from this region. We are also experimenting with the potential to obtain sample DNA from just the ethanol that is used as a preservative from each sample without having to destroy the actual plankton. At present, we have sorted several samples, genetically identified larval fishes from using a small amount of tissue (usually an eye), returned the larvae to the original sample, and homogenized the sample, and extracted DNA from the sample. We are about to send the tissue extraction to a genetics company (Laragen) to carry out the Mi-seq analysis. We sent ethanol from preserved samples to another company and are awaiting results.

Finally, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from 1964 through 2012, and by the end of this year expect to complete samples collected during the second half of 1963 in addition to completing samples collected in 2013 and 2014. This will provide a 50-year time series of larval abundances of the rockfish species visually identifiable as larvae (*Sebastes aurora, S. diploproa, S. goodei, S. jordani, S. levis, S. paucispinis*).

C. BY SPECIES, BY AGENCY

C1. Nearshore rockfish stock assessments

C1.a. California scorpionfish stock assessment

Contact: Melissa Monk (Melissa.monk@noaa.gov)

California scorpionfish is a medium-bodied fish that produce a toxin in its dorsal, anal, and pectoral fin spines, which causes painful wounds. California scorpionfish is a popular recreational fish in southern California found in nearshore waters, commonly between 20-450 feet. The species forms spawning aggregations from May-August and these aggregations are often targeted by anglers.

The SWFSC is currently conducting a full assessment of California scorpionfish (*Scorpaena guttata*) in conjunction with the California Department of Fish and Wildlife (CDFW), and will be reviewed in July 2017. The assessment will report the status of California scorpionfish in southern California, south of Pt. Conception to the U.S.-Mexico border. California scorpionfish was last assessed in 2005 with a catch-only update in 2015. The CDFW temporarily closed the California scorpionfish recreational and commercial fisheries in November 2014 with the expectation that the Annual Catch Limit had been exceeded. The upcoming assessment will include new age and growth data as well as both fishery-independent and fishery-dependent indices of abundance.

C1.b.   Blue rockfish assessment
Contact: E.J. Dick (edward.dick@noaa.gov)

The NMFS SWFSC will conduct a combined stock assessment of Blue and Deacon Rockfishes (*Sebastes mystinus* and *S. diaconus*, respectively) in 2017. This assessment will be the first full assessment since 2007, and will include the most extensive analysis to date of differences between the two species (i.e. growth, maturity, and fecundity). The assessment will include the first analysis of population dynamics off the coast of Oregon, and will examine several new data sources, including CPUE indices derived from spatially-explicit onboard observer programs, age data with expanded temporal and spatial coverage, and revised historical time series of catch and length composition data.

C2.   Shelf Rockfish

C2.a.   Rockfish barotrauma and release device research at SWFSC Lo Jolla Lab
Contact: Nick Wegner (nick.wegner@noaa.gov)

The Genetics, Physiology, and Aquaculture program at the SWFSC continues to evaluate post release survival of rockfishes (*Sebastes* spp.) suffering from barotrauma. Over the past few years we have used commercially available descending devices to release rockfishes tagged with acoustic transmitters containing depth and accelerometer sensors and monitor long-term survival. These results reveal relatively high survival rates, although there are differences between the five species studied. Over the past year we have focused efforts on examining post-release survival of juvenile Cowcod (*S. levis*), the species that dictates many groundfish management decisions in southern California. Because of a rebounding population, juvenile Cowcod are becoming more frequently encountered by recreational fishers. To date, we have acoustically tagged 15 juvenile Cowcod in coastal areas (100-120m depth) off San Diego, and preliminary data suggest high post-release survival for these smaller size classes.

In addition to tagging juvenile Cowcod, we have implemented a cooperative program with the recreational fishing community in San Diego to measure the effectiveness and angler preference for five different types of commercially available devices. While descending devices are now being more commonly used by the recreational fisheries to release fish at depth, quantitative estimates of device effectiveness are limited. This work is showing that all descending devices are effective in recompressing rockfish experiencing barotrauma and that if fish are caught in 75-100m of water, descending fish to a depth of 50 m results in successful release approximately 92% of the time. Although all descending devices work, at-sea conditions, vessel type, and fish size tend to influence effectiveness and user preference of different device types.

C2.b. Stock assessments
Contact: John Field (john.field@noaa.gov)
Investigators: John Field and Xi He

Two stock assessment updates will be conducted in 2017. One is for Blackgill rockfish (*S melanostomus*). The stock were fully assessed in 1998 and 2005, respectively, and was last updated in 2011. The species is a deeply distributed, long lived species with maximum age estimates ranged from 64 to 90 years. The highest historical catches around 1,000 mt were in the late 1980's, but catches in recent years were much lower, ranged between 50 and 200 mt. The last assessment indicated that the stock status was at 30.2% of unfished spawning ouput. The 2017 stock assessment update will include additional age data newly obtained in the Fisheries Ecology Division.

The second stock assessment update is for Bocaccio (*S. paucispinis*). The species is widely distributed in the U.S. West Coast, but is the most abundant in the California waters. It is one of most commonly caught rockfish species in California waters with over 6,000 mt catches in the late 1970's and early 1980's. Catches in recent years, however, were much lower, around 200 mt to 300 mt. The stock has been assessed in more than 10 times in the last thirty years. The last full stock assessment was conducted in 2015, and the stock status was at 36.7% of unfished spawning output. The 2017 stock assessment update will include additional data, including landings, length composition, and survey indices, from the last two years (2015 and 2016).

D. OTHER RELATED STUDIES

D1. SWFSC FED Habitat Ecology Team 2016-17 Research on California Demersal Communities

Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)
FED HET Investigators: Mary Yoklavich, Joe Bizzarro, Tom Laidig, Diana Watters

The SWFSC/FED Habitat Ecology Team (HET) conducts research focused on deep-water California demersal communities. Our goal is to provide sound scientific information to ensure the sustainability of marine fisheries and the effective management of marine ecosystems, with objectives to: (1) improve stock assessments, especially of overfished rockfish species in untrawlable habitats; (2) characterize fish and habitat associations to improve EFH identification and conservation; (3) contribute to MPA design & monitoring; and (4) understand the significance of deep-sea coral (DSC) as groundfish habitat. The HET uses a variety of underwater vehicles to survey demersal fishes, macro-invertebrates (including members of deep-water coral communities), and associated seafloor habitats off northern, central, and southern California. These surveys have resulted in habitat-specific assemblage analyses on multiple spatial scales; fishery-independent stock assessments; baseline monitoring of MPAs;

documentation of marine debris on the seafloor; and predictive models of the distribution and abundance of groundfishes and deep sea corals. The following are a few examples of recent projects conducted by the HET and collaborators.

D2. Characterizing the disturbance and damage to deep-sea coral and sponge communities in areas of high bycatch in bottom trawls off Northern California

Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

During summer 2016, the Ocean Exploration Trust conducted many research cruises in deep water off the west coast using the ROV Nautilus. The FED HET participated as scientists ashore during these cruises by participating in planning before at sea operations and offering advice, identifying organisms, and directing the ROV (e.g., which organisms to sample and photograph) while the cruise was underway. Several ROV dives were conducted near the sites of the 2014 HET DSC research cruise in northern California. In particular, one ROV survey occurred in an area of high coral bycatch off southern Oregon. During this cruise, high incidences of disturbed and damaged corals (such as organisms with broken or missing parts or overturned, displaced, or detached from the seafloor) were observed.

We analyzed the data from three of the ROV surveys off southern Oregon and northern California and combined them with data collected from the HET DSC cruise in 2014 from the same area. Forty strip transects were analyzed along 6,815 m of seafloor. A total of 22,567 corals comprising at least 12 families were counted along with 1,721 sponges from 13 taxa. Only 2% of all corals and sponges evaluated during this study were found to be damaged. By far, most of the damaged corals occurred in a narrow depth band ranging from 1100-1150 m. Eighty seven percent of the damaged corals were bamboo corals (Family Isididae, Figure 5), with nearly half of the 873 bamboo colonies observed showing some type of damage. Sponges were rarely visibly damaged with only 13 out of 1,721 individual sponges showing any form of damage. This area has been fished heavily for years which may have contributed to the damage observed to deep sea corals and sponges.

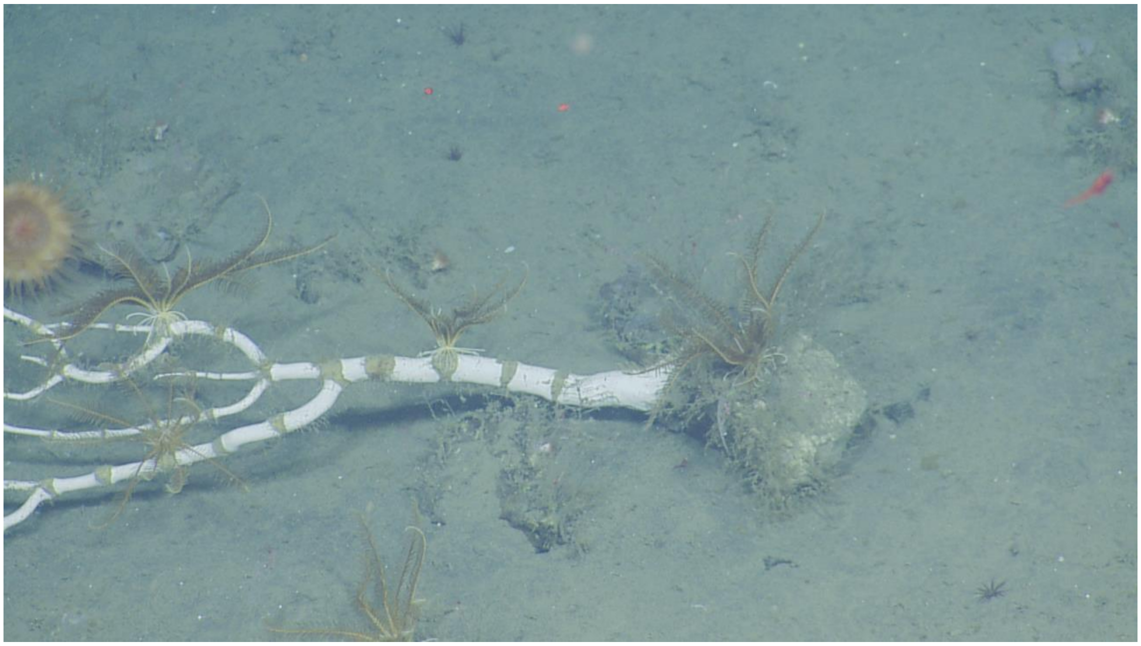


Figure 5: Fallen over and dead bamboo coral (Family Isidella) with its base still attached to a rock. Crinoids are crawling on the skeleton.

D3. Mapping and Visual Surveys of Seafloor Habitats and Fishes, 19-30 October 2016
Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

Aboard the NOAA R/V *Reuben Lasker*, scientists used the vessel's ME70 multibeam sonar to collect high-resolution bathymetric and backscatter data at depths 50-350 meters in three areas (Figure 6) off Santa Rosa Island (Area 1a and 1b) and Santa Cruz/Anacapa Islands (Area 3) in the vicinity of Channel Islands National Marine Sanctuary in Southern California. Approximately 216 km2 of seafloor were mapped during 9 nights of surveying. Thirty expendable bathythermograph (XBT) probes were deployed during the ME70 survey, in order to improve accuracy of depth measurements. Researchers also acquired water column data on the presence, relative abundance, and distribution of fishes associated with various seafloor features by simultaneously using the ship's EK60 and ME70 sonars. NMFS's Seabed autonomous underwater vehicle (AUV), equipped with 3 cameras and strobe light, was deployed from the *Lasker* and used to survey seafloor communities and groundtruth habitat interpretations of mapped areas. Six AUV groundtruthing dives were completed during daytime, with a typical AUV deployment of 4-5 hrs. The AUV typically surveys benthic communities from 2.5-3 m above the seafloor. Five casts were made in association with the AUV dives in order to establish sound velocity profiles for the water column; this information was used to improve communications with the AUV during each dive. Upon completion of each AUV dive, the vehicle surfaced and was retrieved onto the *Lasker*.

The bathymetry and backscatter data collected during this mission and a descriptive summary of these data will be submitted to NOAA Office of Coast Survey and, with OCS approval, to

National Centers for Environmental Information (NCEI) for archiving and access. We currently are analyzing the visual and acoustic fish and habitat data (Figure 7).

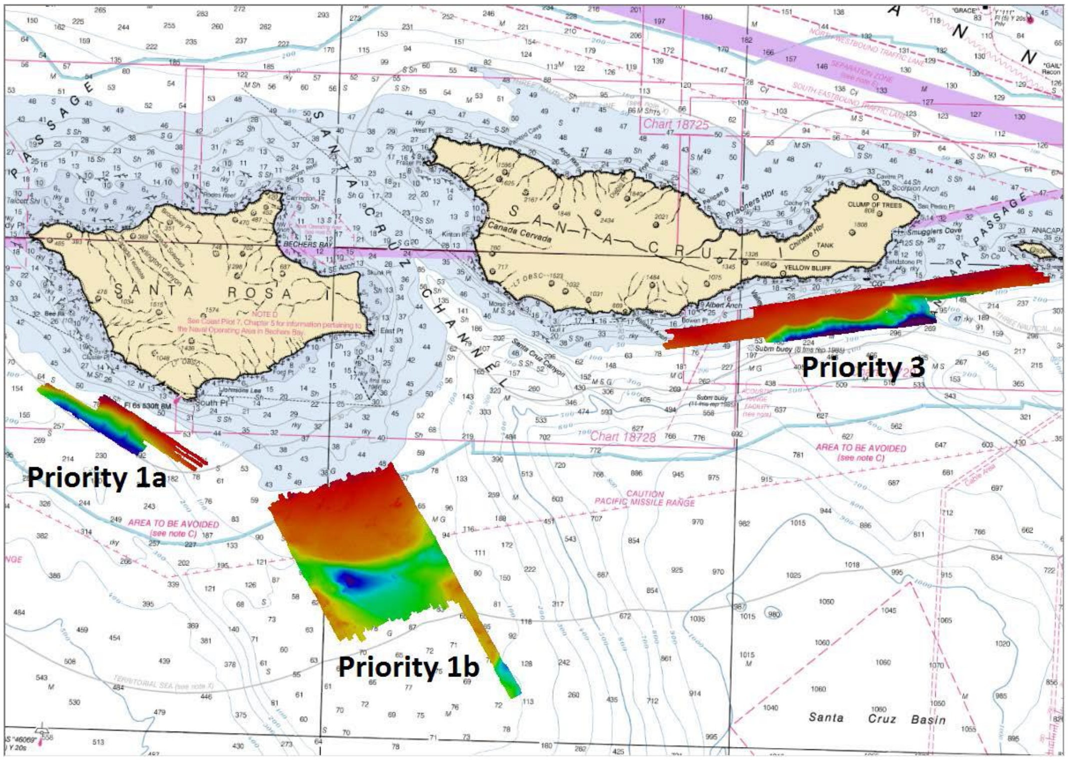


Figure 6. Study sites off Santa Rosa, Santa Cruz, and Anacapa Islands in Southern California, indicating areas (1a, 1b, and 3) of bathymetric and fish surveys using ME70 and EK60 sonar from NOAA R/V *Reuben Lasker* 20-28 October 2016. Colors indicate depth, with red being relatively shallow and blue being deep.

Figure 7. An AUV image of the rocky seafloor covered with many orange gorgonians (*Adelogorgia phyllosclera*) south of Santa Rosa Island in 80 m of water.

D4. FY16-17 NMFS Untrawlable Habitat Strategic Initiative: Southern California Bight Test Bed, 23-30 October 2016
Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

NMFS Untrawlable Habitat Strategic Initiative (UHSI) Team completed the first year of field research in the Southern California Bight. This team is made up of researchers from the Southwest, Northwest, Alaska, and Southeast Fisheries Science Centers along with academic partners. The goal of this project is to further our understanding of the effects of mobile survey vehicles on the behavior of rockfish species living in deep rocky habitats. Surveillance platforms with paired visual and acoustic (DIDSON) cameras were launched from the F/V *Velero IV* and positioned on the seafloor by the DeepWorker manned submersible (Figure 8). Data collected from these platforms will be used to observe rockfish movement and behavior in response to a SeaBED AUV (launched from NOAA R/V *Rueben Lasker*) and a manned submersible in order to estimate efficiency of these survey tools to count and measure demersal rockfish species.

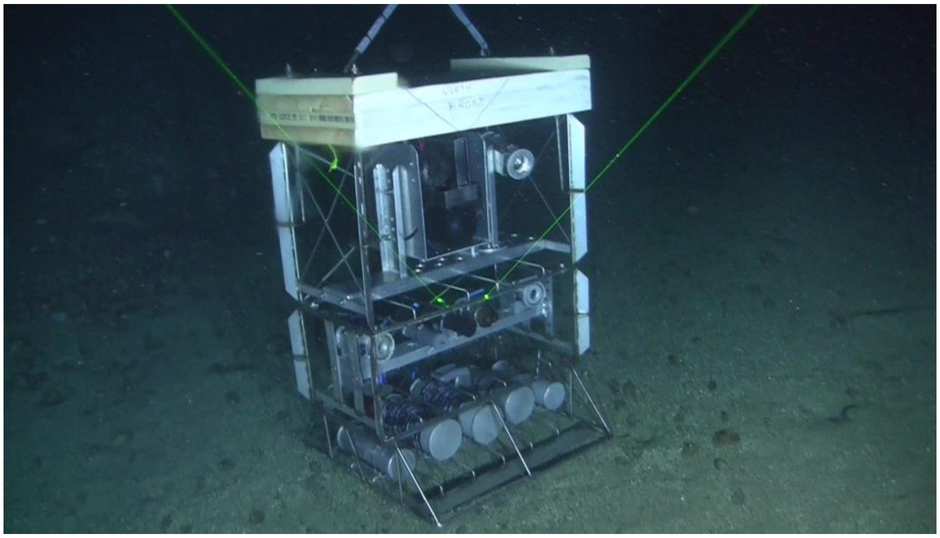


Figure 8. A surveillance platform resting on the seafloor. Lower level contains the computers and batteries, middle level contains the stereo cameras and other instrumentation, and upper level houses the DIDSON sonars and the strobe for the cameras. Image was taken from the manned submersible. For reference, the green lasers are 20 cm apart.

Two surveillance platforms were deployed each day during daylight hours on the top of Footprint Bank at depths of 120 and 130 m. To test the fish reactions, the survey vehicles were flown past the surveillance platforms at a similar speed and height above the seafloor used during visual rockfish surveys. During the study, we successfully completed 12 passes near the platforms with the AUV and 15 passes with the manned submersible. Different experiments (lighting, using a rope as a proxy for a tether) were performed with the submersible that can help us in determining why the fish may react to the vehicles. Over 23,000 paired images (one color and one black and white) were shot during the study.

We have begun to analyze the images to determine baseline numbers of fishes, as determined during periods of undisturbed behavior (quiet times) of fishes when no survey vehicle exerts an impact on the fishes. Using these data we can assess the potential for fish responses when a survey vehicle is in the area of the platform. Baseline values will be determined by counting the number of fishes of each species for a set time (approximately 4 min) before and after a survey passes near a platform. After baseline data are collected, we will determine the number and height above the seafloor along with a measurement total length for individual fishes during periods when a survey vehicle passes near the surveillance platforms (Figure 9). Finally, we will ascertain the fish’s reaction by measuring the distances and directions travelled by individual fishes in response to survey vehicles.

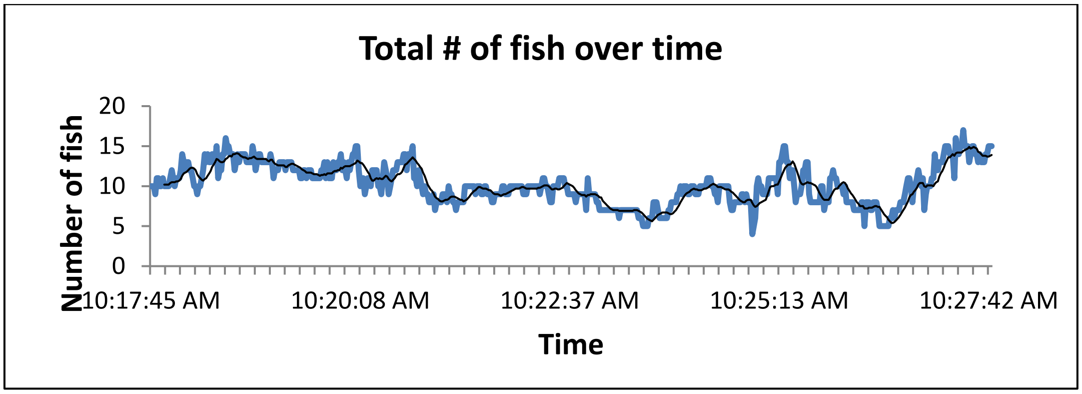


Figure 9: The variability in number of fishes over time in front of one surveillance platform during a 10 min baseline count when no survey vehicles were near the platform.

This is the first year of a multi-year study by the UHSI team in southern California. A second platform survey will be conducted in early FY18 on the same bank as the FY17 study. During the remainder of FY17, we will retool our surveillance platforms to overcome some of the issues encountered during the surveys (including lighting and time between images) and continue to analyze the stereo camera images.

In a related study on spectral sensitivity and reflectance of rockfishes, we collected 18 different species of rockfish from southern California. These fishes were analyzed by researchers from Alaska Fisheries Science Center and Cornell. Most rockfishes had visual pigments that were most responsive to wavelengths of ~445 and ~500nm. This information allows us to build filters or use lights with wavelengths outside the visual range of the fishes and still be able to illuminate the fishes enough for species identification.

D5. Complete Habitat Use Database (HUD) Upgrade
Contact: Joseph Bizzarro (joseph.bizzarro@noaa.gov)

During 2015-2016, the structure and content of the West Coast Groundfish Habitat Use Database (HUD) were substantially modified and upgraded and entry of all available spatial data was completed for approximately half of the 117 species of groundfish identified in the current PFMC Groundfish Fishery Management Plan (FMP). In 2016-2017, data entry will be completed for the remaining FMP species.

D6. Update California Substratum Map for Cross-Shelf Benthic Habitat Suitability Modeling
Contact: Joseph Bizzarro (joseph.bizzarro@noaa.gov)

A collaborative effort between NOS, NMFS, and BOEM personnel to create habitat suitability models for corals and infaunal invertebrates was initiated during 2016 and will continue for two years. A substratum map of the region offshore of California was initially created for the 2005 PFMC review of EFH for West Coast groundfishes and merged with a companion map that was produced for the Pacific Northwest, but has not since been updated. The region off Washington and Oregon, however, have been substantially updated with new information, and contain a more detailed estimation of seafloor induration (soft, mixed, hard categories) than the California substrate map (soft, hard). Additionally, the updated map recently was extended to include the region of Northern California from the Oregon border to Fort Bragg. Effort currently is being devoted to updating the coast-wide substratum map for the region of California south of Fort Bragg. This update is a necessary precursor to coral and infauna modeling efforts for the overall project.

D7. Create Diet Composition Database
Contact: Joseph Bizzarro (joseph.bizzarro@noaa.gov)

In its current format, the HUD documents spatial information for FMP groundfish species. Predator and prey information is contained in a very generalized manner. The incorporation of quantitative diet composition data, using the 47 prey categories that were established during the recent 5-year EFH review, would add considerable utility to the database and make it a complete ecological repository for all FMP groundfishes. A queriable database that contains all documented information on the spatial associations and trophic relationships of FMP groundfishes would be of great value for the consideration of ecological approaches to fisheries management. It also could be used to identify data gaps and focus future research efforts, including hypothesis testing and meta-analyses, and to inform data collection priorities during the West Coast Groundfish Bottom Trawl Survey. Quantitative diet composition information already has been collected and synthesized for 18 FMP groundfish species. The goal during 2017-18 is to locate, synthesize, and enter diet composition data for the remaining 99 species, resulting in the creation of a complete ecological database for all FMP groundfishes.

D8. Investigate ecological relationships among U.S. Pacific coast groundfishes
Contact: Joseph Bizzarro (joseph.bizzarro@noaa.gov)

During 2015-2016, a study of the diet composition and foraging ecology of 18 FMP groundfish species was completed and is available online at Environmental Biology of Fishes (Bizzarro et al 2016). Building on the findings and limitations of this study and the progression of studies D5 and D7, an expanded ecological study will be initiated to incorporate several additional species and investigate both aspects of the ecological niche – spatial associations and trophic relationships. This project also will enable the investigation of spatio-temporal dietary variation, which is believed to be a major driver of dietary differences but was beyond the scope of the original study. A better understanding of the major prey taxa of groundfishes, identification of important foraging habitats, and the determination of ecological guilds have major implications for the development of ecosystem-based management approaches to groundfishes. The findings of this research will be submitted to a leading, peer-reviewed journal for publication.

D9. Community sustainability cooperatives (Economics Team)
Contact: Aaron Mamula (aaron.mamula@noaa.gov)
Investigators: Rosemary Kosaka (FED, SWFSC) and Aaron Mamula (FED, SWFSC)

Groundfish harvesters operating along California's Central Coast differ in important ways from groundfish vessels operating at higher latitudes. In particular, Central California groundfish firms tend to produce at lower volumes and tend to be less vertically integrated than firms fishing north of $40°10'$N. latitude. When the limited entry groundfish trawl fishery adopted the used of individual transferable quota in 2011 there was concern on the part of some California fishing communities that the new management regime would disadvantage California groundfish harvesters due to their limited ability to exploit economies of scale. In order to prevent groundfish quota and groundfish landings from leaving their local economies, several communities in California organized community quota funds (CQFs). The overarching goal of these CQFs was to maintain local groundfish landings by acquiring quota share. To pursue this goal the CQFFs leasing quota pounds to local vessels, on the condition that landings be made in the CQF's homeport. In FY2016 we conducted structured interviews with members of two California fishing communities that have formed CQFs for purposes of acquiring groundfish quota: Morro Bay, California and Monterey/Moss Landing California. We developed six distinct questionnaires which were administered to members of six groups within each fishing community: i) groundfish fishermen, ii) groundfish buyers/processors, iii) community quota fund paid employees, iv) community quota fund non-compensated board members, v) civic leaders, vi) dockside business owners.

In FY2017 we will be analyzing the interview results and developing questionnaires for a follow-up. We plan to follow-up with respondents to the original survey as well as extend the study to include some newly formed CQFs in California (Half-Moon Bay and Fort Bragg have recently formed CQFs). The primary goal of our study is to understand the regional economic impacts of CQFs and to assess the degree to which they can reduce economic uncertainty in vulnerable fishing communities.

D10. Social networks and peer effects among groundfish fishermen (Economics Team)
Contact: Aaron Mamula (aaron.mamula@noaa.gov)
Investigators: Aaron Mamula (FED, SWFSC), Nancy Haskell (University of Dayton), Trevor Collier (University of Dayton)

Prior to the imposition of individual transferable quotas (the 'Catch Share Program') in the West Coast groundfish fishery, vessel participation in formal harvesting cooperatives was limited. Since 2011, there has been a notable rise in the number of formal harvesting cooperatives operating in the fishery. These cooperatives operate in a variety of ways: Bycatch Risk Pools aim to reduce harvesters' operational uncertainty by providing a type of insurance against unexpected harvest of constraining species, Groundfish Marketing Associations focus on improving market conditions for fishermen through brandings and marketing, and Community Quota Funds attempt to stabilize groundfish landings in particular port areas by supplying local fishermen with quota in the amounts and species-designations required to keep local vessels active. Although harvesting cooperatives tend to differ in operational methods, they work on the common principal that individual information pooled as a collective can increase productive efficiency and profitability of the harvesting sector. In late FY2016 we initiated a research project to empirically evaluate the benefits to fishing firms of participation in harvesting cooperatives. The focus of this project is to compare changes in economic and financial success of members of formal harvesting cooperatives relative to non-members. In FY2017 we will continue to refine spatial econometric models of fishing in order to test for effects of informational exchange on fishing success.

D11. VMS logbook matching update (Economics Team)

Contact: Aaron Mamula (aaron.mamula@noaa.gov)

The SWFSC/FED/Economics group has been working with high resolution spatial data collected from vessel monitoring systems for several years. The goals of this work have been discussed in previous TSC updates but will be summarized here for completeness. Along the U.S. West Coast VMS is used primarily to enforce moratoria on fishing in various federally mandated closed areas and, as such, applies principally to groundfish fishing vessels. One goal of our work with VMS data is to create more detailed maps of the spatial distribution of groundfish fishing effort. Trawl and fixed-gear logbooks provide starting and ending positions of fishing events. VMS data, because they record vessel locations which are updated hourly, can be used with logbook and observer data to create more detailed maps of where groundfish fishing effort actually occurs. A second goal of our work with VMS data is to evaluate the spatial distributions of non-groundfish fishing effort. Since VMS units are required on all West Coast fishing vessels that have the potential to interact with groundfish, the data can be used to assess the location of fishing effort targeting other important West Coast fisheries such as Dungeness crab, salmon, and albacore. In FY2017 we will be updating our VMS data feed from NOAA Office of Law Enforcement and continuing our work on integrating VMS data into our existing groundfish data pipeline.

D12. California Saltwater Sportfishing Survey (Economics Team)

Contact: Rosemary Kosaka (rosemary.kosaka@noaa.gov)
Investigators: Rosemary Kosaka (FED, SWFSC)

The California Salwater Sportfising Survey was implemented in 2014 to collect information about angler effort, participation, expenditures, and preferences for different regulatory tools and target species, particularly California groundfish. Effort and participation estimates are underway and a summary report is anticipated by the end of FY2017.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2016 – PRESENT

E1. Primary Literature Publications

Bizzarro, J. J., M. M. Yoklavich, and W. W. Wakefield. 2016. Diet composition and foraging ecology of U.S. Pacific Coast groundfishes with applications for fisheries management. Environmental Biology Fishes. Online version doi:10.1007/s10641-016-0529-2.

Bizzarro, J.J., Peterson, A.N., Blaine, J.M., Balaban, J.P., Greene, H.G., and Summers, A.P. 2016. Burrowing behavior, habitat, and functional morphology of the Pacific Sand Lance (*Ammodytes personatus*). Fishery Bulletin 114: 445–460.

Bjorkstedt, E.P., J.C. Field, M. Love, L. Rogers-Bennett, and R. Starr. 2016. Marine fisheries. In: Harold Mooney and Erika Zavaleta (eds.), Ecosystems of California, p. 779-815. University of California Press.

Cameron, H., K. Monro, M. Malerba, S. Munch, and D. Marshall. 2016. Why do larger mothers produce larger offspring? A test of classic theory. Ecology 97(12):3452-3459.

Carlisle, A.B., Litvin, S.Y., Madigan, D.J., Lyons, K., Bigman, J.S., Ibarra, M., and Bizzarro, J.J. 2017. Interactive effects of urea and lipid content confound stable isotope results in elasmobranch fishes. Canadian Journal of Fisheries and Aquatic Sciences 74: 419–428.

Collie, J.S., L.W. Botsford, A. Hastings, I.C. Kaplan, J.L. Largier, P.A. Livingston, E. Plaganyi, K.A. Rose, B.K. Wells, and F.E. Werner. 2016. Ecosystem models for fisheries management: finding the sweet spot. Fish and Fisheries 17(1):101-125.

Deyle, E.R., R.M. May, S.B. Munch, and G. Sugihara. 2016. Tracking and forecasting ecosystem interactions in real time. Proceedings of the Royal Society B 283(1822):20152258 (9 p.).

Dick, E.J., S. Beyer, M. Mangel, and S. Ralston. 2017. A meta-analysis of fecundity in rockfishes (genus Sebastes). Fisheries Research 187:73-85.

Eddy, T.D., H.K. Lotze, E.A. Fulton, M. Coll, C.H. Ainsworth, J.N. de Araujo, C.M. Bulman, A. Bundy, V. Christensen, J.C. Field, N.A. Gribble, M. Hasan, S. Mackinson, and H. Townsend. 2017. Ecosystem effects of invertebrate fisheries. Fish and Fisheries 18(1):40-53.

Elliott, M.L., A.E. Schmidt, S. Acosta, R. Bradley, P. Warzybok, K.M. Sakuma, J.C. Field, and J. Jahncke. 2016. Brandt's cormorant diet (1994-2012) indicates the importance of fall ocean conditions for northern anchovy in central California. Fisheries Oceanography 25(5):515-528.

Hamilton, S.L., C. A. Logan, H. W. Fennie, S. M. Sogard, J. P. Barry, A. D. Makukhov, L. R. Tobosa, K. Boyer, C. F. Lovera, and G. Bernardi. 2017. Species-specific responses of juvenile rockfish to elevated *p*CO2: from behavior to genomics. PLOS ONE 12(1): e0169670.

He, X., J.C. Field, D.E. Pearson, and L.S. Lefebvre. 2016. Age sample sizes and their effects on growth estimation and stock assessment outputs: Three case studies from U.S. West Coast fisheries. Fisheries Research 180:92-102.

Kemper, J.M., Bizzarro, J.J., and Ebert, D.A. 2017. Dietary variability in two common Alaskan skates (*Bathyraja interrupta* and *Raja rhina*). Marine Biology 164: 52.

Laidig, T.E., and M.M. Yoklavich. 2016. A comparison of density and length of Pacific groundfishes observed from 2 survey vehicles: a manned submersible and a remotely operated vehicle. Fishery Bulletin 114(4):386-396.

Lefebvre, L.S., A.M. Payne, and J.C. Field. 2016. Reproductive dynamics of Pacific sanddab, Citharichthys sordidus, off the central coast of California. Journal of Sea Research 107(pt.1):100-111.

McClatchie, S., J.C. Field, A.R. Thompson, T. Gerrodette, M. Lowry, P.C. Fiedler, W. Watson, K.M. Nieto, and R.D. Vetter. 2016. Food limitation of sea lion pups and the decline of forage off central and southern California. Royal Society Open Science 3(3):150628 (9 p.).

Miller, Rebecca R., John C. Field, Jarrod A. Santora, Melissa H. Monk, Rosemary Kosaka, and Cynthia Thomson. In press. Spatial valuation of California marine fisheries as a ecosystem service. Canadian Journal of Fisheries and Aquatic Sciences.

Monk, M.H., R.R. Miller, J. Field, E.J. Dick, D. Wilson-Vandenberg, and P. Reilly. 2016. Documentation for California Department of Fish and Wildlife's Onboard Sampling of the Rockfish and Lingcod Commercial Passenger Fishing Vessel Industry in Northern and Central California (1987-1998) as a relational database. NOAA Technical Memorandum NMFS-SWFSC-558. 63 p.

Sakuma, K.M., J.C. Field, N.J. Mantua, S. Ralston, B.B. Marinovic, and C.N. Carrion. 2016. Anomalous epipelagic micronekton assemblage patterns in the neritic waters of the California Current in spring 2015 during a period of extreme ocean conditions. CalCOFI Reports 57:163-183.

Santora, J.A., W.J. Sydeman, I.D. Schroeder, J.C. Field, R.R. Miller, and B.K. Wells. 2017. Persistence of trophic hotspots and relation to human impacts within an upwelling marine ecosystem. Ecological Applications 27(2):560-574.

Sogard, S.M., and S.A. Berkeley. 2017. Patterns of movement, growth, and survival of adult sablefish (*Anoplopoma fimbria*) at contrasting depths in slope waters off Oregon. Fishery Bulletin 115(2):233-251

Starr, R.M., M.G. Gleason, C.I. Marks, D. Kline, S. Rienecke, C. Denney, A. Tagini, and J.C. Field. 2016. Targeting abundant fish stocks while avoiding overfished species: video and fishing surveys to inform management after long-term fishery closures. PLoS ONE 11(12):e0168645 (23 p.).

Thompson A.R., J.R. Hyde, W. Watson, D.C. Chen, and L.W. Guo. 2016. Rockfish assemblage structure and spawning locations in southern California identified through larval sampling. Marine Ecology Progress Series 547:177-192.

Vincenzi, S., A.J. Crivelli, S. Munch, H.J. Skaug, and M. Mangel. 2016. Trade-offs between accuracy and interpretability in von Bertalanffy random-effects models of growth. Ecological Applications 26(5):1535-1552.

Vincenzi, S., M. Mangel, D. Jesensek, J. Carlos Garza, and A.J. Crivelli. 2016. Within- and among-population variation in vital rates and population dynamics in a variable environment. Ecological Applications 26(7):2086-2102.

Yoklavich, M., M.E. Clarke, T. Laidig, E. Fruh, L. Krigsman, J. Anderson, J. Taylor, and C. Romsos. 2016. A characterization of deep-sea coral and sponge communities in areas of high bycatch in bottom trawls off northern California. NOAA Technical Memorandum NMFS-SWFSC-556. 39 p.

E2. Other Publications

Cope, J.M., D. Sampson, A. Stephens, M. Key, P.P. Mirick, M. Stachura, T.S. Tsou, P. Weyland, A. Berger, T. Buell, E. Councill, E.J. Dick, K.H. Fenske, M. Monk, and B.T. Rodomsky. 2016. Assessments of California, Oregon and Washington stocks of black rockfish (Sebastes melanops) in 2015. Pacific Fishery Management Council, Portland, Oregon. 402 p.

Dick, E.J., and N. Grunloh. 2017. Bias in estimation of biological reference points when three-parameter stock-recruit relationships are considered appropriate: An extension of the results of Mangel et al. 2013. In: Report of the Groundfish Productivity Workshop of the Pacific Fishery Management Council's Scientific and Statistical Committee (NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington, December 6-8, 2016), p. 8-9. March 2017 Briefing Book, Agenda item I.2, Attachment 2. Pacific Fishery Management Council, Portland, Oregon.

He, X., and J.C. Field. 2017. Effects of recruitment variability and fishing history on estimation of stock-recruit relationships: Three case studies from U.S. West Coast fisheries. In: Report of the Groundfish Productivity Workshop of the Pacific Fishery Management Council's Scientific and Statistical Committee (NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington, December 6-8, 2016), p. 14-15. March 2017 Briefing Book, Agenda item I.2, Attachment 2. Pacific Fishery Management Council, Portland, Oregon.

Munch, S. 2017. Meta-analysis comparing parametric and non-parametric stock-recruit models. In: Report of the Groundfish Productivity Workshop of the Pacific Fishery Management Council's Scientific and Statistical Committee (NOAA Fisheries, Alaska Fisheries Science

Center, Seattle, Washington, December 6-8, 2016), p. 12-14. March 2017 Briefing Book, Agenda item I.2, Attachment 2. Pacific Fishery Management Council, Portland, Oregon.
Sakuma, K. 2016. Cruise report, NOAA Ship Reuben Lasker RL-06-03, April 26 - June 12, 2016: Rockfish recruitment and ecosystem assessment. NOAA National Marine Fisheries Service, SWFSC Fisheries Ecology Division, Santa Cruz, California. 19 p.

STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2016

Prepared for the Fifty-eighth Annual Meeting of the Technical Subcommittee of the Canada-United States Groundfish Committee

With new contributions from:
Mike Byerly, Bob Chadwick, Miranda Westphal, Barbi Failor, Dr. Kenneth J. Goldman, Andrew Olson, Lee Hulbert, Mike Jaenicke, Kevin McNeel, Scott Meyer, Jan Rumble, Elisa Russ, Gail Smith, Nathaniel Nichols, and Carrie Worton

April 2017

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION of COMMERCIAL FISHERIES & DIVISION of SPORT FISH
Capital Office Park
1255 W. 8th Street
Juneau, AK 99802-5526

TABLE OF CONTENTS

STATE OF ALASKA GROUNDFISH FISHERIES AND ASSOCIATED INVESTIGATIONS IN 2016

AGENDA ITEM VII. REVIEW OF AGENCY GROUNDFISH RESEARCH, STOCK ASSESSMENT, AND MANAGEMENT

I. Agency Overview

1. Description of the State of Alaska commercial groundfish fishery program

The Alaska Department of Fish and Game (ADF&G) has jurisdiction over all commercial groundfish fisheries within the internal waters of the state and to three nautical miles offshore along the outer coast. A provision in the federal Gulf of Alaska (GOA) Groundfish Fishery Management Plan (FMP) gives the State of Alaska limited management authority for demersal shelf rockfish (DSR) in federal waters east of 140º W. longitude. The North Pacific Fisheries Management Council (Council) took action in 1997 to remove black and blue rockfish from the GOA FMP. In 2007 the dark rockfish was removed from both the GOA and the Bering Sea and Aleutian Islands (BSAI) FMP. Thus in these areas the state manages these species in both state and federal waters. The state also manages the lingcod resource in both state and federal waters of Alaska. The state manages some groundfish fisheries occurring in Alaska waters in parallel with NOAA Fisheries, adopting federal seasons and, in some cases, allowable gear types as specified by NOAA Fisheries. The information related in this report is from the state-managed groundfish fisheries only.

The State of Alaska is divided into three maritime regions for marine commercial fisheries management. The Southeast Region extends from the Exclusive Economic Zone (EEZ) equidistant line boundary in Dixon Entrance north and westward to 144º W. longitude and includes all of Yakutat Bay (Appendix II). The Central Region includes the Inside and Outside Districts of Prince William Sound (PWS) and Cook Inlet including the North Gulf District off Kenai Peninsula. The Westward Region includes all territorial waters of the Gulf of Alaska south and west of Cape Douglas and includes North Pacific Ocean waters adjacent to Kodiak, and the Aleutian Islands as well as all U.S. territorial waters of the Bering, Beaufort, and Chukchi Seas.

a. Southeast Region

The **Southeast Region** Commercial Fisheries groundfish staff is located in Sitka, Juneau, and Petersburg. Sitka staff is comprised of a fishery biologist, one full-time fishery technician, and a seasonal technician. Staff in Juneau includes the project leader and two full time fishery biologists, and Petersburg staff contains a fishery biologist and a seasonal fishery technician. In addition, the project provides support for port samplers in Ketchikan to allow sampling of groundfish landings at this port. The project also receives biometric assistance from ADF&G headquarters in Juneau.

The **Southeast Region's** groundfish project has responsibility for research and management of all commercial groundfish resources in the territorial waters of the Eastern Gulf of Alaska as well as in federal waters for demersal shelf rockfish (DSR), black, blue, and dark rockfishes, and lingcod. The project cooperates with the federal government for management of the waters of the adjacent EEZ. The project leader participates as a member of the Council Gulf of Alaska Groundfish Plan Team and produces the annual stock assessment for DSR for consideration by the Council.

Project activities center around fisheries monitoring, resource assessment, and in-season management of the groundfish resources. In-season management decisions are based on data collected from the fisheries and resource assessment surveys. Primary tasks include fish ticket collection, editing, and data entry for both state and federally-managed fisheries; dockside sampling of sablefish, lingcod, Pacific cod, and rockfish landings; and logbook collection and data entry. Three resource assessment surveys and a marking survey were conducted in 2015. The ADF&G vessel the R/V *Medeia* is home ported in Juneau and is used to conduct the biennial sablefish marking survey, which was conducted in 2015.

b. Central Region

The **Central Region** groundfish staff is headquartered in Homer and consists of a regional groundfish/shellfish management biologist, a regional groundfish/shellfish research project leader, a groundfish port sampling and age reading coordinator, who also serves as the assistant area management biologist, a groundfish/shellfish fish ticket processing and data analysis position, one groundfish/shellfish research biologist, one GIS analyst, three to four seasonal technicians, and one commercial groundfish sampler, who also serves as the primary groundfish age reader. A seasonal commercial groundfish sampler is located in Cordova and in Seward. Regional support is located in Anchorage. The regional groundfish management biologist serves as a member of the Council's Gulf of Alaska Groundfish Plan Team, the groundfish/shellfish research biologist serves on the Council's Scallop Plan Team, and the research project leader serves as a member of the Kasitsna Bay Lab Science Board. The age reading coordinator is the outgoing Chair of the Committee of Age Reading Experts (CARE), a Working Group of the Technical Subcommittee (TSC). The R/V *Pandalus*, home ported in Homer, and the R/V *Solstice*, in Cordova, conduct a variety of groundfish and shellfish research activities in Central Region waters.

Groundfish staff responsibilities include research and management of groundfish species harvested in state waters of **Central Region,** which includes Cook Inlet (CI) and Prince William Sound (PWS) areas, as well as in federal waters for black, blue, and dark rockfishes, and lingcod. Within Central Region, groundfish species of primary interest include sablefish, Pacific cod, walleye pollock, lingcod, rockfishes, skates, sharks, and flatfishes. Data are collected through commercial groundfish sampling, fishermen interviews, logbooks, onboard observing, and through ADF&G trawl, pot, and remotely operated vehicle (ROV) surveys. Commercial harvest information (fish tickets) is processed in Homer for state and federal fisheries landings in Central Region ports. For some fisheries, logbooks are required and data is collected and entered into local databases to provide additional information, including catch composition, catch per unit effort, depth, and location data.

c. Westward Region

The **Westward Region** Groundfish management and research staff is located in Kodiak and Dutch Harbor. Kodiak staff is comprised of a regional groundfish management biologist, an area groundfish management biologist, an assistant area groundfish management biologist, a groundfish research project leader, a groundfish research project assistant biologist, a groundfish dockside sampling coordinator, a trawl survey biologist, two seasonal fish ticket processing technicians, and several seasonal dockside samplers. A full-time area management biologist, an assistant area groundfish management biologist and a seasonal fish ticket processing technician are located in the Dutch Harbor office. Seasonal dockside sampling also occurs in Chignik, Sand Point, and King Cove. The R/V *Resolution*, R/V *K-Hi-C*, and R/V *Instar* hail from Kodiak and conduct a variety of groundfish related activities in the waters around Kodiak, the south side of the Alaska Peninsula, and in the eastern Aleutian Islands.

Major groundfish activities include: fish ticket editing and entry for approximately 15,000 tickets from both state and federal fisheries; analysis of data collected on an annual multi-species trawl survey encompassing the waters adjacent to the Kodiak archipelago, Alaska Peninsula, and Eastern Aleutians; management of black rockfish, state-waters Pacific cod, lingcod, and Aleutian Island state-waters sablefish fisheries; conducting dockside interviews and biological data collections from commercial groundfish landings; and a number of research projects. In addition, the Westward Region has a member on the Council Bering Sea/Aleutian Island Groundfish Plan Team (Dave Barnard) and the Gulf of Alaska Groundfish Plan Team (Mark Stichert).

d. Headquarters

The 1996 Magnuson-Stevens Act called for developing regional fishery databases coordinated between state and federal agencies. The Alaska Fisheries Information Network (AKFIN), created in 1997, accomplishes this objective. The AKFIN program provides the essential fishery catch data needed to manage Alaska’s groundfish and crab resources within the legislative requirements of the Act in Section 303(a) 5. Alaska has diverse data collection needs that are similar to other states. But the extensive geographic area and complexity of fisheries management tools used in Alaska have resulted in AKFIN becoming a cooperative structure that is responsive to the needs to improve data collection. The Pacific States Marine Fisheries Commission (PSMFC) manages the AKFIN grant with the funding shared by the ADF&G statewide AKFIN contract and the PSMFC sponsored AKFIN Support Center (AKFIN-SC) in Portland, Oregon. The ADF&G has primary responsibility for the collection, editing, maintenance, analysis, and dissemination of these data and performs this responsibility in a comprehensive program.

The overall goal of ADF&G’s AKFIN program is to provide accurate and timely fishery data that are essential to management, pursuant to the biological conservation, economic and social, and research and management objectives of the fishery management plans for groundfish and crab. The specific objectives related to the groundfish fisheries are:

1) to collect groundfish fishery landing information, including catch and biological data, from Alaskan marine waters extending from Dixon Entrance to the BSAI;

2) to determine ages for groundfish samples using age structures (as otoliths, vertebrae, and spines) arising from statewide commercial catch and resource survey sampling conducted by ADF&G;
3) to provide the support mechanisms needed to collect, store, and report commercial groundfish harvest and production data in Alaska;
4) to integrate existing fishery research data into secure and well maintained databases with consistent structures and definitions;
5) to increase the quality and accuracy of fisheries data analysis and reporting to better meet the needs of ADF&G personnel, AKFIN partner agencies, and the public, and to make more of this information available via web-access while maintaining the department's confidentiality standards;
6) to provide GIS services for AKFIN fishery information mapping to ADF&G Division of Commercial Fisheries personnel and participate in GIS and fishery data analyses and collaboration with other AKFIN partner agencies; and
7) to provide internal oversight of the AKFIN contract between the ADF&G and the PSMFC.

Groundfish species include walleye pollock, Pacific cod, sablefish, skates, various flatfish, various rockfish, Atka mackerel, lingcod, sharks, and miscellaneous species.

The foundation of the state's AKFIN project is an extensive port sampling system for collection and editing of fish ticket data from virtually all of the major ports of landing from Ketchikan to Adak and the Pribilof Islands, with major emphasis on Sitka, Homer, Kodiak, and Dutch Harbor. The port sampling program includes collection of harvest data, such as catch and effort, and also the collection of biological data on the species landed. Age determination is based on samples of age structures collected from landed catches. A dockside sampling program provides for collection of accurate biological data (e.g., size, weight, sex, maturity, and age) and verifies self-reported harvest information submitted on fish tickets from shoreside deliveries of groundfish throughout coastal Alaska. In addition, the Gulf of Alaska Groundfish FMP and the Bering Sea and Aleutian Islands Groundfish FMP require the collection of groundfish harvest data (fish tickets) in the north Pacific. The AKFIN program is necessary for management and for the analytical and reporting requirements of the FMPs.

The state's AKFIN program is supported by a strong commitment to development and maintenance of a computer database system designed for efficient storage and retrieval of the catch and production data on a wide area network and the internet. It supports the enhancement of the fish ticket information collection effort including regional fishery monitoring and data management; GIS database development and fishery data analysis; catch and production database development and access; the Age Determination Unit laboratory; database management and administration; fisheries data collection and reporting; and fisheries information services.

Local ADF&G personnel maintain close contact with fishers, processors and enforcement to maintain a high quality of accuracy in the submitted fish ticket records. Groundfish landings are submitted electronically from the interagency electronic reporting system, eLandings, to the eLandings repository database. Signed copies of the fish tickets are submitted to the local office offices of the ADF&G within seven days of landing. Data is reviewed, compared to other observations, edited and verified. Once data processed by local staff members, the fish ticket data is pulled into the ADF&G database of record, the statewide groundfish fish ticket database. Fish ticket data is immediately available to in-season management via the analysis and reporting tool, OceanAK. Verified fish ticket data is also available immediately after processing from this tool, as well.

Within the confines of confidentiality agreements, raw data are distributed to the National Marine Fishery Service (NOAA Fisheries, both the Alaska Regional office and the Alaska Fishery Science Center), the Council, the Commercial Fisheries Entry Commission (CFEC), and the AKFIN Support Center on a regularly scheduled basis. Summary groundfish catch information is also provided to the Pacific States Fisheries Information Network (PACFIN), the State of Alaska Board of Fisheries (BOF), NOAA Fisheries, Council and the AKFIN Support Center.

The fishery information collected by the AKFIN program is not only essential for managers and scientists who must set harvest levels and conserve the fisheries resources, but it is also valuable for the fishermen and processors directly involved in the fisheries, as well as the general public. To meet those needs, the department has designed, implemented, and continues to improve database systems to store and retrieve fishery data, and continues to develop improvements to fishery information systems to provide data to other agencies and to the public.

Groundfish fishery milestones for this ongoing ADF&G AKFIN program are primarily the annual production of catch records and biological samples. In calendar year 2016, ADF&G AKFIN personnel processed 17,524 groundfish fish tickets, collected 25,667 groundfish biological samples and measured 10,094 age structures (see tables below for regional breakdown). These basic measures of ongoing production in support of groundfish marine fisheries management by AKFIN funded ADF&G personnel are representative of the level of annual productivity by the AKFIN program since its inception in 1997 (Contact Lee Hulbert).

Groundfish Fish Tickets Processed - Calendar Year 2016

ADF&G Region		
1 - Southeast		3,161
2 - Central		2,340
4 - Westward; Kodiak, AK Pen.		10,669
4 - Westward; BSAI		1,354
	Total	17,524

Groundfish Biological Data Collection - Calendar Year 2016

ADF&G Region	AWL Samples Collected	Age Estimates Produced by Regional Personnel	Age Estimates Produced by the Age Determination Unit
1 - Southeast	5,521	none	4,506
2 - Central	11,637	1,634	773
4 - Westward	8,509	3,181	N/A
Total	25,667	4,815	5,279

Interagency Electronic Reporting System - eLandings (Contact Gail Smith).

ADF&G maintains a commercial harvest database, based on landing report receipts – fish tickets. These data are comprehensive for all commercial salmon, herring, shellfish, and groundfish from 1969 to present. Data are stored in an Oracle relational database and available to Headquarters and regional staff via the state wide reporting tool, OceanAK . Data are transferred annually to the Commercial Fisheries Entry Commission, where additional license and value information is merged with all fish ticket records. Once completed, the data are provided to the Alaska Fisheries Information Network (AKFIN) support center, then summarized and made available to Pacific Fisheries Information Network (PacFIN).

Beginning in 2001, the agencies tasked with commercial fisheries management in Alaska (ADF&G, NOAA Fisheries, IPHC) began development of consolidated landing, production, and IFQ reporting from a sole source – the Interagency Electronic Reporting System (IERS). The goal is to move all fisheries dependent data to electronic reporting systems. The web-based reporting component of this system is ***eLandings.*** The desktop application for the at-sea catcher processor fleet is ***seaLandings***. Vessels using the seaLandings application email landing and production reports to the centralized database as an email attachment. ***tLandings*** was developed to address electronic reporting on-board groundfish and salmon tender vessels. The application and the landings reports are stored on a portable thumb drive and are delivered to the shoreside processor for upload to the eLandings repository database. Fisheries management agencies use a separate application, the ***IERS Agency Interface***, to view and edit landing reports. The IERS management/development team have implemented an electronic logbook application, ***eLogbook***, currently used by groundfish catcher processors and longline catcher vessels. The ***eLogbook*** will be expanded to be used for all federal groundfish and crab catcher vessels, in the near future. The IERS has been in successful operation in Alaska's commercial fisheries since August 2005. To date, more than 700,000 landing reports have been submitted to the eLandings repository database.

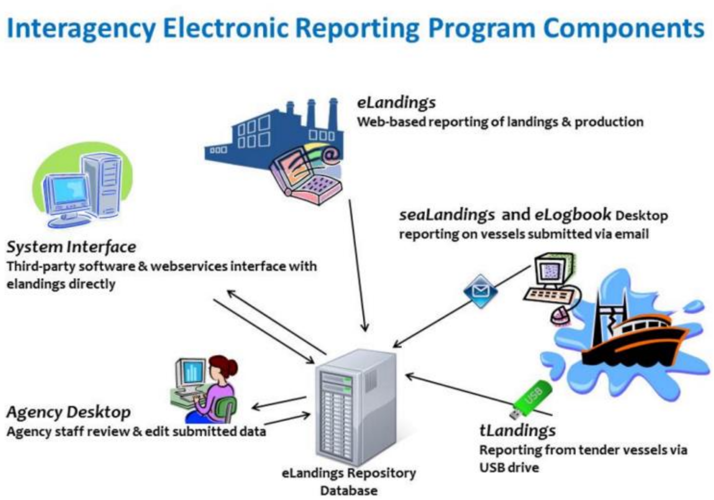


Figure 13. Data is reported by the seafood industry using eLandings web, seaLandings and tLandings. Agency staff review, edit and verify landing and production reports within the

eLandings agency desktop tool. Industry can pull harvest data for their company from the database using the eLandings system interface tools.

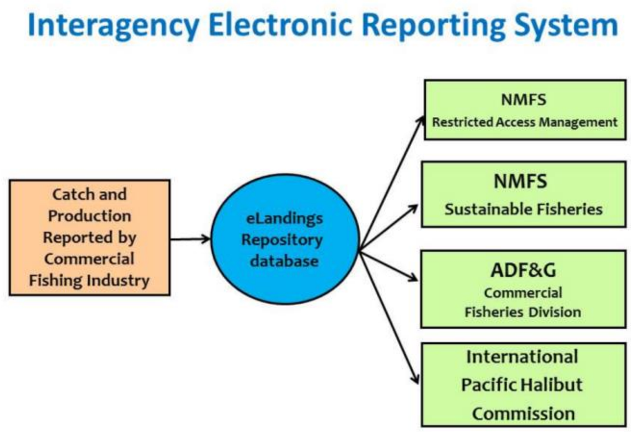


Figure 14. Interagency staff have established methods to pull data from the repository database into their databases of record. The ADF&G fish ticket records are pulled into the commercial fisheries fish ticket database once data verification has occurred.

Our approach, throughout this project, has been staged implementation which allows a small staff to successfully manage this ambitious project. Salmon fisheries are more diverse and seasonal than groundfish and crab fisheries. The ADF&G will always support conventional, paper-based reporting for smaller buyers and processors. November 2015, the ADF&G adopted a regulation to require larger seafood processors to use the tLandings application for all tendered salmon. All tendered groundfish must be reported using the tLandings application, as well. During the 2016 salmon season, 93% percent of all salmon landings were submitted electronically. Statewide shellfish and herring fisheries will be addressed in 2018.

The IERS features include electronic landing and production reports, real time quota monitoring, immediate data validation, and printable (.pdf) fish ticket reports. The IERS provides processors with web-based electronic catch and production data extraction using an XML output. ADF&G personnel, funded by AKFIN, Rationalized Crab Cost Recovery funds and IFQ Halibut/Sablefish Cost Recovery funds, participate in the IERS project on the development, implementation, and maintenance levels. During 2016, the IERS recorded 191,520 landing reports in crab, groundfish and salmon fisheries.

The IERS is extensively documented on a public and secure wiki at https://elandings.alaska.gov/confluence/

Local ADF&G personnel in six locations throughout the state of Alaska (Petersburg, Sitka, Juneau, Homer, Kodiak and Dutch Harbor) maintain close contact with groundfish fishers, processors and state/federal enforcement to maintain a high quality of accuracy in the submitted fish ticket records. The Interagency Electronic Reporting System – eLandings , seaLandings, tLandings and eLogbook applications, with immediate data validation and business rules, has improved data quality and allows personnel to function at a higher level. User support on a 24/7 basis is being provided by GCI, an Alaska based telecommunications company. IFQ reporting support is provided by the NOAA Fisheries Data Technicians.

Landing and production data are submitted to a central database, validated and reviewed, and pulled to the individual agency databases. Landing data are available to agency personnel within seconds of submission of the report. Printable documentation of the landing report and the Individual Fishery Quota debit are created within the applications. Signed fish tickets continue to be submitted to local offices of ADF&G for additional review and comparison to other data collection documents. These documents include vessel/fisher logbooks, agency observer datasets, and dockside interviews with vessel operators.

Detailed data are distributed to the State of Alaska Commercial Fisheries Entry Commission (CFEC) annually. As outlined in State of Alaska statue, 16.05.815, detailed groundfish data are available to the NOAA Fisheries-Alaska regional office from the eLandings repository database. The AKFIN Support Center receives groundfish data on a monthly schedule, which is summarized and provided to the Pacific States Fisheries Information Network (PACFIN). The CFEC merges the ADF&G fish ticket data with fisher permit and vessel permit data. This dataset is then provided to the AKFIN Support Center, which distributes the data to the professional staff of the Council, NOAA Alaska Science Center staff and summarized data to PACFIN. Summary groundfish catch information is also posted on the ADF&G Commercial Fisheries website: http://www.cf.adfg.state.ak.us/geninfo/finfish/grndfish/grndhome.php. Summarized data are provided to the BOF, the Council, and to the State of Alaska legislature as requested.

e. Gene Conservation Laboratory

In the past, the ADF&G Gene Conservation Laboratory collected genetic information on black rockfish, light and dark dusky rockfish, and pollock (a list of *Sebastes* and pollock tissue samples stored at ADF&G's Gene Conservation Laboratory can be found in Appendix III).

f. Age Determination Unit

The Mark, Tag, and Age (MTA) Laboratory's Age Determination Unit (ADU) is the statewide groundfish and invertebrate age reading program based out of Juneau, AK. The ADU is responsible for providing age data support to regional commercial fisheries programs to monitor population health, assess stock size and growth, and research species life history. The ADU also is responsible for monitoring and improving the quality of age data through precision testing of production data and continual training of age readers. During 2016, the ADU received 9,784 otolith sets from central and southeast Alaska commercial and survey sampling (representing 13 groundfish species). The ADU produced 6,358 ages and distributed 4,835 ages to region managers, including data from samples received in previous years but processed in 2016. Age data quality is assessed through precision monitoring using additional, independent estimates. A random 30% of specimens and reads with outlying fish and otolith size-at-age are selected for precision testing (data are compared to estimated ranges from growth models; otolith measurements are described below). Discrepancies between precision tests and original ages are resolved through development of independent age estimates by the disputing readers. During 2016, quality control procedures resulted in an additional 3,534 age estimates. Personnel learn to interpret seasonal banding patterns through training with experienced age readers and independent reading of preprocessed age structures. Trained personnel also continue to calibrate on preprocessed structures to insure consistency of age estimates. Training and calibration procedures resulted in an additional 1,579 age estimates. Given production, quality control, and training procedures, the ADU recorded 11,471 groundfish ages.

Correlations have been found between fish length, otolith morphometrics, and age. The ADU collects otolith measurements and uses them to identify and resolve age estimation, specimen sequence, data entry, and species identification errors. During processing, otolith length, height, and weight are recorded from a minimum of one age structure per fish (17,736 otoliths in 2016, representing 16 groundfish species). To identify possible age estimation errors, the ADU compares fish length, otolith weight, and age to estimated fish and otolith size-at-age ranges for lingcod, yelloweye rockfish, rougheye rockfish, shortraker rockfish, shortspine thornyhead, and sablefish. Estimated sizes-at-age were developed from von Bertalanffy and exponential growth models, and reasonable error ranges per size were entered into a database table.
To ensure consistency of age criteria across programs, the ADU exchanges specimens and data, attends workshops, and presents research through the Committee of Age Reading Experts (CARE; Working Group of the TSC). In 2016, the ADU collaborated with representatives from the Canadian Department of Fisheries and Oceans (CDFO), the Alaska Fisheries Science Center (AFSC), Northwest Fisheries Science Center (NWFSC) to update and edited portions of "The Manual on Generalized Age Determination Procedures for Groundfish" (CARE 2017). Specifically, we updated the section regarding age estimation of sablefish. Also, the ADU finalized results of three age structure exchanges among the ADU, CDFO, and the Washington Department of Fish and Wildlife, reviewed multiagency correspondence, and helped establish workshops for the 2017 meeting. ADF&G personnel also developed and tested an online database for age related publications that will be available through the CARE website. This multiagency catalog of targeted publications will promote current studies regarding age estimation and make information readably accessible to facilitate age estimation, validation, and method standardization.

The ADU is funded by State of Alaska, AKFIN, and special project support. In fiscal year 2016 and 2017, approximately 54% of funding was provided by the State of Alaska, 30% by AKFIN, and 16% from a research grant. During 2016, the ADU employed six people (approximately 49 man months) to age, process samples, enter data, maintain sample archives, measure samples, and complete other support tasks for both groundfish and invertebrates.

2. Description of the State of Alaska sport groundfish fishery program (Sport Fish Division)

ADF&G manages all sport groundfish fisheries within the internal waters of the state, in coastal waters out to three miles offshore, and throughout the EEZ. The Alaska BOF extended existing state regulations governing the sport fishery for all marine species into the waters of the EEZ off Alaska in 1998. This was done under provisions of the Magnuson-Stevens Fishery Conservation and Management Act that stipulate that states may regulate fisheries that are not regulated under a federal fishery management plan or other applicable federal regulations. No sport fisheries are included in the Gulf of Alaska Fishery Management Plan.

Most management and research efforts are directed at halibut, rockfish, and lingcod, the primary groundfish species targeted by the sport fishery. Statewide data collection programs include an annual mail survey to estimate overall harvest (in number of fish) of halibut, rockfishes (all species combined), lingcod, Pacific cod, sablefish, and sharks (all species combined), and a mandatory logbook to assess harvest of selected species in the charter boat fishery. The statewide bottomfish coordinator (Scott Meyer) coordinates or responds to federal data requests and provides scientifically-based advice for assessment and management of halibut and groundfish.

Regional programs with varying objectives address estimation of sport fishery statistics including harvest and release magnitude and biological characteristics such as species, age, size, and sex composition. Research was funded through state general funds and the Federal Aid in Sport Fish Restoration Act. There are essentially two maritime regions for marine sport fishery management in Alaska.

a. Southeast Region Sport Fish

The Southeast Region extends from the EEZ boundary in Dixon Entrance north and westward to Cape Suckling, at approximately 144^{o} W. longitude. Regional staff in Douglas coordinates a data collection program for halibut and groundfish in conjunction with a regionwide Chinook salmon harvest studies project. The project leader, the project biometrician, and the project research analyst are based in Juneau. Beginning in 2014, the Area Management Biologists in Yakutat, Juneau, Sitka, Petersburg, Ketchikan, and Craig were responsible for the onsite daily supervision of the field technicians. A total of 25 technicians worked at the major ports in the Southeast region, where they interviewed anglers and charter operators and collected data from sport harvests of halibut and groundfish while also collecting data on sport harvests of salmon. Biological data collected included lengths of halibut, rockfish, lingcod, and sablefish, sex on black rockfish at Sitka and lingcod, sport sector (charter or unguided), statistical areas fished, and other basic data. Otoliths were collected from black rockfish harvested at Sitka for estimation of age composition. Data summaries were provided to the Alaska BOF, other ADF&G staff, the public, and a variety of other agencies such as the Council, IPHC and NOAA Fisheries.

The Regional Management Coordinator and Area Management Biologists in Yakutat, Haines, Sitka, Juneau, Petersburg, Craig, and Ketchikan are responsible for groundfish management in those local areas. The demersal shelf rockfish and lingcod sport fisheries are managed under the direction of the Demersal Shelf Rockfish Delegation of Authority and Provisions for Management (5 AAC 47.065) and the Lingcod Delegation of Authority and Provisions for Management (5 AAC 47.060) for allocations set by the Alaska Board of Fish.

b. Southcentral Region Sport Fish

The Southcentral Region includes state and federal waters from Cape Suckling to Cape Newenham, including Prince William Sound (PWS), Cook Inlet, Kodiak, the Alaska Peninsula, the Aleutian Islands, and Bristol Bay. The Southcentral Region groundfish staff consisted of two Regional Management Biologists as well as Area Management Biologists and assistants for the following areas: (1) PWS and the North Gulf areas, (2) Lower Cook Inlet, and (3) Kodiak, Alaska Peninsula, and the Aleutian Islands. In addition, a region-wide harvest assessment project was based in the Homer office, consisting of a project leader, project assistant, and six technicians. The research project biometrician was located in Soldotna. Ongoing assessment of sport harvest and fishery characteristics at major ports throughout the region includes interviews of anglers and charter boat operators and sampling of the sport harvest. Data collected included lengths and sex of halibut, rockfishes, lingcod, sharks, sablefish, and Pacific cod, and age structures from halibut, rockfish, lingcod, and sharks. All age reading was done in Homer, and the staff members are active participants in CARE. Seasonal technicians collected data from the sport harvest at seven major ports in the region, and two of them read rockfish and lingcod age structures. Halibut otoliths were forwarded to the IPHC for age reading.

Southcentral Region staff is responsible for management of groundfish fisheries in state and federal waters. The lack of stock assessment information for state-managed species has prevented development of abundance-based fishery objectives. As a result, management is based on building a conservative regulatory framework specifying bag and possession limits, seasons, and methods and means. Stock status is evaluated by examining time series data on age, size, and sex composition. The lack of stock assessments, coupled with increasing effort and harvest in several groundfish sport fisheries, accentuate the need for developing comprehensive management plans and harvest strategies.

Typical duties included providing sport halibut harvest statistics to IPHC and Council, assisting in development and analysis of the statewide charter logbook program and statewide harvest survey, providing information to the Alaska BOF, advisory committees, and local fishing groups, drafting and reviewing proposals for sport groundfish regulations, and dissemination of information to the public.

IV. Groundfish Research, Assessment and Management

1. Hagfish
    1. Research

In 2016, the Southeast Region began opportunistic sampling for *Eptatretus stoutii* and *E. deani* to gather information on distribution and life history information including: size at maturity, fecundity, sex ratio, length and weight frequencies. Samples were collected in Ernest Sound and Behm Canal using longlined 20-L bucket traps dispersed 5.5 m apart with each trap consisting of 9.5 mm escape holes, 1 kg weight and a 102 mm entry funnel and destruct device. Each set was sampled for count-by-weight (number of hagfish and weight per trap) and a sub-sample of 5 hagfish per trap or 125 per set were frozen and sampled for biological information in the lab. To date 192 hagfish have been sampled with the largest recordings for *E. deani* being 770 mm for female and 620 mm for male. (Contact Andrew Olson)

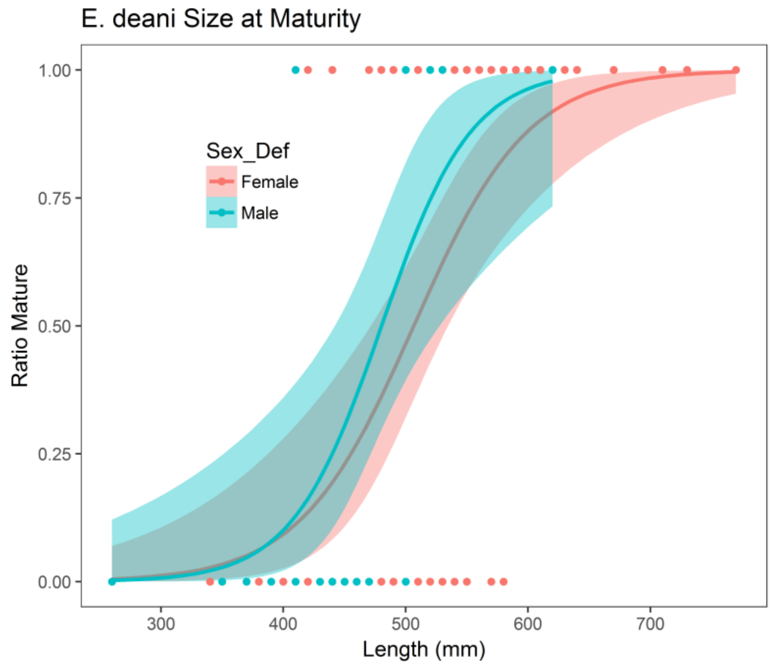


Figure 15. Preliminary size at 50% maturity with 95% confidence intervals for male (480.3 mm, n=36) and female (506.6 mm, n=74) *E. deani* in southern Southeast Alaska.

2. Assessment

There are no stock assessments for hagfish.

3. Management

A commissioner's permit is required before a directed fishery may be prosecuted for hagfish. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes. In 2016, one commissioner's permit was issued for directed fishing of hagfish in the **Southeast Region**.

4. Fisheries

A directed fishery occurred for hagfish in the Southeast region with a guideline harvest level (GHL) of 60,000 lbs. Currently in the **Westward**, **Central**, and **Southeast Regions** hagfish are allowed up to 20% as bycatch in aggregate with other groundfish during directed fisheries for groundfish.

2. Dogfish and other sharks

    a. Research

In 2009, **Central Region** Commercial Fisheries Division began tagging all sharks with spaghetti-type external tags, but discontinued that work after the 2012 field season. A collaboration between ADF&G and NOAA Fisheries staff resulted in the publication of a paper strongly indicating that salmon sharks have a biennial reproductive cycle and a gestation period of no longer than 10 months (Conrath et al. 2014). Another research project on the reproductive biology of salmon sharks via blood hormone concentrations, which was initiated in the summer of 2010, continues with the goal of providing more precise information on the timing and frequency of reproductive activity. A research project examining the energetics of salmon sharks was initiated in the summer of 2012, which includes the concurrent application of temperature/depth transmitters and accelerometers. The department hopes to continue that work in 2017. A collaborative effort led by the National Institute of Polar Research in Japan with collaborators at ADF&G, the University of California at Santa Barbara, the Institute for Ocean Conservation Science at Stony Brook University and the Scottish Oceans Institute's School of Biology at the University of St Andrews, resulted in the publication of a paper on the ecological significance of endothermy in fishes (Watanabe et al. 2015) (Contact Dr. Kenneth J. Goldman).

The **Division of Sport Fish—Southcentral Region** collected harvest and fishery information on sharks through the groundfish harvest assessment program although no specific research objectives were identified. Interviews were conducted representing 2,596 boat-trips and 13,631 angler-days of effort in 2016. Interviewed anglers caught 10 salmon sharks but kept none, and caught 2,323 spiny dogfish and kept 15. Length measurements were obtained from on salmon shark and and four spiny dogfish (Contact Barbi Failor).

    b. Assessment

There is no stock assessment work being conducted on sharks in Central Region (Contact Dr. Kenneth J. Goldman).

    c. Management

The Alaska BOF prohibited all directed commercial fisheries for sharks in 1998. In 2000, the BOF increased the commercial bycatch allowance in **Southeast Region** for dogfish taken while longlining for other species to 35% round weight of the target species and also allowed full retention of dogfish bycatch in the salmon set net fishery in Yakutat. This action was an effort to minimize waste of dogfish in these fisheries and to encourage sale of bycatch. In **Central Region**, bycatch had been set at the maximum allowable retention amount in regulation at 20% of the round weight of the directed species on board a vessel; however, beginning in 2014, allowable bycatch levels were set at 15% by emergency order. In 2004, the BOF amended Cook Inlet Area regulations to provide for a directed fishery for spiny dogfish in the Cook Inlet Area under terms of a Commissioner's permit. Directed fishing for dogfish is also allowed in Southeast Alaska under the terms of a Commissioner's permit but no permits have been issued in recent years.

Also in 2000 the BOF prohibited the practice of "finning", requiring that all sharks retained must be sold or utilized and have fins, head and tail attached at the time of landing. "Utilize" means use of the flesh of the shark for human consumption, for reduction to meal for production of food for animals or fish, for bait or for scientific, display, or educational purposes.

Sport fishing for sharks is allowed under the statewide Sport Shark Fishery Management Plan adopted by the BOF in 1998. The plan recognizes the lack of stock assessment information, the potential for rapid growth of the fishery, and the potential for over harvest, and sets a statewide daily bag limit of one shark and a season limit of two sharks of any species except spiny dogfish which have a daily bag limit of five. Sport demand for sharks continued to be low in 2016.

d. Fisheries

Sharks (which include spiny dogfish) can be harvested as bycatch during directed groundfish fisheries in Cook Inlet and PWS. Commissioner's permits may also be issued although no applications were received in 2016, and no permits have been issued since 2006, in **Central Region**. During 2016 in the Cook Inlet Area, there was minimal harvest (4 lb) of spiny dogfish and in PWS 1.2 mt was harvested.

Estimates of the 2016 sport harvest of sharks are not yet available, but harvest in 2015 was estimated at 125 sharks of all species in Southeast Alaska and 543 sharks in Southcentral Alaska. The precision of these estimates was relatively low; the Southeast estimate had a CV of 46% and the Southcentral estimate had a CV of 33%. The statewide charter logbook program also required reporting of the number of salmon sharks kept in the charter fishery. Charter anglers are believed to account for the majority of the sport salmon shark harvest. Logbooks indicated a charter harvest of eight salmon sharks in Southeast Alaska and 16 salmon sharks in Southcentral Alaska in 2015.

3. Skates

1. Research

In 2009, Central Region Commercial Fisheries Division began tagging all big, longnose and Aleutian skates greater than 70 cm total length with spaghetti-type tags. From 2010 through 2013, all skate species of all sizes were tagged on ADF&G surveys. In addition to ADF&G's interest in skates, tagging was also in support of a UAF doctoral students work (Contact Dr. Kenneth J. Goldman).

2. Assessment

There are no stock assessments for skates.

3. Management

A commissioner's permit is required before a directed fishery may be prosecuted for skates. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

Currently in **Central Region**, skates are harvested as bycatch and had been allowed up to 20% during other directed groundfish fisheries until that allowable amount was reduced to 15% in 2014 and then reduced again by emergency order in 2016 to 5% in order to align with National Marine Fisheries Service (NMFS) change in maximum retainable allowances for skates in the GOA. A directed fishery in the Prince William Sound Area for big and longnose skates was prosecuted under the authority of a Commissioner's permit in 2009 and 2010. However, the fishery was deemed unsustainable, and no permits were issued thereafter. The permit stipulated seasons, district, gear, and a logbook requirement. In the Cook Inlet Area, combined big and longnose skate harvest as bycatch was 21.1 mt in 2016, a large decrease from 74.4 mt harvested in 2015. In PWS, skate harvest was 42.0 mt in 2016, also a large decrease from the amount harvested in 2015, 121.8 mt. Because bycatch limits are set as a percentage of the targeted species, harvest levels of the target species can affect amount of bycatch that are legally harvested. Retention of big skate as incidental catch was closed by emergency order in both Cook Inlet and PWS areas on September 29, 2016 in response to the federal CGOA closure due to the TAC being achieved.

4. Pacific cod

Catch rate and biological information is gathered from fish ticket records, port sampling programs, a tagging program, and during stock assessment surveys for other species. A mandatory logbook program was initiated in 1997 for the state waters of Southeast Alaska. Commercial landings in Southeast, Central Region and the Westward Region are sampled for length, weight, age, sex, and stage of maturity.

1. Research

In the **Central Region**, skipper interviews and biological sampling of commercial Pacific cod deliveries from Prince William Sound (PWS) and Cook Inlet (CI) areas during 2016 occurred in Homer, Seward, and Kodiak. Sample data collected included date and location of harvest, species, length, weight, sex, and gonad condition. Otoliths were collected from approximately 20% of sampled fish. Data is provided to NMFS for use in stock assessment (Contact Elisa Russ).

The **Westward Region** discontinued the cod-tagging program in 2011 that was initiated in 1997 in the Central, Western, and Eastern Gulf of Alaska. Of the 18,529 tagged cod released, a total of 1,272 were recaptured, a tag recovery rate of 6.86%. The last cod tags recovered were in

2015. Fish spent from 1 to 2,503 days (6.86 years) at liberty. While 72% of Pacific cod were recovered within 0.6 – 30 km of their tagging location, much longer recapture distances have occurred. A total of 12 fish were recaptured more than 300 km from their tagging location, the maximum distance recorded was 614 km. The relatively small number of long distance recaptures show movement of cod occurring from the Shumagin Islands and Unalaska into the Bering Sea, the Alaska Peninsula to Kodiak waters, and several fish tagged in Kodiak waters were recovered in Cook Inlet.

2. Assessment

No stock assessment programs were active for Pacific cod during 2016.

3. Management

Regulations adopted by the Alaska BOF during November 1993 established a guideline harvest range (GHR) of 340 to 567 mt for Pacific cod in the internal waters of **Southeast Alaska**. The internal waters of Southeast Alaska are comprised of two areas, the Northern Southeast Inside (NSEI) Subdistrict and the Southern Southeast Inside (SSEI) Subdistrict. The GHR was based on average historic harvest levels rather than on a biomass-based acceptable biological catch (ABC) estimate. This fishery has the most participation in the winter months, and in-season management actions such as small area closures are implemented to spread out the fleet and reduce the risk of localized depletion. Pacific cod in state waters along the outer coast are managed in conjunction with the Total Allowable Catch (TAC) levels set by the federal government for the adjacent EEZ.

In 1996, the BOF adopted Pacific cod Management Plans for fisheries in five groundfish areas, **Prince William Sound**, **Cook Inlet**, **Kodiak**, **Chignik** and **South Alaska Peninsula**. The plans did not restrict participation to vessels qualified under the federal moratorium program. Included within the plans were season, gear and harvest specifications. State-waters fishing seasons were set to begin seven days after the close of the initial federal season in all areas except Cook Inlet Area, which begins 24 hours after the closure. However, in 2011 the BOF adjusted state-waters seasons in Prince William Sound (PWS) for pot gear and jig gear to open 24 hours following the closure of the initial federal season and for longline gear in PWS to open seven days following the initial federal season closure or concurrent with the individual fishing quota (IFQ) halibut season opening date, whichever occurs later. The BOF restricted the state-waters fisheries to pot or jig gear in an effort to minimize halibut bycatch and avoid the need to require onboard observers in the fishery. However, in 2009 a new BOF regulation became effective permitting use of longline gear in PWS. This change was largely in response to the very low levels of effort and harvest and the high level of interest from the longline gear group. Guideline harvest levels (GHL) are allocated by gear type; however, the one exception was longline gear in PWS until 2014. In 2011, the BOF adopted thresholds for PWS whereas longline gear will close when 85% of the GHL is reached and pot gear will close when 90% of the GHL is reached. Further changes were implemented in 2014 making allocation simpler, 85% of the GHL can be harvested by longline gear and 15% is allocated to pot, mechanical jigging machine and hand troll gear with a step up and step down provision.

The Council established sector allocations for the federal Central Gulf of Alaska (CGOA) Pacific cod fisheries implemented in 2012. The Council's action established unique Pacific cod harvest allocations for pot, jig, trawl, and longline gear vessels. Beginning in 2012, the federal/parallel Pacific cod season for each federal gear sector was prosecuted independently of other Pacific cod federal gear sectors, resulting in staggered federal season closure dates. Prior to federal sector allocations, all gear types competed for federal/parallel Pacific cod during a single derby-style fishery. In order to coordinate state-waters Pacific cod fisheries a BOF meeting was held in October 2011 to adopt or amend regulations anticipating these federal changes. In most cases, starting in 2012, state-waters fisheries opened independently for each gear type.

In October 2011, the BOF held a special meeting to coordinate state-managed Pacific cod fisheries with changes occurring in the federal fisheries due to the implementation of gear sector splits (differential allocations of the TAC by gear type), and adjust Pacific Cod Management Plans and related regulations accordingly. The BOF adopted regulatory changes to align the parallel seasons with the federal seasons for each legal gear type. In PWS, the parallel longline season was aligned with the federal catcher vessel less than 50 feet overall length (OAL) hook-and-line gear sector. Different parallel season closures by gear type resulted in different seasons for each gear type in the state-waters seasons, and ADF&G considered these changes manageable. The annual GHLs are based on the estimate of acceptable biological catch (ABC) of Pacific cod as established by the Council. Current GHLs are set at 25% of the Central Gulf ABC, apportioned between the Kodiak, Chignik, and Cook Inlet Areas and 25% of the Eastern Gulf ABC for the Prince William Sound Area. Historically 25% of the Western Gulf ABC was reserved for the South Alaska Peninsula Area. In October 2013, the BOF increased the South Alaska Peninsula Area ABC apportionment from 25% to 30% of the Western Gulf Pacific cod ABC.

Action by the BOF in 2004 reduced the GHL in Prince William Sound to 10% of the Eastern Gulf ABC with a provision to increase subsequent GHLs to15% and then 25% if the GHL is achieved in a year; in 2011 the Prince William Sound GHL was set at the maximum level of 25% after achieving the GHL the two previous years, and in 2011 the BOF removed the step-up provision, as there was no mechanism to lower the GHL to previous levels.

Additional regulations include a 58 foot OAL vessel size limit in the Chignik and South Alaska Peninsula Areas. The BOF also adopted a harvest cap for vessels larger than 58 feet that limited harvest to a maximum of 25% of the overall GHL in the Cook Inlet and Kodiak Areas and 50% of the pot GHL in the Kodiak Area. The fishery management plans also provided for removal of restrictions after October 31 on exclusive area registrations, vessel size, and gear limits to increase late season harvest to promote achievement of the GHL. In addition, observers are occasionally used on day-trips to document catches and at-sea discards in the nearshore pot fisheries.

In February of 2006, the Alaska BOF adopted a Pacific cod Management Plan for a nonexclusive Aleutian Islands District, west of 170° W longitude, state-waters fishery. Included within the plan were season, gear and harvest specifications. The fishery GHL was set by regulation at three percent of the acceptable biological catch (ABC) of Pacific cod as established by the Council for the Bering Sea Aleutian Islands area with a maximum of 70% of the GHL available before June

10. By regulation the fishery opened on or after March 15, at the conclusion of the initial parallel catcher-vessel trawl fishery for Pacific cod in the federal BSAI Area. Non-pelagic trawl, longline, jig and pot gear were all permissible in the 2006 fishery.

In October of 2006 the Alaska BOF amended the Pacific cod Management Plan for the **Aleutian Islands**. Beginning in 2007 a new regulation set the opening date of the fishery at four days after the initial closure of the federal Bering Sea Aleutian Islands catcher vessel trawl season. Additional regulations introduced new vessel size limits of 125 feet or less OAL for pot vessels, 100 feet or less OAL for trawl vessels and 58 feet or less OAL for longline and jig vessels. In 2009, vessels participating in the B season were restricted to under 60 feet OAL for all legal gear types. In 2010, this regulation was once again changed to allow pot vessels 125 feet or less OAL to participate in the B season beginning August 1. Prior to August 1, during the B season, all vessels must still be less than 60 feet OAL.

As of 2012, the state-waters A season opens January 1 in waters between 175° W long and 178° W long to vessels 60 feet OAL or less using trawl, pot, and jig gear, and vessels 58 feet OAL or less using longline gear. Harvests between 175° W long and 178° W long accrue toward the GHL, while harvest in state waters east of 175° W long and west of 178° W long are initially managed under parallel fishery regulations with harvest accruing toward federal TAC. If the state-waters A season GHL has not been taken by April 1, when the federal catcher-vessel trawl B season opens, the state-waters A season in waters east of 175° W long and west of 178° W long will close and a parallel fishery will immediately open in those waters.

Alaska BOF amended the management plan for state-waters Aleutian Islands Pacific cod. In response to federal changes that separated management of groundfish fisheries into two areas, Aleutian Islands and Bering Sea, the GHL for state waters was changed from 3% of the combined Bering Sea-Aleutians ABC to 27% of the Aleutian Islands ABC. Additionally, the B season was eliminated in order to create more opportunity for larger vessels to harvest the GHL.

Currently, on January 1, the Aleutian Islands state-waters Pacific cod season opens in the Adak Section, between 175° W long and 178° W long, to vessels 60 feet OAL or less using trawl, pot, and jig gear, and vessels 58 feet OAL or less using longline gear. The state waters of the Aleutian Islands Subdistrict, west of 170° W long, open 4 days after the closure of the federal Bering Sea-Aleutian Islands A season for catcher-vessel trawl fishery is closed, or 4 days after the federal Aleutian Islands Subarea non-CDQ season is closed, or March 15, whichever is earliest. When waters west of 170° W long are open, trawl vessels may not be greater than 100 feet OAL, pot vessels may not be greater than 125 feet OAL, and vessels using mechanical jig or longline gear not greater than 58 feet OAL.

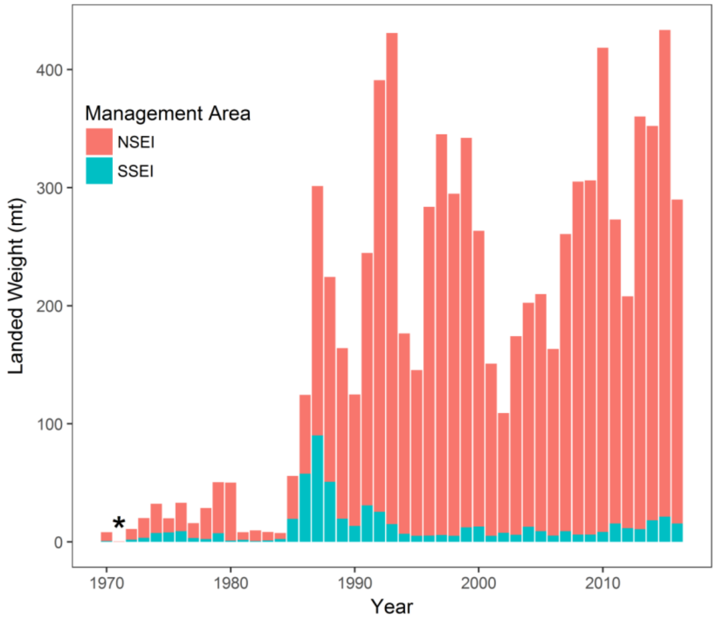
In October 2013, the BOF created a state-waters Pacific cod fishery management plan in waters of the Bering Sea near Dutch Harbor. The Dutch Harbor Subdistrict Pacific cod season is open to vessels 58 feet or less OAL using pot gear, with a limit of 60 pots. The season opens seven days after the federal Bering Sea–Aleutian Islands pot/longline sector’s season closure, and may close and re-open as needed to coordinate with federal fishery openings. The fishery was not opened to jig gear because the federal jig season typically occurs year-round

There is no bag, possession, or size limit for Pacific cod in the sport fisheries in Alaska, and the season is open year-round. Sport harvest of Pacific cod is estimated through the Statewide Harvest Survey (SWHS). The Southcentral Region creel sampling program also collects data on cod catch by stat area (on a vessel-trip basis), and lengths of sport-caught Pacific cod. No information is collected in the Southeast Region creel survey program on the Pacific cod sport fishery.

4. Fisheries

Most of the Pacific cod harvested in **Southeast Alaska** are taken by longline gear in the NSEI Subdistrict during the winter months. For Central Region Pacific cod fisheries, pots have been the dominant gear in **Cook Inlet Area (CI)** and longline gear the dominant gear in recent **Prince William Sound Area (PWS)** fisheries. In 2014 in the **Westward Region** parallel Pacific cod fisheries, pot gear vessels take over 70% of the total harvest, with the remainder divided between trawl, jig, and longline gear. Pot and jig gear are the only legal gear types during state-waters fisheries in the Kodiak, Chignik, and South Alaska Peninsula Areas. Pot gear vessels take approximately 75% of the total Pacific cod catch annually. In the Aleutian Islands trawl gear took 24% of the harvest and pot gear took 76%. Trawl and pot gear were used only during the A season. There was no harvest in the B season.

Prior to 1993 much of the cod taken in **Southeast Alaska** commercial fisheries was utilized as bait in fisheries for other species. In recent years in Southeast Alaska the Pacific cod harvest has been largely sold for human consumption. In 2016, 9% of the Pacific cod catch was recorded as being used for bait. In other areas of the state, Pacific cod are harvested in both state and federal waters and utilized primarily as food fish. A total of 290 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2016 with 257 mt harvested from the directed fishery.



*Indicates harvest by less than 3 permit holders, therefore information is confidential.

Figure 16. Annual harvest of Pacific cod in the Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) management areas in Southeast Alaska from 1970–2016 for the direct and bycatch fisheries.

The 2016 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and Prince William Sound areas of the **Central** Region were 1,849 mt and 2,196 mt, respectively. The CI GHL was down 450 mt from 2015 while the PWS GHL saw a three-fold increase. Pacific cod harvest from the state-waters seasons was 1,327 mt from CI and 482 mt from PWS. Pacific cod harvest during the parallel seasons was 981 mt from CI and 556 mt from PWS. In the Cook Inlet Area in 2016, state-waters GHLs were not achieved by pot and jig gear, and fishing with these two gear types was open all year in parallel or state-waters seasons. In PWS, the GHL was not achieved in part due to the large increase in GHL, and longline gear took over 99% of the harvest. In 2016, Cook Inlet Area received 3.75% of the CGOA ABC, and the PWS allocation was 25.0% of the EGOA ABC.

In the **Westward** Region, the Kodiak Area state-waters Pacific cod GHL is based on 12.5% of the annual CGOA Pacific cod ABC while the Chignik Area GHL is based on 8.75% of the annual CGOA ABC. The 2016 South Alaska Peninsula Area state-waters Pacific cod GHL was based on 30% of the WGOA Pacific cod ABC. Legal gear is limited to pot and jig gear during state-waters Pacific cod fisheries in these three areas. The 2016 Pacific cod GHLs were 6,164 mt in the Kodiak Area, 4,315 mt in the Chignik Area 12,151 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik and South Alaska Peninsula was 4,604 mt, 3,848 mt and 10,352 mt respectively. In the Aleutian Islands District state-waters Pacific cod GHL is based on 27% of the annual AI Pacific cod ABC. Legal gear is limited to non-pelagic trawl, pots, longline and jig gear during state-waters the Pacific cod fishery. The 2016 total state-waters Pacific cod catch in the Aleutian Islands District is confidential due to limited participation. The Dutch Harbor Subdistrict state-waters Pacific cod GHL is based on

6.4% of the annual BSPacific cod ABC and is open to pot gear only. In 2016, the total state-waters catch for the Dutch Harbor Subdistrict was 16,300 mt.

Estimates of the 2016 sport harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2015 estimates were 20,912 fish in **Southeast** and 37,277 fish in **Southcentral Alaska**. The estimated annual harvests for the recent five-year period (2011-2015) averaged about 15,000 fish in **Southeast** Alaska and 34,000 fish in **Southcentral** Alaska.

5. Walleye Pollock

   a. Research

In the **Central Region** skipper interviews and biological sampling of PWS commercial trawl pollock deliveries during 2016 occurred in Seward and Kodiak, and ADF&G observers were deployed on 6 trips. Additionally, onboard observers were placed on vessels participating in the Cook Inlet Area pollock seine fishery prosecuted with a Commissioner's permit from Central Region Management staff. Sample data collected included date and location of harvest, species, length, weight, sex, and gonad condition. Otoliths were collected from approximately half of sampled fish. Homer staff determined ages of 1,854 pollock otoliths (Contact Elisa Russ).

Beginning in 1998, spatial patterns of genetic variation were investigated in six populations of walleye pollock from three regions: North America – Gulf of Alaska; North America – Bering Sea; Asia – East Kamchatka. The annual stability of the genetic signal was measured in replicate samples from three of the North American populations. Allozyme and mtDNA markers provided concordant estimates of spatial and temporal genetic variation. These data show significant genetic variation between North American and Asian pollock as well as evidence that spawning aggregations in the Gulf of Alaska, such as Prince William Sound, are genetically distinct and may merit consideration as distinct stocks. These data also provide evidence of inter-annual genetic variation in two of three North American populations. Gene diversity values show this inter-annual variation is of similar magnitude to the spatial variation among North American populations, suggesting the rate and direction of gene flow among some spawning aggregations is highly variable. This study was published in 2002 in the Fishery Bulletin (Olsen et al. 2002) (Contact Bill Templin).

There are no bag, possession, or size limits for pollock in the sport fisheries in Alaska. Harvest of pollock is not explicitly estimated by the SWHS and no pollock harvest information is collected in charter logbooks or creel surveys in Southcentral or Southeast Alaska.

Central Region staff is evaluating the effectiveness of rockfish excluder devices on commercial pollock trawls during the PWS pollock pelagic trawl fishery. Sorting grid type excluders that sort target from non-target species by fish size are being considered. As an initial step, morphometric data were collected from pollock, rougheye rockfish, and shortraker rockfish from 6 vessels representing 20 tows from observer trips during the 2016 PWS commercial trawl fishery. These data, which included fish length, girth, head height, and width will be used to determine practical sorting grid sizes that could be used in future experiments to evaluate rockfish excluder designs for this fishery. ADF&G observers were dispatched and collected the morphometric data and during the 2016 fishery to corroborate rockfish bycatch caught during pollock trips with fish ticket data, as well as to collect biological samples and spatial data during the fishery.

b. Assessment

No stock assessment work was conducted by the department on pollock in 2016 (Contact Dr. Kenneth J. Goldman).

c. Management

Prince William Sound pollock pelagic trawl fishery regulations were amended by BOF in 2009 and included a January 13 registration deadline, logbooks, catch reporting, check-in and check-out provisions, and accommodation of a department observer upon request. The Prince William Sound Inside District is divided into three sections for pollock management: Port Bainbridge, Knight Island, and Hinchinbrook, with the harvest from any section limited to a maximum of 60% of the GHL. Additionally, the fishery is managed under a 5% maximum bycatch allowance that is further divided into five species or species groups. In 2014, inhouse rockfish bycatch limits for this fishery were put into regulation in the Rockfish Management Plan, allowing only 0.5% rockfish bycatch during this pollock fishery. In 2013, new management measures were implemented to set the PWS pollock GHL at 2.5% of the federal Gulf of Alaska ABC. For **Cook Inlet Area (CI),** directed fishing for pollock is managed under a "Miscellaneous Groundfish" Commissioner's permit. Initiated in December 2014, a Commissioner's permit fishery for pollock using seine gear has been prosecuted. In 2016, season dates ran January 1 to March 31 and from October 1 to December 31 with an allowable annual harvest level set at 220,000 lb. In **Central Region**, pollock is also retained as bycatch to other directed groundfish fisheries, primarily Pacific cod (Contact Jan Rumble).

d. Fisheries

The 2016 PWS pollock pelagic trawl fishery opened January 20, and continued until the regulatory closure on March 31. There were 38 landings made by 18 vessels with a total harvest of 4,249 mt, 67% of the 6,350 mt GHL. Rockfish bycatch during the fishery totaled 11 mt well below the 21 mt allowed as bycatch to the pollock harvested. In the Cook Inlet Area (CI), 2016 was the second full year the seine pollock Commissioner's permit fishery was prosecuted. Fishing was poor with very low effort and only 0.1 mt of pollock was harvested during the fishery and it was determined that no additional permits would be issued after 2016. There were 2 permits issued for the fishery and both vessels participated; both vessels agreed to release confidential data. In addition, pollock was harvested in **Central Region** as bycatch to other groundfish fisheries; in 2016, 6.0 mt was harvested in PWS and 17.7 mt in CI (Contact Jan Rumble).

In Southeast, two commissioner's permit were issued to fish for pollock by purse seine and jig gear. However, no fishing occurred in 2016 (Contact Mike Vaughn).

6. Pacific Whiting (hake)
    1. Research

There was no research conducted on Pacific whiting (hake) in 2016.

2. Assessment

There are no stock assessments for Pacific whiting (hake).

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for Pacific Whiting (hake). This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for Pacific whiting (hake) in 2016. There was no directed fishery for Pacific whiting (hake) in 2015. Currently in **Central Region** and **Southeast Region** Pacific whiting (hake) are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

7. Grenadiers
    1. Research

There was no research conducted on grenadiers in 2016.

2. Assessment

There are no stock assessments for grenadiers.

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for grenadiers. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for grenadiers in 2016. Currently in the **Central Region** and **Southeast Region** grenadiers are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

8. Rockfishes

Commercial rockfish fisheries are managed under three assemblages: demersal shelf (DSR), pelagic shelf (PSR), and slope rockfish. DSR include the following species: yelloweye, quillback, china, copper, rosethorn, canary, and tiger. PSR include black, blue, dusky, dark, yellowtail, and widow. Slope rockfish contain all other *Sebastes* species. Thornyhead, *Sebastolobus* species are defined separately; in Central Region, thornyhead rockfish harvest is combined with slope rockfish for reporting.

a. Research

In the **Southeast Region** biological samples of rockfish are collected from the directed commercial DSR fishery; sampling effort was expanded in 2008 to include the sampling of DSR caught as bycatch in the IFQ halibut fishery. The sampling of the halibut fishery was started in part to obtain more samples in years that the directed fishery was not opened. Fishery data are also collected from the logbook program, which is mandatory for all groundfish fisheries. The logbook program is designed to obtain detailed information regarding specific harvest location. Length, weight and age structures were collected from 1,878 yelloweye rockfish caught in the directed and halibut commercial longline fisheries. Bone and tissue samples were taken from 5 female yelloweye rockfish to conduct a pilot study to determine if hormones could be extracted from rockfish age structures within a temporal context. Preliminary results suggested that cortisol and progesterone could be extracted from subsamples of operculum and the concentrations differed across age related bands within the structure. A full proposal was sent to the North Pacific Research Board in 2016 to further investigate the use of operculum to recreate lifetime hormone profiles for individual fish (Contact Kevin McNeel).

Rockfish habitat mapping projects continue in the **Southeast Region.** Seafloor mapping is performed to identify rockfish habitat in this important fishing ground. To date, ADF&G has mapped approximately 3,097 km^2 of seafloor within SEO. More importantly, over 1,706 km^2 of rocky habitat has been mapped. In 2015, a mapping survey was conducted jointly with the U.S. Geological Survey (USGS) in the NSEO management area and surveyed approximately 849 km^2 area with 442 km^2 rocky habitat. In 2016, collaboration continued with USGS and the Queen Charlotte Fault Line was surveyed with additionally mapping occurring for overlapping rockfish habitat.

In addition, an age-structured assessment model for yelloweye rockfish has been submitted to the Gulf of Alaska Groundfish Plan Team and is under review (Contact Andrew Olson).

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2016 occurred in Homer, Seward, Whittier, Kodiak, and Cordova. Efforts throughout the year were directed at the sampling of rockfish delivered as bycatch to other groundfish and halibut fisheries, primarily slope and demersal shelf species. The directed jig fishery in the Cook Inlet Area that targets pelagic rockfish begins July 1 and historically had been the focus of rockfish sampling during the last half of the year. Limited fishing effort drastically reduced sampling opportunities from 2006 to 2009 until an increase in effort resulted in additional sampling opportunity with sampling goals for CI black rockfish being met in 2014, 2015, and 2016. Additional rockfish samples were collected from bycatch fisheries in CI and PWS with the sampling goal achieved or nearly achieved for quillback and yelloweye rockfish in both areas, and shortraker rockfish in PWS. Sample data collected included date and location of harvest, species, length, weight, sex, gonad condition, and otoliths. Homer staff determined ages of pelagic and demersal shelf rockfish otoliths, and otoliths from slope and Thornyhead rockfish species were sent to the ADF&G Age Determination Unit in Juneau. Additional sampling occurred during CI and PWS research trawl surveys (Contact Elisa Russ).

Tissue samples were collected from 10 rougheye and 10 shortraker rockfish for genetic analysis in 2015 along with otoliths. Tissue was analyzed in 2016 and the results suggested that 8 of the 10 rougheye belonged to the species *Sebastes melanostictus* (commonly referred to as blackspotted rockfish), the remaining two rougheye belonged to species *S. aleutianus* (rougheye rockfish), and the 10 identified as shortraker rockfish belonged to species *S. borealis* (shortraker rockfish). These samples were mainly collected to support a larger investigation on Central Region slope rockfish otolith species identification and otolith growth, but also support future investigation on rockfish species identification and composition (Contact Kevin McNeel or Elisa Russ).

Work in **Central Region** continued on delineating rocky seafloor features for the Inside and Outside districts of the PWS Area. An evaluation of existing ROV groundfish survey and seafloor bathymetry data was done to determine the location and scale of the DSR and lingcod ROV survey to be conducted in 2016. Commercial and sport DSR and lingcod harvest density and current management concerns were studied to help guide this process. Since sport fish DSR harvest in the PWS Area have increased steadily in recent years as has the commercial harvest since the inception of the directed Pacific cod longline fishery in 2009, it was determined that the PWS Area should be the location of the 2016 survey. Mapping the extent of available rocky habitat is necessary for conducting habitat-based ROV surveys since fish density estimates are expanded to available habitat to obtain estimates of population size. The extents of the survey area were determined by mapping historical sport and commercial harvest densities for DSR and lingcod. Habitat delineations (hard or soft/mixed substrates) were made using a combination of analytical methods and heads-up digitizing using multibeam and single beam sonar data, seafloor sediment samples, visual observations, and survey catch data. The final delineation resulted in 1157 km^2 of hard substrate identified within the survey extents for the Inside and Outside districts combined (Contact Mike Byerly or Josh Mumm).

The **Westward Region** continued port sampling of several commercial rockfish species and Pacific cod in 2016. Rockfish sampling concentrated on black and dark rockfish with opportunistic sampling of other miscellaneous *Sebastes* species. Skippers were interviewed for information on effort, location, and bycatch. Length, weight, gonadal maturity, and otolith samples were collected (Contact Sonya El Mejjati). Staff from the Kodiak office has completed aging black rockfish otoliths through the 2015 season. Pacific cod otolith aging is ongoing.

The **Westward Region** also continued to conduct hydroacoustic surveys of black and dark rockfish in the Northeast, Afognak, Eastside, and Southeast districts of the Kodiak Management Area in 2016 in an effort to generate biomass estimates for both black and dark rockfish. Surveys of the these districts in the Kodiak Management Area will continue in 2017 (Contact Carrie Worton).

The **Division of Sport Fish—Southeast Region** continued to collect catch and harvest data from rockfish as part of a marine harvest onsite survey program with rockfish harvests tabulated back to 1978 in some selected ports. Rockfish objectives included estimation of 1) species composition, 2) length composition and average weight, 3) age and sex composition of black rockfish at Sitka, and 4) biomass of total sport removals (harvest and release mortality). Primary species harvested in Southeast Alaska included yelloweye, black, copper, and quillback rockfish. A total sample size of 11,995 rockfish was obtained from the sport harvests at Ketchikan, Craig, Klawock, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2016 (Contact Mike Jaenicke).

The **Division of Sport Fish—Southcentral Region** continued collection of harvest and fishery information on rockfish as part of the harvest assessment program. Rockfish objectives included estimation of 1) species composition, 2) age, sex, and length composition of primary species, and 3) the spatial distribution of harvest by port. The 2016 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, and Homer was 5,041 rockfish (Contact Barbi Failor).

The Division of Sport Fish continued research in Prince William Sound on survival of rockfish following recompression. In 2016, 56 rockfish were caught using sport fishing gear over a range of depths, and held for two days at capture depths of at least 35 m to evaluate survival. Overall the course of this study, prior years included, approximately ninety percent of held fish survived, which is consistent with results from other studies indicating high survival for yelloweye and quillback rockfish in Prince William Sound and for other species in the Pacific Northwest. This study will be continued through 2017 to achieve sample sizes that are adequate to estimate post-recompression survival for as many demersal rockfish species as possible in Prince William Sound (Contact Brittany Blain or Jay Baumer).

b. Assessment

The **Southeast Region** performs multi-year stock assessments for DSR in the Southeast District. Biomass is estimated by management area as the product of yelloweye rockfish density determined from line transect surveys, the area of rocky habitat within the 100 fathom contour, and the yelloweye rockfish average weight. Yelloweye rockfish density for the stock assessment is based on the most recent estimate by management area. Yelloweye rockfish densities for each area are multiplied by the current year’s average commercial fishery weight of yelloweye rockfish specific to that management area. Allowable biological catch for the SEO is set by multiplying the lower bound of the 90% confidence interval of total biomass for yelloweye rockfish by the natural mortality rate (0.02). In the past, the yelloweye biomass estimate was expanded to the entire DSR assemblage by multiplying the proportion of other DSR species in the commercial catch (2–4.0%). However, starting in 2015, the non-yelloweye DSR biomass estimate was calculated from the catch data from 2010–2014 recreational, commercial, and subsistence fisheries; the non-yelloweye ABC was added to the yelloweye ABC to obtain a total for the entire DSR assemblage. There is no stock assessment information available for DSR in NSEI and SSEI management areas, and no surveys for non-DSR species (e.g. black rockfish) have been conducted since 2002.

Prior to 2012, line transect surveys were conducted using a submersible; after that time, visual surveys have been conducted using an ROV. The last submersible surveys were conducted in 2009 in EYKT, 2005 in SSEO, 2007 in CSEO, and 2001 in NSEO; density estimates were derived from each of these surveys with the exception of the NSEO management area where data were too limited to obtain a valid density estimate. Consequently, the most recent valid density estimate for NSEO is from 1994. Density estimates by area for the most recent submersible surveys ranged from 765 to 1,755 yelloweye rockfish per km^2 with CV estimates of 12–33%. ROV surveys were performed in collaboration with Central Region staff in 2016 in NSEO and CSEO,2013 in SSEO, and 2015 in EYKT. Yelloweye rockfish density was, 701 yelloweye per km^2 (CV=20%) for NSEO in 2016, 752 yelloweye per km^2 (CV=13 %) for CSEO in 2012, 986 yelloweye per km^2 (CV=22%) in SSEO in 2013, and 1,755 yelloweye per km^2 (CV=25%) for EYKT in 2015. An update to the CSEO density estimate based on the 2016 ROV survey is currently under review. In addition from ROV video data, we are able to measure fish lengths for yelloweye rockfish, lingcod, and halibut using stereo camera imaging software (SeaGIS, Ltd).

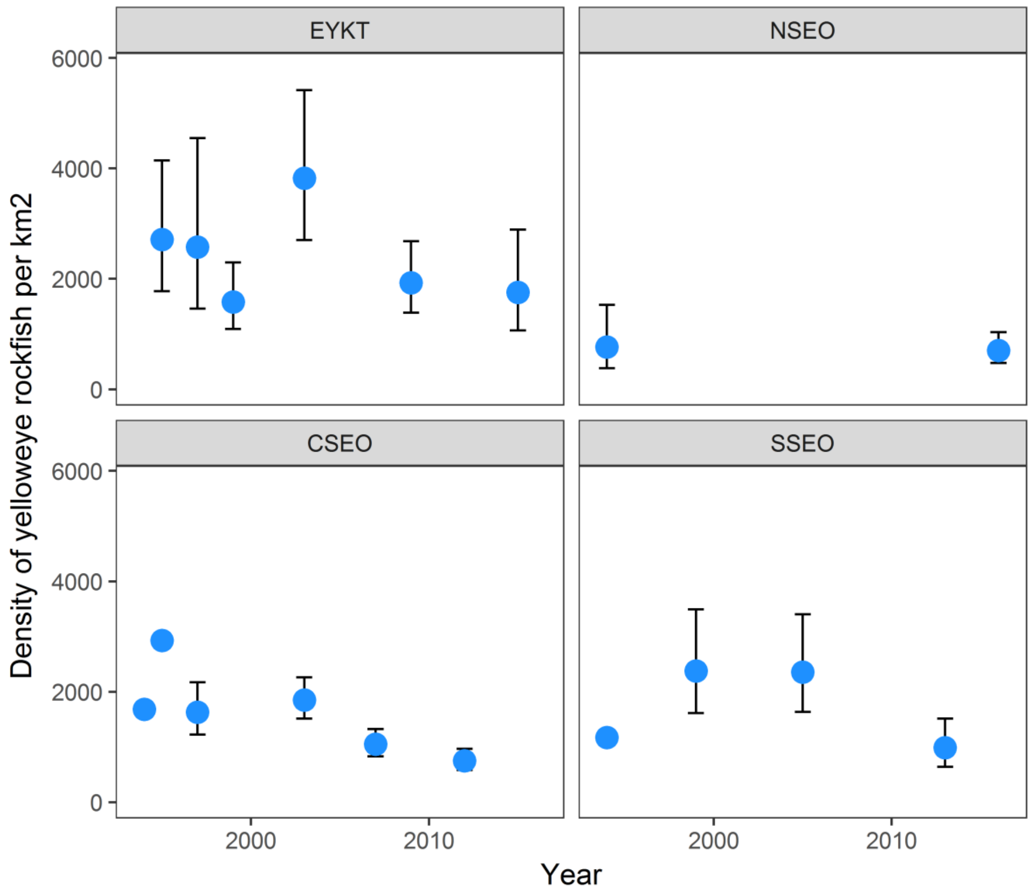


Figure 17. Density estimates of yelloweye rockfish with 90% CIs in the Eastern Gulf of Alaska management areas. Management areas include: Eastern Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (CSEO).

Central Region conducts ROV surveys along the northern Gulf of Alaska coast from the Kenai Peninsula to Prince William Sound to monitor the local abundance of lingcod and DSR in selected index sites. These sites are on the order of 100’s of sq km and tend to be relatively isolated rocky banks bordered by land masses, deep fjords, and/or expanses of deeper soft substrates. The loss of SOA and future federal funds for these surveys and the need to address more urgent management concerns prompted the design of the much larger PWS ROV survey discussed in the preceding research section of this report. The goal of this survey was to provide management staff with district wide DSR and lingcod population abundance and biomass estimates. There were 150 transects planned for the survey which was composed of three strata. The PWS Area DSR and lingcod ROV survey was conducted in two stages with the Inside District and parts of the Outside District being surveyed between May 1 and 10, 2016 and the remaining Outside District surveyed starting on June 18, 2016. There were 108 transects completed in the first stage and 11 in the second stage after which technical issues with the ROV forced the termination of the survey. Reviews of the image data are still being completed and population estimates will be available in summer 2017. (Contact Mike Byerly or Dr. Kenneth J. Goldman).

In the **Westward Region** rockfish surveys using hydroacoustic equipment were deployed in an effort to assess black and dark rockfish stocks in the Kodiak Management Area. Surveyed areas included the Northeast, Afognak, Eastside, and Southeast districts of the Kodiak Management Area (Contact Carrie Worton).

c. Management

Management of DSR in the **Southeast Region** is based upon a combination of GHRs, seasons, gear restrictions, and trip limits. Directed commercial harvest of DSR is restricted to hook-and-line gear. Directed fishing quotas are set for the four outside water management areas (NSEO, CSEO, SSEO, and EYKT) based on the stock assessment. Directed fishery quotas for the two internal water management areas (NSEI and SSEI) are set at 25 mt annually. Regulations adopted in 1994 include trip limits (within any five-day period) of 6,000 pounds per vessel in all areas except for EYKT where the trip limit is 12,000 pounds and added a requirement that logbook pages must be submitted with fish tickets for each fishing trip. At the BOF meeting in early 2006 the season for the directed DSR fishery in SEO was changed to occur only in the winter from January 5th until the day before the start of the commercial halibut IFQ season, or until the annual harvest limit is reached whichever occurs first. At this meeting the total allowable catch (TAC) for DSR was allocated 84% to the commercial sector and 16% to the sport sector. At the 2009 BOF meeting it was decided that the anticipated harvest of DSR in the subsistence fisheries would be deducted from the ABC before the split in allocation is made between commercial and sport fisheries. The 2016 ABC for DSR was 231 mt, which resulted in a TAC of 224with a 188 mt to commercial fisheries and 36 mt to sport fisheries, and the 2017 ABC is set at 227 mt, resulting in a TAC of 185 mt for commercial and 35 mt for sport fisheries. The TACs are set after deducting the subsistence catch, 7 mt for 2016 and 7 mt for 2017. A significant portion of the total commercial harvest is taken as bycatch during the halibut fishery; each year this is estimated and decremented from the commercial TAC. Prior to the 2012 fishery, we had used IPHC survey data to estimate bycatch rate by depth and apply this to the commercial catch to estimate DSR bycatch. Since 2012, commercial landing data has been used to calculate the commercial bycatch rate of DSR in the halibut fishery and this bycatch rate has been applied to the current year's quota to estimate bycatch of DSR. This change in methodology was made for greater accuracy and was implemented once several years of landings were available under the DSR full retention regulation. This regulation has been in place in state waters since 2002 and in federal waters since 2005.

Management of the commercial black rockfish fishery in the **Southeast Region** is based upon a combination of GHLs and gear restrictions. Directed fishery GHLs are set by management area and range from 11 mt in EYKT and IBS to 57 mt in SSEOC with a total GHL of 147 mt for all of SEO. A series of open and closed areas was also created in order for managers to better understand the effects of directed fishing on black rockfish stocks. Halibut and groundfish fishermen are required to retain and report all black rockfish caught. Shortspine thornyhead, shortraker rockfish, rougheye rockfish and redbanded rockfish may be taken as bycatch only (no directed fishing) (Contact Andrew Olson).

Rockfish in **Central Region's** Cook Inlet and PWS areas are managed under their respective regulatory Rockfish Management Plans. Plan elements include a fishery GHL of 68 mt for each area and 5-day trip limits of approximately 0.5 mt in the Cook Inlet District, 1.8 mt in the North Gulf District, and 1.4 mt in PWS. Rockfish regulations underwent significant change beginning in 1996 when the BOF formalized the GHL into a harvest cap for all rockfish species in Cook Inlet and PWS areas and adopted a 5% rockfish bycatch limit for jig gear during the state-waters Pacific cod season. In 1998, the BOF adopted a directed rockfish season opening of July 1 for the Cook Inlet Area and restricted legal gear to jigs to target pelagic shelf rockfish species. At the spring 2000 BOF meeting, the BOF closed directed rockfish fishing in the PWS Area and established a bycatch-only fishery with mandatory full retention of all incidentally harvested rockfish. In November 2004, the BOF also adopted a full retention requirement for rockfish in the Cook Inlet Area and restricted the directed harvest to pelagic shelf rockfish. Rockfish bycatch levels were also set at 20% during the sablefish fishery, 5% during the state-waters Pacific cod season and 10% during other directed fisheries. In 2010, the BOF adjusted rockfish bycatch levels for Cook Inlet to 10% during halibut and directed groundfish, other than rockfish, and 20% nonpelagic rockfish during the directed pelagic shelf rockfish fishery. In addition, logbooks are required to be filled out daily during the CI directed jig fishery. In 2014, the BOF adopted regulations to adjust rockfish bycatch levels during the parallel Pacific cod season in PWS to 5%, for consistency with the state-waters season. In addition, a .05 % rockfish bycatch limit was established for the PWS pollock pelagic trawl fishery. Proceeds from rockfish landed in excess of allowable bycatch and harvest levels are surrendered to the State of Alaska (Contact Jan Rumble).

The **Westward Region** has conservatively managed black rockfish since 1997, when management control was transferred to the State of Alaska. Area GHLs were set at 75% of the average production from 1978–1995 and sections were created to further distribute effort and thereby lessen the potential for localized depletion. Since 1997, section GHLs have been reduced in some areas that have received large amounts of effort.

In the Kodiak Area, vessels may not possess or land more than 2.3 mt of black rockfish in a 5-day period. Additionally, vessel operators are required to register for a single groundfish fishery at a time. Registration requirements also exist for the Chignik and South Alaska Peninsula areas. The Chignik Area was designated as superexclusive for the black rockfish fishery beginning in 2003.

In 2016, 60 mt of black rockfish were harvested from seven sections in the Kodiak Area. GHLs were attained in five sections of the Kodiak Area. In the South Alaska Peninsula Area, the 2016 GHL was attained when 35 mt of black rockfish were harvested. Harvest in the Chignik Area remain confidential. In 2016, vessels made directed black rockfish landings in the Aleutian Islands Area but harvest information is confidential due to limited participation. Fishers are allowed to retain up to 5% of black rockfish by weight incidentally during other fisheries. The incidental harvest in the Aleutian Islands Area is confidential due to limited participation in 2016. A voluntary logbook program was initiated in 2000 in the hope of obtaining CPUE estimates as well as more detailed harvest locations; the logbook program was made mandatory in 2005 (Contact Nathaniel Nichols).

Statewide, the majority of sport caught rockfish is taken incidental to sport fisheries for halibut or salmon. Size limits have never been set for rockfish harvested in the sport fishery, although there has been a progression of bag and possession limit changes over the last 20 years.

Sport fisheries are managed primarily under two assemblages: pelagic, defined the same as for commercial fisheries, and nonpelagic, which includes all other species. For the 2016 season, the **Southeast Alaska** region's sport bag and possession limit for pelagic rockfish was five fish per day, 10 in possession. However, an emergency order reduced the limit for pelagic rockfish in outside waters near Sitka (north of the latitude of Cape Ommaney and south of 57° 30' N. lat.) to three fish per day, six in possession, effective May 2 through the end of the year.

The sport fishery in Southeast outside waters is allocated a portion of the TAC for demersal shelf rockfish. The non-pelagic rockfish regulations were set as follows:

<u>Southeast Alaska Outside Waters</u>: 1) all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) resident bag limit was two fish, only one of which could be a yelloweye; four fish in possession, of which no more than two could be yelloweye; 3) nonresident bag limit was one fish, two in possession, only one of which could be a yelloweye.

<u>Southeast Alaska Inside Waters</u>: 1) all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) resident bag limit was three fish, only one of which could be a yelloweye; six fish in possession, of which no more than two could be yelloweye; 3) nonresident bag limit was two fish, only one of which could be a yelloweye, four fish in possession, of which no more than two could be yelloweye.

For the entire Southeast Alaska region, the nonresident annual limit was three yelloweye, not more than two of which could be taken from inside waters and not more than one of which could be taken from outside waters. In addition, charter operators and crewmembers could not retain non-pelagic rockfish while clients were on board the vessel. All anglers fishing from charter vessels were required to release non-pelagic rockfish to the depth of capture or at least 100 feet, whichever is shallower, using a deepwater release device. Charter vessels were required to have at least one functional deep water release device on board and available for inspection (Contact Bob Chadwick).

Sportfish rockfish regulations in **Southcentral Alaska** have been designed to discourage targeting of rockfish yet allow and mandate retention of incidental harvest. As in Southeast Alaska, bag limits are more restrictive for non-pelagic species to account for their lower natural mortality rates. The open season for rockfish was year-round in all areas. The bag limit in Cook Inlet was five rockfish daily, only one of which could be a non-pelagic species (DSR or slope species). The bag limit in Prince William Sound during the period May 1-September 15 was four rockfish, no more than two of which could be a non-pelagic species. During the period September 16-April 30, the bag limit was eight rockfish, of which no more than two could be non-pelagic species. During both periods, the first two non-pelagic rockfish caught in Prince William Sound were required to be retained. The bag limit in the North Gulf Coast area was four rockfish daily, including no more than one non-pelagic rockfish. The bag limit in the Kodiak and Alaska Peninsula areas was five rockfish, no more than two of which could be non-pelagic species, and no more than one of the non-pelagic species could be a yelloweye.

d. Fisheries

Directed fisheries for DSR and black rockfish occurred in **Southeast** in 2016. Effort in the directed black rockfish fishery in Southeast Outside District (SEO) was low with 3.7 mt and 10 vessels participating; consequently, directed harvest is confidential. Black rockfish harvest in all groundfish, halibut, and salmon troll fisheries in SEO was 11.2 mt. In addition, one application for a commissioner's permit was made for directed fishing of black rockfish in inside waters. Because there are no GHLs set for black rockfish in internal waters by regulation, a commisioner's permit is required. The directed fishery for DSR in SEO only opened in the East Yakutat (EYKT) area. The Central Southeast Outside (CSEO), Southern Southeast Outside (SSEO), and Northern Southeast Outside (NSEO) sections did not open to directed fishing, because the portion of the TAC allocated to those areas was not large enough to support an orderly fishery. Directed fishing for DSR was also opened in internal waters. The 2016 harvest of DSR by directed fisheries in EYKT was 34.3 mt and in internal waters (SSEI and NSEI) was 10.9 mt. In addition, DSR was taken as bycatch with 76.3 mt harvested in SEO and 22.5 mt in internal waters. Sixety-four percent in SEO was harvested from the IFQ halibut or sablefish fisheries, and 51% in internal waters was harvested from the IFQ halibut fishery. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 59.3 mt harvested in 2016.

In **Central Region**, both the Cook Inlet and PWS areas have a rockfish GHL of 68 mt. In the Cook Inlet Area in 2016, the total rockfish harvest, including the directed pelagic shelf rockfish (PSR) jig fishery and bycatch, was the highest since 2000 with a harvest of 66 mt. PSR harvest comprised 62% of the total harvest, with the majority of harvest coming from the directed PSR fishery. There has been a steady increase in harvest and effort in the CI directed fishery in recent years and the fishery was closed by emergency order on November 25, 2016. In PWS, rockfish are only harvested as bycatch, as there is no directed fishery. For PWS, the rockfish harvest exceeded the GHL in 2016 with a total harvest of 73 mt. A majority of this rockfish bycatch was caught by longline gear (84%) then by trawl gear (15%) with the minimal remaining harvested by jig and pot gear. Although all rockfish caught must be retained in Central Region commercial fisheries, allowable rockfish bycatch allowances in PWS were reduced in half by emergency order on July 29 to discourage fishing in areas with high rockfish bycatch.

Overall **sport harvest** (guided and unguided) is estimated primarily through the Statewide Harvest Survey (SWHS). Charter vessel logbooks provide reported harvest for the guided sector only. Harvest reporting areas for these programs are different than commercial reporting areas, making direct comparisons difficult. Additionally, species-specific data are available only from creel surveys.

The SWHS estimates are for the general category of "rockfish" (all species combined), and the charter vessel logbooks require reporting of rockfish harvest in three categories - pelagic, yelloweye, and other non-pelagics. Sport rockfish harvest is typically estimated in numbers of fish. Estimates of the 2016 harvest are not yet available from the SWHS, but the 2015 estimates for all species combined were 186,816 fish in Southeast and 144,857 fish in Southcentral Alaska.

The average estimated annual harvest for the recent five-year period (2011–2015) was 151,480 rockfish in Southeast Alaska and 121,256 fish in Southcentral Alaska.

9. Thornyheads

1. Research

There was no research conducted on thornyheads in 2016.

2. Assessment

There are no stock assessments for thornyheads.

3. Management

A commissioner's permit is required before a directed fishery may be prosecuted for thornyheads. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for thornyheads in 2016. In **Central Region** thornyheads are retained as bycatch up to 10% in aggregate with other groundfish during a halibut or directed groundfish fishery, with exceptions occurring for the bycatch allowance for the directed sablefish fishery (20%), Pacific cod (5%), and directed pollock trawl fishery (0.5%). For directed drift or set gillnet fisheries for salmon or herring up to 10% of thornyheads and other rockfish in aggregate may be retained. Proceeds from bycatch overages are forfeited to ADF&G.

In **Southeast Region** thornyheads are retained as bycatch of up to 15% in aggregate with other rockfish for a directed DSR fishery, 5% in aggregate with other rockfish for halibut fishing and a directed lingcod fishery, 15% for a directed black rockfish, sablefish, and Pacific cod, 0% for a directed pot fishery for sablefish and Pacific cod, and 5% for a directed fishery in outside waters of **Southeast Region**. Any bycatch overages that occur are forfeited to ADF&G.

10. Sablefish

a. Research

In 2016, sablefish longline surveys were conducted for both the NSEI and SSEI areas. These surveys are designed to measure trends in relative abundance and biological characteristics of the sablefish population. Biological data collected in these surveys include length, weight, sex and maturity stage. Otoliths are collected and sent to the ADF&G age determination unit in Juneau for age reading. The cost of these surveys is offset by the sale of the fish landed; however, in 2016 five commercial fishermen participated in the surveys and were allowed to sell their

Personal Quota Share (PQS); thus, reducing the impact on the quota by approximately 44% for fish harvested and sold by the state. The department plans to allow permit holders to harvest their PQS aboard future NSEI longline surveys.

The survey CPUE for NSEI increased in 2016 by 10.3% for individuals per hook and 4.5% round pounds per hook relative to 2015. In the SSEI stock assessment, analyses revealed a 19% increase in the overall longline survey CPUE index (round lb/hook) from 2015 to 2016. Proportion of immature fish harvested in the commercial longline fishery from 2015 to 2016 decreased from 58% to 48% for females and from 64% to 36% for males. In the commercial pot fishery from 2015 to 2016 proportions of immature fish harvested increased from 45% to 67% for females and from 59% to 67% for males..

A mark-recapture survey has been conducted using longlined pots since 2000 with this survey performed using the state vessel the R/V *Medeia* since 2012. In May and June 2015, 6,862 fish were marked and released in NSEI over the course of the tagging survey. Over the 18 day survey, 33 longline pot sets were made. Sablefish were targeted by area and depth in proportion to the commercial catch using logbook data from the three previous years. The mark-recapture results serve as the basis of our NSEI stock assessment. A tagging survey is scheduled for 2017 and occurs biannually due to budget restrictions.

In 2015, groundfish staff met with port samplers in Ketchikan and 26 ovary samples were collected from the SSEI pot and longline fisheries in order to determine if samplers were correctly classifying fish using macroscopic methods. During these fisheries it is difficult to accurately classify fish as immature or mature for inexperienced samplers, because there is little yolk development in mature fish with the spawning season months away. We hope to use the information and pictures collected from this study to develop guidelines for samplers to better distinguish mature and immature fish using macroscopic classification (Contact Andrew Olson).

Central Region, ADF&G conducted longline surveys for sablefish from 1996 through 2006 in Prince William Sound. Longline survey effort was extended into the North Gulf District in 1999, 2000 and 2002. All longline surveys were discontinued due to lack of funding, and with the goal of transitioning to a pot longline survey, particularly in PWS. Between 1999 and 2005, sablefish were opportunistically tagged in PWS on ADF&G trawl surveys. Sablefish tagging surveys were conducted in PWS in 2011, 2013, and 2015 using pot longline gear. There were 1,203, 318, and 26 fish tagged in 2011, 2013, and 2015, respectively. CPUE was very low in 2013 with an average of 0.11 fish per pot. To date, 302 fish have been recaptured from the 2011 survey and 41 were captured from the 2013 survey. Of all tagged releases, 65% have been recaptured within PWS and 25% outside in the GOA with the remainder of unknown location. There is no PWS sablefish tagging survey planned for 2017.

Short-terms goals are to determine whether the portion of the GOA sablefish stock that resides in and used PWS is well- or poorly-mixed with the larger GOA population. If well-mixed, there would be no need for a PWS sablefish stock assessment as the Federal assessment could be used to apportion catch for the PWS sablefish fishery. If poorly-mixed, there would be a need to conduct more tagging work in PWS to provide an assessment of the abundance within those waters from which to set harvest limits and manage the fishery. The department will continue to conduct more sablefish tagging as funding allows, and work towards addressing the mixing question via tag-recapture analysis. If data results indicate that a PWS assessment needs to be conducted, the department would continue its tagging study potentially in combination with an age-structured model to accomplish the goal of providing information with which to best manage the fishery. With such small catches in the recent survey and the reduction in funding to continue this work, a request will be made for biometric support for analysis of all Central Region sablefish data (Contact Dr. Kenneth J. Goldman).

Skipper interviews and biological sampling occurred in Cordova, Whittier, and Seward for the PWS Area commercial fishery and in Seward and Homer for the Cook Inlet Area fishery. After PWS sampling goals were not achieved in 2015, due to extremely low effort and poor fishery performance, staff endeavored in 2016 to ensure sampling goals for sablefish were achieved. Expanded interviews were also conducted with PWS fishermen to collect additional information on fishery dynamics. Data obtained included date and location of harvest, length, weight, sex, and gonad condition. Otoliths were removed and sent to the Age Determination Unit. Logbooks are required for both fisheries and provide catch and effort data by date and location (Contact Elisa Russ).

b. Assessment

In **Southeast**, the department is using mark-recapture methods with external tags and fin clips to estimate abundance and exploitation rates for sablefish in the NSEI Subdistrict. Sablefish are captured with pot gear in May or June, marked with a tag and a fin clip then released. Tags are recovered from the fishery and fish are counted at the processing plants and observed for fin-clips. The 2016 recommended ABC of 366 mt for the NSEI fishery was calculated by applying the 2015 fishery mortality at age (based on a harvest rate of 6.8% using the $F_{50\%}$ biological reference point (BRP)) to the 2016 forecast of total biomass at age and summing across all ages. The 2016 ABC was a 18.2% decrease from the 2015 ABC (447mt), which was also based on the $F_{50\%}$ BRP (the harvest rate was 7.1% for 2015). Since 2009 BRPs have become more conservative, i.e. $F_{45\%}$ in 2009 and $F_{50\%}$ since 2010.

In addition to the mark-recapture work, an annual longline survey is conducted in NSEI to provide biological data as well as relative abundance information. In SSEI only an annual longline survey is conducted to provide biological data as well as relative abundance information. Unlike NSEI, the department does not currently estimate the absolute abundance of SSEI sablefish. There appears to be substantial movement of sablefish in and out of the SSEI area, which violates the assumption of a closed population; consequently, Peterson mark-recapture estimates of abundance or exploitation rates are not possible for this fishery. Instead, the SSEI sablefish population is managed based on relative abundance trends from survey and fishery CPUE data, as well as with survey and fishery biological data that are used to describe the age and size structure of the population and detect recruitment events (Contact Andrew Olson).

c. Management

There are three separate internal water areas in Alaska which have state-managed limited-entry commercial sablefish fisheries. The NSEI and SSEI (**Southeast Region**) and the Prince William

Sound Inside District (**Central Region**) each have separate seasons and GHLs. In the Cook Inlet Area, there is a state-managed open access sablefish fishery with a separate GHL.

In the **Southeast Region** both the SSEI and NSEI sablefish fisheries have been managed under a license limitation program since 1984. In 1994 the BOF adopted regulations implementing an equal share quota system where the annual GHL was divided equally between permit holders and the season was extended to allow for a more orderly fishery. In 1997 the BOF adopted this equal share system as a permanent management measure for both the NSEI and SSEI sablefish fisheries. There were 78 permit holders eligible to fish in 2016 in NSEI and 23 permit holders eligible to fish in SSEI.

The NSEI quota was set at 366 mt and the SSEI quota was set at 219 mt for 2016.

During the February 2009 BOF meeting, the BOF made no changes affecting the regulation of commercial sablefish fisheries. The BOF did however establish bag and possession limits for sablefish in the sport fishery. At the 2012 BOF meeting, a regulation was passed to require personal use and subsistence use sablefish permits, and at the 2015 BOF meeting, limits were defined for personal use sablefish fisheries for the number of fish, number of permits per vessel, and number of hooks. No changes were made to sablefish subsistence fisheries in 2015.

There is no open-access sablefish fishery in the Southeast Outside District as there are limited areas that are deep enough to support sablefish populations inside state waters. In some areas of the Gulf, the state opens the fishery concurrent with the EEZ opening. These fisheries, which occur in Cook Inlet Area's North Gulf District and the Aleutian Island District, are open access in state waters, as the state cannot legally implement IFQ management at this time. The fishery GHLs are based on historic catch averages and closed once these have been reached.

Within the **Central Region** the Cook Inlet Area North Gulf District sablefish GHL is set using an historic baseline harvest level adjusted annually by the relative change to the ABC in the federal CGOA. In 2004, the BOF adopted a sablefish fishery-specific registration, logbook requirement, and 48-hour trip limit of 1.36 mt in the Cook Inlet Area. For PWS, a limited-entry program that included gear restrictions and established vessel size classes was adopted in 1996. Between 1996 and 2014, the PWS fishery GHL was set at 110 mt, which is the midpoint of the harvest range set by a habitat-based estimate. Tagging studies conducted by the National Marine Fisheries Service (NMFS) and ADF&G indicate that sablefish populations throughout the Gulf of Alaska (GOA) including the PWS area are likely mixed. Therefore, the GHL was adjusted by applying the relative change each year in the NMFS GOA sablefish acceptable biological catch (ABC), which is derived from NMFS stock assessment surveys. The GHL was adjusted beginning in 2015 by applying the relative change in the GOA-wide ABC for sablefish back to 1994; this adjustment continued in 2016. PWS fishery management developed through access limitation and in 2003 into a shared quota system wherein permit holders are allocated shares of the guideline harvest guideline level. Shares are equal within each of four vessel size classes, but differ between size classes. In 2009, the BOF adopted regulations which included a registration deadline, logbooks, and catch reporting requirements. In 2009, new season dates were also adopted by the BOF for PWS sablefish, April 15 – August 31. The new season opening date, one month later than in previous years, was adopted to reduce the opportunity for orca depredation on hooked sablefish which predominately occurred prior to May 1.

The sole **Westward Region** sablefish fishery occurs in the Aleutian Islands. The GHL for the Aleutian Islands is set at 5% of the combined Bering Sea Aleutian Islands TAC. The state GHL can be adjusted according to recent state-waters harvest history when necessary. From 1995 to 2000 the fishery opened concurrently with the EEZ IFQ sablefish fishery. In 2001 the BOF changed the opening date of the state-waters fishery to May 15 to provide small vessel operators an opportunity to take advantage of potentially better weather conditions. From 1995 to 2000 all legal groundfish gear types were permissible during the fishery. Effective in 2001, longline, pot, jig and hand troll became the only legal gear types. Vessels participating in the fishery are required to fill out logbooks. In 2013, the BOF changed the season opening and closing dates to revert back to coinciding with the federal IFQ season.

The Southeast Alaska **sport fishery** for sablefish was regulated for the first time in 2009. Sport limits in 2016 were four fish of any size per day, four in possession, with an annual limit of eight fish applied to nonresidents only in lower Lynn Canal and Chatham Strait. Creel surveys in Southeast Alaska in 2016 sampled 254 sablefish, reflecting the small harvest relative to other species. The sablefish sport fishery in Southcentral Alaska was unregulated, with no bag, possession, or size limits. Port samplers in Southcentral Alaska measured one sablefish from the sport harvest, again reflecting the relatively small harvests.

d. Fisheries

In the **Southeast Region** the 2016 NSEI sablefish fishery opened August 15 and closed November 15. The 78 permit holders landed a total of 293 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 3.8 mt. In the NSEI fishery, the overall CPUE (adjusted for hook spacing expressed in round lb/hook) increased 14.9% in 2016. The 2016 SSEI sablefish fishery season was June 1–August 15 for longline gear and September 1–November 15 for pot gear. In SSEI, 20 permits were designated to be fished with longline gear and 3 permits for pot gear. Twenty-three permit holders landed a total of 216 mt of sablefish, each with an equal quota share of 9.5 mt.. SSEI longline fishery CPUE has remained fairly stable in the last four years (0.30–0.33 lb/hook from 2012–2015) (Contact Andrew Olson).

In the **Central Region,** the 2016 Cook Inlet Area sablefish fishery opened at noon July 15 with a GHL of 21.8 mt and closed by emergency order on November 8 when the GHL was achieved. The 2016 PWS sablefish fishery opened April 15 with a GHL of 50.3 mt and closed by regulation on August 31. PWS sablefish harvest totaled 18.4 mt, up from the 7.7 mt historical low in 2015, although still the second lowest harvest on record and less than 20% of the historical average (Contact Jan Rumble).

Within the **Westward Region**, only the Aleutian Islands have sufficient habitat to support mature sablefish populations of enough magnitude to permit commercial fishing. All other sections within the region are closed by regulation to avoid the potential for localized depletion from the small amounts of habitat within the jurisdiction of the state. Bycatch from the areas closed to directed fishing is limited to 1%. The 2016 Aleutian Island fishery opened on March 11 with only pot, longline, jig and hand troll gear allowed. Additional requirements for the fishery include registration and logbook requirements. The GHL was set at 135 mt for the state-waters fishery. The harvest from the 2016 Aleutian Islands sablefish fishery was 35 mt. The season remained open until the November 7 closure date (Contact Miranda Westphal).

The most recent sablefish sport harvest estimates from the SWHS are for 2015. The estimated harvest was 13,338 fish in Southeast Alaska and 9,936 fish in Southcentral Alaska. SWHS estimates are up substantially from 2015 but are suspected to be biased high due to misidentification and misreporting. Sablefish are not commonly taken by anglers, and relatively high catches were reported from some areas where sablefish are rarely or never observed by creel survey crews. Charter logbooks indicated guided harvests of 6,153 sablefish in Southeast Alaska and 4,529 sablefish in Southcentral Alaska in 2015 (Contact Bob Chadwick, Dan Bosch).

K. Lingcod

a. Research

Since 1996, 9,189 lingcod have been tagged and 499 fish recovered in the **Southeast** Region. Length, sex and tagging location are recorded for all tagged fish. Dockside sampling of lingcod caught in the commercial fishery continued in 2016 in Sitka, and Ketchikan with 1,030 fish sampled for biological data. Samples were not collected in Yakutat due to weather. Otoliths were sent to the ADU in Juneau for age determination (Contact Andrew Olson).

In the **Central Region**, skipper interviews and port sampling were conducted in Cordova, Seward, and Homer. Data obtained included date and location of harvest, length, weight, sex and age structures. Otoliths were sent to the ADU in Juneau for age determination. Gonad condition was generally not determined as nearly all fish were delivered gutted (Contact Elisa Russ).

Lingcod research in 2016 in Central Region involved delineating seafloor habitat in the PWS Area for the purpose of designing and conducting a habitat-based ROV survey to estimate abundance and biomass. The impetus and goals of this research are the same for and have been described above in the Rockfishes Research section (Contact Mike Byerly or Josh Mumm)

In the **Westward Region**, no directed lingcod effort occurred during 2016. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2016 harvest totaled 22 mt in the Kodiak Area and <1 mt in the Chignik and South Alaska Peninsula areas combined.

The Division of Sport Fish—Southeast Region continued to collect catch, harvest, and biological data from lingcod as part of a marine harvest survey program with lingcod harvests tabulated back to 1987 in selected ports. Data collected in the program include statistics on effort, catch, and harvest of lingcod taken by Southeast Alaska sport anglers. Ports sampled in 2016 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,637 lingcod in 2015, primarily from the ports of Sitka, Ketchikan, Craig, Klawock, Gustavus, Elfin Cove, and Yakutat (Contact Mike Jaenicke).

The **Division of Sport Fish—Southcentral Region** continued collection of harvest and fishery information on lingcod through the groundfish harvest assessment program. Lingcod objectives include estimation of 1) the age, sex, and length composition of lingcod harvests by ports and 2) the geographic distribution of harvest by each fleet. The program sampled 538 lingcod from the sport harvest at Seward, Valdez, Whittier, Kodiak, and Homer in 2016. These ports accounted for the majority of sport lingcod harvest in Southcentral Alaska (Contact Barbi Failor).

b. Assessment

The **Southeast Region** is not currently able to reliably estimate lingcod biomass or abundance. Lacking abundance estimates, and given the complex life history and behavior of lingcod, impacts to lingcod populations from fishing are difficult to assess. Analysis of catch per unit effort data (CPUE) from fishery logbooks, in terms of fish per hook-hour for 1988–1998, showed that CPUE had declined between 21 to 62% in areas where a directed fishery and increased sport catch had developed. Consequently the quota for lingcod was reduced in all areas in 2000. After reductions in GHRs, CPUE increased in CSEO until around 2007; since then CPUE has generally decreased. CPUE in NSEO has been generally stable since reductions in GHRs. In SSEOC, CPUE was highly variable from 1994 to 2003; since then, limited participation in this fishery is too erratic to characterize CPUE. In EYKT, after the GHR was reduced, CPUE was fairly stable; however, in last four years CPUE has been the lowest since 2000. Yet, CPUE in EYKT remains high relative to other management areas, likely because fishing is concentrated in smaller areas with typically higher abundances of lingcod. The CPUE in IBS was stable between 2004 and 2009, increased from 2010 to 2014, and has been declining since 2015. Higher CPUE in recent years may be due to increases in stocks or changes in fishery dynamics—vessel participation has decreased with experienced fishermen remaining in this area.

Central Region conducts ROV surveys along the northern Gulf of Alaska coast from the Kenai Peninsula to Prince William Sound for to estimate local abundance and biomass of lingcod concurrently with DSR. The impetus and goals of these surveys are the same for and have been described above in the Rockfishes Assessment section (Contact Mike Byerly or Dr. Kenneth J. Goldman).

c. Management

Management of lingcod in **Southeast Alaska** is based upon a combination of GHRs, season and gear restrictions. Regulations include a winter closure for all users, except longliners, between December 1 and May 15 to protect nest-guarding males. GHLs were greatly reduced in 2000 in all areas and allocations made between directed commercial fishery, sport fishery, longline fisheries, and salmon troll fisheries. This was the first year sport catch was included in a quota allocation. The 27” minimum commercial size limit remains in effect and fishermen are requested to keep a portion of their lingcod with the head on, and proof of gender to facilitate biological sampling of the commercial catch. Vessel registration is required and trip limits are utilized by ADF&G staff, when needed, for the fleet to stay within its allocations. The directed fishery is limited to jig or dinglebar troll gear. In 2003 the Board of Fish (BOF) established a super-exclusive directed fishery registration for lingcod permit holders fishing in the IBS Subdistrict.

The **Central Region** has directed commercial fisheries for lingcod in Cook Inlet and PWS. Regulations for the commercial lingcod fishery include open season dates of July 1 to December 31 and a minimum size limit of 35 inches (89 cm) overall or 28 inches (71 cm) from the front of the dorsal fin to the tip of the tail and a jig-only gear requirement for the directed lingcod fishery in the Cook Inlet Area. Guideline harvest levels (GHLs) are 24 mt for Cook Inlet and 3.3 mt in the Inside District of PWS and 11.5 mt for the PWS Outside District. Resurrection Bay, near Seward, is closed to commercial harvest of lingcod. In 2009, a new BOF regulation permitted retention of lingcod at a 20% bycatch level in PWS waters following closure of the directed season. Cook Inlet Area also allows 20% bycatch levels for lingcod, however, no bycatch may be retained after the GHL is achieved.

In **Southeast Alaska**, sport harvests of lingcod are incorporated into a regionwide lingcod management plan. This plan reduced GHLs for all fisheries (combined) in seven management areas, and allocated a portion of the GHL for each area to the sport fishery. Since 2000, harvest limits reductions, size limits, and mid-season closures have been implemented by emergency order in various management areas to ensure sport harvests do not exceed allocations.

The sport fishery lingcod season for 2016 was May 16-November 30. Charter vessel operators and crew members were prohibited from retaining lingcod while guiding clients. For resident anglers, the limits regionwide were one fish per day and two in possession, with no size limit. Additional restrictions were put into place for nonresidents to keep harvest from exceeding allocations specified by the Alaska Board of Fisheries. Nonresidents were allowed one fish daily and one in possession. In the Yakutat and Southern Southeast districts, nonresidents were allowed to harvest fish 30-45 inches in length, or fish 55 inches and greater in length. In the Northern Southeast District, nonresidents were only allowed to harvest fish that were 30-35 inches in total length, or fish 55 inches and greater in length. Nonresidents were limited to two lingcod annually in each area, only one of which could be 55 inches or greater in length, and four annually among all areas of Southeast Alaska. In addition, the Pinnacles area near Sitka has been closed to sport fishing year-round for all groundfish since 1997 (Contact Robert Chadwick).

A suite of regulations was established in 1993 for sport lingcod fisheries in **Southcentral Alaska** in light of the lack of quantitative stock assessment information. Resurrection Bay remained closed to lingcod fishing year-round to rebuild the population, although there is no formal rebuilding plan. The season was closed region-wide from January 1 through June 30 to protect spawning and nest guarding lingcod. Daily bag limits in 2016 were two fish in all areas except the North Gulf, where the daily bag limit was one fish. All areas except Kodiak had a minimum size limit of 35 inches to protect spawning females (Contact Dan Bosch or Matt Miller).

d. Fisheries

Lingcod are the target of a "dinglebar" troll fishery in **Southeast Alaska**. Dinglebar troll gear is power troll gear modified to fish for groundfish. Additionally lingcod are landed as significant bycatch in the DSR and halibut longline and salmon troll fisheries. At the 2009 BOF meeting a regulation was adopted that allowed Southeast management staff to adjust the lingcod bycatch levels in the halibut fishery to maximize the harvest of the lingcod longline allocations. The directed fishery landed 104 mt of lingcod in 2016. An additional 61 mt was landed as bycatch in halibut and other groundfish fisheries and 15 mt in the salmon troll fishery.

Central Region commercial lingcod harvests have primarily occurred in the North Gulf District of the Cook Inlet Area and PWS. Lingcod harvests in 2016 totaled 10.6 mt in Cook Inlet Area and 6.4 mt in PWS. Approximately 84% of the lingcod harvest from Cook Inlet Area resulted from participation in the directed lingcod jig fishery. CI harvest increased more than three-fold from 2015 to 2016; many participated concurrently in the directed rockfish, which had an increase and effort, and directed lingcod fisheries. In PWS, approximately 89% of lingcod harvest was from directed longline effort. In both areas, the remaining harvest resulted from bycatch to other directed (primarily halibut) longline fisheries and in PWS, about 10% additional bycatch by trawl gear. Cook Inlet and PWS fisheries remained open through December 31 (Contact Jan Rumble).

No directed effort occurred for lingcod in the **Westward Region** during 2015. Most lingcod are taken as bycatch to federally managed bottom trawl fisheries. Incidental take by trawl vessels peaked in 2008 when 250 mt of lingcod were harvested in 2008. In response, ADF&G reduced bycatch limits in 2009 from 20% to 5%. Incidental take of lingcod had ranged between 30 to 106 mt per year since 2009. Most lingcod are harvested in federal waters northeast of the Port of Kodiak.

Sport lingcod harvest estimates from the statewide mail survey for 2015 (the most recent year available) were 12,764 lingcod in Southeast Alaska and 15,007 lingcod in Southcentral Alaska. The average estimated annual harvest for the recent five-year period (2011-2015) was 12,492 fish in Southeast Alaska and 19,553 fish in Southcentral Alaska.

L. Atka Mackerel

1. Research

There was no research on Atka mackerel during 2016.

2. Assessment

There are no state stock assessments for Atka mackerel.

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for Atka mackerel. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for Atka mackerel in 2016. Currently in the **Central Region** and **Southeast Region** Atka mackerel are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

M. Flatfish

a. Research

There was no research on flatfish during 2016.

b. Assessment

There are no stock assessments for flatfish.

c. Management

Trawl fisheries for flatfish are allowed in four small areas in the internal waters of **Southeast Alaska** under a special permit issued by the department. The permits are generally issued for no more than a month at a time and specify the area fished and other requirements. Trawl gear is limited to beam trawls, and mandatory logbooks are required, observers can be required, and there is a 20,000 pound weekly trip limit.

Within **Central Region** flatfish may be harvested in a targeted fishery only under the authority of an ADF&G Commissioner's permit. The permit may stipulate fishing depth, seasons, areas, allowable sizes of harvested fish, gear, logbooks, and "other conditions" deemed necessary for conservation or management purposes. No permits have been issued to harvest flatfish.

There are no bag, possession, or size limits for flatfish (excluding Pacific halibut) in the sport fisheries in Alaska. Harvest of flatfish besides Pacific halibut are not explicitly estimated by the SWHS and no information is collected in the creel surveys and port sampling of the sport fisheries in Southcentral or Southeast Alaska. Flatfish are occasionally taken incidentally to other species and in small shore fisheries, but the sport harvest is believed to be negligible.

d. Fisheries

Very little effort has occurred in the **Southeast** fishery in recent years. Since the 1998–1999 season only once vessel has applied for a Commissioner's permit to participate in this fishery; this vessel made a single flatfish landing in 2013. Due to limited participation, harvest information is confidential for this landing. The Southeast flatfish trawl areas are also the sites of a shrimp beam trawl fishery. In the past, most of the Southeast harvest was starry flounder. In state waters of the **Westward Region**, the State of Alaska adopts most NOAA Fisheries regulations and the flatfish fishery is managed under a parallel management structure. No permits to harvest flatfish were issued in **Central Region** during 2015.

N. Pacific Halibut and IPHC Activities

The sport halibut fishery is a focus of a statewide monitoring and management effort by the Division of Sport Fish. Data on the sport fishery and harvest are collected through port sampling in Southeast and Southcentral Alaska. Estimates of harvest and related information are provided annually to the IPHC for use in the annual stock assessment, and to the North Pacific Fishery Management Council. The council's Scientific and Statistical Committee has periodically reviewed the state's estimation and projection methods. ADF&G provides an analysis each year that is used by the Council to recommend regulatory changes for the charter fishery to keep its harvest within allocations specified in the Catch Sharing Plan for Guided Sport and Commercial Fisheries in Alaska. The Council's recommendations are incorporated by the IPHC as annual management measures for the charter fishery. Estimates of sport harvest and associated analyses are posted on the North Pacific Fishery Management Council's web page at http://www.npfmc.org (Contact Scott Meyer).

O. Other groundfish species

In 1997 the BOF approved a new policy that would strictly limit the development of fisheries for other groundfish species in **Southeast**. Fishermen are required to apply for a "permit for miscellaneous groundfish" if they wish to participate in a directed fishery for species that do not already have regulations in place. Permits do not have to be issued if there are management and conservation concerns. The state also has a regulation that requires that the bycatch rate of groundfish be set annually for each fishery by emergency order unless otherwise specified in regulation.

Other Related Studies

Staff in the **Central Region** currently house all data in an MS Access database format. Queries are complete for calculating CPUE, abundance, and biomass estimates from most surveys. All data are additionally captured in GIS for spatial analysis.

ADF&G manages state groundfish fisheries under regulations set triennially by the BOF.

ADF&G announces the open and closed fishing periods consistent with the established regulations, and has authority to close fisheries at any time for justifiable conservation reasons. The department also cooperates with NOAA Fisheries in regulating fisheries in offshore waters.

2. Marine Reserves

In September of 1997 the ADF&G submitted proposals to both the BOF and the Council requesting that they implement a small no-take marine reserve in **Southeast**. The purpose of these proposals was to permanently close a 3.2 sq. mile area off Cape Edgecumbe to all bottomfish and halibut fishing (including commercial, sport, charter, bycatch and subsistence) and anchoring to prevent over-fishing and to create a groundfish refuge. Two large volcanic pinnacles that have a diversity and density of fishes not seen in surrounding areas dominate the Edgecumbe Pinnacles Marine Reserve. The pinnacles rise abruptly from the seafloor and sit at the mouth of Sitka Sound where ocean currents and tidal rips create massive water flows over this habitat. These two pinnacles provide a very unique habitat of rock boulders, encrusted with *Metridium*, bryozoans and other fragile invertebrate communities, which attracts and shelters an extremely high density of juvenile rockfishes. The area is used seasonally by lingcod for spawning, nest-guarding, and post-nesting feeding. Yelloweye rockfish and pelagic rockfish species as well as large numbers of prowfish and Puget Sound rockfish also densely inhabit the pinnacles. This closure protects the fragile nature of this rare habitat and prevents the harvest or bycatch of these species during critical portions of their life history. In February 1998 the BOF approved the reserve and the Council approved the reserve at their June 1998 meeting. The Council recommended to the BOF that they consider closure of the area to salmon trolling which would make the area a complete-no take zone. In February 2000 the BOF rejected closing the area to salmon trolling. The area is an important "turn-around" area for commercial trollers and the BOF did not believe there was sufficient conservation benefit to warrant closing the area to salmon fishing.

3. User Pay/Test Fish Programs

The department receives receipt authority from the state legislature that allows us to conduct stock assessment surveys by recovering costs through sale of fish taken during the surveys. Receipt authority varies by region. In **Southeast Alaska** several projects are funded through test fish funds (total receipt authority is approximately 600k), notably the sablefish longline assessments and mark-recapture work, the herring fishery and some salmon assessments.

4. Statistical Area Charts

Digital groundfish and shellfish statistical area charts are available and can be viewed or downloaded at:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps
(Contact Lee Hulbert)

WEBSITES

ADF&G Home Page: http://www.adfg.alaska.gov

Commercial Fishing home page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingCommercial.main

Sport Fisheries home page: http://www.adfg.alaska.gov/index.cfm?adfg=fishingSport.main

News Releases: http://www.adfg.alaska.gov/index.cfm?adfg=newsreleases.main

Rockfish Conservation page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportFishingInfo.rockfishconservation

Age Determination Unit Home Page:
http://mtalab.adfg.alaska.gov/ADU/

Region I, Southeast Region, Groundfish Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.groundfish

Gene Conservation Laboratory Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishinggeneconservationlab.main

Region II, Central Region, Groundfish Pages:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingcommercialbyarea.southcentral

Westward Region, Groundfish Pages:
http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherygroundfish.groundfishareas

ADF&G Groundfish Overview Page:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.main

Commercial Fisheries Entry Commission: http://www.cfec.state.ak.us/

State of Alaska home page: http://www.alaska.gov

Demersal shelf rockfish stock assessment document:
https://www.afsc.noaa.gov/REFM/Docs/2016/GOAdsr.pdf

Groundfish charts:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps

VI. Publications

Baumer, J., B. Blain, and S. Meyer. 2016. Fisheries management report for the sport fisheries of the North Gulf Coast, 2010-2015. Alaska Department of Fish and Game, Fishery Management Report No. 16-33, Anchorage.

Byerly, M., B. Chadwick, H. Fitch, B. Failor, K. Goldman, K. Green, L. Hulbert, M. Jaenicke, K. McNeil, S. Meyer, J. Rumble, E. Russ, G. Smith, M. Stichert, and C. Worton. 2014. State of Alaska Groundfish Fisheries Associated Investigations in 2013, Prepared for the Fifty-fourth Annual Meeting of the Technical Sub-committee of the Canada-United States Groundfish Committee, April 2014.

Conrath, C.L., C.A. Tribuzio and K.J. Goldman. 2014. Notes on the reproductive biology of female salmon shark *Lamna ditropis*, in the eastern North Pacific Ocean. Trans. Am. Fish. Soc. 143:363-368.

Meyer, S. and R. Powers. 2016. Analysis of management options for the Area 2C and 3A charter halibut fisheries for 2017. Unpublished report prepared for the North Pacific Fishery Management Council, December 2016. Available online at npfmc.legistar.com/gateway.aspx?M=F&ID=c4d10d23-75b1-4d61-930e-892f6a8a8d53.pdf (accessed 3/20/17).

Olson, A., J. Stahl, K. Van Kirk, M. Jaenicke, and S. Meyer 2016. Chapter 14: Assessment of the demersal shelf rockfish stock complex in the Southeast Outside District of the Gulf of Alaska. Pages 565-608 in Appendix B, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, Anchorage, Dec. 2016.

Powers, B. and D. Sigurdsson. 2016. Participation, effort, and harvest in the sport fish business/guide licensing and logbook programs, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-02, Anchorage.

Stahl, J. P., K. Green, A. Baldwin, and K. Carroll. 2015. Southern Southeast Inside commercial sablefish fishery and survey activities, 2014. Alaska Department of Fish and Game, Fishery Management Report No. 15-22, Anchorage.

Watanabe, Y.Y., K.J. Goldman, J.E. Caselle, D.D. Chapman and Y.P Papastamatiou. 2015. Comparative analyses of animal-tracking data reveal ecological significance of endothermy in fishes. PNAS, 112(19):6104-6109. supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1500316112/-/DCSupplemental.

Wessel, M., J. Rumble, K.J. Goldman, E. Russ, M. Byerly, and C. Russ. 2014. Prince William Sound Registration Area E Groundfish Fisheries Management Report, 2009-2013. Alaska Department of Fish and Game, Fishery Management Report No. 14-42, Anchorage. November 2014.

APPENDICES

Appendix I. Alaska Department of Fish and Game Full-time Groundfish Staff During 2016

COMMERCIAL FISHERIES DIVISION

HEADQUARTERS, P.O. Box 25526, Juneau, Alaska 99802-5526

Chief, Computer Services Kathleen Jones (907) 465-4753	Age Determination Unit Supervisor Kevin McNeel Box 115526 Juneau, AK 99811 (907) 465-3054	Elandings Program Coordinator II Gail Smith (907) 465-6157
Alaska Fisheries Information Network (AKFIN) Program Coordinator Lee Hulbert (907) 465-6109	Fishery Biologist I April Rebert Box 115526 Juneau, AK 99811 (907) 465-1174	

SOUTHEASTERN REGION

Groundfish Project Leader Andrew Olson Box 240020 Douglas, AK 99824-0020 (907) 465-4259	Fishery Biologist II Jennifer Stahl Box 240020 Douglas, AK 99824-0020 (907) 465-4071	Fishery Biologist II Mike Vaughn 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6688
Project Biometrician Kray Van Kirk Box 240020 Douglas, AK 99824-0020 (907) 465-4216	Fishery Biologist I Aaron Baldwin Box 240020 Douglas, AK 99824-0020 (907) 465-3896	Fishery Technician IV Kamala Carroll 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6688
Fishery Biologist I Asia Beder P.O. Box 667 Petersburg, AK 99833-0667 (907) 772-5223	Fishery Technician IV Jennifer Dupree P.O. Box 667 Petersburg, AK 99833-0667 (907) 772-5231	Fishery Technician III Naomi Bargmann 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6831

CENTRAL REGION

CI/PWS Groundfish & Shellfish Research Project Leader Dr. Kenneth J. Goldman 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	CI/PWS Area Management Biologist Jan Rumble 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	Groundfish Sampling/Ageing Mgr; Asst. Area Management Biologist Elisa Russ 3298 Douglas Place, Homer AK 99603-7942 (907) 235-8191
Fish Ticket Processing and Data Analyst Chris Russ 3298 Douglas Place, Homer, AK 99603-7942 (907) 235-8191	Fishery Biologist Mike Byerly 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	GIS Analyst Josh Mumm 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191

WESTWARD REGION

Shellfish/Groundfish Biologist Wayne Donaldson 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1840	Area Management Biologist Mark Stichert 351 Research Ct., Kodiak, AK 99615-6399 (907) 486-1840	Groundfish Research Biologist Carrie Worton 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1849
Groundfish Sampling Coordinator Kally Spalinger 351 Research Ct Kodiak, AK 99615 (907) 486-1840	Assistant Area Management Biologist Nathaniel Nichols 351 Research Ct Kodiak, AK 99615 (907) 486-1840	Area Management Biologist Miranda Westphal P.O. Box 920587 Dutch Harbor, AK 99692 (907) 581-1239
Assistant Groundfish Research Biologist Philip Tschersich 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1871	Assistant Area Management Biologist VACANT P.O. Box 920587 Dutch Harbor, AK 99692 (907) 581-1239	

SPORT FISH DIVISION

STATEWIDE, P.O. Box 25526, Juneau, Alaska 99802-5526

Deputy Director Tom Taube P.O. Box 115526 Juneau, AK 99811-5526 (907) 465-6187	Statewide Bottomfish Coordinator Scott Meyer 3298 Douglas Place Homer, AK 99603-8027 (907) 235-1742	Logbook Program Coordinator Bob Powers 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2299

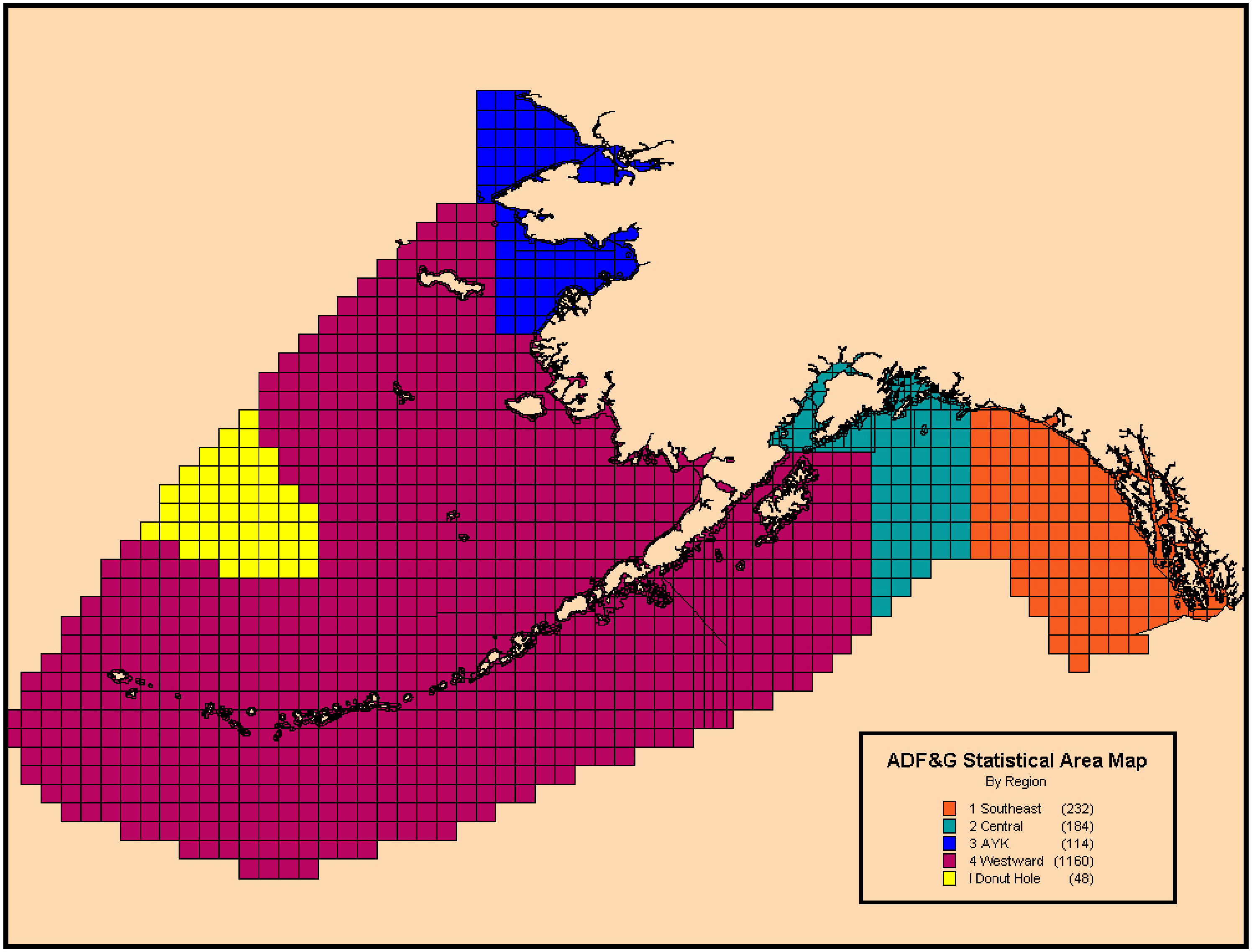
SOUTHEAST REGION

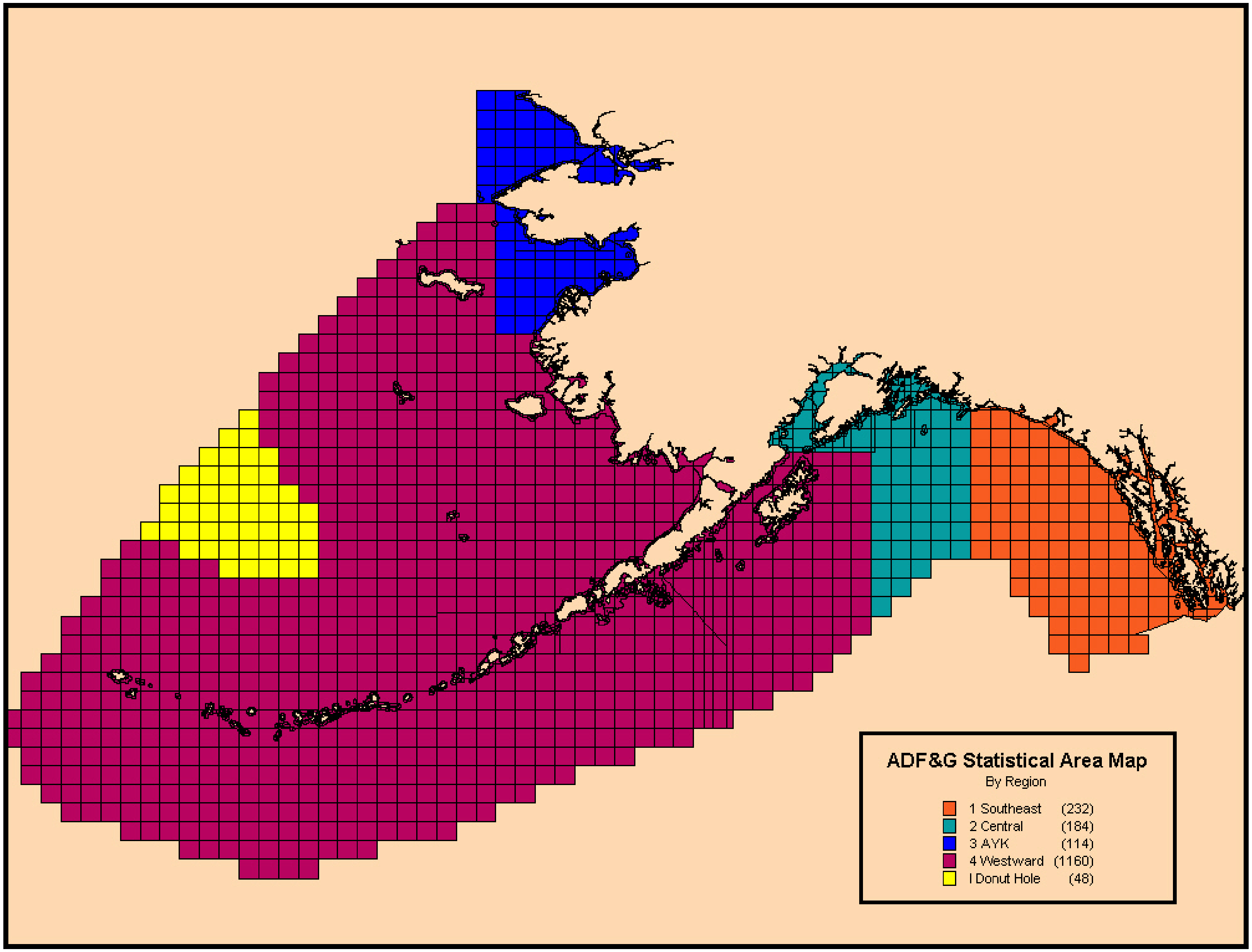
Project Leader, Marine Harvest Studies Michael Jaenicke PO Box 110024 Juneau, AK 99811-0024 (907) 465-4301	Regional Management Biologist Robert Chadwick 304 Lake St., Room 103 Sitka, AK 99835-7563 (907) 747-5551	Regional Research Biologist Jeff Nichols P.O. Box 110024 Juneau, AK 99811-0024 (907) 465-4398
Yakutat Area Management Biologist Brian Marston P.O. Box 49 Yakutat, AK 99689-0049 (907) 784-3222	Haines/Skagway Area Mgmt. Biol. Richard Chapell P.O. Box 330 Haines, AK 99827-0330 (907) 766-3638	Juneau Area Management Biologist Daniel Teske PO Box 110024 Juneau, AK 99811-0024 (907) 465-8152
Sitka Area Management Biologist Troy Tydingco 304 Lake St., Room 103 Sitka, AK 99835-7563 (907) 747-5355	Petersburg/Wrangell Area Mgmt. Biologist Patrick Fowler P.O. Box 667 Petersburg, AK 99833-0667 (907) 772-5231	Prince of Wales Area Management Biologist Craig Schwanke P.O. Box 682 Craig, AK 99921 (907) 826-2498
Ketchikan Area Mgmt. Biologist Kelly Piazza 2030 Sea Level Drive, Suite 205 Ketchikan, AK 99901 (907) 225-2859	Biometrician Sarah Power Division of Sport Fish-RTS PO Box 110024 Juneau, AK 99811-0024 (907) 465-1192	

SOUTHCENTRAL REGION

Halibut/Groundfish Project Leader Barbi Failor 3298 Douglas Place Homer, AK 99603 (907) 235-8191	Regional Management Biologists Dan Bosch, Matthew Miller 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2218	Regional Research Biologist Tim McKinley 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2218
Lower Cook Inlet Mgmt. Biol. Carol Kerkvliet 3298 Douglas Place Homer, Alaska 99603-8027 (907) 235-8191	PWS and North Gulf Mgmt. Biol. Jay Baumer, Brittany Blain 333 Raspberry Road Anchorage, AK 99518-1599 (907) 267-2153	Kodiak, Alaska Pen., and Aleutian Islands Management Biologist Tyler Polum 211 Mission Road Kodiak, AK 99615-6399 (907) 486-1880
	Biometrician Adam Reimer Division of Sport Fish-RTS 43961 Kalifornsky Beach Road, Suite B Soldotna, AK 99669-8276 (907) 262-9368	

Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions.




ADF&G Statistical Area Map
By Region
1 Southeast (232)
2 Central (184)
3 AYK (114)
4 Westward (1160)
I Donut Hole (48)

Appendix III. Tissue samples of *Sebastes* species and pollock collected for genetic analyses and stored at Alaska Department Fish and Game, Gene Conservation Laboratory, Anchorage. Species, sampling location, year collected, sample size, and tissue type are given.

Species	Location	Year	Sample size	Tissues
Yelloweye rockfish, *Sebastes ruberrimus*				
	Gravina, Danger, Herring	1991	27	muscle, liver, eye
	Knight Is./Naked Islands area	1998	100	fin
	Flamingo Inlet	1998	46	fin, larvae
	Tasu Sound	1998	50	fin
	Topknot	1998	49	fin
	Triangle Island	1998	63	fin, larvae
	Sitka	1998	49	fin
	Kachemak Bay	1999	58	fin
	Kodiak Island	1999	115	fin
	Resurrection Bay	1999	100	fin
	Fairweather Grounds	1999	100	fin
	SE Stat Areas 355601, 365701 (CSEO)	1999	100	fin
	Whittier	2000	97	fin
	Whittier	2000	50	fin
Black rockfish, *S. melanops*				
	Kodiak Island	1996	2	muscle, liver, heart, eye
	Ugak Bay, Kodiak Island	1997	100	muscle, liver, heart, eye
	Resurrection Bay - South tip Hive Island	1997	82	muscle, liver, heart, eye, fin
	Carpa Island	1998	40	fin
	Eastside Kodiak Is.: Ugak and Chiniak Bays	1998	100	fin
	Southwest side Kodiak Island	1998	86	fin
	Westside Kodiak Island	1998	114	fin
	North of Fox Island	1998	24	fin
	Washington - Pacific Northwest	1998	20	fin
	Sitka	1998	50	fin
	Castle Rock near Sand Point	1999	60	fin
	Akutan	1999	100	fin
	Oregon - Pacific Northwest	1999	50	muscle, liver, heart
	SE Stat Areas 355631, 365701 (CSEO)	1999	83	fin
	Sitka Sound Tagging study	1999	200	fin
	Dutch Harbor	2000	6	fin
	Chignik	2000	100	fin
	Valdez	2000	13	fin
	Whittier	2000	16	fin
	Valdez	2001	50	fin

Whittier	2001	93	fin
Yakutat Bay	2003	130	fin
Dusky rockfish, *S. ciliatus*			
Kodiak Island	1997	50	muscle, liver, heart, eye
Resurrection Bay	1998	3	fin
Eastside Kodiak Is.: Ugak, Chiniak, Ocean Bays	1998	100	muscle, liver, heart, eye
Sitka Black RF Tagging study	1999	15	muscle, liver, heart, eye
Sitka	2000	23	liver, fin
Sitka	2000	23	fin
Harris Bay - Outer Kenai Peninsula	2002	37	muscle
North Gulf Coast - Outer Kenai Peninsula	2003	45	fin
Walleye pollock, *Gadus chalcogrammus*			
Exact location unknown; see comments	1997	402	fin
Bogoslof Island	1997	120	muscle, liver, heart
Middleton Island	1997	100	fin
NE Montague/E Stockdale	1997	100	fin
Orca Bay, PWS	1997	100	fin
Port Bainbridge	1997	100	fin
Shelikof Strait	1997	104	muscle, liver, heart, eye, fin
Bogoslof Island	1998	100	muscle
Eastern Bering Sea	1998	40	muscle, liver, heart
Middleton Island	1998	100	muscle, liver, heart
Port Bainbridge	1998	100	muscle, liver, heart
Resurrection Bay	1998	120	fin
Shelikof Strait	1998	100	muscle, liver, heart
PWS Montague	1999	300	heart
Eastern PWS	1999	94	heart
Kronotsky Bay, E. Coast Kamtchatka	1999	96	muscle, liver, heart, eye, fin
Avacha Bay	1999	100	unknown
Bogoslof Island	2000	100	muscle, liver, heart
Middleton Island	2000	100	muscle, liver, heart
Prince William Sound	2000	100	muscle, liver, heart
Shelikof Strait	2000	100	muscle, liver, heart

California Department of Fish and Wildlife
Agency Report
to the
Technical Subcommittee
of the
Canada-United States Groundfish Committee

April 2017

Prepared by

Adam Frimodig
Joanna Grebel
Traci Larinto
Caroline Mcknight
Melanie Parker
Michael Prall
Travis Tanaka
Amanda VanDiggelen

Contents

I. Agency Overview

Within the California Department of Fish and Wildlife (CDFW), the Marine Region is responsible for protecting and managing California's marine resources under the authority of laws and regulations created by the State Legislature, the California Fish and Game Commission (CFGC) and the Pacific Fishery Management Council (PFMC). The Marine Region is unique in the CDFW because of its dual responsibility for both policy and operational issues within the State's marine jurisdiction (0 – 3 miles). It was created to improve marine resources management by incorporating fisheries and habitat programs, environmental review and water quality monitoring into a single organizational unit. In addition, it was specifically designed to be more effective, inclusive, comprehensive and collaborative in marine management activities.

The Marine Region has adopted a management approach that takes a broad perspective relative to resource issues and problems. This ecosystem approach considers the values of entire biological communities and habitats, as well as the needs of the public, while ensuring a healthy marine environment. The Marine Region employs approximately 140 permanent and 100 seasonal staff that provide technical expertise and policy recommendations to the CDFW, CFGC, PFMC, and other agencies or entities involved with the management, protection, and utilization of finfish, shellfish, invertebrates, and plants in California's ocean waters. The Groundfish project staff are tasked with managing groundfish and providing policy recommendations to the CDFW, CFGC, and PFMC. Other staff work indirectly on groundfish, such as our California Recreational Fisheries Survey staff that sample our recreational fisheries and our Marine Protected Areas Project and their ROV work which benefits groundfish. Additionally, Pacific States Marine Fisheries Commission staff sample the state's commercial groundfish fishery.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

II. Surveys

CDFW Marine Region's Statewide Marine Protected Area (MPA) Management Project continued a contract with Marine Applied Research and Exploration (MARE) to perform visual surveys statewide using a remotely operated vehicle (ROV) (see 2015 TSC report for description of the program). This project was funded by the Coastal Impact Assistance Program for 2014-2016. The final research cruise to complete statewide surveys was performed on the central California coast in September and October of 2016 (Figure 1).

Two 12-day deployments were completed surveying 32 sites and 98 kilometers (61 miles) of transects. Initial findings indicate relatively high densities of rockfish and lingcod, especially at the more remote sites in and near Point Sur and Big Creek State Marine Reserves. Also observed in 2016, was a die off of red gorgonians at several sites, decreases in some macro algal species, and increases in red and purple urchins. Since the beginning of the statewide survey, 142 sites were visited from Pt. Saint George (Del Norte County) in the north to Point Cabrillo (San Diego County) completing 370 kilometers (230 miles) of quantitative transects. Over 400 hours of video was recorded during these transects and approximately 45,000 high resolution digital still images were collected.

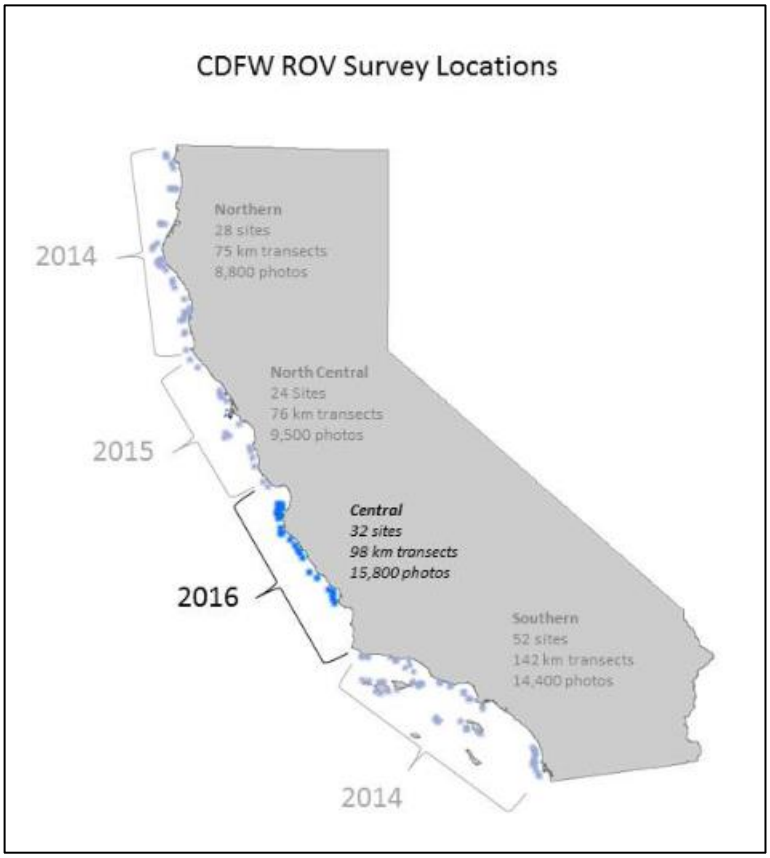


Figure 18. Survey locations completed in 2014 through 2016.

Currently the dataset from all three years of surveys are being analyzed for statewide and regional MPA monitoring and fishery specific needs. This extensive effort will provide much needed fishery-independent data for multiple management uses and establishes an unprecedented set of index sites across the entire California coast.

Contributed by Michael Prall (michael.prall@wildlife.ca.gov)

III. Reserves

California is home to the largest scientifically designed network of MPAs in the United States, including 124 MPAs and 15 special closures protecting approximately 16 percent of state waters. CDFW manages California's MPAs as a statewide network using a partnership based approach through the MPA Management Program. The MPA Management Program includes four core components: 1) outreach and education, 2) research and monitoring, 3) enforcement and compliance, and 4) policy and permitting. This collaborative program facilitated the design and implementation of MPAs, and continues to facilitate ongoing adaptive management of California's MPA network to meet the goals of the Marine Life Protection Act (MLPA). This report includes brief updates regarding MPA research and monitoring, and policy and permitting.

MPA Research and Monitoring

Research and monitoring within the MPA Management Program is managed in partnership with the Ocean Protection Council (OPC) and Ocean Science Trust (OST) through the MPA Monitoring Program. The MPA Monitoring Program consists of two phases: 1) regional baseline monitoring and 2) statewide long-term monitoring. Phase 1 is expected to be completed in 2018, while Phase 2 began in 2016 concurrent with Phase 1, and is now ramping up.

Phase 1

California invested $16 million in regional MPA baseline monitoring at or near the time of MPA implementation. This investment generated an unprecedented assessment of ecological and socioeconomic conditions of California's coast, both inside and outside MPAs. D ue to the staggered implementation of MPAs, two regions, the Central Coast and North Central Coast, have completed Phase 1; the South Coast and North Coast are expected to complete Phase 1 in 2017 and 2018 respectively (Table 1).

Baseline monitoring results from the first five years of MPA implementation are summarized into a "State of the Region" report (SoR report). The Central Coast SoR report and its corresponding CDFW 5-year management review was completed in 2013. In late 2015, the OST, CDFW, and OPC completed the North Central Coast SoR report and corresponding CDFW 5-year management review and they were presented to the CFGC in April 2016. In March 2017, OST, CDFW, and OPC completed the South Coast SoR report. This report, and its corresponding CDFW 5-year management review, will be presented to the CFGC in April 2017. Also in March 2017, principal investigators from each of the 11 North Coast baseline monitoring projects completed a draft baseline technical report. These reports are scheduled for a peer review in late March 2017, and final reports are anticipated for completion in May 2017. These technical reports will inform the fourth and final SoR report for the North Coast which is anticipated to be released in 2018. This report will accompany CDFW's final 5-year management review when presented to the CFGC. Upon the presentation of the management review, Phase 1 of the MPA Monitoring Program will be complete.

Phase 2

Planning for long-term monitoring under Phase 2 began in 2016. California has committed an annual allotment of $2.5 million to support long-term monitoring with the first two years of funding going to support: maintaining multi-year and multi-region data collection in priority ecosystems, and developing and launching a comprehensive data management system to connect existing data platforms. This funding has also allowed three post-doc fellows to be hired who will: 1) help develop a Statewide MPA Monitoring Action Plan to inform long-term statewide MPA monitoring; 2) help analyze and integrate extensive remotely operated vehicle data to gain insights on MPA performance; and 3) develop effective methods to integrate MPAs with fisheries management. T he fellows began their work in February 2017, and are co-mentored by CDFW staff and UC Davis faculty.

Table 1. Phase 1, baseline monitoring timeline.

Coastal Region	Review & Select Projects	Collect & Analyze Data	Synthesize & Share Results	5-year Mgmt Review
Central Coast	2007	2007-2012	2012-2013	2013
North Central Coast	2010	2010-2014	2014-2015	2016
South Coast	2011	2011-2015	*2016-2017*	*2017*
North Coast	2013	2014-2017	*2017-2018*	*2018*

= completed = underway = ~ year complete

MPA Policy and Permitting

The MLPA required CDFW to develop, and the FGC to adopt, a "master plan" that guides the implementation of a Marine Life Protection Program (better known as the "MPA Management Program") to improve the design and management of California's MPAs to the extent possible, as a statewide network. A draft Master Plan for MPAs, adopted by the CFGC in February 2008, guided the regional development of MPA proposals. The 2016 Master Plan for MPAs, adopted by the CFGC in August 2016, focuses on the shift from MPA design and planning to managing California's redesigned MPA network to meet the goals of the MLPA. To create the 2016 Master Plan for MPAs, CDFW worked in close collaboration with the CFGC, OPC, and OST. The 2016 Master Plan for MPAs also reflects input received from other state and federal agencies, California Tribes and Tribal governments, many other organizations and the general public.

Through interagency cooperation and coordination, CDFW and OPC's Science Advisory Team continued to develop an ecological impact assessment tool that will assist in understanding and estimating ecological impacts from scientific collecting in MPAs, with a goal of shielding MPAs against cumulative impacts from research activities or projects. Staff is beta testing the assessment on a variety of MPA related projects and plans to fully implement the new assessment tool at the end of 2017.

Contributed by Amanda Van Diggelen (Amanda.VanDiggelen@wildlife.ca.gov) and Adam Frimodig (Adam.Frimodig@wildlife.ca.gov)

IV. Review of Agency Groundfish Research, Assessment and Management

A. Hagfish

There are two species of hagfish that reside off California, Pacific hagfish (*Eptatretus stoutii*) and black hagfish (*Eptatretus deani*). Of the two, the Pacific hagfish (hagfish) is the preferred species for California's export-only fishery. Using traps, fishermen land hagfish in live condition. The hagfish are usually stored dockside until packaged for live export to South Korea where they are sold live for human food. Considered scavengers, hagfish are found over deep, muddy habitat.

1. Assessment

Little is known about the status or biomass of Pacific hagfish stocks. Since 2007, the Department's Northern and Central California Finfish Research and Management Project has been monitoring the fishery and documenting changes in the average weight and spawning status of landed hagfish through dockside sampling. Sampling activity began with the emergence of the fishery in Moss Landing, ended there in 2008 due to market changes, occurred in southern California from 2009 to 2011, and began in Morro Bay in 2010 and Eureka in 2012. The Moss Landing fishery reemerged in 2016 with one vessel making landings of hagfish taken with barrel traps, and sampling resumed. Due to the physical impossibility of accurately measuring hagfish in a live condition, staff employs a count-per-pound method to monitor changes in average size of retained hagfish. Randomly selected hagfish from sampled landings are retained for spawning status and length data. Landings have been relatively stable from 2010 to 2015, fluctuating between 360 and 745 metric tons (0.8 and 1.6 million pounds) annually with an ex-vessel value of $565,000 to $1.3 million. In 2016 there were 690 metric tons landed for an ex-vessel value of $1.35 million. Fishing effort and export demand is market driven and can be influenced by Washington and Oregon markets.

2. Management

The commercial hagfish fishery is open access; only a commercial fishing license and a general trap permit are required. Hagfish may be taken in 19 liter (5 gallon) bucket traps, Korean traps, or, since January 1, 2016, barrel traps [approximately 150 liters (40 gallons) each]. The maximum number of traps allowed is 200 bucket, 500 Korean, or 25 barrel traps. Fishermen must choose one trap type and may not combine hagfish trap types or have other non-hagfish traps onboard when fishing with a chosen hagfish trap. There is no limit on the number of groundlines for bucket or Korean traps, however barrel traps may be attached to no more than three groundlines. All traps must have a CDFW approved destructive device and all holes, except for the entrance, in any hagfish trap must have a minimum diameter of 14.2 millimeters (9/16 inches). When in possession of hagfish, no other finfish species may be possessed on board. Currently logbooks are not required for this fishery. There are no annual quotas or minimum size limits.

Due to the unavailability of 40-gallon barrels, fishermen began to modify larger, more common barrels to comply with the regulation. These modifications made enforcement difficult, prompting an amendment to the regulation. In 2016 Department staff completed the CFGC regulatory process to amend the regulation to restrict barrel size by dimension (total length and outside diameter) rather than capacity. This amendment became effective January 1, 2017.

Contributed by Travis Tanaka (Travis.Tanaka@wildlife.ca.gov)

B. Groundfish, all species combined

1. Research off California
Scientific Collecting Permits are issued by CDFW to take, collect, capture, mark, or salvage, for scientific, educational, and non-commercial propagation purposes. Permits are generally issued for three years, except that student permits are for one year. Each year the Marine Region reviews about 60 permits involving the take of groundfish. While a complete report of groundfish-related research activities isn't available for this report, the permits fall into four broad categories: 1) public display in aquariums and interpretive centers; 2) environmental monitoring; 3) life history studies that include age and growth, hormone assays and genetics for population structure; and, 4) studies related to changing environmental conditions such as ocean acidification and hypoxia.

2. CDFW Research
In 2016, Marine Region continued its ongoing research on yelloweye rockfish (*Sebastes ruberrimus*). The population off the West Coast was designated as an overfished stock in the early 2000s. Commercial and recreational regulations were implemented to minimize gear interactions in combination with a prohibition on retention (or limited retention in designated fishing sectors) and area closures. As a result, there has been limited opportunity to collect biological information for studying age and growth parameters that are crucial components of stock assessment modeling.

In 2010, CDFW implemented a data collection policy within the recreational sampling program (California Recreational Fishery Survey Program) to collect yelloweye that are that mistakenly landed by recreational anglers. Since these fish are retained and quantified in the recreational sampling program, they are included as part of CDFW's monthly recreational fishery mortality estimate for this species.

Between 2010 and 2016, the CDFW's Groundfish Ecosystem Management and Science Project staff has processed approximately 94 yelloweye from the recreational fishing sector. Length, weight, sexual maturity, and otoliths were collected from each specimen. The sample set ranges between 134-706 mm in total length, and are approximately 44 percent female, 36 percent male and 18 percent unknown sex. The geographic samples extend from Monterey to Crescent City with the majority coming from North of Point Arena (Fort Bragg, Shelter Cove, Eureka and Crescent City).

In late 2016, CDFW sent the data from all processed samples to the National Marine Fisheries Service for ageing and incorporation into the upcoming stock assessment's data streams.

Contributed by Caroline Mcknight (Caroline.Mcknight@wildlife.ca.gov)

3. Yellowtail Rockfish
   Starting in 2013, the PFMC recommended issuance of an Exempted Fishing Permit (EFP) to commercial fishermen to study a method of commercial jig fishing to determine whether it is possible to target yellowtail rockfish (*Sebastes flavidus*) inside the Rockfish Conservation Areas (RCA) while avoiding overfished rockfish species. The goal of this study is to determine if targeting species in the midwater column can provide additional fishing opportunities for the commercial fishery in the RCAs while avoiding overfished stocks that are more likely to reside on the bottom. Data from trips taken between 2013 and 2015 indicate that the gear is successfully targeting healthy stocks (yellowtail and widow) while avoiding overfished species. Catch of overfished species bocaccio (*S. paucispinis*), canary (*S. pinniger*) and yelloweye rockfish was minimal. This EFP is under consideration for renewal for 2017-18.

   Contributed by Joanna Grebel (Joanna.Grebel@wildlife.ca.gov)

4. Assessment
   The CDFW did not conduct any stock assessments in 2016 for groundfish species.

5. Management
   Groundfish management is a complex issue and is conducted by the PFMC with input by CDFW as well as the states of Oregon and Washington and the treaty tribes, and guided by the federal Pacific Coast Groundfish Fishery Management Plan. With the exception of some nearshore species, discussed below, harvest guidelines, fishery sector allocations, commercial trip limits and recreational management measures (e.g., bag limits, season limits) are established by the PFMC and implemented by National Marine Fisheries Service (NMFS). Additionally, the PFMC establishes RCAs which are spatial closures to protect overfished species.

   The state's Nearshore Fishery Management Plan manages 16 species that are also listed in the federal Groundfish Fishery Management Plan [black (*Sebastes melanops*), black-and-yellow (*S. chrysomelas*), blue (*S. mystinus*), brown, calico (*S. dallii*), China (*S. nebulosus*), copper (*S. caurinus*), gopher (*S. carnatus*), grass (*S. rastrelliger*), kelp (*S. atrovirens*), olive (*S. serranoides*), quillback (*S. maliger*), and treefish (*S. serriceps*) rockfishes; cabezon (*Scorpaenichthys marmoratus*); kelp greenling (*Hexagrammos decagrammus*); California scorpionfish (*Scorpeana guttata*)], along with three other species [California sheephead (*Semicossyphus pulcher*), rock greenling (*H. lagocephalus*), and monkeyface prickleback (*Cebidichthys violaceus*)].

Inseason monitoring is used to track landings against statewide total allowable catches and/or regional allocations. Inseason monitoring of California commercial nearshore species landings is now conducted by CDFW biologists for the areas north and south of 40°10' North Latitude near Cape Mendocino. This work is done in conjunction with inseason monitoring, management and regulatory tasks conducted by the PFMC's Groundfish Management Team. Weekly tallies of landing receipts are used for inseason monitoring. At present, inseason monitoring focuses on black rockfish and sablefish (*Anoplopoma fimbria*).

For the recreational fisheries, inseason monitoring relies on data collected by CDFW's California Recreational Fisheries Survey (CRFS) staff using a combination of CRFS weekly reports that are replaced by CRFS monthly estimates, as they become available. Inseason monitoring for the recreational fisheries focuses on black rockfish and California scorpionfish as well as some overfished species, such as cowcod (*Sebastes levis*) and yelloweye rockfish. Inseason monitoring of recreational yelloweye rockfish catch is posted on CDFW's website so that the angling public can see how the season is progressing.

6. Commercial Fishery Monitoring
   Statistical and biological data from landings are continually collected and routinely analyzed by CDFW staff to provide current information on groundfish fisheries and the status of the stocks. California's primary commercial landings database is housed in CDFW's Commercial Fisheries Information System. Outside funding also enables California fishery data to be routinely incorporated into regional databases such as Pacific Coast Fisheries Information Network.

   Commercial sampling occurs at local fish markets where samplers determine species composition of the different market categories, measure and weigh fish and take otoliths for future ageing. Market categories listed on the landing receipt may be single species (e.g., bocaccio), or species groups (e.g., group shelf rockfish). Samplers need to determine the species composition so that landings of market categories can be split into individual species for management purposes. Biological data are collected for use in stock assessments and for data analyses to inform management decisions.

7. Recreational Fishery Monitoring
   The CRFS program was initiated in January 2004 to provide catch and effort estimates for marine recreational finfish fisheries. The CRFS program generates monthly estimates of total recreational catch for four modes of fishing [beach/bank, man-made structures, commercial passenger fishing vessels, and private and rental boats] for six geographic districts along California's 1,100 miles of coast. The data are used by state and federal regulators to craft regulations to protect fish stocks and provide recreational fishing opportunities. The sampling data and estimates are available on the Recreational Fisheries Information Network website.

   Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

EE. Pacific halibut & IPHC activities

1. Research and Assessment
   Research and assessment activities for Pacific halibut (*Hippoglossus stenolepis*) off the coast of California are conducted by the International Pacific Halibut Commission (IPHC). Both sport and commercial fishery activities were monitored by CDFW staff in 2016.

2. Management
   The CDFW collaboratively manages the Pacific halibut resource off the coast of California with the IPHC, NMFS, PFMC, other west coast states, and the CFGC. Pacific halibut management activities occur on an annual timeline, with most changes to management occurring through the PFMC's Catch Sharing Plan and federal regulations published by NMFS. Changes to the Catch Sharing Plan for the following year are approved in November by the PFMC.

   The recreational fishery was scheduled to be open the first through the fifteenth of each month from May through August, and September 1 through October 31, or until the quota was met, whichever was earlier.

   To track Pacific halibut catch, CDFW generated a Preliminary Projected Catch amount by using sample information directly from CRFS weekly field reports to approximate catch during the lag time until monthly CRFS catch estimates are available six weeks later. The Preliminary Projected Catch would be replaced by the monthly CRFS catch estimate, once available. The CDFW provided this information online so that the angling public could view how the season progressed. Using this inseason tracking methodology, the quota was projected to have been met on September 23, 2016, and the fishery closed early on September 24, 2016. Final season catch estimates were 30,894 net pounds, 104 percent of the 29,640 net pound quota.

   Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

V. Publications

CDFW. 2016. Master Plan for Marine Protected Areas. 261 p. Available at: https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Master-Plan.

CDFW. 2017. California Department of Fish and Wildlife Report to the International Pacific Halibut Commission on 2016 California Fisheries. 14 p. Available at: http://www.iphc.int/meetings/2017am/IPHC-2017-AM093-AR07.pdf.

OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2016

OREGON DEPARTMENT OF FISH AND WILDLIFE

2017 AGENCY REPORT
PREPARED FOR THE 25-26 APRIL 2016 MEETING OF THE TECHNICAL SUB-COMMITTEE OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE

Edited by:

Alison Whitman

Contributions by:

T. Buell, C. Don, C. Heath, L. Kautzi, G. Krutzikowsky, S. Marion, L. Mattes, L. Rasmuson, B. Rodomsky, J. Watson, C. Whiteside, and A. Whitman

Oregon Department of Fish and Wildlife
Marine Resources Program
2040 SE Marine Science Drive
Newport, OR 97365

Table of Contents

I) Agency Overview

MRP Program Manager:	Dr. Caren Braby
Resource Management and Assessment:	Dave Fox
Fishery Management:	Maggie Sommer
Technical and Data Services:	Dan Erickson (current acting: Justin Ainsworth)

The Oregon Department of Fish and Wildlife's Marine Resources Program (MRP) is responsible for assessing, monitoring, and managing Oregon's marine habitat, biological resources, and fisheries. The MRP is based in Newport at the Hatfield Marine Science Center, with field stations in Astoria, Charleston, Brookings, and Corvallis. The MRP has primary jurisdiction over fisheries in state waters (from shore to three miles seaward), and participates in regional and international fishery management bodies including the Pacific Fishery Management Council and the International Pacific Halibut Commission. Management strategies developed at all levels affect Oregon fish and shellfish stocks, fisheries, resource users, and coastal communities. Staffing consists of approximately 60 permanent and more than 60 seasonal or temporary positions. The current annual program budget is approximately $8.75 million, with about 77% coming from state funds including sport license fees, commercial fish license and landing fees, and a small amount of state general fund. Grants from federal agencies and non-profit organizations account for the remaining 23% of the annual program budget.

II) Surveys

a) Sport Fisheries Monitoring

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2016. Starting in November 2005, major ports were sampled year-round and minor ports for peak summer-fall season. We continue to estimate catch during un-sampled time periods in minor ports based on the relationship of effort and catch relative to major ports observed during summer-fall periods when all ports are sampled. Lingcod (*Ophiodon elongatus)*, multiple rockfish species (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus)* and kelp greenling (*Hexagrammos decagrammus)* are the most commonly landed species.

The ORBS program continued collecting information on species composition, length and weight of landed groundfish species at Oregon coastal ports during 2016. Since 2003, as part of a related marine fish ageing research project, lingcod fin rays and otoliths from several species of nearshore groundfish, including rockfish species, kelp greenling and cabezon, were gathered. Starting in 2001, a portion of sport charter vessels were sampled using ride-along observers for species composition, discard rates and sizes, location, depth and catch per angler. Beginning in 2003, the recreational harvest of several groundfish species is monitored inseason for catch limit tracking purposes.

Other ODFW management activities in 2016 include participation in the U.S. West Coast Recreational Fish International Network (RecFIN) process, data analysis, public outreach and education, and public input processes to discuss changes to the management of groundfish and Pacific halibut fisheries for, 2017-2018, and beyond.

Contact: Lynn Mattes (lynn.mattes@state.or.us), Christian Heath (Christian.t.heath@state.or.us)

b) Commercial Fisheries Monitoring

Data from commercial groundfish landings are collected throughout the year and routinely analyzed by ODFW to provide current information on groundfish fisheries and the status of the stocks. This information is used in management, including in-season adjustments of the commercial nearshore fishery, which is conducted in state waters, and for participation in the Pacific Fisheries Information Network (PacFIN). Species composition sampling of rockfish and biological sampling of commercially landed finfish continued in 2016 for commercial trawl, fixed gear and hook and line landings. Biological data including length, age, sex and maturity status continued to be collected from landings of major commercial groundfish species.

Contact: Carla Sowell (Carla.Sowell@state.or.us), Scott Malvitch (Scott.Malvitch@state.or.us)

c) Pilot study – Using Electronic Monitoring in Commercial Fishery sampling

Sampling tools for collecting biological data from commercial groundfish landings have not changed in many years. Currently, lengths are determined on manual plastic length boards. Data are recorded on paper datasheets, and transcribed and entered into spreadsheets once back in the office. Funding was secured in 2015 to acquire and test new electronic-based system that includes an electronic length board and scale connected to tablets for commercial landings in 2016. Field and office based tests collected data on effort, precision and accuracy of the new electronic system throughout 2016 to compare with the existing paper-based system. Study design was finalized in early 2016, and testing occurred during the second half of 2016 and early 2017. Preliminary results indicated that the electronic system did not save sampling time in the field, but did save time in the office (data entry) time component, particularly with large samples. A final report for the project will be developed in 2017.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

d) Pilot study – Reinitiating the Shore and Estuary Boat Survey (SEBS)

In July 2005, sampling of the shore and estuary fishery was discontinued due to a lack of funding. Marine finfish catches outside the ocean boat modes have not been sampled since. In late 2015, ODFW received funds from two outside sources to resume a survey of limited scope for estimating shore and estuary marine finfish catches in 2016. This pilot study includes two main components – an angler intercept survey and a fishing effort survey that compares effort estimates from both phone and mail surveys.

In preparation for data collection (a) the angler intercept survey was redesigned by the SEBS coordinator and the SEBS advisory team, (b) a database was designed by ODFW staff to collect angler interview data electronically on hand held instruments (i.e., NOMADS), and (c) phone and mail survey instruments were constructed for offsite data collection. Shore and estuary boat angler catch data was collected through an in-person angler-intercept survey for Lincoln County, and statewide marine effort data was collected using phone and mail surveys for recreational trips taken from May 1 through October 31, 2016.

Data analysis is currently in progress. If this project is successful, we will develop improved estimates of finfish catch in bays and estuaries and from the shore. In addition, this project will directly compare and evaluate use of phone and mail surveys to estimate recreational fishing effort off Oregon. This comparison will allow us to select the best method to estimate fishing effort for a potential SEBS program.

Contact: Alison Whitman (alison.d.whitman@state.or.us), Cassandra Whiteside (cassandra.j.whiteside@state.or.us)

III) Marine Reserves

a) Management

The ODFW Marine Reserves Program is responsible for overseeing the management and scientific monitoring of Oregon's five marine reserve sites. ODFW has launched a new Oregon Marine Reserves website: OregonMarineReserves.com. Also, a new Oregon Marine Reserves *Ecological Monitoring Plan* was released in 2015, which includes information on survey study designs, the four core monitoring tools used by the Marine Reserve Program, and site specific monitoring plans and timelines for ecological surveys. Finally, harvest restrictions began at Oregon's fifth and final marine reserve site, at Cape Falcon, on January 1, 2016.

b) Monitoring

Hook and Line Surveys: The ODFW Marine Reserves Program continued hook and line surveys in 2016 at two of the marine reserves: Cape Perpetua and Cascade Head and their associated comparison areas. Data collection was broken into two periods: Spring (April-May) and Fall (September-October). Surveys were conducted on 18 at-sea fishing days with the assistance of 84 volunteer anglers. Although each site is unique in species composition, the 2016 survey caught a total of 2,855 fish, representing 16 species and three families.

Lander Surveys: In 2016, the ODFW Marine Reserves Program completed lander surveys at Cascade Head, Cape Falcon, and Otter Rock marine reserves and their associated comparison areas. A total of 174 drops were conducted with 46% meeting requirements for view, habitat and visibility. Surveys were conducted March - May and August-September of 2016. The drops conducted at these three sites contained observations of nine different species from four families.

ROV Surveys: The Marine Habitat project conducted video transect surveys of seafloor habitats, fish, and invertebrates using a remotely operated vehicle (ROV) at Redfish Rocks Marine Reserve and its two nearby comparison areas, Orford Reef and Humbug Reef. These surveys were part of the ecological assessments for this Marine Reserve that was closed to fishing in 2010. Over 8 days in April and May 2016, at total of 74 transects were conducted at the three sites in water depths between 18 and 45 meters.

ROV surveys were also initiated for Cascade Head Marine Reserve and its two comparison areas, Cavalier Reef and Schooner Creek. Two days of transects were attempted in October 2016, but unsuitable visibility and poor ocean conditions forced the postponement of the rest of the intended survey to spring 2017.

Both 2016 surveys incorporated a new stereo camera approach in addition to the traditional HD video main camera. GoPro cameras were mounted in custom dive housings in a stereo configuration on the front of the ROV, allowing the measurement of length for many of the fish observed.

c) Research

Development and Testing of a Fishery-independent Longline Method for Studying Demersal Fishes on Nearshore Rocky Reefs:

While in the early stages of establishing robust, long-term monitoring protocols for evaluating fish communities in Oregon's system of marine reserves, the ODFW Marine Reserve Program is experimenting with alternative fishery-independent methods tailored to each specific reserve site. In 2016, the longline pilot study was continued for the second year and conducted concurrently with a hook-and-line survey in an attempt to increase the catch of species of interest (e.g. rockfishes such as Quillback, Copper, China, Vermilion, and Yelloweye), that are valued in the local fishery surrounding Redfish Rocks Marine Reserve. Our objectives were threefold. First, we sought to document selectivity, or the probability of observing a species, among the sampling approaches. Second, we wanted to compare the observed species richness, catch rate (i.e. CPUE at the day scale) and size distributions for fish species among the sampling approaches. Finally, we sought to compare the cost-benefit of each approach including survey costs, workforce needed and prevalence of body injury and mortality on fishes by sampling method.

Over 12 days of sampling (2015-16), a total of 638 fishes were caught on longline, while 655 fishes were caught on hook-and-line. Twelve species comprised >1% of the catch. Daily catch rates between the two gear types were comparable (longline mean: 54.17 fish/day ± 3.92 SE; hook-and-line mean: 55.08 fish/day ± 8.23 SE) and did not differ statistically (two sample t-test, t-ratio= -1.58, P = 0.14). While total number of fishes landed were similar between the gear types, the species composition of those landed fishes differed significantly among the gear types (ANOSIM: Global R = 0.80, P < 0.01). Species-specific catch rates per sampling day differed among the two gear types. Black Rockfish, the dominant species observed, were more than twice as abundant in the hook-and-line catch as the longline catch. Hook-and-line gear also caught significantly more Kelp Greenling. However, for the remaining 10 species, longline daily catch rates equaled or exceeded the hook-and-line catch rates. For several of the target species, including Cabezon, Copper Rockfish, and Vermilion Rockfish, this difference was significant (t-test or non-parametric Wilcoxon Rank-Sum test; p < 0.05).

The sizes of fish caught by the two gear types differed. In general, larger individuals were caught on the longline. For four different species (Blue/Deacon Rockfish, Canary Rockfish, Quillback Rockfish, and Lingcod), this difference in mean size was significant. Longlining resulted in higher incidence of hook damage (7%), bodily injury (3%), and mortality (3%) in the fishes retrieved than hook-and-line gear (5%, 1%, and 0%, respectively). The mortality observed during longlining was restricted to three species groups: Black, Blue/Deacon, and Canary Rockfish and was highest for the Blue/Deacon complex (33% of individuals caught died, largely from predation events from Lingcod). Incidences of observed barotrauma symptoms among the rockfishes were lower for longlining compared to hook-and-line.

With the over-arching goal of improving ODFW's ability to resolve ecological changes within the state's newly established system of marine reserves, this study illustrates how supplementing the existing hook-and-line monitoring surveys with longlines can expand the dataset for currently under-sampled species that are targeted in the local fishery around Redfish Rocks marine reserve. By combining longline and hook-and-line sampling, we will be able to broaden both the species and size ranges we are sampling. This study is an example of tailoring our monitoring efforts to reflect local fishing activities to help ensure the effects of marine reserve protection are being adequately studied. This pilot study was recently submitted for publication to Marine and Coastal Fisheries.

Construction and Evaluation of a Custom Stereo-Video Lander System:

Stereo-video imagery is becoming a popular non-extractive technique for measuring fish length *in situ.* The importance of understanding population and age structure, using size as a proxy, is a critical component for fisheries management considerations. Particularly in marine reserves monitoring, where documenting ecosystem function is often a key objective, size and age structure provide metrics of biomass and replenishment stability. Stereo-video methods use two cameras mounted on a rigid beam with overlapping fields of view. Through calibrating the dimensions of this overlapping field of view, subsequent observations of fishes and other organisms are possible. The objectives of this pilot study were threefold: 1) develop a stereo video system to take stereo measurements, 2) assess the error variability within the stereo system's field of view, and 3) assess feasibility of a lander platform (for data continuity with current single camera video lander).

Two nearly identical stereo video camera systems were constructed for this project. Both systems were constructed to accommodate two *GoPro™4 Black Edition* cameras in *Sexton™ GoDeep Acrylic* housings, bolted onto an aluminum beam 1cm thick and 60cm long by 8cm wide. The cameras were separated by 44 cm and angled inward at 7 degrees to allow for overlapping stereo images. A custom aluminum lander frame was built to hold two of the stereo systems described above, facing opposite directions. The cameras are positioned at a height of 42cm from the seafloor, to mimic the same height-off-the seafloor the mini-lander systems. The total height of the lander system (66cm) was kept to a minimum in order to increase the ease of hauling it onboard ODFW's *RV Shearwater* with the vessel's davit and pot-hauler.

To test whether error in size estimates varies with fish size and/or video reviewer, five independent reviewers used fish length software to size the 57 fishes at 3m distance, centered in the overlapping field of view of the cameras. To test whether error varies with size and/or distance from the camera the same set of fishes were measured at varying distances (1m, 3m, 5m, and 7m) from the camera. Finally, to test whether error varies for fish size and/or distance off the center line of the camera was tested by measuring the fishes at 3m distance from the cameras and at varying distances (0.5m, 1m, 1.5m, and 2m) off the center line.

Overall the results of this pilot study found that this new stereo lander design is able to collect relative abundance estimates, community composition, and species richness metrics that were collected with the previous lander while also allowing size data to be collected. Video reviewers were able to collect fish size data with this tool, as long as fish are within a meter off center in either direction and are closer than 5m from the camera to still be within the pre-determined margin of error (10%).

More information, including copies of monitoring plans and reports, is available on the Oregon Marine Reserves website at [OregonMarineReserves.com.](OregonMarineReserves.com)

Contact: Cristen Don (cristen.n.don@state.or.us)

IV) Review of Agency Groundfish Research, Assessment and Management
  a) Hagfish
    i) Research

No research on hagfish was conducted by ODFW in 2016.

ii) Assessment

No hagfish assessments were completed by ODFW in 2016.

iii) Management

The commercial hagfish fishery operates year-round. Two types of trap gear are typically used by the hagfish fleet, a 55 gallon drum and five gallon bucket. Each of these contains escape holes to increase the size selectivity of the commercial fishery. Commercial hagfish landings in 2016 were 1,498,829 pounds, the lowest total since hagfish were first recorded on fish tickets in 2010. No major management actions were taken in 2016 by ODFW.

Contact: Brett Rodomsky, (Brett.T.Rodomsky@state.or.us), Troy Buell (Troy.V.Buell@state.or.us)

b) Dogfish and other sharks

i) Research

No research on dogfish or other sharks was conducted by ODFW in 2016.

ii) Assessment

No dogfish or shark assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for dogfish or other sharks by ODFW in 2016.

c) Skates

i) Research

No research on skates was conducted by ODFW in 2016.

ii) Assessment

No skate assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for skates by ODFW in 2016.

d) Pacific cod

i) Research

No research on Pacific cod was conducted by ODFW in 2016.

ii) Assessment

No Pacific cod assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for Pacific cod by ODFW in 2016.

e) Walleye pollock

i) Research

No research on pollock was conducted by ODFW in 2016.

ii) Assessment

No pollock assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for pollock by ODFW in 2016.

f) Pacific whiting (hake)

i) Research

No research on whiting was conducted by ODFW in 2016.

ii) Assessment

No whiting assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for whiting by ODFW in 2016.

g) Grenadiers

i) Research

No research on grenadiers was conducted by ODFW in 2016.

ii) Assessment

No grenadier assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for grenadiers by ODFW in 2016.

h) Rockfish

i) Research

There were several ongoing research projects for rockfish. These are detailed below.
Combined visual acoustic survey of semi-pelagic rockfish
The goal of our recent stock-assessment-related hydroacoustic research is to determine if we can use a combination of hydroacoustics and stereo-video to estimate the approximate size of major nearshore rockfish populations, primarily black and the deacon/blue rockfish complex. Determining the approximate size of nearshore rockfish species populations should be extremely helpful in developing more reliable stock assessments for fishery management. The first component of this research is to complete what we call the "school study". The objective of the school study is to determine if the estimates of mean target strength produced from hydroacoustic data for individual fish schools (suspended fish) can be used as a proxy to estimate species composition of these schools.

Work has been completed on fabrications and implementation of a live feed GoPro based stereo camera system. This device has been purpose built for a visual component in estimating species and size composition of suspended rockfish schools for use in conjunction with acoustic estimates of rockfish abundance. The data gathered so far suggest a strong possibility of using target strength estimated from hydroacoustic data to estimate species composition, although some video sampling would still be recommended for any survey. Continued sampling during 2017 will be conducted to ensure the target strength method is valid at other locations in the state and to test additional assumptions inherent in a hydroacoustic survey.

Contact: Matthew Blume (matthew.blume@state.or.us)

Yelloweye discard mortality
The study of discard mortality of hook-and-line caught yelloweye rockfish with barotrauma was published in 2016, in Fisheries Research.

Rebuilding of some U.S. West Coast rockfish (Sebastes spp.) stocks relies heavily on mandatory fishery discard, however the long-term condition of discarded fish experiencing capture-related barotrauma is unknown. We conducted two studies designed to evaluate delayed mortality, physical condition, and behavioral competency of yelloweye rockfish, Sebastes ruberrimus, experiencing barotrauma during capture followed by recompression (assisted return to depth of capture). First, we used sea-cage and laboratory holding to evaluate fish condition at 2, 15, and 30 days post-capture from 140 to 150 m depth. All external barotrauma signs resolved following 2 days of recompression, but fish that survived (10/12) had compromised buoyancy regulation, swim bladder injuries, and coelomic and visceral hemorrhages at both 15 and 30 days post-capture.

For the second study, we used a video-equipped sea-cage to observe fish behavior for one hour following capture and return to the sea floor. Trials were conducted with 24 fish captured from 54 to 199 m water depth. All fish survived, but 50% of fish from the deepest depth ranges showed impairment in their ability to vertically orient ($P < 0.01$). Most (75%) deep-captured fish did not exhibit "vision-dependent" behavior ($P < 0.001$) and appeared unable to visually discern the difference between an opaque barrier and unobstructed or transparent components of the cage. These studies indicate physical injuries and behavioral impairment may compromise yelloweye rockfish in the hours and weeks following discard, even with recompression. Our results reiterate the importance of avoiding fishing contact with species

under stock rebuilding plans, especially in deep water, and that spatially-managed rockfish conservation areas remain closed to fishing.
Contact: Polly Rankin (polly.s.rankin@state.or.us.)

Offshore Yelloweye Rockfish Lander Survey
In September, the Research team conducted a one-day test of the most recent version of the baited HD stereo video lander, equipped with a pair of stereo-calibrated high-definition Canon Vixia® HFS21 video cameras, in the relatively deeper (depth range), darker waters of Heceta Banks. A previous survey in 2011 of this area was unsuccessful with standard definition video in imaging yelloweye rockfish, and lead the team to investigate different lighting options. This current configuration has increased the illumination from two Deep Sea Power and Light, LED Mini-SeaLites® (850 lm, 6500 K) to two DSPL Sea Lite Spheres totaling 7000 lm, @ 6500 K. Additionally, a WetLabs ECO-BBB Scattering meter (measuring water clarity) and a Wildlife computer MK9, ambient light, temperature, and depth meter were installed on the frame of the lander to quantify video footage. Yelloweye Rockfish were readily imaged, as were canary rockfish, kelp greenling, a tiger rockfish, and a Deacon Rockfish (submitted as a depth extension to Milton Love). Bottom time was 12 minutes, and bait consisted of herring squid and sardines.

Contact: Matthew Blume (matthew.blume@state.or.us)

Pilot Study: Deacon Rockfish Offshore/Nearshore Population Comparison Study
Fishery-dependent data for the newly described cryptic species, Deacon Rockfish, is largely from the hook and line catch from nearshore areas. ODFW video lander observations show adult and juvenile fish are both present nearshore, but offshore schools observed at Stonewall Banks are comprised of larger fish. In 2016, we initiated a year-long study to capture and sample Deacon Rockfish monthly, in order to provide fishery-independent data on the size, sex, and age composition of both the offshore and nearshore populations. The goal of this study will be to provide data to aid in interpretation of stock assessment models.

In the spring of 2016 we tested and confirmed our ability to differentiate live adult blue and deacon rockfish and to capture small fish of a size not usually landed, but needed for age and length data. We started sampling Dec 2016, and were able to target Deacon Rockfish and catch a wide variety of sizes in the nearshore. Offshore fish collected were considerably larger and small fish remained elusive in that area. Data collection included: photos upon capture, length, weight, gender, gonad weight, gonad histology sample for all females and unknowns, otoliths for ageing, and DNA samples on fish ≤ 21 cm to confirm species.

Contact: Polly Rankin (polly.s.rankin@state.or.us.)

Pilot Study: Movements of Deacon Rockfish (Sebastes diaconus)
In May 2016, the At-Sea Research team executed a pilot study to investigate the movements of Deacon Rockfish, in the nearshore reef area of Seal Rocks, Oregon. Deacon rockfish are particularly vulnerable to fatal injuries from barotrauma and show reduced submergence success with rough handling (being dropped on the deck), so we used a number of techniques to try to mitigate this challenge. 1. We elected to use large fish to compensate for the weight and size of the tag, so fish tagged were females ranging in size from 33-41 cm. 2. Fish were captured hook and line in water depths less than 26 m and were immediately recompressed in drum-type cages. Fish were held at depth for 24 hours to resolve barotrauma *before tagging.*

3. We used external tagging methods to attach acoustic tags to avoid trauma, surgery and venting needed to create room in the body cavity. After tagging, all fish were able to swim down under their own power, without recompression assistance.

Fish were tagged with Vemco coded tags which transmit and ID, depth, and accelerometer (activity) data. The acoustic array included a 21 receiver VPS high-resolution grid (250 m spacing) and a 19 receiver perimeter “fence” placed several hundred meters outside the array (500 m spacing) to detect any fish leaving the area. Additionally moored was a CTD/O2 sensor, scattermeter and a light meter. The VPS and Fence arrays were pulled 9/30/16, but due to the continued presence and high detectability of 6 fish, we elected to leave a 9-receiver “presence/absence” array in place over winter.

Three fish tags were confirmed inactive (one in May, 2 in July) either in the array or on the fence. Two fish are missing: one resided on the fence for several weeks before departing and the other tag was detected leaving the area through the fence. However 6 fish remained within the array, demonstrating very high detectability and high site fidelity for the entire 7 months. Preliminary analysis of activity levels shows definitive patterns of activity, depth distribution, and home range, as well as a disruption of that pattern for all 6 fish, during a period of summertime hypoxia.

Contact: Polly Rankin (polly.s.rankin@state.or.us.)

ii) Assessment

Multiple federal rockfish assessments were scheduled to begin in 2016, including blue/deacon rockfishes, yelloweye, yellowtail, and darkblotched rockfish, and Pacific ocean perch. These assessments will be completed in mid-2017. Beginning in fall 2016, ODFW staff were creating data products for all of these rockfish assessments, with a focus on the nearshore species, blue/deacon and yelloweye rockfish. ODFW staff also began the process of assembling data-use agreements, providing background, and disseminating data products to the assessment authors. An ODFW staff member will be on the stock assessment team and a co-author on the blue/deacon rockfish stock assessment.

iii) Management

Commercial fishery: Nearshore rockfish are mainly taken in the commercial nearshore fishery. The commercial nearshore fishery in Oregon became a limited-entry permit-based program in 2004, following the development of the open access nearshore fishery in the late 1990’s. The commercial nearshore fishery exclusively targets groundfish, including Black Rockfish, Blue/Deacon Rockfish, Cabezon, Kelp Greenling, and Oregon’s “Other Nearshore Rockfish” complex. The fishery is primarily composed of small vessels (25 ft. average) fishing in waters less than 30 fathoms. Fishing occurs mainly with hook-and-line jig and bottom longline gear types. Fish landed in this fishery supply mainly live fish markets, but also provide product for fresh fish markets. Landings are regulated through two-month trip limits, minimum size limits, and annual harvest guidelines. Weekly updates on landings allow MRP staff to more effectively manage the fishery in-season.

2015 reductions to allowable impacts to federal minor nearshore rockfish continued in 2016. To manage to these reductions state trip limits for other nearshore rockfish and Blue/Deacon

Rockfishes were reduced from 2014 levels, however set at levels higher than 2015. Landings from 2015 commercial nearshore fishing, logbook compliance, economic data, and biological data were published in the 2015 Commercial Nearshore Fishery Summary (Rodomsky et al. 2016). Overall, the majority of active fishery permit holders are located on the southern Oregon coast, resulting in most of the catch landed in Port Orford, Gold Beach and Brookings. Black rockfish continued to comprise the majority of landings. In-season management in 2016 included increases to two-month trip limits for Black rockfish, Blue rockfish, Other Nearshore Rockfish, Greenling, and Cabezon. ODFW also conducted a mailer survey to gauge permit holders' satisfaction levels with current commercial nearshore management. Results from that survey will be available in the 2016 Commercial Nearshore Fishery summary.

Contact: Brett Rodomsky (Brett.T.Rodomsky@state.or.us), Troy Buell (Troy.V.Buell@state.or.us)

Recreational fishery: Black rockfish (*Sebastes melanops*) remains the dominant species caught in the recreational ocean boat fishery. As in recent years, the retention of yelloweye rockfish (*S. ruberrimus)* was prohibited year round. In order to remain within the yelloweye rockfish impact cap (via discard mortality), the recreational groundfish fishery was restricted pre-season to inside of 30 fathoms from April 1 to September 30. New in 2015, and continuing in 2016 for the first time since 2004, retention of canary rockfish (*S. pinniger;* one fish sub-bag limit) was allowed, due to increasing trends in the stock abundance.

Contact: Lynn Mattes (lynn.mattes@state.or.us), Christian Heath (Christian.t.heath@state.or.us)

Outreach: To reduce bycatch mortality of overfished rockfish species in the sport fisheries, ODFW began an outreach campaign in 2013 with the goal of increasing descending device usage among sport anglers. The effort, branded "No Floaters: Release At-Depth", has distributed over 15,000 descending devices to date, to all charter vessel owners and to the majority of sport boat owners who had previously targeted groundfish or halibut. ODFW staff have also participated in a number of angler education workshops, meetings, and shows to educate anglers and distribute devices. In addition, several thousand stickers and a few hundred hats bearing an emblem of the brand have been distributed with the goal of making rockfish conservation an innate aspect of fishing culture. This outreach and education campaign appears to be successful. Prior to the beginning of the campaign, fewer than 40 percent of anglers used descending devices. After the campaign, the percentage of users increased to greater than 80 percent. The percentage of users has remained near between those two levels, at approximately 60 percent over the last two years. Additional outreach efforts include: videos online that show fish successfully swimming away after release with a device, rockfish barotrauma flyers have been produced, and videos on how to use the various descending devices have been produced. This outreach campaign has been the result of collaboration between ODFW, two angler groups (Oregon Coalition for Educating Anglers and Oregon Angler Research Society), Utah's Hogle Zoo, ODFW's Restoration and Enhancement (R & E) program, and the National Marine Fisheries Service (NMFS) Saltwater Recreational Policy.

Contact: Lynn Mattes (lynn.mattes@state.or.us), Christian Heath (Christian.t.heath@state.or.us)

i) Thornyheads

i) Research

No research on thornyheads was conducted by ODFW in 2016.

ii) Assessment

No thornyhead assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for thornyheads by ODFW in 2016.

j) Sablefish

i) Research

No research on sablefish was conducted by ODFW in 2016.

ii) Assessment

No sablefish assessments were completed by ODFW in 2016.

iii) Management

There were no major management actions taken for sablefish by ODFW in 2016.

k) Lingcod

i) Research

No research on lingcod was conducted by ODFW in 2016.

ii) Assessment

A federal stock assessment of lingcod was scheduled to begin in 2016, and to be completed in mid-2017. As with the rockfish assessments, beginning in fall 2016, ODFW staff were creating data products for this assessment. ODFW staff also acquired a data-use agreement from the assessment author, provided preliminary assessment data background, and began disseminating data products to the assessment author in 2016. A stock assessment review panel will convene to review the assessment in mid-2017.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

iii) Management

Lingcod are landed both commercially and recreationally. Commercial lingcod landings are monitored weekly as part of the nearshore commercial groundfish fishery. In 2016, nearshore landings were dominated by hook and line catches (84%) and totaled 106,768 pounds. Recreational lingcod landings are monitored by ORBS and subject to a daily bag limit (two fish) and a minimum size limit (22 inches). Recreational landings of lingcod were 142.8 metric tons in 2016.

Contact: Brett Rodomsky (Brett.T.Rodomsky@state.or.us), Troy Buell (Troy.V.Buell@state.or.us)

l) Atka mackerel
   i) Research

No research on atka mackerel was conducted by ODFW in 2016.

   ii) Assessment

No atka mackerel assessments were completed by ODFW in 2016.

   iii) Management

There were no major management actions taken for atka mackerel by ODFW in 2016.

m) Pacific halibut & IPHC activities
   i) Research

ODFW did not conduct any halibut research projects in 2016.

   ii) Assessment

ODFW did not complete any halibut assessments in 2016.

   iii) Management

Oregon's recreational fishery for Pacific halibut continues to be a popular, high profile fishery requiring International Pacific Halibut Commission (IPHC), federal, and state technical and management considerations. In 2016, the IPHC recommended an annual catch limit for Area 2A (Oregon, Washington, and California) of 1.14 million pounds. The recreational fishery for Pacific halibut is managed under three subareas with a combination of all-depth and nearshore quotas. In 2016, the Columbia River subarea quota was 11,009 pounds, the Central coast subarea quota was 206,410 pounds, and the Southern coast subarea quota, was 8,605 pounds. Landings in the sport Pacific halibut fisheries are monitored weekly for tracking landings versus catch limits. The majority of halibut continue to be landed in the central coast subarea, with the greatest landings in Newport followed by Garibaldi or Pacific City. Total 2016 recreational landings in the Central coast subarea was 202,651 pounds (98% of quota). Landings in the Southern subarea were 4,173 pounds (48% of quota) and in the Columbia River subarea, landings were 11,896 pounds (108 %).

Contact: Lynn Mattes (lynn.mattes@state.or.us), Christian Heath (Christian.t.heath@state.or.us)

n) Other groundfish species
   i) Kelp greenling

Kelp greenling are a component of both the nearshore commercial fishery and the recreational fishery. Commercial landings from the nearshore commercial fishery totaled 18,262 pounds in 2016. Recreational catches totaled 5,732 pounds (2.6 metric tons).

ii) Cabezon

Commercial cabezon landings from the commercial nearshore fishery in 2016 were 35,208 pounds. Recreational landings were 11.1 metric tons in 2016. Continuing in 2016, the cabezon season was modified to July 1 through December 31. This allowed the cabezon season to proceed with a lower chance of inseason actions being necessary.

V) Ecosystem Studies

a) Development of a Fishery Independent Survey

The Marine Resources Program in 2016 reiterated its commitment to the development of a fishery independent survey for nearshore groundfish species as a high priority for the MRP. Four working groups were established in 2015 to accomplish this and other identified high priorities, and all working groups continued to meet and move forward with research and projects in support of this goal in 2016. One specific task assigned to the Stock Assessment and Management working group was to host a workshop with federal assessors to invite their input on preliminary designs and tools appropriate for a fishery independent survey. This is detailed in section V.g below.

Multiple projects at MRP have been working on the development of both visual and acoustic tools for the purposes of estimating population size and fish habitat associations of various types of groundfish for many years. Further information on these tools can be found in sections V.b – V.c below and in the Marine Reserves section above (Section III).

Contact: Alison Whitman (alison.d.whitman@state.or.us)

b) Video lander development and surveys

The study investigating the effects of ambient light and turbidity/scattering on the effective sampling range of a stereo-video lander was published in 2016 in Marine and Coastal Fisheries journal.

We studied how variation in seafloor water clarity, ambient light, and fish fork length influenced the maximum detection range of fish with a stereo-video lander on three temperate reefs of different depths (12–40, 44–91, and 144–149 m). Although the results are somewhat approximate and specific to the camera system, the methods we used can be applied to any stereo remote underwater visual survey system. In the 52 total lander deployments distributed between nearshore, mid-shelf and deep-shelf reefs in Oregon waters, seafloor light levels varied over 4 orders of magnitude, primarily as a function of depth. The seafloor scattering index was higher (low water clarity) and highly variable at the nearshore reef and lower (high water clarity) and less variable at the deeper reefs. In the 15 deployments with sufficient numbers of fish for detection range analysis, the mean maximum range of detection across species varied from3.89 to 4.23m at the deep-shelf reef, 3.32–5.55 m at the mid-shelf reef, and 1.57–3.42 m at the nearshore reef. Multiple regression analysis of the analyzed deployments showed a strong negative relationship between mean maximum detection range and the scattering index but no relationship with log of seafloor ambient light. The lack of a light effect showed that the artificial lights were adequately illuminating the field of view in which fish were identifiable, potentially an important system test for sampling across a range of seafloor light levels. Analysis of detection range versus fish fork length for Blue Rockfish Sebastes mystinus and Deacon Rockfish S. diaconus from a single deployment showed a reduction in detection range for 10–20-cm fish of about 1.15 m relative to the detection range of 25–45-cm fish, or about 41%.

Contact: Matthew Blume (matthew.blume@state.or.us)

Surveys of subtidal rocky areas with the video lander: Surveys of shallow (<55 m) subtidal rocky areas were continued in the spring of 2015 in the waters near Newport, OR. This effort focused on exploring the use of the video lander designed by ODFW (Hannah and Blume 2012) as a tool for fishery independent surveys of nearshore rocky reef associated fishes and invertebrates and their habitat associations. In addition to collecting information to classify the primary and secondary substrates in view, water column properties were collected at the drop site using a casting conductivity temperature depth instrument (Seabird 19plus) equipped with an oxygen sensor. In 2015 we sampled 102 stations, adding to the 105 stations sampled in 2014. The lander sampled the bottom for approximately 14 minutes. Initial examination of the video collected in 2014 by both this project and similar video lander tools utilized by the ODFW marine reserves group suggests that the number of fish species seen in the videos collected on Oregon's nearshore rocky reefs tends to level off after approximately 8 to 10 minutes and the maximum number for any given species seen at any one time also occurs within that time frame.

We utilized Canonical Correspondence Analysis (CCA), a direct gradient analysis technique to examine the relationship among a suite of measured environmental gradients and the community of fish species observed. Abundance for 12 species at each location was characterized by maximum number observed in a single frame for each lander drop. Seven types of primary and secondary substrate, five categories of biogenic habitat, time of day, visibility, view, temperature, salinity, depth, dissolved oxygen, latitude and longitude for each sample were some of the environmental variables examined. Raster bathymetry data in ArcGIS was used to derive a number of other environmental variables that were examined including: rugosity at 4, 8, 10, 20, 30, 40 and 50 m extents; the maximum and mean slope at 4 and 30 meters; and the fractal complexity at 10, 30 and 50 m extents. We used CCA to examine data from 51 video lander drops for which all 41 environmental variables were available.

The final selected model included 5 environmental gradients that explained 17.2% of the total inertia in the fish community, with the first three axes of the selected model explaining 81.5% of the constrained inertia. The selected model was: $\log_{10}$(Fish Spp. MaxN) = $\log_{10}$(Longitude) + Large Boulder Primary Habitat + $\log_{10}$(Complexity (50m)) + $\log_{10}$(Complexity (10m)) + $\log_{10}$(Dissolved Oxygen). CCA model results provide coefficients that indicate the relative importance of each environmental gradient along each of the three axes in predicting community composition. CCA also provides species scores that indicate the environmental optima for each species on the three axes with the abundance and/or probability of occurrence for the species decreasing as the distance from the optima center increases. This exploratory analysis was done with a relatively small data set with limited spatiotemporal extent, but it would be beneficial to utilize these techniques with a dataset with greater spatial and temporal coverage.

Contact: Greg Krutzikowsky, (greg.krutzikowsky@state.or.us), Brett Rodomsky (Brett.T.Rodomsky@state.or.us)

c) Acoustic survey development

Surveys for Pacific herring in Yaquina Bay with an acoustic system began in 2014 to estimate spawning population size in early spring. A DT-X acoustic system was purchased from BioSonics Inc. to continue these surveys in 2015 and to expand use of this system to groundfish fishery independent surveys. Accompanying tool development was initiated by the Research Project and infrastructure for acoustic deployment on larger vessels was manufactured in late 2015. Initial testing of simultaneous deployment of the acoustic and drop camera occurred in 2016 and will continue in 2017.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

d) Aging Activities

During 2016, 5358 age estimates were produced for recreation, commercial, and research purposes within the Marine Resource Program. For recreation and commercial programs, 3,476 deacon and 908 blue rockfish ages were produced, with an additional 693 and 182 test ages respectively generated. To fulfill research needs within MRP, 82 black rockfish (17 tested), were aged.

Contact: Lisa Kautzi (Lisa.A.Kautzi@state.or.us)

e) Maturity Studies

In 2016, a report summarizing the efforts within ODFW's Stock Assessment Research Project from 2000 – 2016 to improve maturity data for a variety of groundfish species was completed. The goal of the report is to both provide a status report of past efforts and guide future maturity research efforts. Additionally, new length and age-at-maturity data are provided for two species, China rockfish and cabezon, with data from a greater geographic coverage from originally published. A list of citations and summary age- and length-at-maturity statistics are provided for each species. Database structure is detailed in the report as well. Agency Informational Reports on individual maturity report findings can be accessed at: http://www.dfw.state.or.us/MRP/publications/#Research. The summary report will be posted on MRP's website in 2017.

Contact: Leif Rasmuson (leif.k.rasmuson@state.or.us>)

f) Historical Catch Reconstruction workshop

Multiple ODFW staff attended a workshop on groundfish historical catch reconstructions in November 2016, in preparation for the upcoming federal stock assessment cycle. Historical estimates of groundfish landings are key to determining unfished biomass levels, a primary component to setting current harvest levels. The purpose of the workshop was to improve understanding of the different approaches used by the state agencies to develop reconstructions, and to highlight major issues related to uncertainties and choices in development of the reconstruction. The workshop focused on years prior to those covered by PacFIN (pre-1981).

ODFW staff presented information on ongoing issues with the Oregon historical commercial reconstruction, a recently identified issue with unspeciated rockfish landings during the PacFIN era for two market categories (URCK and POP), and progress related to the ongoing effort to comprehensively reconstruct historical sport landings. A workshop report was being developed in late 2016 to detail best practices and identify areas of improvement among state reconstructions, and would be finalized in early 2017.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

g) Workshop for Fishery Independent Surveys

Hosted by MRP staff, the "Workshop on Developing Fishery-Independent Surveys to Support Nearshore Stock Assessment" occurred in March 2016, and included experts on stock assessment, fishery-dependent surveys and fishery data from ODFW, OSU, WDFW, CDFW and the Northwest and Southwest Fishery Science Centers. The workshop was held over two days and included updates on fishery-dependent monitoring programs and presentations on tools and techniques to develop nearshore fishery independent surveys. Specific objectives included sharing information on existing surveys and experience with various visual, extractive, tagging, and acoustic tools and methods; identifying opportunities for cooperative work; and discussing pros and cons of various approaches in order to narrow the range of possible survey efforts to those most likely to be informative to nearshore assessments.

There were multiple conclusions drawn from the workshop and its associated discussions. First, that communication and coordination between the state agencies and NFMS is critical. High levels of documentation and standardization are necessary. Uncertainty was identified as an ongoing issue, and quantifying uncertainty is challenging but critically important. Approaches with combinations of multiple tools is needed to adequately survey and provide necessary information and data to stock assessments, including extractive surveys. The overall value of a fishery-independent survey would be to provide population scale estimates, allowing for the calibration of assessment models. A report summarizing the workshop and its outcomes is currently in development.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

VI) Publications

Hannah, R. W. and M. T. O. Blume. 2016. Variation in the Effective Range of a Stereo-Video Lander in Relation to Near-Seafloor Water Clarity, Ambient Light and Fish Length. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science Volume 8: 62-69.

Huntington, BE and JL Watson. Tailoring ecological monitoring to individual marine reserves: comparing longline to hook-and-line gear to monitor species targeted by a local fishery. Marine and Coastal Fisheries (In Review).

Rankin, P.S., R.W. Hannah, M.T.O Blume, T.J. Miller-Morgan and J.R. Heidel. 2017. Delayed effects of capture-induced barotrauma on physical condition and behavioral competency of recompressed Yelloweye Rockfish, *Sebastes ruberrimus*. Fisheries Research 186: 258-268.

Rodomsky, B. T., T. R. Calavan, and A. L. Carpenter. 2016. The Oregon Commercial Nearshore Fishery Summary: 2015 (pdf). Oregon Department of Fish and Wildlife Marine Resources Program. 51 pp.

Washington Contribution to the 2017 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2016-April 2017

April 25th-26th, 2017

Edited by:
Dayv Lowry

Contributions by:
Dayv Lowry
Robert Pacunski
Lorna Wargo
Mike Burger
Taylor Frierson
Todd Sandell
Jen Blaine
Brad Speidel
Larry LeClair
Donna Downs
Theresa Tsou

Washington Department of Fish and Wildlife

April 2017

Contents

Agency Overview

The WDFW Marine Fish Science (MFS) Unit is broadly separated into two groups that deal with distinct geographic regions, though there is some overlap of senior staff. The Unit is overseen by Theresa Tsou, who also oversees the Coastal Marine Fish Science Unit (see below) and supported by Phil Weyland (programming and data systems). On April 17th, 2017 Phill Dionne was hired to assume authority for state-wide marine forage fish research and management.

Staff of the Puget Sound Marine Fish Science (PSMFS) Unit during the reporting period included Dayv Lowry (lead), Robert Pacunski, Larry LeClair, Todd Sandell, Jen Blaine, Adam Lindquist, Lisa Hillier, Taylor Frierson, Patrick Biondo, Andrea Hennings, Mike Burger, Mark Millard, Chris Fanshier, Will Dezan, Amanda Philips, and Phil Campbell. In addition, Courtney Adkins and Peter Sergeeff work as PSMFS employees during the annual spring bottom trawl survey. Within the Fish Management Division of the Fish Program a second work unit also conducts considerable marine forage fish and groundfish research in Puget Sound, but focuses on the accumulation of toxic contaminants in these species. The Toxics-focused Biological Observation System for the Salish Sea (TBiOS) (formerly Puget Sound Ecosystem Monitoring Program or PSEMP) consists of Jim West (lead), Sandy O'Neill, Jennifer Lanksbury, Laurie Niewolny, Mariko Langness, and Rob Fisk.

PSMFS Unit tasks are primarily supported by supplemental funds from the Washington State Legislature for the recovery of Puget Sound bottomfish populations, and secondarily by a suite of collaborative external grants. The main activities of the unit include the assessment of bottomfish and forage fish populations in Puget Sound, the evaluation of bottomfish in marine reserves and other fishery-restricted areas, and the development of conservation plans for species of interest. Groundfish in Puget Sound are managed under the auspices of the Puget Sound Groundfish Management Plan (Palsson, et al. 1998) and management has become increasingly sensitive to the ESA-listing of Canary Rockfish, Yelloweye Rockfish, and Bocaccio, in Puget Sound since 2010 (National marine Fisheries Service 2010). In 2017 Canary Rockfish were delisted, but Yelloweye Rockfish and Bocaccio still very much drive management of all groundfish species.

Primary Contacts – Puget Sound:

Groundfish Monitoring, Research, and Assessment – *Contact: Dayv Lowry 360-902-2558, dayv.lowry@dfw.wa.gov; Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov.*

Forage Fish Stock Assessment and Research – *Contact: Phillip Dionne 360-902-2641, phillip.dionne@dfw.wa.gov; Todd Sandell 425- 379-2310, todd.sandell@dfw.wa.gov; Dayv Lowry 360-95-2558, dayv.lowry@dfw.wa.gov.*

Toxics-focused Biological Observation System for the Salish Sea (TBiOS) (formerly Puget Sound Ecosystem Monitoring Program or PSEMP) – *Contact: Jim West 360-902-2842, james.west@dfw.wa.gov).*

Staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Lorna Wargo, Brad Speidel, Rob Davis, Donna Downs, Bob Le Goff, Kristen Hinton, Jamie Fuller, Hannah Grout, Michael Sinclair, Grace Thornton, and Tim Zepplin. Unit tasks are supported through a combination of state general and federal funds. Long-standing activities of the unit include the assessment of groundfish populations off Washington coast, the monitoring of groundfish commercial landings, and the rockfish tagging project. More recently, unit activity has expanded to include forage fish management and research. The CMFS Unit is also overseen by Theresa Tsou and supported by Phil Weyland and Phill Dionne.

The MFS Unit contributes technical support for coastal groundfish and forage fish management via participation on the Groundfish Management Team (GMT), the Coastal Pelagics Management Team (CPSMT), the Scientific and Statistical Committee (SSC), and the Habitat Steering Group (HSG) of the Pacific Fishery Management Council (PFMC). The Department is also represented on the SSC and Groundfish Plan Teams of the North Pacific Fishery Management Council. Landings and fishery management descriptions for PFMC-managed groundfish are summarized annually by the GMT and the CPSMT in the Stock Assessment and Fishery Evaluation (SAFE) document. Additional regional fishery management support is provided by the Ocean Policy Unit, which consists of Michele Culver, Corey Niles, Heather Reed, and Jessi Doerpinghaus.

Primary Contacts – Coastal Washington:
Groundfish Management, Monitoring, Research, and Assessment – *Contact: Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Lorna Wargo 360- 249-1221 lorna.wargo@dfw.wa.gov; Corey Niles, 360-249-1223, corey.niles@dfw.wa.gov (Regional Fisheries Management).*
Forage Fish Management, Monitoring, Research, and Assessment – *Contact: Lorna Wargo 360- 249-1221 lorna.wargo@dfw.wa.gov; Phillip Dionne 360-902-2641, phillip.dionne@dfw.wa.gov.*

Surveys

Puget Sound Bottom Trawl – Since 1987, the WDFW has conducted bottom trawl surveys in Puget Sound – defined as all marine waters of the State of Washington east of a line running due north from the mouth of the Sekiu River in the Strait of Juan de Fuca – that have proven invaluable as a fisheries-independent indicator of population abundance for fishes living on unconsolidated habitats. These surveys have been conducted at irregular intervals and at different scales since their initiation. Surveys in 1987, 1989, and 1991 were synoptic surveys of the entire Puget Sound. From 1994-1997 and 2000-2007, surveys were annual, stratified-random surveys focusing on individual sub-basins. Starting in 2008, surveys became synoptic again, sampling annually at fixed index sites throughout Puget Sound.

The specific objectives of the annual "Index" trawl survey are to estimate the relative abundance, species composition, and biological characteristics of bottomfish species at pre-selected, permanent index stations. Key species of interest include Pacific Cod, Walleye Pollock, Pacific Whiting (Hake), English Sole, North Pacific Spiny Dogfish, and skates, but all species of fishes and invertebrates are identified and recorded. For the "Index" survey, the study area is subdivided into eight regions (eastern Strait of Juan de Fuca, western Strait of Juan de Fuca, San Juan Islands, Georgia Basin, Whidbey Island sub-basin, Central Puget Sound, Hood Canal, and South Puget Sound) and four depth strata ("S"= 5-20 fa, "T"= 21-40 fa, "U"= 41-60 fa, "V"= >60 fa), and 51 index (fixed) stations throughout the study area are sampled each spring (late April-early June) (Figure 1).

These index stations were originally selected from trawl stations sampled during previous trawl survey efforts at randomized locations throughout Puget Sound. Station selection was based on known trawlability and other logistical concerns and was informed by previously obtained biological data. Stations are named using a four-letter system with the first two letters designating the region, the third letter indicating the sub-region, or position within the region (north, south, mid), and the final letter designating the depth stratum. The index stations have remained relatively consistent since 2008, with a few exceptions: starting in 2009, 5 stations were added to make the current 51-station design; in 2012 and 2013, stations in the shallowest stratum (S) were not surveyed because of concerns from NOAA about impacts to juvenile salmonids; and in 2014 and 2015, stations JEWU and CSNV, respectively, were moved slightly to accommodate concerns raised by fiber-optic cable companies.

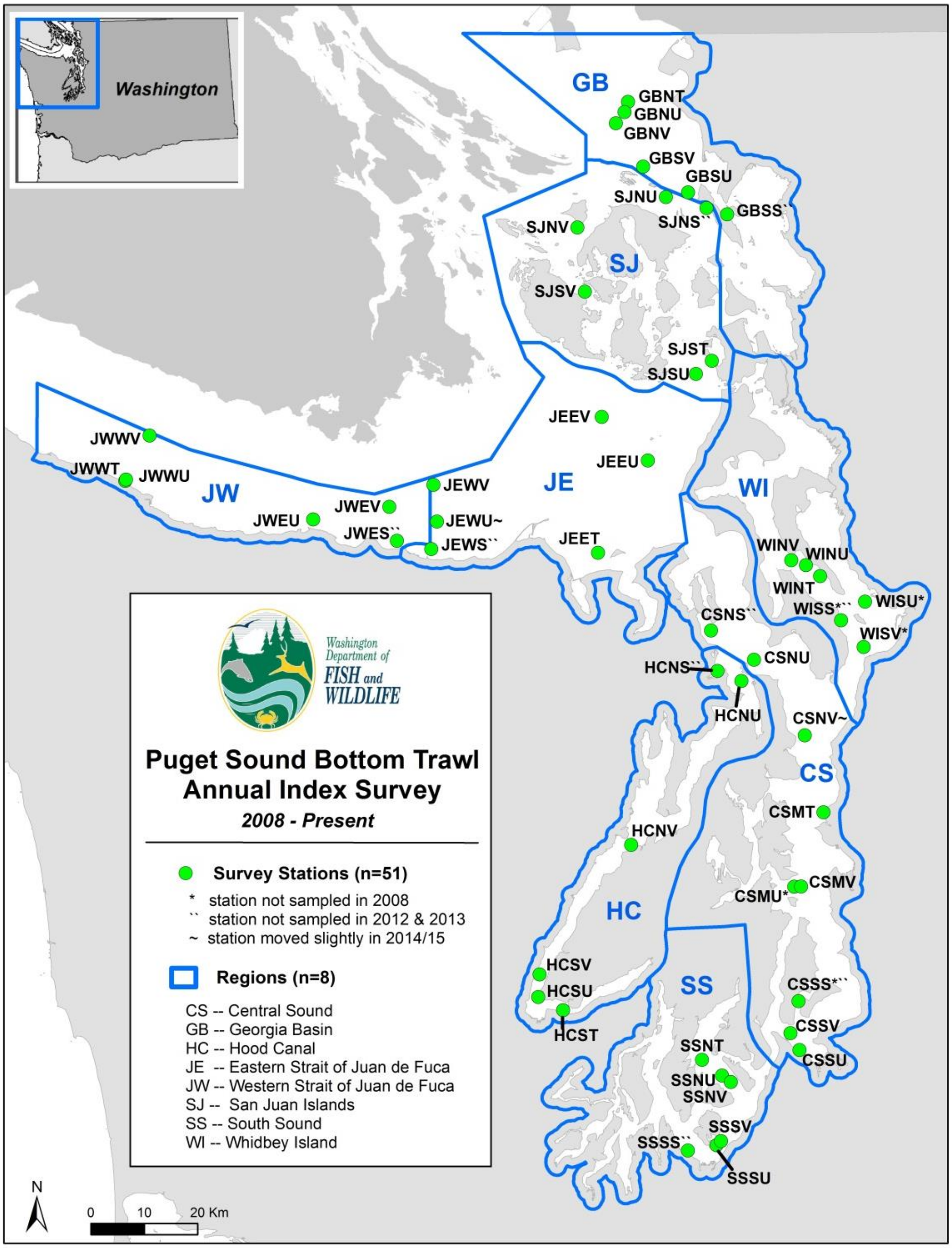


Figure 1. Trawl site locations for the Index survey design sampled in 2016

The trawling procedure of the survey has remained largely consistent. The 57-foot F/V CHASINA is the chartered sampling vessel, and it is equipped with an agency-owned 400-mesh Eastern bottom trawl fitted with a 1.25 inch codend liner. The net is towed at each station for a distance of ~0.40 nautical miles at a speed of 1-3 knots, and the tows last approximately 11 minutes. The resulting catch is identified to the lowest taxonomic level possible, weighed, counted, and most of the catch is returned to the sea. The density of fish at each station is determined by dividing the catch numbers or weight by the area sampled by the net. Some of the catch is taken for biological samples that are sampled on deck or preserved for laboratory analysis.

From 2008 to 2013, two trawl samples were collected at each station and were spaced several hundred meters apart to be close to each other but not directly overlapping. However, based on the similarity of catches in these paired tows at most stations, and in the interest of minimizing bottomfish mortality associated with the trawl survey, we altered our protocol in 2014. After the first tow is completed, the processed catch is compared to the average catch at that station since 2008. If the species comprising the majority (>75% by weight) of the tow falls within the previous years' confidence interval around the average, no second tow is conducted at that station. If it is determined that the species composition was substantially different than expected, only then is a second tow conducted. This greatly improved the efficiency of the survey, as only 6 stations in 2014 and 4 stations in both 2015 and 2016 required a second tow. This newly gained efficiency has allowed us to institute two new sampling programs: vertical plankton tows, and gastric lavage/stomach collection on large predatory species (Pacific Cod, North Pacific Spiny Dogfish, Lingcod, Walleye Pollock, Pacific Whiting/Hake). We also included the addition of bottom-contact sensors to the footrope to improve our understanding of net performance and increase the accuracy of density estimates from the trawl, and a mini-CTD on the headrope to collect water quality data at each trawl station and provide more accurate depth readings.

In 2016, the WDFW conducted the 9th Index trawl survey of Puget Sound from May 2 through May 25. During our 15 survey days, we occupied all 51 stations and conducted 55 bottom trawls. An estimated 22,400 individual fish among 80 species weighing 7.9 mt were collected (2015: 20,300 fish; 77 species; 7.7 mt). Similar to 2014 and 2015, Spotted Ratfish constituted 56% of the total fish catch by weight and 30% of the total number of individual fish, followed by English Sole at 18% and 17%, respectively. The remaining fish species contributed 5% or less to the fish catch weight and 9% or less to the total number of individual fish. For invertebrates, an estimated 7,000 individuals from 73 different species/taxa weighing 1.5 mt were caught in 2016, compared to 9,500 individuals from 67 species/taxa weighing 1.8 mt caught in 2015. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 41% and 30% of the total invertebrate catch weight. By number of individuals, Alaskan Pink Shrimp, Dungeness Crab, and Sidestriped Shrimp comprised 22%, 13%, and 13%, respectively, of the invertebrate catch. The remaining species contributed 10% or less to the total invertebrate catch by weight or by number.

Pacific Eulachon was the most abundant ESA-listed species encountered during the 2016 survey; 34 individuals were caught (up from 24 in 2015) in regions JE, JW, GB, and SJ (Figure 1). Additionally, two juvenile Coho Salmon were caught in HC. Genetic samples were collected for each of these in accordance with the Section 10 permit for the trawl survey. Bocaccio were also encountered for the second time in the history of the bottom trawl survey (first in 2012); however, all 11 individuals were found in the western portion of region JW, which is outside of the species' Puget Sound DPS boundary. Fin clips were taken as genetic samples and a few individuals were sacrificed for otoliths.

Catches of two key Gadiformes species, Walleye Pollock and Pacific Whiting (Hake), increased in the 2016 survey compared to the 2015 survey. Walleye Pollock catch increased in abundance but not in weight, as an estimated 893 individuals weighing a total of 87 kg were caught in 2016, compared to 810 individuals/114 kg in 2015. Pacific Whiting (Hake), however, increased substantially in both metrics from an estimated 450 individuals weighing a total of 25 kg in 2015 to 2,100 individuals totaling 390 kg in 2016; increases occurred in every region except JW, in which Pacific Hake haven't been captured in the survey since 2011. While overall lengths of Hake ranged from 7 cm-59 cm, 85% of those measured were 15cm-20cm long. Catches of Pacific Cod, however, continued to decline. In 2016, only caught 26 individuals weighing a total of 48 kg were caught, down from 43 individuals/75 kg in 2015 and 88 individuals/86 kg in 2014. Similar to previous years, 88% of Pacific Cod were found in JW.

Despite the higher North Pacific Spiny Dogfish catch in 2015 of 246 individuals weighing a combined 387 kg, the catch rate in 2016 of 65 individuals/78 kg was more similar to values observed in 2014. Dogfish were most prevalent in GB and JE regions, with over 50% of both total individuals and total weight coming from these regions. Catches of Raja sp. skates (i.e., Big and Longnose Skates) increased in total individuals from 162 in 2015 to 270 in 2016; total weight of these skates, however, decreased slightly from 395 kg in 2015 to 389 kg in 2016. Encounter rates were highest in GB (31% of total individuals) and CS (22%), but while GB also contributed the highest catch weight (34% of total), CS only contributed 5% of the total.

The 2017 Index bottom trawl survey is scheduled to occur from April 24 – June 1, concurrently with the Toxics-focused Biological Observation System (TBiOS) trawl survey.

Threatened and Endangered species surveys at Naval Installations – The U.S. Navy controls multiple restricted areas throughout Puget Sound that have been exempted from ESA-listed rockfish critical habitat designation by the NMFS. As a prerequisite, the Navy maintains an Integrated Natural Resource Management Plan (INRMP) to fulfill the requirements that authorize these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at Naval Base (NAVBASE) Kitsap Bremerton and Keyport in 2013, the WDFW's PSMFS Unit entered into a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and their critical habitat at the following installations: Naval Air Station (NAS) Whidbey Island Crescent Harbor, Naval Magazine (NAVMAG) Indian Island, NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, NAVBASE Kitsap Keyport, Naval Station (NAVSTA) Everett. These surveys were conducted during 2014-15 and expanded on the 2013 pilot surveys. The combination of survey methods included ROV, scuba, hydroacoustics, and lighted fish traps to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted with conclusions that: no ESA-listed rockfish were observed; no deep-water critical habitat (>30m) for adult rockfish was present; and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do exist within the surveyed areas. Due to the absence of deep-water critical habitat within the Naval restricted areas, deep-water surveys were discontinued after 2015. The nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect and fish trap methods, which began in January 2017.

Underwater visual strip transects by divers are being conducted monthly throughout 2017 at the NAVBASE Kitsap Bangor and NAVMAG Indian Island to monitor juvenile rockfish recruitment and settlement within nearshore vegetative zones. Several comparison areas in the vicinity of these Naval installations with optimal juvenile rockfish habitat (i.e., kelp forests), including a series of index stations near Edmonds, are also being surveyed with the same methods to assess the relative success of the 2017 recruitment cohort. As a supplement to the dive surveys, fish traps modified for juvenile rockfish are deployed at each of the dive sites and retrieved during each survey event (1-2 times a month). Preliminary results from January through April include the occasional capture of juvenile Copper/Quillback and Yellowtail Rockfish (from the 2016 cohort) when the dive surveys observe zero juvenile rockfish. Peak recruitment is expected to occur during summer and fall.

The WDFW's PSMFS Unit also entered into a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NAS Whidbey Island Crescent Harbor and Lake Hancock, NAVMAG Indian Island, NAVBASE Kitsap Bangor and Zelatched Point, Manchester Fuel Department, NAVSTA Everett. Monthly sampling at each installation began in May 2015 and continued through September 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. Additionally, tissue samples (n=326) were collected from Chum Salmon captured in Hood Canal and Admiralty Inlet during 2016 sampling, and genetically analyzed to determine either summer-run or fall-run assignment. Analysis of the tissue samples revealed that ESA-listed Hood Canal summer-run fish comprised 95% of all Chum captured in both January and February, while 80% of all Chum captured from March through May were fall-run fish. Tissue samples (n=100) were also collected from Coastal Cutthroat Trout to detect possible hybridization with ESA-listed steelhead; a single F1 hybrid and two F3 hybrids were confirmed. As of April 2017, a final report for each installation was submitted, and confirmed that ESA-listed fish species captured in the beach seine included Chinook Salmon, Puget Sound Steelhead, Hood Canal summer-run Chum Salmon, and Bull Trout (varied by location). Regarding timing and abundance, juvenile salmonids and forage fish species generally followed the same trends previously documented in similar reports, which supports the work windows outlined in the WAC Hydraulic Code Rules.

Annual Pacific Herring Assessment in Puget Sound – Annual herring spawning biomass was estimated in Washington in 2016 using spawn deposition surveys. WDFW staff based in the Mill Creek, Olympia, and Port Townsend offices conduct these assessment surveys of all 21 known herring stocks in Puget Sound waters annually from early January to mid-June.
The herring spawning biomass estimate for all Puget Sound stocks combined in 2016 was 12,192 tons, a slight decrease from 2015 (13,2446 tons) (Table 1). The 2016 cumulative total is an increase from the 2013 low point of 7,332 tons and also higher than the mean cumulative total for the previous ten year (2007-2016) period of 11,101 tons. The general trend is driven mainly by increases in the Quilcene Bay stock (Hood Canal), estimated at 7,409 tons in 2016, the highest spawning biomass on record for this stock (a 59% increase from 2015). The other stock in this region, South Hood Canal, decreased slightly from 282 in 2015 to 249 tons in 2016, but is the third highest total in the past ten years.

Table 1. Pacific Herring spawning biomass estimates (short tons) in Puget Sound by stock and year

STOCK	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Squaxin Pass	557	1,025	824	510	565	589	554	394	324	260
Purdy		496	125	500	711	135	260	83	32	0
Wollochet Bay	35	45	360	11	21	31	10	39	0	0
Quartermaster Harbor	441	491	843	143	96	108	157	44	55	0
Elliot Bay						290	214	29	135	109
Port Orchard-Port Madison	1,589	1,186	1,768	350	123	217	184	90	92	0
Port Gamble	826	208	1,064	433	1,464	404	273	170	345	179
Kilisut Harbor	24	0	0	0	0	0	0	5	0	0
Port Susan	643	345	252	152	138	61	29	68	70	61
Holmes Harbor	572	686	1,045	673	3,003	678	585	459	456	494
Totals for South and Central Puget Sound	**4,687**	**4,482**	**6,281**	**2,772**	**6,121**	**2,513**	**2,266**	**1,381**	**1,509**	**1,103**
Skagit Bay	1,236	1,342	1,036	402	469	443	454	294	285	48
Fidalgo Bay	159	156	15	103	119	89	100	221	80	5
Samish/Portage Bay	348	409	320	649	387	430	693	778	559	1,025
Int. San Juan Islands	33	60	0	24	0	5	0	5	38	
NW San Juan Islands	0	0	0	0	0	0				
Semiahmoo Bay	1,124	662	990	909	1,605	879	569	2,828	5,852	1,798
Cherry Point	2,169	1,352	1,341	774	1,301	1,120	908	1,003	524	516
Totals for North Puget Sound/SJI	**5,069**	**3,981**	**3,702**	**2,861**	**3,881**	**2,966**	**2,724**	**5,129**	**7,338**	**3,392**
South Hood Canal	70	223	156	214	156	264	199	112	282	249
Quilcene Bay	2,372	2,531	3,064	2,012	4,443	2,626	2,072	3,097	4,097	7,160
Totals for Hood Canal	**2,442**	**2,754**	**3,220**	**2,226**	**4,599**	**2,890**	**2,271**	**3,209**	**4,379**	**7,409**
Discovery Bay	42	248	205	26	0	105	0	5	12	244
Dungeness/Sequim Bay	34	69	46	75	104	43	71	72	8	44
Totals for Straight of Juan de Fuca	**76**	**317**	**251**	**101**	**104**	**148**	**71**	**77**	**20**	288
Annual Totals	**12,274**	**11,534**	**13,454**	**7,960**	**14,705**	**8,517**	**7,332**	**9,796**	**13,246**	**12,192**

The combined spawning biomass of South/Central Puget Sound herring stocks in 2016 was 1,103 tons, a slight decrease from the 2015 total of 1,509. A number of stocks in the region that were previously at relatively large abundances are now at low levels, particularly the Purdy, Wollochet Bay, Quartermaster Harbor, Port Orchard-Port Madison, Kilisut Harbor stocks, which had no spawn recorded in 2016. Two of these sites- Purdy and Wollochet Bay- have now recorded zeros for two years in a row, and are being closely monitored in 2017.

The cumulative biomass of North Puget Sound stocks declined dramatically from 2015 (7,338 tons) to 3,392 tons, which was also a decrease from 2014 (5,129 tons). This was primarily the result of a return to a more average year (1,798 in 2106) for the Semiahmoo Bay stock, which had a record year in 2015 (5,852 tons). However, the spawning biomass of the Cherry Point stock also decreased slightly in 2016 to 516 tons, falling from 2015 (524 tons) and almost half of the ten year average for this site (1,101 tons). This stock, which is genetically distinct from other herring stocks in Puget Sound and British Columbia, continues to be at critically low levels of abundance. Estimated herring spawning activity for the Strait of Juan de Fuca region increased dramatically in 2016 to 288 tons, a ten-fold increase from 2015 (20 tons) that was driven by the Discovery Bay stock, which had the highest estimated spawn since 2008. The 2017 spawn surveys are now underway and will continue through mid-June.

Yelloweye Rockfish habitat exploration on the Washington outer coast – The WDFW has been conducting longline surveys off the northern Washington coast to better understand seasonal changes in catch rates for rockfish that inhabit rocky habitat. Results from these surveys will be used to improve future strategies to monitor and assess rockfish populations, evaluate the risk of localized depletion and survey effects, and to monitor the growth and movement of several important rockfish species. Recent research has focused on Yelloweye Rockfish (*Sebastes ruberrimus*). In 2002, the Pacific Fishery Management Council declared Yelloweye Rockfish overfished under provisions of the Magnuson Stevens Fishery Conservation and Management Act. To achieve rebuilt status, conservation measures including prohibiting catch and area closures have been implemented during ensuing years. Effects of these measures have been two-fold. Fishery catch, a customary source of biological and population trend data, is now severely limited or lacking altogether; and more than any other single groundfish species, Yelloweye Rockfish constrain both commercial and recreational groundfish fisheries.

Due to stringent catch restrictions on slope and shelf rockfish, fishery-dependent data is very limited for many of these species. A lack of data exists for rockfish species such as Yelloweye Rockfish, Rougheye Rockfish (*S. aleutianus*), Shortraker Rockfish (*S. borealis*), and Redbanded Rockfish (*S. babcocki*) as a result of a low number of encounters with these species.

Fishery-independent data sources have also had limitations. The International Pacific Halibut Commission (IPHC) has conducted longline surveys off the Oregon and Washington coasts since 1997 to monitor halibut abundance. These are standardized fixed-station surveys based on a 10 NM grid. Beginning in 2007, a number of rockfish stations were added to the IPHC survey to enhance knowledge of rockfish populations. The addition of rockfish stations to the survey improved the opportunity to collect biological data from these rockfish during summer halibut stock assessment surveys, however the survey fishing effort is not concentrated on specific habitat and halibut monitoring is the primary focus. The NMFS triennial trawl survey has also been an insufficient source of data for rockfish species that inhabit rocky habitat due to fish behavior and habitat inaccessible to trawl gear. Using the IPHC survey design and data, the WDFW is refining a survey more specific to rockfish that inhabit rocky habitat. Such a survey is needed to collect species specific data to inform population assessments and conservation efforts.

One issue that has been apparent in the longline surveys is the lack of occurrence of yelloweye rockfish that are less than 40 centimeters (cm) in length. To understand why only larger fish were coming up on the survey, gear and area experiments were conducted. Smaller hooks were used to see if smaller fish could be caught and gear was deployed in shallower areas where yelloweye were known to occur. It was determined that it is likely an area issue- the smaller, younger fish don’t seem to reside out at the survey zone which is located in the 80-100 fathom depth range. So, additional areas need to be surveyed in order to sample a representative portion of the population. Also, not all areas that contain yelloweye are well documented and this information would be valuable for future survey design.

In the fall of 2016, an effort to document some additional areas in shallower waters than 80 fathoms where Yelloweye Rockfish occur was undertaken. These areas were searched with a rod and reel gear vessel to document location and evaluate size distribution of Yelloweye and other rockfish. The F/V Hula Girl out of Westport, WA was chartered for this work. The skipper of the Hula Girl, Steve Westrick, had experience encountering Yelloweye Rockfish on past recreational fishing trips as well as agency sponsored research. Several areas were identified in the northern part of Marine Area 1 and Marine Area 2 within a 30-80 fathom depth range for searching and a plan was developed to visit these areas starting in late September. Previous surveys have searched shallower areas in Marine Area 3 for Yelloweye Rockfish with some success but a shallower area in Marine Area 4 where Yelloweye Rockfish are concentrated is unknown. The timing for these trips was based on charter availability and weather. For each trip, 4-6 volunteers were enlisted to fish with typical recreational rod-reel gear.

For each day, information was collected for each fishing set and all species encountered. A fishing set was defined as a block of fishing time for which there was no significant change in effort, gear, or location. GPS location of the start of each set, disposition of vessel (anchored or drifting), number of anglers, amount of time fished, depth, and gear used was collected for each fishing set made. Gear used was uniform among all anglers for each set. Anglers were monitored to account for any significant breaks from fishing that were taken within a set and recorded as less than one angler based on the length of the break. All catch was identified to species, measured (FL, cm), scanned for previously implanted tags, recorded by fish identification number if either recaptured or receiving a tag. A caudal fin clipping was collected, preserved, and recorded by individual fish for yelloweye encountered. Yelloweye, Quillback, and Tiger Rockfish were also tagged with an internal PIT tag and an external spaghetti tag.

The weather only allowed three trips to be taken aboard the Hula Girl in September where three distinct areas were fished one per day. A total of 30 yelloweye were encountered and the catch was similar at each location (Table 2). Six other species of rockfish were encountered and the total catch of rockfish for the three days was 300 fish. Overall, yellowtail rockfish was the most prevalent species but was only encountered in large numbers at the areas fished on the 26th and 29th. The other predominant species encountered were Lingcod and North Pacific Spiny Dogfish. Depths fished ranged from 239-478 ft (39.8-79.7 fathoms). A total of 24 Yelloweye, 7 Quillback, and 3 Tiger rockfish were tagged and released at the fishing locations. Additional searching for Yelloweye Rockfish habitat is planned to take place on future cruises in order to provide information to aid design of a relative abundance survey for Yelloweye Rockfish and other rockfish that inhabit similar areas.

Table 2. Catch and CPUE (fish/rod hour) for each cruise and combined cruises.

				Cruise Date				
Species	**9/26/2016**		**9/29/2016**		**9/30/2016**		**All Cruises**	
Bocaccio rockfish		0.000	6	0.260		0.000	6	0.102113
Canary rockfish	6	0.330	26	1.128	11	0.628	43	0.731811
Spiny dogfish		0.000		0.000	39	2.226	39	0.663736
Lingcod	14	0.770	18	0.781	7	0.400	39	0.663736
Longnose skate		0.000	1	0.043		0.000	1	0.017019
Pacific sanddab		0.000		0.000	1	0.057	1	0.017019
Quillback rockfish		0.000		0.000	7	0.400	7	0.119132
Spotted ratfish	1	0.055	1	0.043		0.000	2	0.034038
Rosethorn rockfish	2	0.110		0.000		0.000	2	0.034038
Tiger rockfish	1	0.055	1	0.043	1	0.057	3	0.051057
Yelloweye rockfish	12	0.660	8	0.347	10	0.571	30	0.510566
Yellowtail rockfish	68	3.738	40	1.735	1	0.057	109	1.855056
Totals	**104**	**5.717**	**101**	**4.382**	**77**	**4.396**	**282**	**4.799319**

Nearshore rockfish longline surveys on the outer coast – The focus of the spring 2016 cruise season was to experiment with longline gear in nearshore waters (inside 30 fathoms or 55 meters) to target rockfish. The WDFW has been considering longline gear as a potential tool for future nearshore rockfish surveys due to its use in nearshore fisheries for demersal rockfish species. Previously, the existing rod-reel survey for black rockfish had been modified to accommodate the need for information on additional rockfish species that inhabit nearshore waters. Issues with fishing tackle selection and general concern about gear standardization with rod and reel surveys prompted the effort to begin experimentation with longline gear in nearshore waters. Pilot use of this gear began in 2015; additional modifications to the gear were made in 2016 prior to this cruise.

In April of 2016 a seven day cruise deployed fixed longline gear to target nearshore groundfish species. The timing for this cruise was based on vessel availability for both the longline vessel and rod reel charters. It was desired to deploy effort of both of these gears within a short time period. Also, low catch rates have been the norm for spring rod and reel surveys when deploying effort too early in the spring (March) months. The second half of April was chose to complete this work to accommodate these needs. Seven general fishing areas were predetermined for operations: Westport, Pt. Grenville, Destruction Island, Giants Graveyard (south La Push), Cape Johnson, Ozette/Cape Alava, and Makah Bay/Pt. of Arches. These areas were identified as potential target species habitat by looking at species compositions from previous rod-reel survey data and the longline cruise from the previous fall. It was estimated that six sets could be deployed each charter day and that a charter day would be spent at each of the seven general areas. Specific set locations were chosen each day after reconnoitering substrate characteristics with the vessel's onboard sounding equipment. Gear was deployed in an orientation that would adhere to the shape of the reef and also to be contained in a grid cell.

It was intended to send a vessel using rod-reel gear to similar locations that the longline gear was deployed at to compare catch rates and composition. Each longline set was deployed within a grid cell with one to two sets deployed within each chosen cell. Each day, four to six cells were used. As soon as it was possible, the rod-reel vessel would follow (usually next day if possible) with effort based on the proportional effort deployed by the longline vessel. For instance if the longline vessel deployed one set in each of six cells, the rod-reel vessel would deploy the same amount of effort (time based) in each of those six cells for the day that they were fishing that area. The goal is to compare the catch rates and composition between the two methods based on the charter day and the area that could be covered in one day.

Gear for this cruise consisted of 5/16” sinking groundline with either 12/0 or 11/0 circle hooks affixed by a #48 nylon double braid gangion line 24-28 inches in length. The mainline is broken into “skates” 1800’ long with gangions spaced at 1.5 fathom (9 feet) intervals to accommodate 200 hooks per skate. For storage and deployment purposes, skates are kept in ½ skate “tubs” (100 hooks) which are tied together to form the skate at the time of deployment. The 12/0 and 11/0 hooks were consistent throughout each tub. Each skate was deployed with one tub (1/2 skate) of 11/0 hooks and one tub with 12/0 hooks.

The seven planned fishing areas were covered over seven charter days with 41 individual locations (sets) fished at 5-6 sets per day. Individual sets ranged in depth from 6-37 fathoms. Cruise operations began out of Westport, WA to begin sampling directly off of Grays Harbor and incrementally moved northward, ending operations in Makah Bay. Before gear deployment each day, time was spent getting familiarized with reef structures at specific locations identified from rod-reel survey data and the fall 2015 longline cruise to determine suitability for longline fishing operations. Specific locations and set orientations were chosen based on rugosity, previous rod-reel and longline catch rates and compositions, safety, and reef size and shape. The gear was set to maximize hard substrate coverage yet minimize potential snagging on steep pinnacle structures.

A total of 430 hooks were recorded with catch at the vessel rail upon retrieval for a total hook occupancy rate of 5.3%. Hook occupancy rates ranged from 0.5% to 13.1% (0.0% sets listed were unsuccessful sets) for individual sets. The full range of catch rates were seen coast wide. Higher catch rates were observed on the far norther parts of the coast such as Makah Bay. Nineteen different species were encountered (excludes invertebrates) including eight different species of rockfish. All focus species except Tiger Rockfish were caught. Cabezon, Lingcod, and China Rockfish were the most frequently encountered catch (Tables 3-5). All locations were fished with one skate of gear (200 hooks) except for set 16 at Destruction Island where two skates were set on an area that had a long rocky structure. Soak times varied from 185 to 343 minutes with an average soak time of 251 minutes. Due to vessel mechanical issues, the CTD was not deployed during this cruise.

Table 3. Marine Area 2 Catch Summary

	Survey Area and Set Number												
	Westport						Pt. Grenville						
Species	1	2	3	4	5	6	7	8	9	10	11	12	**Totals**
Big Skate			3								1		**4**
Black Rockfish						1	2	7	3	1		3	**17**
Cabezon					2		1	4	1			1	**9**
Canary Rockfish				6	2	2							**10**
Copper Rockfish								1				1	**2**
Deacon Rockfish					3								**3**
Inanimate Object				1									**1**
Kelp Greenling												1	**1**
Lingcod					1	6	5	2	2	1		4	**21**
Pacific Halibut	1							2					**3**
Pacific Sanddab	5	1											**6**
Quillback Rockfish						1							**1**
Unidentified Invertebrate				1		2		2					**5**
Unidentified Sculpin							1	1			1		**3**
Unidentified Starfish							4	5	5	2	1	3	**20**
Yelloweye Rockfish						1							**1**
Totals	**6**	**1**	**3**	**8**	**8**	**13**	**13**	**24**	**11**	**4**	**3**	**13**	**107**

Table 4. Marine Area 3 Catch Summary

	Survey Area and Set Number																				
	Destruction Island					South LaPush - Giants Graveyard						North LaPush - Cape Johnson						Ozette Lake			
Species	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	**Totals**
Big Skate	2					4	1	2	2	2			1	1	1	1	2				**19**
Black Rockfish										2			1			1	1		6		**11**
Buffalo Sculpin				5	2	1			1	1				2							**12**
Cabezon	2	2	5	4	4		1		2	7		2	21	5	9	5	9	6	3	3	**90**
China Rockfish			2							1			1					4	2	9	**19**
Copper Rockfish			1																		**1**
Deacon Rockfish																1			4		**5**
Kelp Greenling		1	1	6	1		1			1		1	1		1			1		1	**16**
Lingcod			1	5	2			1		1					1			1		2	**14**
Spiny Dogfish						1	1														**2**
Starry Flounder				1																	**1**
Unidentified Flatfish							1														**1**
Unidentified Invertebrate													1							1	**2**
Unidentified Starfish				16									1		1					1	**19**
Totals	**4**	**3**	**10**	**37**	**9**	**6**	**5**	**3**	**5**	**15**	**0**	**3**	**27**	**8**	**13**	**8**	**12**	**12**	**15**	**17**	**212**

Table 5. Marine Area 4 Catch Summary

	Survey Area and Set Number									
	Cape Alava			Point of Arches - Makah Bay						
Species	33	34	35	36	37	38	39	40	41	**Totals**
Big Skate			3							**3**
Black Rockfish					2				1	**3**
Cabezon	1	3	3	3	7	8		13	8	**46**
Canary Rockfish				1				3	4	**8**
China Rockfish	1	6		2	1	2		3	3	**18**
Copper Rockfish									3	**3**
Deacon Rockfish	2									**2**
Kelp Greenling		1		1	2				1	**5**
Lingcod		3		1	4	4		1		**13**
Pacific Halibut								5		**5**
Quillback Rockfish	1			1					3	**5**
Unidentified Sculpin			1	1						**2**
Unidentified Starfish		1								**1**
Vermilion Rockfish								1	1	**2**
Totals	**5**	**14**	**7**	**10**	**16**	**14**	**0**	**26**	**24**	**116**

Biological information was collected from retained and released fish; released fish were measured and retained fish were measured, weighed, sexed, and dissected for otoliths. All data was immediately logged electronically as gear was set and hauled. Biological information from retained fish was collected during the mid-cruise weather day and after the cruise in port. The cruise data was housed in a master MS Access database for all WDFW coastal longline surveys.

Toward a synoptic approach to reconstructing west coast groundfish historical removals – Quantifying the removal time series of a stock is an essential input to a variety of stock assessment methods and catch-based management. Estimating removals is really hard, though, especially for periods with limited record keeping. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are just some of the complications that vary across time and space, and for which the level of reporting detail can vary widely. Given that most groundfish stocks are distributed coast-wide and a complete time series of removals is needed, this project aims to coordinate approaches across the states of Washington, Oregon, and California to confront removal reconstruction challenges and establish common practices. Both California and Oregon have attempted historical removal reconstructions and continued making necessary revisions. Washington’s first attempt in reconstructing commercial landings for lingcod and rockfish market categories was completed to support 2017 PFMC groundfish stock assessments. Efforts will continue to reconstruct flatfish catch histories.

Reserves

Marine reserve monitoring and evaluation – Due to changes in program priorities and staffing limitations brought on by intensive ROV survey work over the last five years, very little directed monitoring of marine protected areas and reserves has occurred in Puget Sound since 2011 and no monitoring activities were conducted in 2016. A systematic evaluation of data from SCUBA-based surveys collected between 2000 and 2010 at six sites for which sufficient data are available has been performed to evaluate reserve efficacy.

Results indicate that site-specific variation in average fish size, biomass, and density are all significant factors influencing long-term trends in these variables. Despite this, significant trends toward more, larger fish are apparent for Lingcod, Copper Rockfish, and Quillback Rockfish at some locations. Notable recruitment pulses are clearly apparent at multiple sites, specifically for rockfishes during 2006. For most species and locations a 15-yar evaluation period simply doesn't represent a long enough time frame to observe significant changes in abundance, biomass, and density, given the level of noise observed in these parameters. Planning has begun to replicate these studies at longer intervals (e.g., 20 years, 30 years) and dives at select sites will occur in 2017.

Larry LeClair, Lisa Hillier, Bob Pacunski, Jen Blaine, and Dayv Lowry have generated a report on these six sites that includes, as an appendix, data from other sites surveyed during the evaluation period for which data collection was more sparse. This report is under final review and should be available later this summer.

Review of Agency Groundfish Research, Assessment, and Management

Hagfish

The Washington Hagfish commercial fishery – Opened in 2005 under developmental regulations, the Washington hagfish fishery is small in scale, exporting hagfish for both frozen and live-fish food markets in Korea. Management of the Washington hagfish fishery is challenged by a lack of life history information, partial controls, and high participant turnover. Active fishery monitoring and sampling began in 2009. Due to limited agency resources, only fishery dependent data programs have been developed to inform management, including logbooks, fish receiving tickets and biological sampling of catch. Current efforts intend to focus on refining and improving these programs, including improving systematic sampling, developing species composition protocols, shifting to use the maturity scale developed by Martini (2013). Interest in conducting a study similar to research conducted in California (Tanaka, 2014) to evaluate escapement relative to barrel dewatering-hole size exists but will depend on funding availability.

The Washington hagfish fishery operates by rule only in offshore waters deeper than 50 fathoms and is open access. Figure 2 presents annual landings by state since 2000. However, landings don't necessarily represent where fishing actually occurred. Washington licensed fishers can fish federal waters off Oregon and land that catch into Washington. Live hagfish vessels typically fish grounds closer to their home port, while at-sea freezing allows ovther vessels to fish further afield. The fishery catches predominantly Pacific Hagfish (*Eptatretus stoutii*). Occasionally, Black Hagfish (*Eptatretus deani*) are landed incidentally. Landings data cannot distinguish between species as only one code exists for hagfish. Hagfish are caught in long-lined barrels (Figure 3); rules limit each fisher to 100. The barrels are constructed from olive oil or pickle barrels modified with an entrance tunnel and dewatering holes. Average soak time is 21 hours.

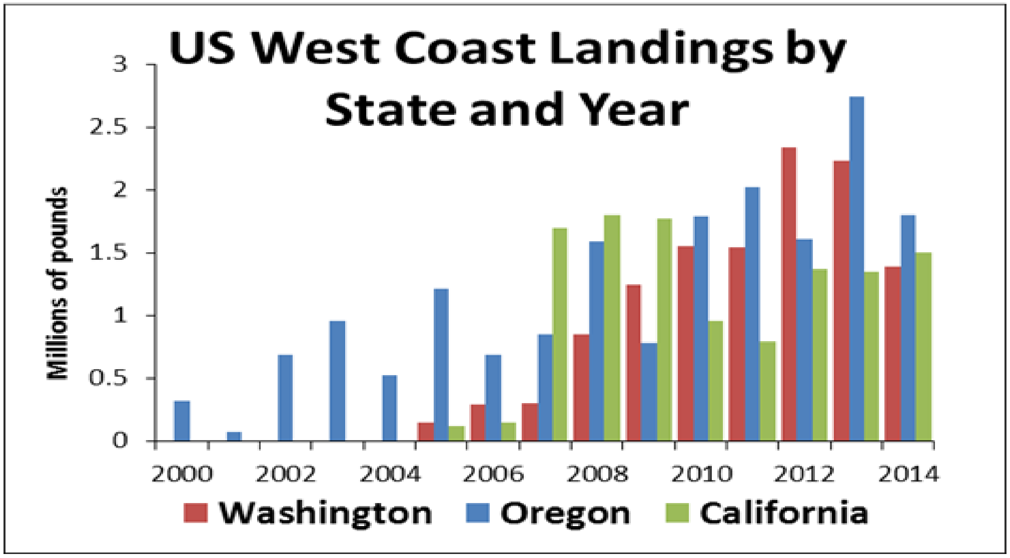


Figure 2. Hagfish Landings in pounds by Washington, Oregon, and California; 2000-2014.

Fishing occurs on soft, muddy habitat (Figure 4). Pacific hagfish are predominant from 50 to 80 fathoms. Deeper sets, up to 300 fathoms, have been made to target Black Hagfish. Pacific and Black Hagfish ranges appear to overlap between 80 and 100 fathoms. Median CPUE is about 4.5 pounds. Instances of high CPUE are evident; in these situations skippers reported "plugged" barrels.

Figure 3. Hagfish barrels used in the commercial fishery.

Length, weight, and maturity data have been collected from Pacific and Black Hagfish; however, only Pacific Hagfish data are reported here. Male and female hagfish present similar size distributions, ranging from 30 to 65 cm (Figure 5). The in-sample largest specimen was 78 cm male, the smallest a 25 cm female. By depth, male and female distribution is similar at the depths the fishery operates; none of the samples were from sets shallower than 59 fathoms (Figure 6). An evaluation of maturity suggests year-round spawning (Figure 7). Fecundity is low; the number of mature eggs rarely exceeds 10 to 12. Very few females with fully developed eggs and even fewer spent females have been sampled.

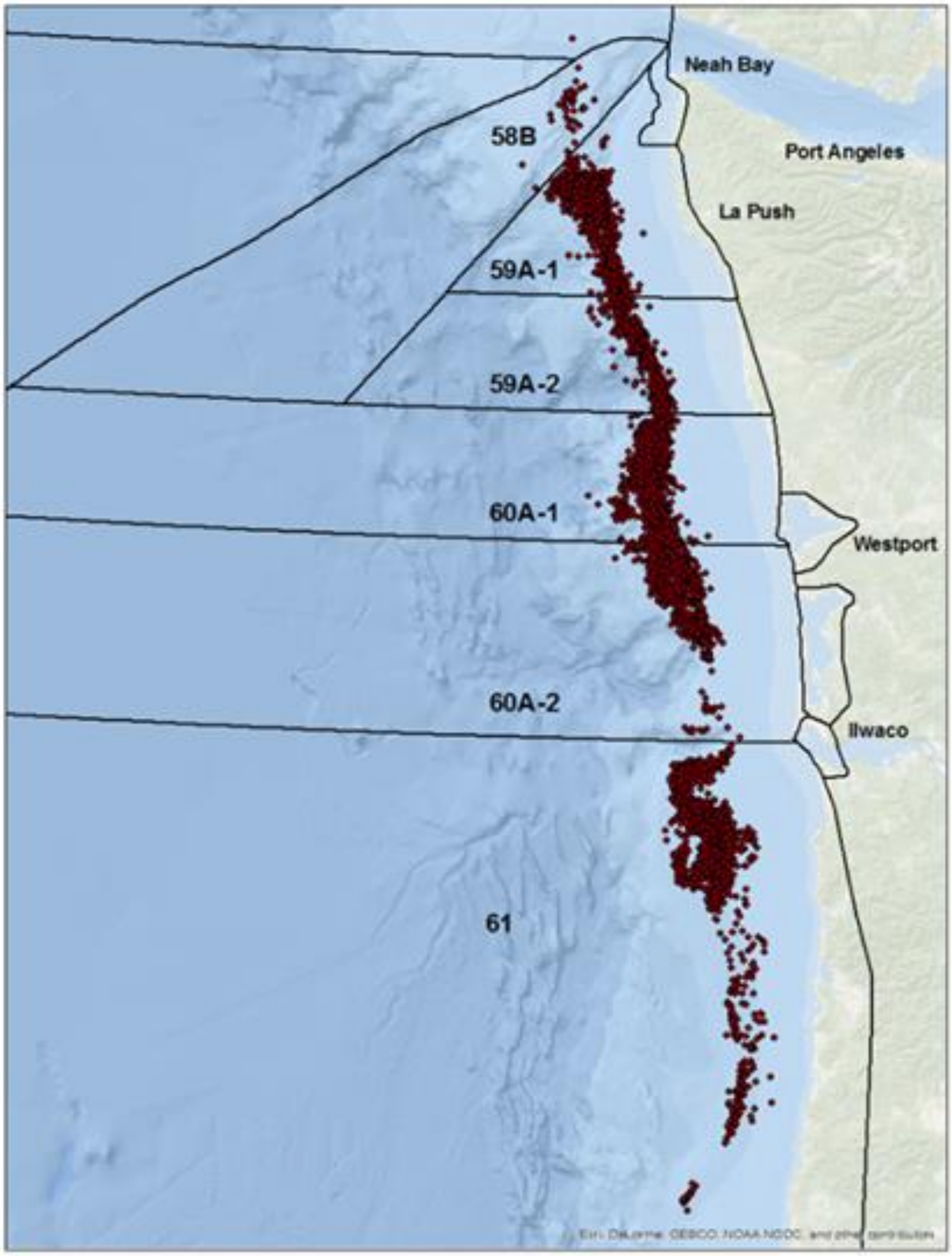


Figure 4. Hagfish fishing off WA and OR, from Washington logbooks, 2005-2014.

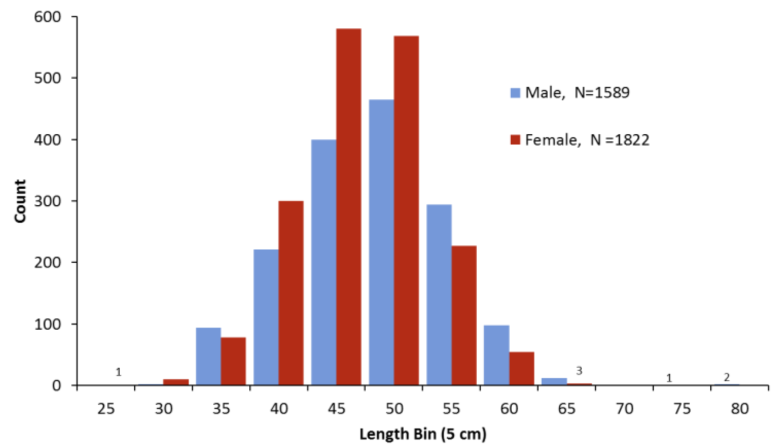


Figure 5. Length (cm), male and female Pacific Hagfish only.

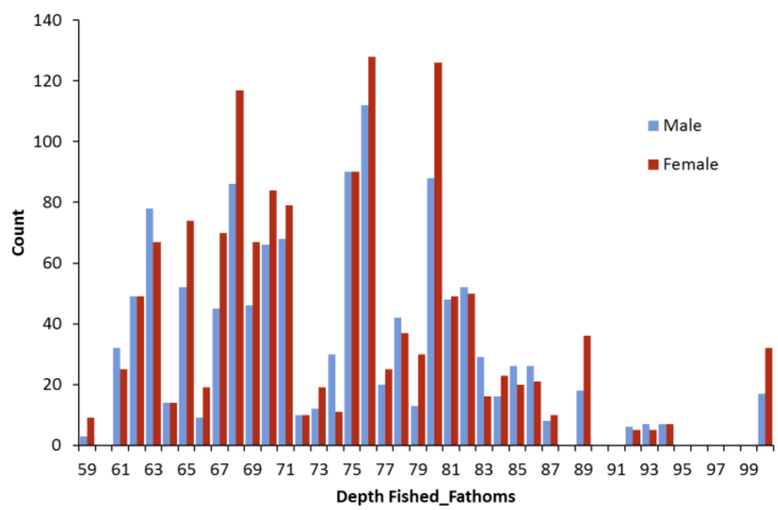


Figure 6. Distribution, by depth (fa), of male and female Pacific Hagfish.

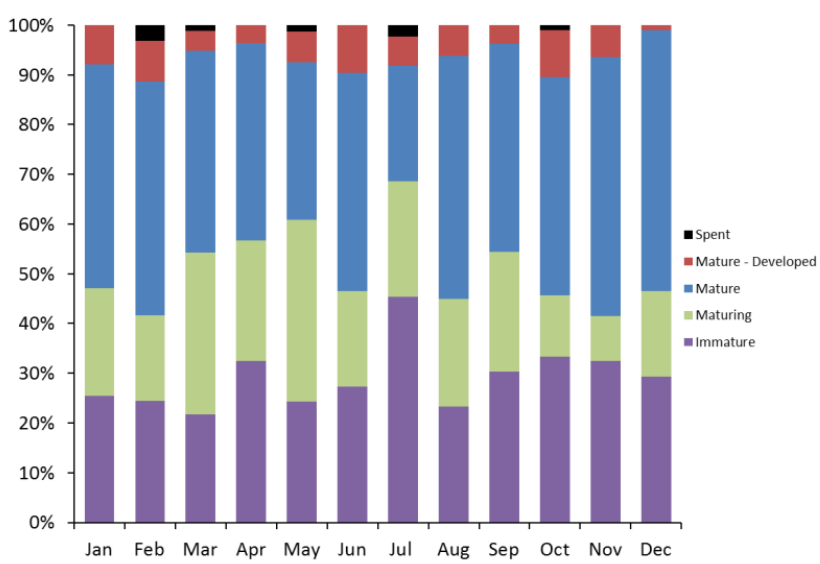


Figure 7. Female Pacific Hagfish maturity, proportion by month.

North Pacific Spiny Dogfish and other sharks

Lummi Nation dogfish fishery in northern Puget Sound – Directed commercial fishing for North Pacific Spiny Dogfish *Squalus suckleyi* was formally closed in Puget Sound in 2010 to protect ESA-listed rockfishes (Canary Rockfish, Yelloweye Rockfish, and Bocaccio) and their habitats. This included both State-sponsored and Tribal commercial fisheries. Prior to this closure, annual Sound-wide State harvest was below 500k lbs since 1997, though harvests as large as ~8.6M lbs once occurred (1979). By contrast, dogfish harvest in Puget Sound by Native American tribes peaked in 1996 at 159k lbs.

In 2014 the Lummi Nation initiated a directed drift- and set-gillnet fishery for dogfish in their Usual and Accustom Fishing Ground in northern Puget Sound. The harvest quota for this fishery was set at 250k lbs, 159k of which was taken in 2014 and 217k of which was taken in 2015. In 2016 harvest was 262k lbs. Harvest occurs predominantly from May-August, involves little to no reported bycatch, and tails off as fishers transition to targeting salmon in the fall.

In August of 2015 and 2016 Lummi Nation biological staff collected biological data and fin clips from a representative sub-sample of sharks caught in two locations as part of the tribal fishery. Every one of the 100 sharks sampled both years was female, and their average size was 88.8 cm. Many contained full-term embryos. Lummi biologist Breena Apgar-Kurtz confirmed this was a representative sub-sample both years and that the "vast majority" of the harvest consisted of relatively large female sharks.

Shark book -- Together with Dr. Shawn Larson of The Seattle Aquarium, Dayv Lowry is co-editing a book entitled *Northeast Pacific Shark Biology, Research, and Conservation.* Planning for this undertaking began in November of 2015 and final author commitments were obtained in March of 2016. Topics covered include regionally specific policy, current taxonomy and population trends, fisheries impacts/interactions, food web ecology, advances in aging techniques, genetic population identification, the role of captive husbandry programs in conservation, the economy of ecotourism, and future challenges to long-term conservation. Final versions of chapters are due May 30th and publication is expected in the summer of 2017 through Elsevier Scientific.

Skates

No specific, directed research or management to report.

Pacific Cod

Assigning individual Pacific Cod to population of origin along an isolation-by-distance gradient, and assessing implications of genetic selection of aquaculture – Many marine species are characterized by an isolation-by-distance pattern (IBD), where more geographically distant samples are also more genetically differentiated. IBD patterns are problematic for management because population boundaries, and thus spatial management units, cannot be cleanly delineated. Assignment tests could potentially be used to identify population of origin, facilitating management by estimating seasonal migration patterns and distances, as well as detecting productive areas. In 2015 the team of Kristen Gruenthal and Lorenz Hauser at the University of Washington, Mike Canino at NOAA's Alaska Fisheries Science Center, and Dayv Lowry successfully applied restriction site associated DNA (RAD) sequencing toward stock identification in the Pacific Cod (*Gadus macrocephalus*), which exhibits nearly perfect IBD along the northeastern Pacific coast. Using 6,756 SNPs, they were able to reassign 95-100% of fish to their population of origin, with high confidence, while still reproducing the strong IBD pattern found in earlier studies. Moreover, they were able to identify over 200 SNPs that may be under selection across the sampled range. These results lay the groundwork for future genetic stock identification and genetics-based management of Pacific cod. A report detailing these results was produced (Hauser et al., 2016) and Co-PI Kristen Gruenthal presented a talk at the World Aquaculture Society's annual meeting in Las Vegas, NV detailing the potential value of genetic variation at these SNP sites for aquaculture of Pacific Cod. Specifically, she proposed that active selection in this population, which experiences a considerably warmer thermal regime than populations of the species that reside north of Washington waters, may predispose this stock to being more suitable for hatchery cultivation in coming years as global warming continues and sea surface temperatures further elevate.

Walleye Pollock
No specific, directed research or management to report.

Pacific Whiting (Hake)
No specific, directed research or management to report.

Grenadiers
No specific, directed research or management to report.

Rockfishes
i. Research
Genetic study on ESA-listed rockfish – In April of 2014 the WDFW partnered with NOAA's Northwest Fishery Science Center to conduct a two-year fishing study aimed at collecting genetic samples from ESA-listed rockfish (Dayv Lowry and Bob Pacunski are co-PIs, along with Kelly Andrews and Dan Tonnes). The fishing portion of the study was completed in early 2016 and utilized several local charter operators and recreational fishing club members with experience fishing for these species prior to the closure of rockfish fisheries in Puget Sound. The study collected samples from various locations along the west coast and Canada for comparison to samples collected in Puget Sound (Table 6). The study obtained samples from 67 Yelloweye Rockfish, 69 Canary Rockfish, and 3 Bocaccio in the Puget Sound DPS, with collections occurring throughout the Sound (Figure 8). Many of these fish were visibly tagged to aid in identification during future diving and remotely-operated vehicle surveys (one fish sighted by each method in 2015, and one additional fish sighted by each method in 2016). Based on the results of this study, Canary Rockfish were removed from the Endangered Species List on March 24th, 2017 after thorough evaluation of the results by a Biological Review Team. This represents the first time that a marine fish has ever been delisted under the ESA. Samples collected from Canadian waters north of the current DPS boundary line resulted in an expansion of the Yelloweye Rockfish DPS further north to include more of Johnstone Strait and interior waters to the northern end of Vancouver Island (Figure 9). No changes were made to the listing status of Bocaccio due to low sample size. A manuscript of the study was developed and has been submitted for publication in Biological Conservation (Andrews et al, in review).

Table 6 (from Andrews et al., in review)**.** Number of fin clip samples successfully sequenced from each region and used in subsequent analyses for each species.

Region of collection	Yelloweye	Canary	Bocaccio
Southeast Alaska	1[f]	0	0
Inland British Columbia, Can	18[b]	0	0
Coastal British Columbia, Can	10[b]	0	2[d]
U.S. West Coast	55[c]	19[c]	15[cd]
Strait of Juan de Fuca	19[a]	22[a]	1[e]
San Juan Islands	28[a]	24[a]	0
Hood Canal	16[a]	0	0
Central Puget Sound	4[a]	23[a]	3[a]
South Puget Sound	0	0	0
Total samples	**151**	**88**	**21**

[a]Cooperative fishing, this study; [b]Department of Fisheries & Oceans Canada (Yamanaka et al. 2006); [c]Northwest Fisheries Science Center (Bradburn et al. 2011); [d]Southwest Fisheries Science Center; [e]Washington Department of Fish & Wildlife; [f]Nichols opportunistic sampling.

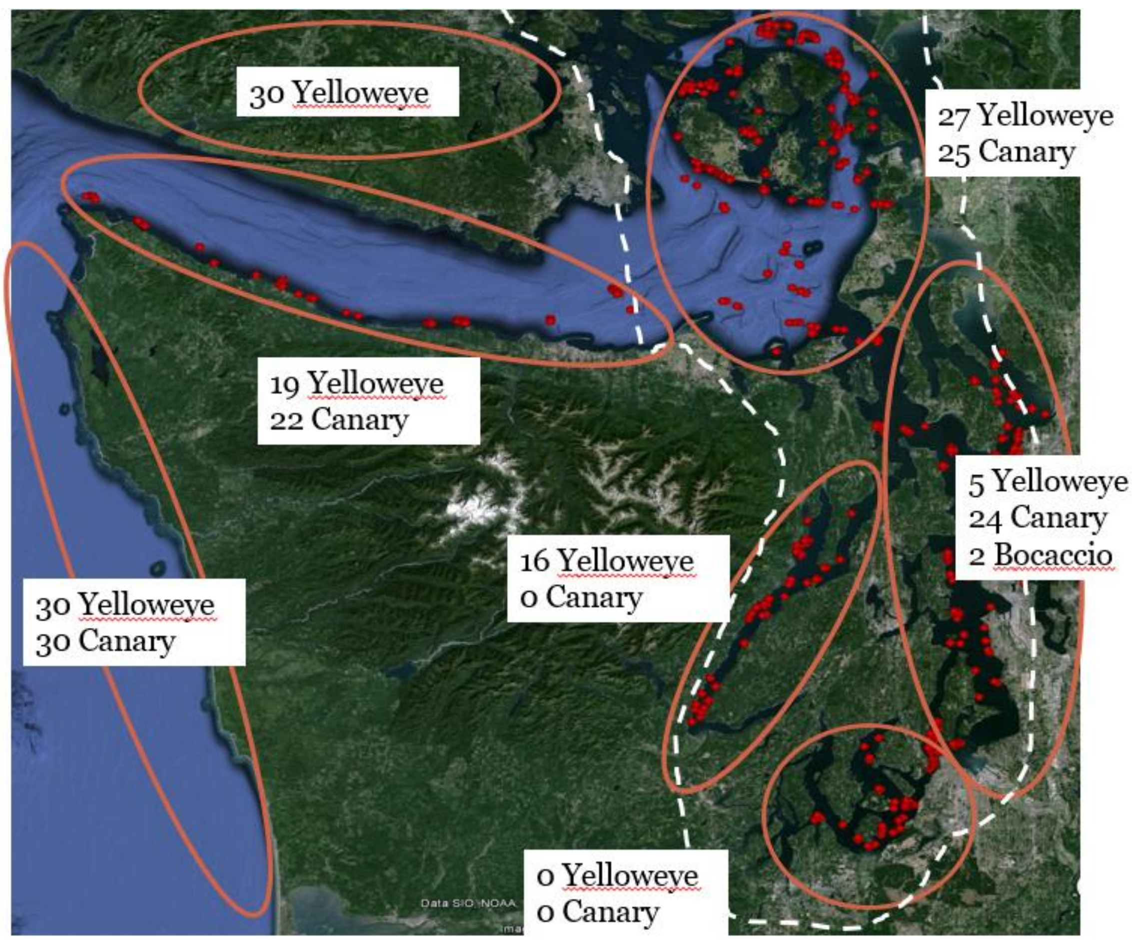


Figure 8. Total sample numbers for ESA-listed rockfish by region as of December 2016 for the Sound-wide genetic study. The 30 Yelloweye Rockfish samples shown on Vancouver Island were provided by DFO from fish collected throughout the inside waters

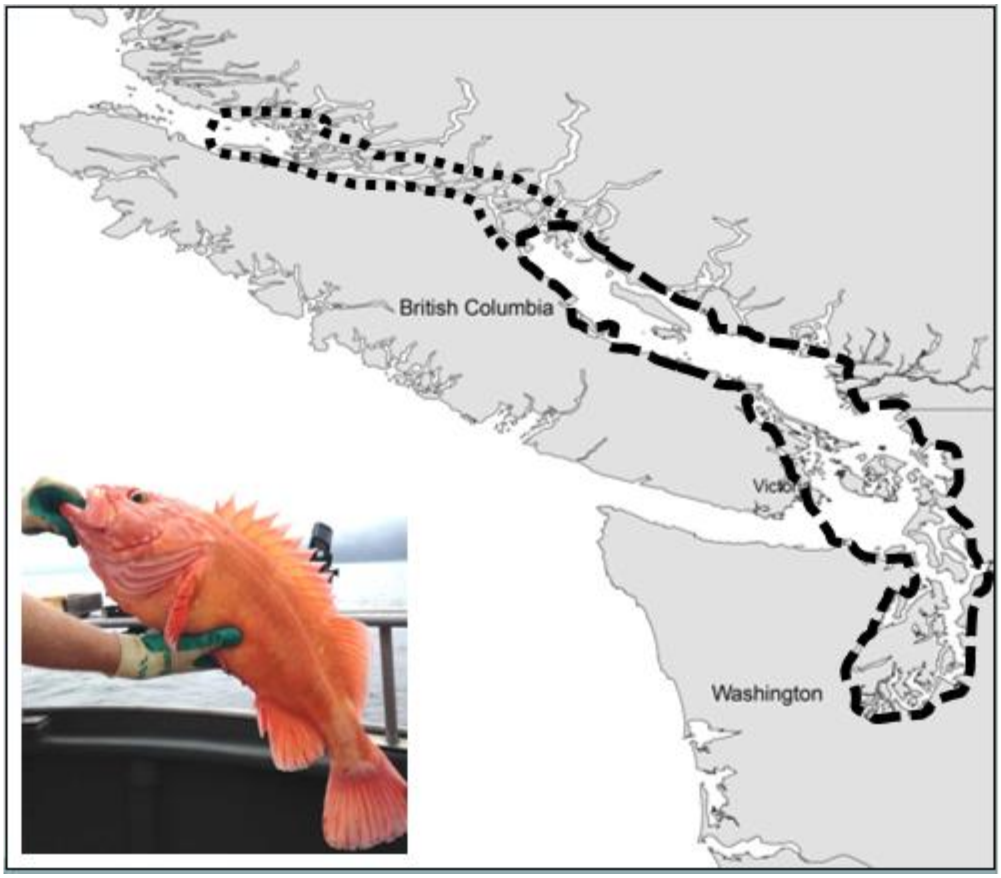


Figure 9. Depiction of the initial (long dashes) and revised (short dashes) DPS boundaries for Yelloweye Rockfish. The revised boundary was proposed based on the results of a collaborative genetic study.

Developing an index of abundance for Yelloweye Rockfish (*Sebastes ruberrimus*) off the Washington coast – Yelloweye Rockfish (*Sebastes ruberrimus*) was declared overfished by the PFMC in 2002 and since has been a “choke species” limiting groundfish fishing opportunities along the U.S. west coast. One of the many challenges in monitoring and managing this stock is the lack of adequate fisheries-independent surveys. The conventional bottom trawl survey does not consistently sample Yelloweye Rockfish habitat; and the only survey used in the past assessments was the International Pacific Halibut Commission’s fixed-station setline survey. For Yelloweye Rockfish caught by the IPHC survey off the Washington coast, more than 90% were from one single station off Cape Alava and the minimum size was 40 cm (older than 10 years old). The abundance trend derived from the IPHC survey is uninformative for the population in Washington waters, thus the need for another survey.

Since 2006, the Washington Department of Fish and Wildlife has been conducting pilot projects to identify the best location, season, and hook-size for constructing a representative Yelloweye Rockfish abundance index trend. Working together with Jason Cope from NOAA’s FRAM Division, the CMFS Unit has conducted pilot projects, compared abundance trends, and is working toward future research recommendations. Surveys continued in 2016 as noted above in the Surveys section (due to captures of more than just Yelloweye Rockfish).

ROV survey for ESA-listed rockfish, and their habitats, in Puget Sound – Dan Tonnes at NOAA's NWFSC was able to secure supplemental funding that allowed the WDFW to conduct a 2-year remotely-operated vehicle survey of large portions of Puget Sound. Year 1 of the survey was completed in January 2016 and Year 2 was completed in January 2017. This study was limited to Central Puget Sound, the Whidbey Basin, Hood Canal, and South Puget Sound (in total, referred to as Puget Sound proper) due to the availability of population estimates from recent ROV surveys in the San Juan Archipelago. A stereology-based ROV survey covering the same area in 2012 did not encounter ESA-listed rockfish in significant numbers, thus this supplemental survey was needed to provide baseline population estimates necessary to evaluate recovery of these species per the conditions of the ESA. The goal of this new study was to develop valid population estimates for ESA-listed rockfish species in this undersampled portion of the U.S. DPSs. The survey design and methodology was consistent across both years, which will allow for independent population estimates to be made for all encountered species in each year. A secondary goal of this survey was to catalog and quantify high-relief, rocky habitat in Puget Sound proper in an effort to better define attributes of Critical Habitat for these ESA-listed rockfish species.

WDFW staff worked with Chris Rooper at NOAA's Alaska Fisheries Science Center to design a survey using a Maximum Entropy model to predict the potential distribution of listed rockfish habitat. The model inputs included all verified locations of Yelloweye and Canary Rockfish, a 30m x 30m bathymetry grid of Puget Sound, and bottom current velocities (resampled to 30m x 30m). From the bathymetry grid we extracted bottom depth, and measures of slope and bottom roughness (rugosity). Based on these attributes, combined with the bottom current velocities at the locations of ESA rockfish, the MaxEnt model predicts a probability surface representing the potential species distribution within the study area, which is represented as a probability surface. The probability surface was parsed into high, medium, and low probability bins, which were used to stratify the study area. We used the encounter rates for ESA rockfish from previous ROV surveys in the San Juan Islands to model expected coefficients of variation and partitioned sampling effort among the three strata as follows: 60% high, 20% medium, 20% low. High probability habitats composed 7% of the study area, whereas medium and low probability strata composed 12% and 81% of the study area, respectively. We planned to conduct 900, half-hour ROV transects, 450 in each year. Using a random point generator in ArcGIS sampling locations were generated proportionally to each of the three strata, with additional buffer stations to accommodate potential need to drop stations in response to various field conditions (e.g., map inaccuracies, hazards to navigation).

In Year 1 of the survey, the WDFW Marine Fish Science group conducted 68 days of sampling between February and December of 2015 and completed 387 transects; 249 high, 82 medium, and 56 low, representing 86% of the planned survey stations and over 90% of the High and Medium stations (Figure 10). Technical issues with the ROV and poor weather conditions prevented completion of the remaining stations, most of which were in the Low stratum. All three species of ESA-listed rockfish were encountered in Year 1; 35 Yelloweye Rockfish at 19 stations, 7 Canary Rockfish at 4 stations, and 1 Bocaccio, with all encounters occurring on High probability habitats.

In Year 2 we conducted 66 days of sampling from February 2016 to January 2017 and completed 418 transects; 266 High, 70 Medium stratum, and 73 Low. Sampling rates were higher than Year 1, with 96%, 76%, and 79% of the planned High, Medium, and Low stations sampled, respectively. In total, fewer ESA-listed rockfish were encountered in Year 2, although more Canary Rockfish were seen than in Year 1. Twenty-two Yelloweye Rockfish were observed at 15 High stations and 22 Canary Rockfish were seen at 7 High stations. No Bocaccio were encountered in Year 2.

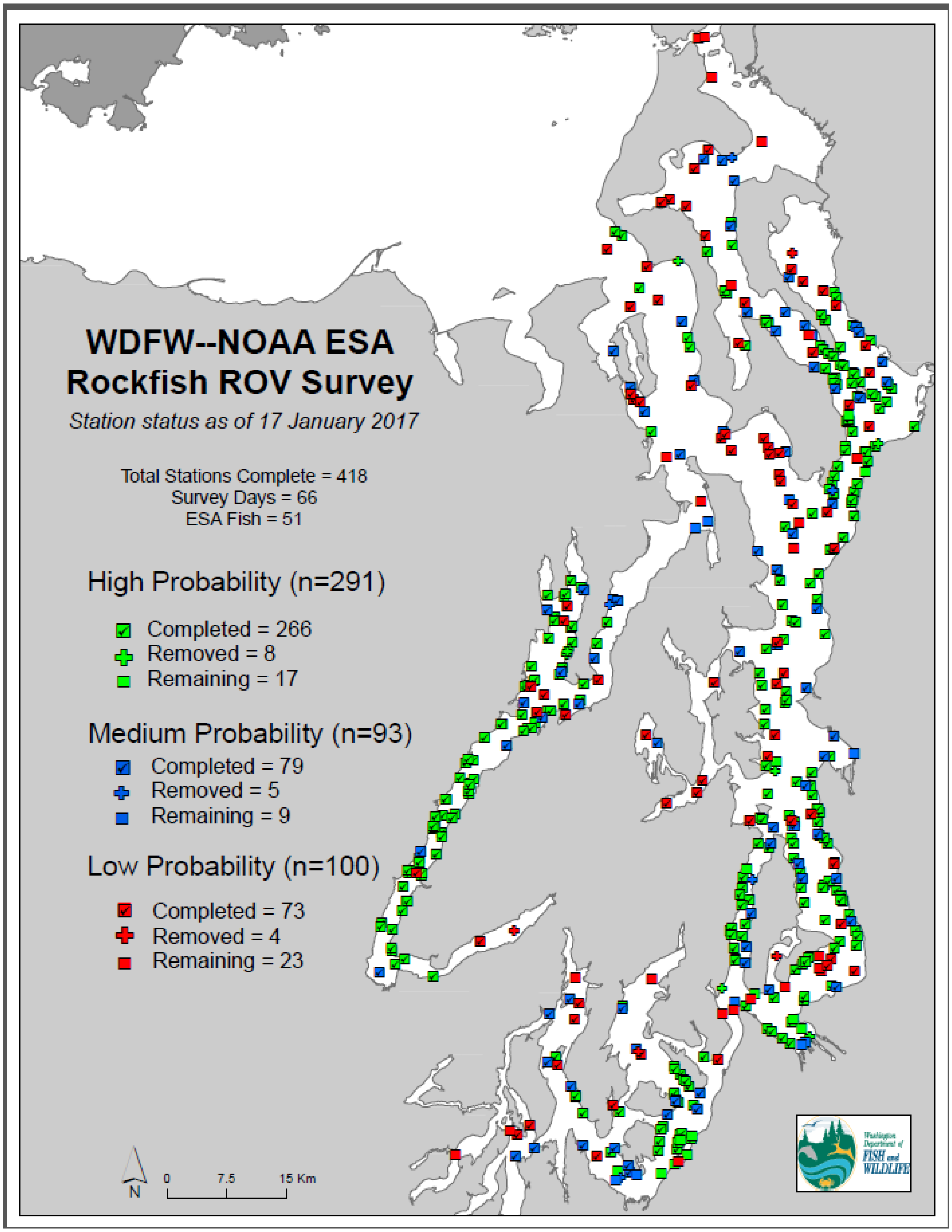


Figure 10. Stations sampled for ESA-listed rockfish and habitat in Year 2 of the Puget Sound ROV Survey. Stations are symbolized by their end-of-survey status.

Yelloweye Rockfish life history project – A collaborative, ongoing project involving the NWFSC, SWFSC, ODFW, and WDFW has been collecting and analyzing data for a Yelloweye Rockfish life history project for the last two years. Port samplers and survey teams have collected Yelloweye Rockfish ovaries for fecundity and maturity estimates from WDFW port-sampled fish, the West Coast groundfish bottom trawl survey, southern California hook and line survey, and ODFW port sampled-fish. The goal is to complete a coast-wide analysis of Yelloweye Rockfish size and age at maturity, as well as look at temporal trends in maturity since the data span from 2002-2016. In addition, we hope to investigate spatial and temporal relationships in length, weight, age, and growth relationships with the available Yelloweye Rockfish data. We also have access to Yelloweye Rockfish genetic samples collected during 2004-2016 and, if we can secure funding, could look for potential shifts in genetic structure over the sampled period, as well as determine whether different stock structures are present.

Current collaborators and contributors who've helped with this project include: Melissa Head (NWFSC, project lead), Neosha Kashef & David Stafford (SWFSC), Kari Fenske (previously WDFW), Robert Le Goff (WDFW), and Sheryl Flores (ODFW)

ii. Management

Participation in the Federal Rockfish Technical Recovery Team – Since 2012 Dayv Lowry and Bob Pacunski have served on NOAA's Rockfish Technical Recovery Team, which was charged with developing a detailed recovery plan for the three ESA-listed species (Canary Rockfish, Yelloweye Rockfish, and Bocaccio) in Puget Sound and the Strait of Georgia. The team met in person twice during the reporting period and held several conference calls focused on revising the delisting and down-listing criteria and finalizing the plan for public consideration. The team held its last official meeting on February 27th, 2017 and is now dedicated solely to finalization of a draft recovery plan.

The draft recovery plan developed by the team underwent pre-public review by the WDFW and other state agencies at large, tribal co-managers, and representatives at the Department of Fisheries and Oceans Canada in mid-2016, and was released for public comment in August. Three public meetings to solicit feedback on the plan were held in western Washington in October of 2016. A 5-year review of the listed species was completed in April of 2016 and released to the public on May 5th, 2016. In July of 2016, NOAA Fisheries proposed the removal of Canary Rockfish from the Federal List of Threatened and Endangered Species, the removal of its critical habitat designation, and the update and amendment of the listing descriptions for Bocaccio and Yelloweye Rockfish based on the results of a genetic study of listed rockfish (see above). This rule became final on March 24th, 2017 (82 FR 7711) and the draft plan is now being revised to recognize these significant changes. The results of population change rate modelling in a MARSS framework conducted for the 5-year review were recently published in Ecology and Evolution (Tolimieri et al. 2017). Dayv Lowry and Bob Pacunski are co-authors on this paper. A talk will also be given on this topic at the national American Fisheries Society meeting in 2017.

Thornyheads
No specific, directed research or management to report.

Sablefish
No specific, directed research or management to report.

Lingcod
Comparison of ages determined from various skeletal elements, and support of a coast-wide stock assessment – An accurate and economical methodology for determining fish age is important to the successful management of any species. For Lingcod (*Ophiodon elongatus*), dorsal fin rays have been the primary structure used to determine age for use in stock assessments. However, this method is labor intensive and concerns have been raised regarding the precision of age determinations. In 2015 the WDFW conducted a study to evaluate the utility of otoliths and vertebrae as alternate ageing structures to dorsal fin rays while evaluating, cost, precision, bias, and uncertainty of determinations among structures. We opportunistically sampled 124 lingcod from recreational and commercial fisheries off the coast of Washington, stratified by length (Large > 90 cm; Medium = 60-89 cm; Small < 59 cm TL). A set of 121 paired otoliths and fin rays, and 47 paired otoliths, fin rays, and vertebrae, were prepared using standard methodology, aged by two readers independently, and given a readability code. We evaluated each structure using average percent agreement (APE), age-bias plots, readability anomalies, and preparation and ageing time for each structure. Otoliths (surface aged) took only minutes per sample to prepare and age but, had below average readability (readability anomaly = -0.8), the least precision between readers (APE = 14%), and the most bias between readers. Otoliths and vertebrae tended to produce younger age estimates than fin rays, particularly for fish older than age 7. We observed a negative relationship between the cumulative time it takes to prepare and age each sample and precision between readers. For example, ageing structures that were more intensive to prepare and age (fin rays and vertebrae > 30 minutes/sample), had the most repeatable age determinations. These results indicated that despite some concordance between structures for younger fish, fin rays currently produce the most precise estimates across age classes, and are the only validated structure for ageing lingcod.

Having confirmed that fin rays are the most appropriate structure to use for aging studies, the WDFW is now moving forward with substantial collection of these samples from recreational fisheries, commercial fisheries, and scientific surveys throughout Washington waters in support of a coast-wide evaluation of regional differences in age and growth rate of Lingcod. Staff are coordinating these efforts with Jameal Samhouri and Kelly Andrews of NOAA’s NWFSC and may enlist the services of recreational/charter fishers who also participated in the ESA-listed rockfish genetic survey detailed above. Cultivating these relationships has led to benefits for all parties, and has advanced research and management efforts.

Atka mackerel
No specific, directed research or management to report.

Flatfishes
No specific, directed research or management to report.

Pacific halibut & IPHC activities
No specific, directed research or management to report.

Other groundfish species
Ratfish toxin research – The PSMFS Unit has been providing specimens of Spotted Ratfish to Dr. Dominique Didier of Millersville University in Pennsylvania, and her students, for the past several years. Their goal is to use mass spectrometry to evaluate the chemical composition of the venom associated with the dorsal fin in an effort to identify chemicals that might be of medical value for the treatment of neurological, or other, diseases. Specimens come from the annual trawl survey and initially consisted of whole frozen fish. The past two years, however, students have traveled from Pennsylvania to participate in the collection of specimens and to excise venom glands aboard the survey vessel. This has provided a rare opportunity for undergraduate students from the east coast to gain valuable field experience in a novel ecosystem. One of these students have since moved on to pursue a graduate degrees in marine biology.

No addition directed research or management to report. Various species of groundfish are counted, and density and abundance estimates are derived for them, during ROV, scuba, and trawl surveys described above and below.

Ecosystem Studies

Puget Sound Ecosystem Monitoring Program update – WDFW's PSEMP Unit has changed its name! As noted above, the PSEMP Unit has now been rebranded as The Toxics-focused Biological Observation System for the Salish Sea, or TBiOS. This renaming recognizes that, while the WDFW is a key partner of a multi-agency effort to assess the health of Puget Sound known as PSEMP, there are also Unit goals that expand on and diverge from the needs of PSEMP. The TBiOS group conducts regular status and trends monitoring of toxic contaminants in a wide range of indicator species in Puget Sound, along with evaluations of biota health related to exposure to contaminants. This group has recently conducted additional focus studies on toxic contaminants in Dungeness crab (*Cancer magister*), spot prawn (*Pandalus platyceros*), blue mussels (*Mytilus* spp), as well as a field experiment testing the effects of chemicals leaching from creosote-treated wooden pilings on the health of developing Pacific herring (*Clupea pallasii*) embryos. For additional details and several recent reports on toxic contaminants in Puget Sound biota contact Jim West at james.west@dfw.wa.gov or 360-902-2842.

Groundfish, Forage Fish, and Salmonid Surveys at U.S. Navy Facilities – The U.S. Navy controls multiple restricted areas throughout Puget Sound which have been exempted from rockfish critical habitat designation by NMFS, however an Integrated Natural Resource Management Plan (INRMP) provided by the Navy is required to fulfill the obligations necessitated by these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at NBK-Bremerton and NUWC-Keyport in 2013, the WDFW entered a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NASWI-Crescent Harbor, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NUWC-Keyport, NAVSTA-Everett. These surveys, which expanded on the 2013 surveys, were conducted during 2014-15 and included ROV, scuba, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted which concluded: no ESA-listed rockfish were observed, no deep-water critical habitat (>30m) for adult rockfish was present, and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do occur. These nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect methods in 2016-17. The deep-water surveys have concluded and will not continue in 2016.

The WDFW has also entered a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NASWI-Crescent Harbor, NASWI-Lake Hancock, NAVMAG-Indian Island, NBK-Bangor, Manchester Fuel Depot, NAVSTA-Everett. Monthly sampling at each installation began in May 2015 and will continue through the summer of 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. A summary of the results from 2015 sampling was included with the rockfish final reports. The only ESA-listed fish captured in the beach seine in 2015 were Puget Sound Chinook Salmon, Puget Sound Steelhead, Hood Canal Summer Chum Salmon, and Bull Trout. Regarding timing and abundance, juvenile salmonids and forage fish species generally followed trends previously documented in similar reports, which supports the work windows outlined in the Washington Administrative Code.

Puget Sound mid-water trawl study – Funding from the Washington State Legislature was appropriated through Substitute Senate Bill No. 5166 in May of 2015 to support an evaluation of the abundance and distribution of forage fish and other mid-water species throughout Puget Sound using an acoustic/trawl survey design. The resulting survey, running every other month from February 2016 – February 2017, obtained hydroacoustic data (Biosonics DT-X; 38 kHz and 120 kHz transducers), mid-water biota samples via a Polish rope trawl, and plankton samples from 18 reaches throughout Puget Sound, the San Juan Islands, and the southern Strait of Georgia (Figure 11).

The acoustic analyses from the mid-water trawl are nearing completion and we will have species-specific estimates of abundance, density, and total biomass by site and across sites by the end of April, 2017. The catch data from 225 individual mid-water trawls showed that herring were the most common forage fish in Puget Sound in 2016-17, making up 61% of the total catch (Figure 12). Herring were the most abundant species in each of the four basins (Figure 13), although they exhibited wide fluctuations seasonally and were a minor component of the catch in June, August, and December (Figure 14). The last finding was surprising given that herring catches were quite large in October. We suspect that during December herring had largely moved to their shallow, pre-spawn holding locations and thus were not sampled effectively in the offshore, mid-water trawl.

As expected, other components of the catch also varied both between basins and seasonally. Pacific Whiting (hake) comprised 15% of the overall catch but were really only abundant in the Central basin (Figures 12, 13), particularly in Saratoga Passage where they were the dominant species caught during several months. Northern anchovy were infrequently captured but sometimes accounted for a large percentage of any given trawl, particularly in the North and South basins (Figure 13) in the late summer and early fall (Figure 14). During the summer (June-August), invertebrates (predominately a suite of jellyfish species) accounted for roughly 60% of the catch (data not shown) and fish catches declined (Figure 14), due in part to the emigration of Pacific herring to the ocean

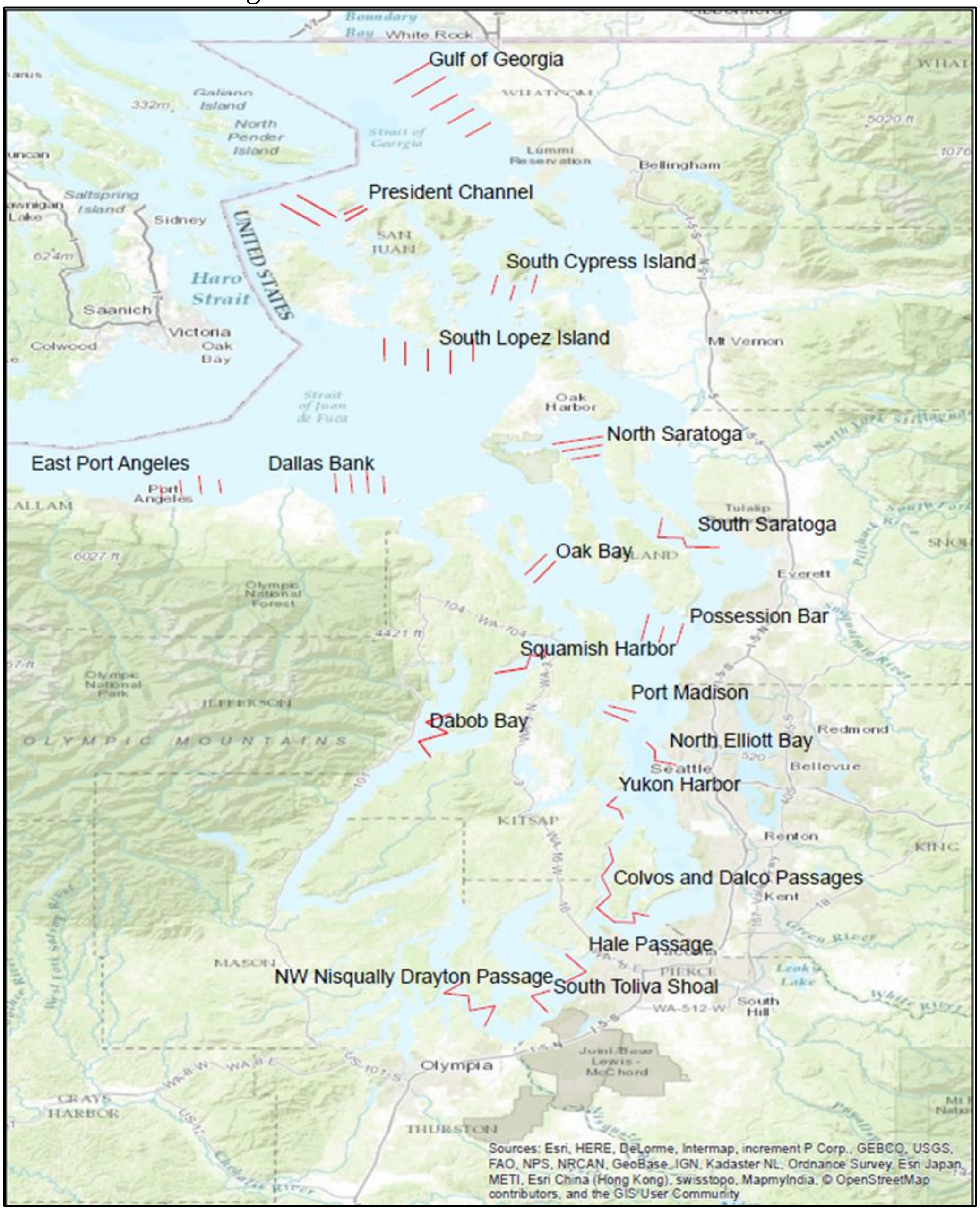


Figure 11. Map of station locations for the Puget Sound Mid-water acoustic trawl survey, Southern Salish Sea, WA.

Overall, a total of 52 different species of fish and invertebrates were captured in the trawls, although only nine made up 96% of the overall catch (Figure 12). Throughout the year a total of 183 juvenile and sub-adult Chinook salmon (163 were frozen for collaborators and the rest released), 69 chum salmon (13 released), 16 coho salmon (all retained), and 33 pink salmon (all retained) were captured. Besides the listed Puget Sound population of Chinook salmon, other ESA listed species captures were limited to 30 Eulachon (frozen for further analysis) and one Canary rockfish, which was descended according to protocol after the removal of a fin clip for genetic analysis.

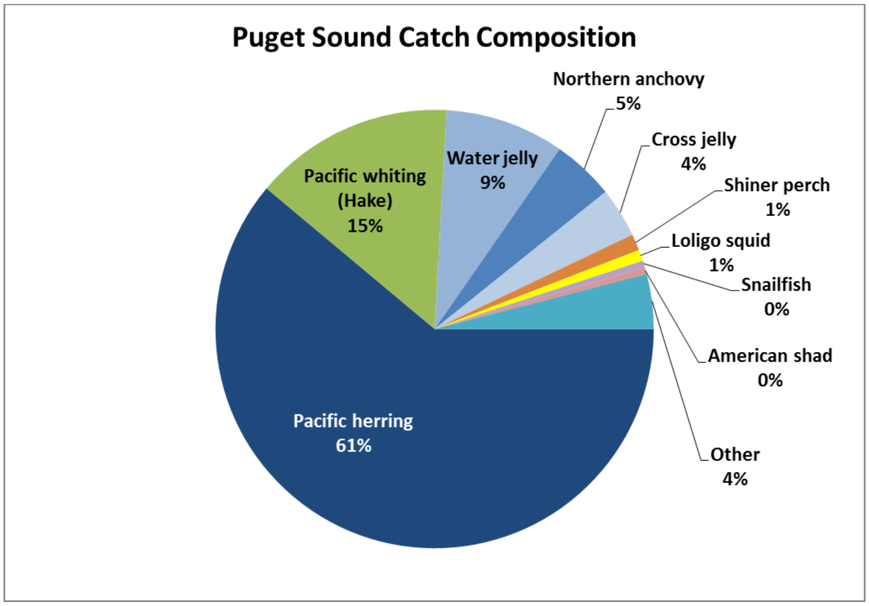


Figure 12. Overall catch composition during the Puget Sound Mid-Water Acoustic Trawl Survey. Species listed at "0%" made up <1% of the total catch.

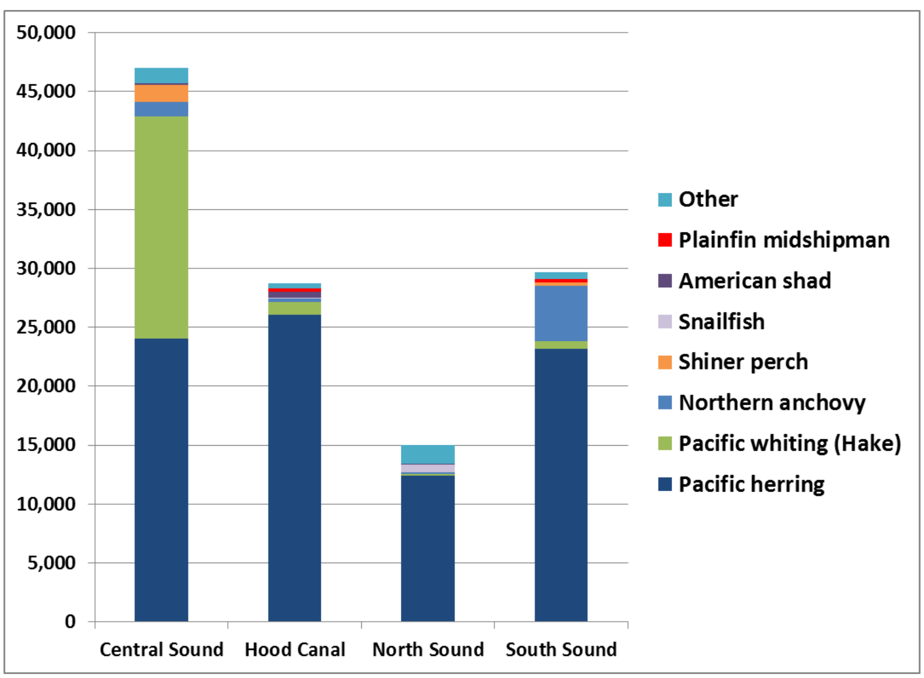


Figure 13. Mid-water trawl fish catch composition, all months by basin.

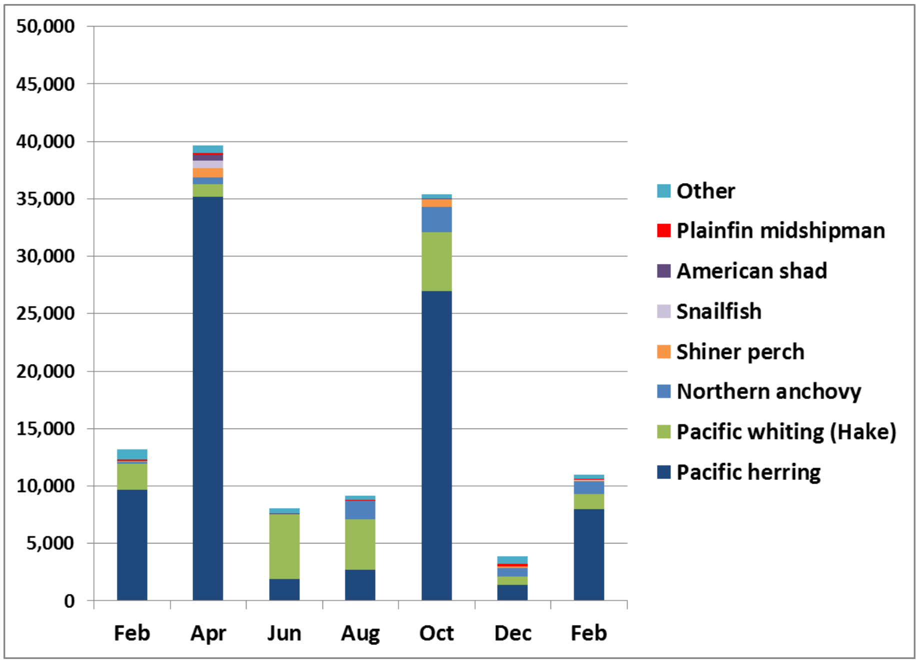


Figure 14. Mid-water trawl fish catch composition, all basins by month

A total of 127 vertical plankton tows (half meter nets) were conducted during the trawl surveys. The contents were preserved in buffered formalin and are currently stored at the WDFW waiting sorting and speciation. In addition, roughly 123 CTD (conductivity-temperature-depth sensor) casts were made to profile the water column and inform both the acoustic analyses and the catch interpretation.

In a broad effort to reach out to collaborators, the trawl survey has provided research specimens for Paul Hershberger, USGS (Pacific herring, *Ichthyphonus* research), Sandie O'Neill and Jim West, WDFW (herring and American shad, ecology and toxicology), Virginia Butler (fish archaeology, University of Portland), Lorenz Hauser (Pacific herring genetics, UW), Julie Keister (zooplankton ecology, UW), Katherine Maslenikov (fish collections, UW Burke Museum) and numerous researchers at NOAA's Northwest Fisheries Science Center (juvenile and sub-adult salmon ecology). Thousands of samples were also retained frozen by the WDFW for use in evaluating age structure, maturation stage, and sex ratios of the sampled portion of each population; this "post-trawl" effort will continue throughout 2017. The next phase of the Puget Sound Mid-water Acoustic/Trawl will be a final report delivered to the State Legislature at the end of June, 2017.

High-resolution modeling of fish habitat associations, and predictive models -- In collaboration with the SeaDoc Society and Tombolo Laboratories, PSMFS Unit staff worked to integrate high-resolution multibeam bathymetry data from the San Juan Islands with fish occurrence data obtained from ROV and drop camera surveys over five years. H. Gary Greene, a geologist, has spent several years mapping and typing benthic habitats in the San Juans. Leveraging visual survey work conducted by WDFW that overlaps these focal areas, a unique opportunity has arisen to groundtruth Dr. Greene's bottom typing and to use benthic terrain modeler in ArcGIS to evaluate the occurrence of fish species over particular bottom types. A cooperative agreement was established between WDFW and the SeaDoc Society in 2014 to conduct a pilot analysis in a small area of the San Juan Islands. The pilot study was completed in early 2015, with strong correlations established between rockfish occurrence and habitat variables such as slope, depth, and benthic position index. A second contract established in 2016 has moved this project to the next phase, which is focused on expanding the study to areas of Puget Sound with high-resolution bathymetry data to cross-validate the model in areas lacking a true habitat map (see below). Data collected during a 2-year ROV survey of Puget Sound (see next section) is being used in this study and the results are expected to help to pave the way for a Puget Sound-wide model that can be used to evaluate rockfish critical habitat designations made by NOAA in 2015.

Derelict gear reporting, response, and removal grant funding – Marine fish mortality associated with derelict fishing gear has been identified as a threat to diverse species around the world. In Puget Sound, removal of derelict fishing nets has been the focus of a concerted effort by the Northwest Straits Foundations since 2002. In late 2013 the Washington State Legislature granted $3.5 million to the Foundation to "complete" removal of all known legacy fishing nets in waters shallower than 105 ft and this effort was finalized in 2015. In August of 2015 a celebration ceremony was held to recognize these extensive efforts to remove 5,660 fishing nets from the Sound and restore 813 acres of benthic habitat. The Northwest Straits Foundation and the PSMFS Unit then moved on to pilot methods to remove several deep-water nets using an ROV instead of scuba divers. A manual was developed detailing the pros and cons of various approaches to retrieve these nets and funding is now being sought to aggressively go after these remaining nets.

In 2012 a reporting hotline was developed, and a rapid response and removal team was formed, to prevent the accumulation of additional fishing nets due to loss during ongoing and future fisheries. Because these nets are a direct threat to ESA-listed rockfish, in 2014 WDFW and the Foundation were able to obtain Section 6 funding to continue hotline service and ensure support for the response team through 2017. Combined with the legislative grant money mentioned above, this funding source allows the WDFW and Foundation to remove old nets, stay informed about newly lost nets, and remove new nets to minimize/eliminate this threat to rockfish, and the ecosystem at large. To date reports for several dozen nets have been responded to, resulting in the removal of numerous free-floating nets, a handful of sunken/entangled nets, and ample opportunity for public outreach regarding when nets are derelict and when they are legal fishing. Funding has now been secured through the Puget Sound Marine and Nearshore Grant Program administered by the WDFW to continue this work through at least 2018. Funding beyond that date is uncertain.

Publications

Andrews, K., K. Nichols, A. Elz, N. Tolimieri, C.J. Harvey, R. Pacunski, D. Lowry, K.L, Yamanaka, and D.M. Tonnes. (In Review). Cooperative research sheds light on population structure and listing status of threatened and endangered rockfish species. *Biol Cons.*

Carson, HS, Ulrich, M, Lowry, D, Pacunski RE, and R Sizemore. (2016). Status of the California sea cucumber (*Parastichopus californicus*) and red sea urchin (*Mesocentrotus franciscanus*) commercial dive fisheries in the San Juan Islands, Washington State, USA. *Fish Res*. **179**: 179-190.

Hauser, L, Gruenthal, K, Canino, M, and D Lowry. (2016). Local adaptation in Puget Sound Pacific Cod (*Gadus microcephalus*) phenotypic and genomic differentiation and the conservation of a depleted population in a warming environment. Washington Sea Grant Final Report for OMB Project Number 0648-0362. 12 pp.

LeClair, L, Pacunski, RE, Blaine, J, Hillier, L, and D Lowry. (In Final Review). A summary of findings from periodic scuba surveys of bottomfish conducted over a sixteen year period at six nearshore sites in central Puget Sound. Washington Department of Fish and Wildlife Technical Report. Expected completion June 2017.

Lowry, D, Pacunski, RE, Blaine, J, Tsou, T, Hillier, L, Beam, J, Wright, E, Cheng, YW, and A Hennings. (In Prep). 2010 Assessment of San Juan Island bottomfish populations utilizing a remotely operated vehicle and a stereological survey protocol. Washington Department of Fish and Wildlife Technical Report. Expected completion July 2017.

Lowry, D, Pacunski, RE, Blaine, J, Tsou, T, Hillier, L, Beam, J, Wright, E, and A Hennings. (In Prep). Assessing groundfish occurrence, abundance, and habitat associations in Puget Sound via a small remotely operated vehicle: results of the 2012-13 stereological survey. Washington Department of Fish and Wildlife Technical Report. Expected completion September 2017.

McNeil, B, Lowry, D, Larson, S, and D Griffing. (2016). Feeding behavior of subadult sixgill sharks (*Hexanchus griseus*) at a bait station. *PLoS One*. **11(5)**: e0156730.

Pacunski, RE, Lowry, D, Hillier, L, and J Blaine. (2016). A comparison of groundfish species composition, abundance, and density estimates derived from a scientific bottom-trawl and a small remotely operated vehicle for trawlable habitats. Washington Department of Fish and Wildlife Technical Report. FPT 16-03. 36 pp.

Siple, MC, Shelton, AO, Francis, TB, Lowry D, Lindquist, A, and TE Essington. (In Review). Contributions of adult mortality to declines of Puget Sound Pacific herring. *ICES J Mar Sci*.

Tolimieri, N, Holmes EE, Williams GD, Pacunski R, Lowry D. (2017). Population assessment using multivariate time-series analysis: A case study of rockfishes in Puget Sound. *Ecol Evol*. 2017;00:1–15. https://doi.org/10.1002/ece3.2901

Conferences and Workshops

In 2016-17 staff of the PSMFS Unit presented at, participated in research presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events as indicated below.

- ICES/PICES Symposium on Drivers of Dynamics of Small Pelagic Fish Resources, Mar. 6-11, 2017. Co-authors on presentations included Dayv Lowry and Todd Sandell.
- Washington State Shellfish Growers Association annual meeting, Feb. 27, 2017. Dayv Lowry was invited speaker on forage fish survey requirements.
- Seattle Aquarium Discover Science Days, Nov. 12-13, 2016. Presenters: Robert Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Taylor Frierson, Phil Campbell, and Amanda Phillips.
- South Sound Science Symposium, Sept. 20, 2016. Phill Dionne and Dayv Lowry were invited speakers, and Dayv Lowry served on the organizing committee.
- Salish Sea Ecosystem Conference, Apr. 13-15, 2016. Dayv Lowry, Bob Pacunski, and Phill Dionne were coauthors on a total of three talks.

Committee of Age Reading Experts

2016 Committee Report

and

Executive Summary of the

Nineteenth Biennial Meeting April 4-6, 2017

Prepared for the Fifty-eighth Annual Meeting of the

Technical Subcommittee of the Canada-USA Groundfish Committee

April 25 – 26, 2017

Prepared by
Christopher Gburski
2015-2017 CARE Chair

National Oceanic Atmospheric Administration
National Marine Fisheries Service
Resource Ecology and Fisheries Management
Alaska Fisheries Science Center
Age and Growth Program
7600 Sand Point Way NE
Seattle, Washington
98115

A. CARE Overview

1. **History**
   The Committee of Age-Reading Experts, CARE, is a subcommittee of the Canada-USA Groundfish Committee's Technical Subcommittee (TSC) charged with the task to develop and apply standardized age determination criteria and techniques and operate within the Terms of Reference, approved by the TSC in 1986, and the CARE Charter, developed in 2000 and approved by the CARE in 2004.

2. **Report Period**
   This report covers the work period of January 1 – December 31, 2016. However, to promote timely reporting of work and recommendations occurring during the recent CARE conference, an Executive Summary of the 19th CARE conference held April 4-6, 2017 is included here as part of the TSC report. Current officers through June 30, 2017 (elected at April CARE 2015 Meeting) are:
   - Chair – Chris Gburski (AFSC)
   - Vice-Chair – Lance Sullivan (NWFSC-PSMFC)
   - Secretary – Kevin McNeel (ADF&G-Juneau)

   The Secretary will prepare a draft of the minutes from the recent CARE meeting to be distributed to CARE members for review and subsequent approval prior to the end of his term. Due to the close proximity of the TSC meeting following the CARE meeting, it is necessary to for the Chair to prepare the report to TSC to include proceedings of the recent meeting as an executive summary. Finalized minutes will be included in the annual 2017 report.

3. **2016 Annual Report**
   - Initial CARE 2017 Meeting Announcement sent by CARE Chair to CARE members on December, 15, 2016 with overview (i.e., logistics, agenda, workshops).
   - The CARE Vice Chair contacted CARE members to finalize all age structure exchanges. Two exchanges were initiated and finalized in 2016 by CDFO and WDFW for Pacific herring.
   - Jon Short (AFSC) and Nikki Atkins (NWFSC) updated the CARE website for current info, CARE officers, 2015 CARE Meeting minutes, and structure exchanges.

4. **CARE Conference – Executive Summary**
   CARE meets biennially for a conference that usually lasts three days. Conferences typically consist of one and a half "business" days and one and a half days for a hands-on calibration workshop at microscopes to review and standardize age reading criteria with any extra time scheduled for a specific focus group or workshop.
   a. **Overview:** The most recent biennial CARE Conference was held in Seattle, WA, April 4-6, 2017 at the NOAA Western Regional Center at the Alaska Fisheries Science Center (AFSC), Sand Point facility, and hosted by the Age and Growth AFSC staff (Appendix I). The conference was attended by 41 CARE members (Table 1, Figure 1) from seven participating agencies ADF&G (5), AFSC (17), CDFO (3), IPHC (5), NWFSC/PSMFC (5), ODFW (1), and WDFW (5). The next CARE Conference in 2019 will be held prior to the TSC meeting in April at a location to be determined by the end of the calendar year 2017. The following officers were elected at the April 2017 meeting and will take office July 1, 2017:
      - Chair – Kevin McNeel (ADF&G-Juneau)
      - Vice-Chair – Barbara Campbell (CDFO)
      - Secretary – Nikki Atkins (NWFSC-PSMFC)

   b. **Business Session Highlights:**
      i. **Scientific presentations:**
      An official Call for Presentations and Posters for the 2017 CARE Conference was sent to members on February 23, 2017 (Appendix II and III). Submissions were requested to address topic sessions on current research (e.g., comparative age structure studies, otolith microchemistry, climate driven studies).

Abstracts were due to the CARE Chair by March 17, 2017. There were two oral presentations and one poster abstract submitted for the scientific presentations session. (Appendix IV).

Five oral presentations in PowerPoint format were given during the CARE meeting:

1. April Rebert, *How old is that crab? Progress on an age old question* (20 min)
2. Kevin McNeel, *Update on shortraker rockfish (Sebastes borealis) otolith analyses* (20 min)
3. Craig Kastelle, *Elevating the management tier of commercially important rockfish: II-Age determination and accuracy* (20 min)
4. Dr. Thomas Helser, *Fish Tales: isotopes, trace elements and increments, and what they tell us* (20 min)
5. Andrew Claiborne, *Lingcod ageing & structure comparison* (20 min), during lingcod workshop

Three posters were available for viewing during the CARE Conference:

1. Dana Rudy, *Reconstructing the growth history of Pacific halibut (Hippoglissoides stenolepsis) natural population by otolith increment analysis*
2. Thomas E. Helser, Craig R. Kastelle, Todd T. TenBrink, *Elevating the management tier of commercially important rockfish: II – Age determination and accuracy*
3. Thomas E. Helser et. al., *A 200 year archaeological record of Pacifc cod life history as revealed through ion microprobe oxygen isotope ratios in otoliths*

ii. Agency Reports:

CDFO (Steve Wischniowski), IPHC (Joan Forsberg), AFSC (Thomas Helser), ADF&G-all sites (Elisa Russ, Kevin McNeel, Sonya El Mejjati), NWFSC-PSMFC (Patrick McDonald), WDFW (Andrew Claiborne), and ODFW (Lisa Kautzi) provided reports summarizing and updating agency activities, staffing, organization, new species and projects. There was no representative at CARE from SWFSC or CDFG. Details from agency reports will be available in the finalized CARE minutes, published to the CARE website by year's end.

iii. Workshops:

a) Longnose skate age standardization:

The goal of this workshop was for standardizing age determination protocols across multiple ageing labs through investigating a reference collection of vertebra thin sections and images from a validated ageing method. Chris Gburski and Beth Matta from the AFSC described images of thin sections and pointed out defining features as well as growth zones. They showed annotated images and specimens (under stereo scopes) to demonstrate hematoxylin-staining effects. Chris explained how water helps reduce glare of thin sections under reflected light but oil, while it reduces glare, tends to blur the pattern with time. Beth described how "birth marks" or "birth bands" (emergence from the egg case) are indicated by a slight change in the angle of the thin section. The current maximum age for longnose skate (18 years) was given. For validation efforts, Chris and Beth showed bomb radiocarbon data with a cluster of data suggesting potential issues with the analysis. Regarding precision efforts, they mentioned that structures were exchanged for ageing between AFSC, Pacific Shark Research Center/Moss Landing Marine Laboratories, and DFO. Both Chris and Beth mentioned they were trained on criteria at Moss Landing. The group looked at specimens and attempted band counts, and then Chris and Beth lead the group on a tour of the processing lab (showing saws, resins, and molds). Individuals took turns at the microscopes and imaging stations (including looking at 1-year-old specimens). Beth described life history events and biological differences between regional populations. Finally, Beth mentioned it might be worth trying the Mutvei's staining solution (that Bethany Stevick-WDFW mentioned earlier in the CARE meeting) to improve pattern clarity. Individual discussion included graduate work with Morgan Arrington (AFSC) and lighting conditions (Morgan, Chris, Beth, and Tyler Johnson-NWFSC. There were a total of 6 participants from AFSC, ADF&G, NWFSC, and ODFW.

b) **Rougheye rockfish early growth years:**
The goal of this workshop was to look at early growth years and investigate any inter-lab/agency ageing criteria for rougheye rockfish. Additionally, mixed species with rougheye rockfish (i.e., blackspotted rockfish) was discussed. Attendees viewed annotated rougheye rockfish break and burn otoliths on dissecting microscopes at imaging workstations. Samples were provided by the AFSC, Kevin McNeel (ADF&G), and WDFW (Sandra Rosenfield and Jennifer Topping). Measured early year (first year) growth patterns and size from different regions were compared. Jeremy Harris (AFSC) provided support while using imaging software to calibrate measurements and scale bars for first year growth bands. There were a total of 13 participants from AFSC, ADF&G, CDFO, and NWFSC.

c) **Lingcod ageing structure comparison:**
Comparative age structures (i.e., sectioned fin rays, whole vertebrae and otoliths) and ageing was discussed at this workshop. Andrew Claiborne (WDFW) began the workshop with a PowerPoint presentation 'Lingcod ageing & structure comparison.' Nikki Atkins (NWFSC) demonstrated lingcod fin ray preparation (pinning and drying) prior to sectioning and slide mounting for ageing. There were a total of 14 participants from WDFW, AFSC, ADF&G, CDFO, and NWFSC.

iv. **Hands-on Session Highlights and Demonstrations:**
A total of seven readers reviewed four species during the hands-on workshop at microscopes, mainly for the purpose of calibration between age readers and agencies. Members aged black rockfish, yelloweye rockfish, eulachon, and Pacific ocean perch. A demonstration for preparing (pinning and drying) lingcod fin rays was demonstrated by Nikki Atkins (PSFMC). See species aged, participating members, and agencies in Table 2.

v. **Exchanges:**
Lance Sullivan (NWFSC) gave updates on CARE exchanges. He reported that all 2014 and 2015 exchanges were finalized, but two of the four 2016 exchanges were not complete. The two incomplete exchanges were arrowtooth flounder, blue and deacon rockfish complex; and these were waiting on age reader calibration and sample size, capture area, and participating agency information. There was one 2017 exchange with yelloweye rockfish, but no agency information, sample size have been received. Sullivan requested additional information.

B. CARE Subcommittee (Working Group) Reports – Executive Summary

There were five active working groups that reported at the 2015 CARE Conference:

1. **TSC Meeting 2016:** Chris Gburski (AFSC) gave an overview of the 2016 meeting that Lance Sullivan presented for the CARE Chair in Newport, Oregon. Chris Gburski read CARE updates posted on the TSC website including:
    - No consensus has been reached on the preferred method of otolith storage and agencies will continue with different techniques
    - Thin section updates will be added to the manual

- The CARE website committee will update agency production numbers for 2015 and 2016, post exchanges, and meeting minutes (All of these were done)
- All age structure exchanges were finalized
- The Charter committee wants to update timelines on the TSC report submissions.
- The Sablefish working group added new members and tasks were reassigned and an update to the manual was scheduled to be completed by Summer of 2016
- The Shortraker working group will continue to focus on pattern criteria and exchange specimens. A workshop will be help at CARE 2017
- Ergonomic recommendations were drafted CARE to CARE and CARE to TSC

2. **CARE Website:** Jon Short (AFSC) gave updates on the CARE website. Short presented the current website and pointed out updated content including production numbers and previous meeting minutes. Short also addressed updating or changing the website content management system (CMS), because the current version of Joomla has not been supported since 2009. Short commented that the current PSMFC server is no longer using Joomla; that contributors may not need prior experience; and that moving to a new version or CMS would require time to program and update links likely, but would not cost anything if CARE moved to a free CMS. Suggested servers were updated versions of Joomla, Drupal (used by PSMFC), and WordPress. Short also commented that updating tables, populated by databases, would time as well. In the previous meeting, other agencies had suggested using ASP as a server, but that is not compatible with the PSMFC website. CARE members suggested that two servers could be suggested by the website committee. Short also commented that the database parts of the website could be supported by other agencies (ADF&G) and the updated CMS could support ASP windows.

    a. CARE Forum: Nikki Atkins (NWFSC) gave an update on the CARE website forum. Atkins remarked that the forum has users form CARE as well as users from different countries, but there is not much information on the forum. Further, with potential updates to the website, Atkins suggested members copy information off of the forum before it is potentially erased. Also, to get a username and password, contact Atkins, and updates to the website might help forum security.

    b. Tom Helser (AFSC) commented that the current Age and Growth Programs webpage may change. Jon Short elaborated that current information may be combined with other centers to group similar information.

    c. Kevin McNeel (ADF&G) gave updates on the website publication database portal and walked through the use of the portal. The portal has search and upload features currently available for member publications. The link to the database is a sublink within “Related Links” and the link to the publication database is not visible until the Related Links is clicked. There currently are no publications on the website and some of that is due to questions about distributing copyrighted material. Jon Short (AFSC) mentioned that when these questions get answered, this can be moved into the main links. Tom Helser and Craig Kastelle (AFSC) commented that it will be an issue getting copyrighted material and suggested that maybe abstracts could be uploaded and agencies could upload their own reports. Sonya El Mejjati (ADF&G) reminded the group about the publication list already published online and suggested that we use this to help populate the database. Helser suggested that the journal source should be a drop down to make standardized journal names to make searching possible. Short suggested that a complete list be presented first, but to include the search at the top of the page. Short also suggested looking into copyright laws regarding posting abstracts.

3. **CARE Manual/Glossary:** Elisa Russ (ADF&G) provided updates on the CARE manual. The additional changes have not been incorporated into the manual, but the baking otolith section, ergonomic section, and lingcod otolith section are complete, reviewed by the working group and approved by CARE. The new sablefish section is complete, but still needs to be reviewed by the manual working group. The manual is getting clunky, but all sections should be reviewed by all members.

a. Chris Gburski (AFSC) reported on progress made on the skate and spiny dogfish section of the manual. Beth Matta (AFSC) recommended that this be included in the manual as a reference to the published literature. There is a draft of the skate manuscript that is not yet complete but the dogfish section was published by Dr. Cindy Tribuzio (AFSC, not present). Either a citation or summary should be included within the manual, but Tribuzio should be contacted.
b. Russ commented that the pollock section has not yet started, and baking otolith references and removing redundancies within the manual will get coved in the CARE recommendations.

4. **Charter:** Elisa Russ (ADF&G) gave updates on the charter working group. The time between the CARE meeting and the TSC meeting is short. Developing an executive summary to report at the meeting is two days to a few weeks. Russ proposed moving meeting times to help chairs write executive reports. TSC and CARE did not want to change meeting times in previous years. Sandy Rosenfeld (WDFW) suggested moving the meeting back to even years and Nikki Atkins (NWFSC) commented that the CARE meetings were moved to odd years to facilitate people going to the Western Groundfish Conference and Russ commented that TSC meets every year. Russ commented that a later meeting, after the TSC meeting, would conflict with survey activities. Russ finished updates with reiterating that it was recommended to put agency production numbers in the charter and coordination with host agencies.

5. **Sablefish Ad Hoc Working Group:** Delsa Anderl (AFSC) gave updates on the working group. The participating agencies: Sclerochronology Lab (CDFO), AFSC, Age Determination Unit (ADF&G), and NWFSC, age sablefish across the western coast, Gulf of Alaska, and Bering Sea. The group tries to have at least one exchange per CARE. In the 2008 CARE, the ad hoc committee was created to 1) revisit criteria, 2) recalibrate, and 3) look at potential latitude differences. To look at latitudinal difference, the agencies sent 0 and 1 year old sablefish otoliths to the ADU to be measured. To recalibrate, the agencies performed a round robin exchange of approximately 100 otoliths prior to the 2009 CARE meeting. At the 2009 meeting, representatives reviewed discrepancies and identified common patterns to look at. AFSC received known age sablefish from sablefish tagged and released as 0 and 1 year olds at St. John the Baptist Bay. Anderl chose otoliths that represented the pattern and exchanged 15 samples with the other agencies. During a WebEx meeting and at the 2011 CARE meeting, the group discussed the results of the exchanges. At the 2013 CARE, the working group agreed to submit an update to the sablefish manual, summarize the 0 and 1 year old otolith measurements, and document each lab's protocols. These were completed and sent to the manual committee, and suggested that the working group be disbanded.

C. CARE & TSC Recommendations

1. CARE to CARE 2017

A. Recommends the CARE Manual working group finalize and add the following sections to the CARE Manual on Generalized Age Determination and distribute the updated version of the manual to the CARE membership by June 1, 2017 with the finalized version to be submitted to the website working group by June 30, 2017 for posting on the CARE website:
   1. Lingcod Otolith Ageing Procedures section;
   2. Sablefish Ageing Procedures section;
   3. Thin Sectioning Method section – add a section under the General Ageing Procedures;
   4. Add section on baking otoliths under General Otolith Ageing Procedures;
   5. Ergonomics section including equipment checklist as appendix;

B. Recommends the Manual working group continue the revision and expansion of the CARE Manual on Generalized Age Determination with the following sections drafted or revised by May 1, 2018 for review and addition of edits to the manual by the 2019 CARE meeting:
   1. Walleye Pollock Ageing Procedures section (use AFSC manual as starting point);
   2. Spiny Dogfish Ageing Procedures section – summary of spiny dogfish age determination paper by Dr. Cindy Tribuzio;

3. Rockfish Ageing Procedures section;
   a. Edit to avoid redundancy with Thin Sectioning section;
   b. Revise/move some information to General Otolith Ageing Procedures section where appropriate;
4. Remove documentation sections regarding changes to CARE Manual
   a. See Recommendation C to post archived editions.
   b. Remove 2015 recommendation to add Acknowledgements section.

C. Recommends the CARE Manual working group submit archived editions of the CARE Manual to the website working group for posting on the CARE website to preserve historical records.

D. Recommends that the CARE Forum be continued.

E. Recommends the website working group continue to refine the searchable publication database to be housed at ADF&G-Juneau, so that relevant information is more accessible to the age reading community and stock assessors. Recommend CARE members enter publications into the database using the online form to populate the database. Recommend publications page includes full list of all publications with searchable feature at the top of page with a link to the publication entry form by CARE 2019. Verify online publication permissions prior to adding publication or abstract; may add abstract if not allowed to post full publication.

F. Additional recommendations for the website to be completed prior to the 2019 meeting are as follows:
   1. Add information at the top of the Species Information page to "Check with specific agency about changes in historical techniques"; report that "Methods listed are for most recent reporting year," or adjust in conjunction with changes incorporated in Recommendation G;
   2. Add table for agency contacts with e-mail address of agency leads and information on age readers and species (to be completed by April 30, 2017);
   3. Update agency production numbers annually (update website with current production numbers by April 30, 2017), and
      a. Include methods for current year and use appropriate codes (B&BN = Break- and-burn, B&BK = Break-and-bake);
      b. Update Species Information page to include new codes;
      c. Edits such as consistent capitalization on the Species Information page;

G. Recommends the Website subcommittee continue to research the possibility of converting the CARE website and CARE Forum to a different technology (Joomla is out-of-date and it requires a major undertaking to update to new version). The website working group will research software options and make a recommendation (e.g. WordPress, Drupal, or new version of Joomla).

H. Recommends that an Otolith Storage Ad Hoc Working Group be created to address the issues of short and long-term storage of otoliths with a complete report reviewed by membership for CARE 2019. This is in response to prior TSC to CARE recommendations and due to the issue of otolith storage becoming a 2017-2021 research priority for the North Pacific Fishery Management Council. It is imperative that the historical archive of age structures is preserved.

I. Recommends the Charter Working Group revise the charter and submit it to CARE membership for approval by 2019 meeting; changes to include:
   1. Information on timelines including preparation of TSC report following same year CARE meeting;
   2. Submission of production numbers (species aged table); and
   3. Chair coordination with host agency regarding meeting logistics.

J. Recommends that the Sablefish Ad Hoc Working Group produce a final report summarizing their work to be published on the CARE website by the 2019 meeting with possible publication as a formal report.

K. Recommends that a Skate Ad Hoc Working Group be created for standardization of age determination methods; this project already has funding through NOAA Fisheries.

L. Recommends that a Rougheye/Blackspotted/Shortraker Rockfish Ad Hoc Working Group be created for addressing mixed sample issues involving these three long-lived species and possibly other slope rockfish species.

M. Recommend posting list of maximum ages on CARE website (or link to lists on AFSC and ADF&G/ADU - Juneau, websites). Recommend developing a process to update maximum ages including a CARE age structure exchange between appropriate agencies (age structure exchange may be done at CARE meeting to minimize transport and maximize efficiency).

2. CARE to TSC 2017

A. CARE recognizes that otolith storage was approved as a 2017-2021 research priority for the North Pacific Management Council. CARE appreciates that the TSC recognizes that CARE members are experts in the field of otolith reading and storage, and are thus best suited to develop and use best practices. As requested by the TSC, CARE has initiated this process to document structures and storage methods currently in use (by species and agency) with information on their benefits and deficits. This request has been addressed by creating an ad hoc working group to report on current procedures for short and long-term storage of otoliths by CARE agencies and produce a document to support this research priority.

3. TSC to CARE 2015/2016

A. The TSC thanks CARE for taking time during their biennial meeting to work towards developing a set of best practices for short and long-term storage of otoliths. However, the TSC is discouraged that CARE was unable to come to agreement on this and considers this important to all member agencies. The TSC believes that CARE members are experts in the field of otolith reading and storage, and are thus best suited to develop and use best practices. The TSC asks CARE to reconsider TSC's request at their next meeting and initiate this process by documenting structures and storage methods currently in use (by species and agency) with notes on their benefits and deficits. The TSC will also move this request forward to the U.S. Groundfish Management Teams for their consideration through the Councils' Science and Statistical Committees to develop a study proposal to investigate best practices. The TSC acknowledges the valuable work of CARE and encourages work on this problem and recognizes that this is a long term goal for agencies.

B. The TSC understands the importance of ergonomic issues for CARE members and shares their concern regarding potential ergonomic injuries to age readers. In response, the TSC voiced their concern about this issue in the 2014 Letter to Supervisors that was sent to each TSC member agency, specifically to supervisors and managers for groundfish research activities in each agency. The TSC places this issue within agencies' health and safety policies and urges agencies to pursue this matter directly through lab supervisors and their agency's health and safety committees. The TSC recommends that, where there are concerns in this regard, CARE send a letter to the specific agency or supervisor, with specific suggestions to alleviate the ergonomic conditions, highlighting the health and safety issue.

C. The TSC is supportive of CARE taking on non-groundfish work because it advances fisheries research. However, the TSC reminds CARE that its mandate has always been groundfish and they should be given priority within CARE. CARE does not need to include shellfish investigations in their report to the TSC.

D. The TSC understands that CARE is concerned about the short amount of time, usually less than one month, between the biennial CARE meeting and the TSC meeting which makes it difficult for the CARE Chair to prepare the CARE minutes in time for the TSC meeting. If there is not enough time to submit a full report for the TSC annual meeting, the TSC will accept a brief summary and conclusions from the CARE meeting along with any recommendations to the TSC. The full report can then be submitted at a later date when the final agency reports are due, usually the end of June. *Note:* In recent years the TSC has met the last week of April, and that should not change. The TSC cannot schedule their meeting any later because many TSC members start their field season the first week of May.

4. TSC to the Parent Committee 2016

A. After the 2016 TSC meeting, TSC member Jim Armstrong reported his progress towards the TSC to CARE recommendation in 2015 on the otolith storage issue: "Prior to every June Council meeting, the Joint Groundfish Plan Team, the Crab Plan Team, and the Scallop Plan Team review all existing research priorities. Their review considers modifications to priority category and research progress, and the possibility of eliminating or adding new priorities. As a participant in the Groundfish Plan Team review in 2016, I communicated the otolith storage issue to the Team, and it was included among their recommendations to the (North Pacific Fishery Management) Council. At the June 2016 Council meeting, the Council's SSC (Scientific and Statistical Committee), which reviews the collective plan team's recommendations, agreed with the addition of that priority item. Finally, the Council approved the addition of the otolith storage issue in its final determination of its five year (2017-2021) research priorities, which it communicated to the Secretary of Commerce, fulfilling a mandate of the Magnuson-Stevens Act." The TSC is delighted to report that the otolith storage issue is approved as a 2017-2021 research priority for the North Pacific Management Council and will remove the TSC to CARE recommendation pertaining to this issue. The TSC thanks the Parent Committee for their support in moving this issue forward.

B. The TSC would like to thank CARE for its ongoing reporting and research into the otolith storage issue and is delighted to report that this issue will be a 2017-2021 research priority for the North Pacific Management Council. The TSC encourages CARE and all its member agencies to support this research priority.

Table 1. Attendees of the CARE Conference, April 4-7, 2017, Seattle, Washington, U.S.A.

Last name	First name	Agency	Location	Country	Email
Pollak	Andrew	ADF&G	Homer	USA	andrew.pollak@alaska.gov
Russ	Elisa	ADF&G	Homer	USA	elisa.russ@alaska.gov
McNeel	Kevin	ADF&G	Juneau	USA	kevin.mcneel@alaska.gov
Rebert	April	ADF&G	Juneau	USA	april.rebert@alaska.gov
El Mejjati	Sonya	ADF&G	Kodiak	USA	sonya.elmejjati@alaska.gov
Anderl	Delsa	AFSC	Seattle	USA	delsa.anderl@noaa.gov
Arrington	Morgan	AFSC	Seattle	USA	morgan.arrington@noaa.gov
Benson	Irina	AFSC	Seattle	USA	irina.benson@noaa.gov
Brogan	John	AFSC	Seattle	USA	john.brogan@noaa.gov
Gburski	Chris	AFSC	Seattle	USA	christopher.gburski@noaa.gov
Goetz	Betty	AFSC	Seattle	USA	betty.goetz@noaa.gov
Harris	Jeremy	AFSC	Seattle	USA	jeremy.harris@noaa.gov
Helser	Thomas	AFSC	Seattle	USA	thomas.helser@noaa.gov
Hutchinson	Charles	AFSC	Seattle	USA	charles.hutchinson@noaa.gov
Kastelle	Craig	AFSC	Seattle	USA	craig.kastelle@noaa.gov
Matta	Beth	AFSC	Seattle	USA	beth.matta@noaa.gov
Neidetcher	Sandi	AFSC	Seattle	USA	sandi.neidetcher@noaa.gov
Pearce	Julie	AFSC	Seattle	USA	julie.pearce@noaa.gov
Piston	Charlie	AFSC	Seattle	USA	charlie.piston@noaa.gov

Short	Jon	AFSC	Seattle	USA	jon.short@noaa.gov
TenBrink	Todd	AFSC	Seattle	USA	todd.tenbrink@noaa.gov
Williams	Kali	AFSC	Seattle	USA	kali.williams@noaa.gov
Campbell	Barbara	CDFO	Nanaimo	Canada	barbara.campbell@dfo-mpo.gc.ca
Groot	Joanne	CDFO	Nanaimo	Canada	joanne.groot@dfo-mpo.gc.ca
Wischniowski	Stephen	CDFO	Nanaimo	Canada	stephen.wischniowski@dfo-mpo.gc.ca
Forsberg	Joan	IPHC	Seattle	USA	joan@iphc.int
Johnston	Chris	IPHC	Seattle	USA	chris@iphc.int
Planas	Josep	IPHC	Seattle	USA	josep@iphc.int
Rudy	Dana	IPHC	Seattle	USA	dana@iphc.int
Tobin	Robert	IPHC	Seattle	USA	robert@iphc.int
Atkins	Nikki	NWFSC	Newport	USA	nikki.atkins@noaa.gov
Hale	James	NWFSC	Newport	USA	james.hale@noaa.gov
Johnson	Tyler	NWFSC	Newport	USA	tyler.johnson@noaa.gov
McDonald	Patrick	NWFSC	Newport	USA	pmcdonald@psmfc.org
Sullivan	Lance	NWFSC	Newport	USA	lance.sullivan@noaa.gov
Kautzi	Lisa	ODFW	Newport	USA	lisa.a.kautzi@state.or.us
Claiborne	Andrew	WDFW	Olympia	USA	andrew.claiborne@dfw.wa.gov
Hildebrandt	Anna	WDFW	Olympia	USA	anna.hildebrandt@dfw.wa.gov
Rosenfield	Sandra	WDFW	Olympia	USA	sandra.rosenfield@dfw.wa.gov
Stevick	Bethany	WDFW	Olympia	USA	bethany.stevick@dfw.wa.gov
Topping	Jennifer	WDFW	Olympia	USA	jennifer.topping@dfw.wa.gov

Table 2. 2015 CARE Hands-On “Scope Time” Session – Species Aged, Participants, and Agency.

Species	Participants	Agency	Comments
Black Rockfish	Sonja El Mejjati	ADF&G	Calibration
	Lisa Kautzi	WDFW	
Yelloweye Rockfish	Elisa Russ	ADF&G	Calibration
	Andrew Pollak	ADF&G	
	Patrick McDonald	NWFSC	
Eulachon		WDFW	Calibration
		DFO	
		NWFSC	
Pacific Ocean Perch	Betty Goetz	AFSC	Calibration
	James Hale	NWFSC	

Table 3. CARE age structure exchanges initiated in 2016.

Exchange ID No.	Species	Originating Agency	Coordinator	Coordinating Agency
16-001	Pacific herring	CDFO	Joanne Groot	WDFW
16-002	Pacific herring	WDFW	Andrew Claiborne	CDFO

Figure 1: Attendees of the 2017 CARE Conference, April 4-7, 2017 Group Photo.

APPENDIX-I

C.A.R.E. 2017 Agenda

Nineteenth Biennial Meeting of the Committee of Age Reading Experts

Working Group of the Canada – US Groundfish Committee
Technical Subcommittee

AFSC Sand Point Facility, NOAA Western Regional Center
7600 Sand Point Way NE, Seattle, WA, USA 98115
Bldg. #4, Room 2076 April 4 – 6, 2017

Tuesday, April 4

I. Call to Order [8:30 am] – CARE Chair (Chris Gburski)

II. Host Statement

1. Welcome statements & host info: safety/security orientation, refreshments, social. etc. (Tom Helser-Age and Growth Program Director, Chris Gburski)

III. Introductions

1. Round-table intro (name, agency, location)
2. Attendance-name, agency, location, email (distributed)

IV. Approval of 2017 Agenda

V. Working Group Reports [9:00 – 9:45] Activity since CARE 2015 (~ 5 min each)

- **D.** TSC Meeting 2016 (Chris Gburski)
- **E.** Age Structure exchanges (Lance Sullivan)
- **F.** CARE Website and publication database (Jon Short, Kevin McNeel)
- **G.** CARE Forum (Nikki Atkins)
- **H.** CARE Manual (Elisa Russ)
- **I.** Charter Committee (Elisa Russ)
- **J.** Sablefish (Delsa Anderl)

VI. CARE & TSC Recommendations [9:45 – 10:15]

5. CARE to CARE 2015 (see pages 25-27 in 2015 CARE Meeting Minutes)
6. CARE to TSC 2015 (see pages 27-28 in 2015 CARE Meeting Minutes)
7. TSC to CARE 2015/2016

Break 10:15 – 10:30

VII. Agency Reports [10:30 – 11:15] Activity since CARE 2015 (~ 5 min each)

1. CDFO – (Steve Wischniowski)
2. IPHC – (Joan Forsberg)
3. ADF&G – (Elisa Russ, Kevin McNeel, Sonya El Mejjati)
4. AFSC – (Tom Helser)

Lunch 12:30 – 1:45

VIII. Agency Reports [1:45 – 2:15] Activity since CARE 2015 (~ 5 min each)

5. NWFSC – (Patrick McDonald)
6. WDFW – (Andrew Claiborne)
7. ODFW – (Lisa Kautzi)

IX. Scientific PowerPoint Presentations [2:15 – 3:15]

6. April Rebert, *How old is that crab? Progress on an age old question* (20 min)
7. Kevin McNeel, *Update on shortraker rockfish (Sebastes borealis) otolith analyses* (20 min)
8. Craig Kastelle, *Elevating the management tier of commercially important rockfish: II-Age determination and accuracy* (20 min)

Break 3:15 – 3:30

X. Workshops, working groups, hands-on microscope work [3:30 – 5:30]

1. Longnose Skate Workshop (Imaging Room 1110) k for add time if needed.
2. Working Groups (Traynor Room and Room 2079)
3. Hands-on microscope work and calibration (Traynor Room)

<u>Wednesday, April 5</u>

XI. Workshops, working groups, hands-on microscope work [8:30 – 5:00]
*schedule lunch as appropriate for respective groups

1. Rougheye rockfish workshop [9:00 – 10:30] Imaging Room 1110
2. Lingcod workshop [10:30 – 12:00] (Imaging Room 1110, Groundfish Lab 1125 for structure preparation)
3. Working Groups (Traynor Room and Room 2079 available all day)
4. Hands-on microscope work and calibration (Traynor Room)

XII. Scientific PowerPoint Presentation [1:00 – 1:45]

Tom Helser, *Fish tales: isotopes, trace elements and increments, and what they tell us*

XIII. Workshops, working groups, hands-on microscope work (continued)

5. Longnose skate workshop [2:00 – 5:00] (Imaging Room 1110)

--- Posters available for viewing during breaks from other tasks all day---

CARE Social at the Wedgwood Ale House and Café-see sign-up sheet and directions (5:30-9:00)
<u>Thursday, April 6</u>

XIV. Recommendations [8:30 – 9:00]

1. CARE to CARE 2017

2. CARE to TSC 2017
3. TSC to CARE 2015/2016

XV. Topics for Discussion/New Business [9:00 – 9:30]

1. Symposia/Conferences since CARE 2015 meeting & upcoming
2. Non-agenda items

XVI. Concluding CARE Business [9:30 –10:00]

1. Administration nominations
2. Schedule and location of 2019 meeting

XVII. Working groups & Hands-on Workshop [10:00 – 12:00]

1. Working Groups – additional time available to meet and schedule tasks for 2019
2. Hands-on Workshop – dual microscopes available for calibration work until noon
3. Workshops – additional time if needed
4. Group photo

XVIII. CARE Business Meeting Adjourns [12:00 noon]

APPENDIX-II

CARE 2017

CALL FOR PRESENTATION ABSTRACTS

Please submit abstracts by March 17, 2017 to: christopher.gburski@noaa.gov

See attached for complete details on abstract submission.

The 2017 CARE Meeting will be held April 4-6, 2017 at NOAA, AFSC, Seattle, WA.

APPENDIX-III

CARE Meeting 2017

April 4-6, 2017

NOAA, Western Regional Center,
Alaska Fisheries Science Center,
Sand Point, Seattle, WA

CALL FOR PRESENTATIONS &POSTERS

The Committee of Age Reading Experts is pleased to announce the Call for Presentations and Posters for the 2017 CARE Meeting.

While no specific theme has been designated, topic sessions can focus on exciting ‘current research’, e.g., comparative age structure studies, otolith microchemistry, climate-driven studies.

Please submit abstracts by Friday, March 17, 2017 to Chris Gburski, CARE Chair:

christopher.gburski@noaa.gov

Submit abstract as a Word document (preferably) and include the following information:

- Type of presentation (oral or poster)
- Title
- First and Last Name of Author(s)
  - Include any preferred appellation (e.g. Dr. or Ph.D.)
  - Name of Presenter (if more than one author)
  - Include any affiliations (spell out agency), city, country, and e-mail
- Text of abstract in 250 words or less
- Amount of time needed for presentation (maximum of 20 minutes-including questions)

The CARE meeting includes presentations, age reader calibration, workshops and workgroup meetings, held April 4-6, 2017.

- Oral presentations-Tuesday (afternoon), April 4
- Poster session-Wednesday, April 5

CARE Website: http://care.psmfc.org

APPENDIX-IV

Nineteenth Biennial Meeting of the Committee of Age Reading Experts

Working Group of the Canada – US Groundfish Committee TSC
AFSC Sand Point Facility, NOAA Western Regional Center
April 4 – 6, 2017

Abstracts

Type of Presentation: Oral

Title: How old is that crab? Progress on an age old question

Authors and affiliation:
April Rebert[1,2], Joel Webb[1], Kevin McNeel[1], and Gordon Kruse[2]
[1]Alaska Department of Fish and Game, Division of Commercial Fisheries, Mark, Tag and Age Laboratory, Juneau, AK 99811
[2]University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, Juneau, Alaska 99801

Abstract:
Age information provides direct insight into rates of growth, reproduction, and survival essential to stock assessment and fishery management. Crab and shrimp have long supported vital fisheries in Alaska, but direct determination of their ages has not been possible. Structures useful for age determination (e.g. fish otoliths) are generally retained throughout the lifespan; banding patterns on these growth structures associated with seasonal growth variability are interpreted as indices of chronological age. Due to the loss of the calcified cuticle during molting, it has been presumed that age determination in crab and shrimp is impossible. However, banding patterns potentially useful for age determination were recently identified in the gastric mill (grinding apparatus in stomachs) of snow and red king crabs and eyestalks of spot shrimp from Alaska. This study investigates whether banding patterns on these structures yield reliable indices of chronological age for crabs and shrimp by: (1) developing standardized workflows to facilitate evaluation of differences in band counts between groups of small and large individuals for each species; (2) examining whether the endocuticle layer of each structure is retained through the lifetime to describe potential band retention or formation; and (3) evaluating chemical marking methods that can be used to validate that bands form annually. Project milestones to date include: (1) production of over 2,000 thin-sections for band counts; (2) sampling of red king crab and spot shrimp before and after molting to evaluate cuticle retention; and (3) identification of calcein as an effective fluorescent marker for age validation.

Type of Presentation: Oral

Title: Update on shortraker rockfish (*Sebastes borealis*) otolith analyses

Authors and affiliation:
Kevin McNeel
Alaska Department of Fish and Game, Division of Commercial Fisheries, Mark, Tag and Age Laboratory, Juneau, AK 99811

Abstract:
Shortraker rockfish (*Sebastes borealis*) are a long-lived, high trophic-level fish found in the North Pacific that are caught as bycatch in longline, and trawl fisheries. Management of these fisheries is potentially constrained by limited life history and catch information for this species. Furthermore, species misidentification and limited age validation force management to use potentially conservative estimates of allowable catch. A greater understanding of species specific characteristics, current age criteria accuracy, and factors influencing productivity would provide insights helping to reduce uncertainty in stock assessments. Studies of sagittal otolith shape, chemistry, and annual increments have been used to investigate these issues. The Alaska Department of Fish and Game has a historic archive of shortraker and other rockfish otoliths and otolith measurements including otolith length, height, weight, and core ^{14}C activity. To improve life history information I propose to (1) use available and shape measurement data to discriminate between potentially misidentified species, (2) provide a limited age criteria validation with available ^{14}C data, and (3) develop a chronology of shortraker rockfish growth using otolith annual increment measurements to compare with climate and ecosystem trends from fish caught in Prince William Sound.

Type of Presentation: poster

Title: Reconstructing the growth history of Pacific halibut (Hippoglossus stenolepis) natural population by otolith increment analysis

Poster Presenter: Dana M. Rudy

Authors and affiliation:
Dana Rudy, Chris Johnston, Robert Tobin, Tim Loher, Ian Stewart, Josep V. Planas, Joan Forsberg. International Pacific Halibut Commission, 2320 W. Commodore Way, Seattle, WA 98119. All email correspondence to dana@iphc.int

Abstract:
The Pacific halibut (*Hippoglossus stenolepis*) is one of the largest and longest lived flatfish in the world, reaching up to 200 kg in body weight and 2.4 m in length and with the oldest individual caught aged at 55 yrs. Although female Pacific halibut attain much larger sizes than males, the average size at age for both males and females has significantly decreased during the last 25 years, especially in the Gulf of Alaska. This has led to a decrease in the exploitable biomass of halibut stocks. Several factors, including environmental, fisheries-related and even anthropogenic, could be responsible for the observed decrease in the growth potential of this species. Here, we looked at Pacific halibut otoliths from the 1977, 1987, 1992, and 2002 cohorts from the Gulf of Alaska. Over the past few decades, which include these cohorts, the International Pacific Halibut Commission (IPHC) has observed a significant decline in halibut size at age throughout their range. However, we did not find a similar decline in otolith growth during this time period for halibut in the Gulf of Alaska. For example, in 15-year-old females sampled from the 1977 and 1992 cohorts, there was a 2.45% increase in mean otolith radius during that time period, despite a 14.97% decrease in mean body length for those fish. Additionally, we found that otolith accretion in male and female halibut does not reflect their large dimorphic size differences. Although factors regulating otolith growth in Pacific halibut are not well understood, otolith growth appears to be independent of somatic growth.