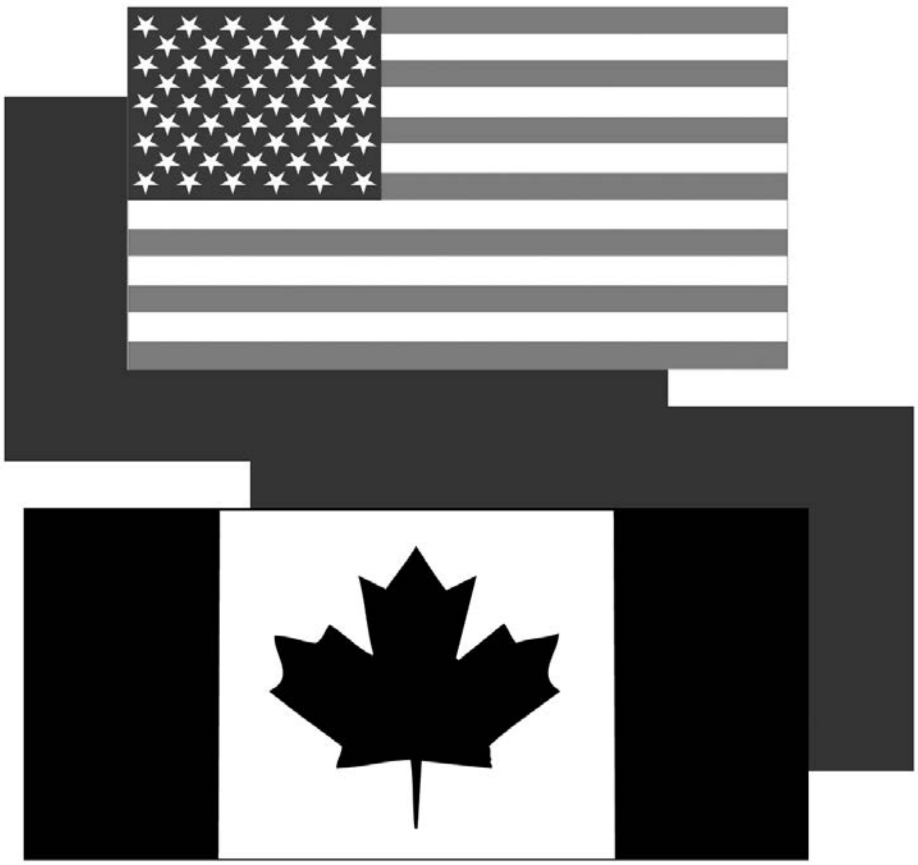
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

59th Annual Meeting of the TSC

April 24 – 25, 2018
Santa Cruz, California



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
2018	April 24-25	Santa Cruz, CA	Field	Lowry

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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 24 scientific/management workshops, organized 25 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, Developing Electronic Data Capture Systems, and Descending Device Policy and Science.

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.

September 5, 2018

B. Executive Summary

The TSC met at the Southwest Fisheries Science Center/ UCSC Coastal Science Campus in Santa Cruz, California, April 24-25, 2018.

This year's meeting was hosted by the SWFSC (list of attendees is included in the minutes). Dayv Lowry, Washington Department of Fish and Wildlife chaired the meeting. As is done each year at the meeting, participants reviewed previous year (2017) research achievements and projected current year (2018) research for each agency. Each agency also submitted 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 techniques again. The TSC also encouraged CARE to evaluate the machine reading of otoliths (near infrared) as a valid method.

There were several suggestions for TSC workshops in the future, perhaps as part of the 2020 Western Groundfish Conference including the identification and management of cryptic species, species distribution modelling for assessments, discard mortality rates, and Essential Fish Habitat.

There was discussion led by Wayne Palsson on the US-Canada Border Dixon Entrance "dispute." The US and Canada identify different international boundaries in Dixon Entrance separating SE Alaska and northern British Columbia. Canada appears to recognize the "A-B Line" established in 1903 to separate land masses between the two countries, but the line didn't necessarily demarcate the water boundary at that time. The U.S. doesn't not recognize the A-B line as the international boundary. The U.S. demarcates the border in the middle of Dixon Entrance between the landmasses, essentially splitting Dixon Entrance. However, Canada extends the A-B line westward through the water as the boundary. There are several impacts to this conundrum. AFSC includes the northern half of Dixon Entrance in its bottom trawl survey while in theory, DFO manages and assesses portions of the same territory. Canada is enforcing fishing vessel transit requirements in their claimed territory and questioned the US chartered fishing vessel used for the Gulf of Alaska Bottom Trawl Survey in 2017 as to why it had active fishing gear on is decks.

TSC annual report provides a wealth of overview information, and there was a discussion on ways to broaden the distribution of the report including adding the link to the Western Groundfish Conference webpage. The TSC annual report should also be used as an education tool for background baseline information for students, new hires, etc.

Dayv Lowry, WDFW, will continue as Chair of the TSC for 2019. The next TSC meeting will be held in Olympia, WA - April 23-24, 2019 and hosted by WDFW.

Meeting Notes

59th Annual Meeting of the TSC
April 24-25th, 2018
SWFSC Laboratory, UCSC Coastal Science Campus
Santa Cruz, CA

I. Call to order (8:30 am Tuesday April 24th)

II. Appointment of Rapporteurs
John Field, Melissa Monk, and Rebecca Miller appointed to share duties via Google doc

III. Housekeeping

IV. Introductions
Karla Bush - ADFG
Stephen Phillips - PSFMC
Jon Heifetz - NOAA Auke Bay Laboratory
Maria Surry - DFO Canada
Tracee Geernaert - IPHC
Greg Workman - DFO Canada
Alison Whitman - ODFW
Josep Planas - IPHC
Dayv Lowry - WDFW
Tom Wilderbuer - NOAA AFSC REFM
Traci Larinto - CDFW
Melissa Monk - NOAA SWFSC
Jim Armstrong - NPFMC
Wayne Palsson - NOAA AFSC RACE
Kevin McNeel - Representing ageing group CARE, ADFG

Others from SWFSC: John Field, Xi He, Rebecca Miller

V. Approval of Agenda

Motion to approve agenda -

Wayne Palsson asked to consider a transboundary dispute somewhere in the agenda. The decision was made to discuss this under current year recommendations on day two.

Moved and seconded to adopt the agenda as amended.

VI. Approval of 2017 Report

Final version of the 2017 Report has been posted to webpage, motion to adopt the report as it stands (pending correction of minor typos) was made, seconded, and passed.

VII. Agency Overviews

Alaska Department of Fish and Game - no major structural changes, relatively flat funding, Jennifer Stahl was previous TSC participant, has moved on to Hawaii. Karla Bush (filing in for Andrew Olson) is current TSC participant, regional coordinator for Agency. SE Groundfish staff Asia Beder is now an assistant manager in Dutch Harbor office. Few changes in sportfishing side of things. Note that Ken Goldman and Scott Meyer (Homer staff) are soon to retire.

Auke Bay lab - Phil Mundy retired, lab is recruiting for new director, Jon Heifetz is retiring this summer and Chris Lunsford is filling his position. Cara Rogdveller will take Jon's place on TSC. More of an emphasis on early recruitment dynamics of sablefish (due to poor recruitment) in recent years. Note that Doug DeMaster is soon to retire.

AFSC RACE Division - The survey group and process studies group (Janet Duffy-Anderson, Libby Logerwell) has many new faces. Kodiak lab has shellfish focus, but Sean Rooney and Cristina Conrath work on groundfish at the lab. The Newport Lab also focuses on behavioral and ecological research and especially on groundfishes in the Arctic. The new Deputy Director is Michael Martin, replaces Guy Fleisher, as DD for RACE. David Somerton retired (to Aptos), Stan Kotwicki is replacement manager for the Groundfish Assessment Program. Chris Wilson heads MACE (acoustic methods) surveys, recent hire is Noelle Yochum who focuses on bycatch engineering. Center Director (Doug DeMaster) is retiring in June, the new DD is Jeremy Rusin (formerly from SWFSC).

REFM- Dan Ito (DD) is retiring in June, advertising now, Jack Turnoff in assessment group is retired (crab assessment), Fisheries Monitoring and Assessment program is going strong- Director retired last year.

North Pacific Fishery Management Council - Executive Director Chris Oliver left NPFMC to serve as NOAA Assistant Administrator in charge of the National Marine Fisheries Service in Silver Spring, Deputy Director David Witherell is now the current Executive Director, Diana Evans is current Deputy Director. On the Council the Oregon representative (Roy Hyder) was replaced by Steve Marx, Council Chair Dan Hull will term out in June and step down.

IPHC- new Director, David Wilson, some staff turnover – Fisheries Statistics & Services branch manager Jamie Goen recently resigned to move onto Alaskan Bering Sea Crab group (position currently open).

DFO Canada - not much change in overall structure since last year (following significant reorganization of science branch in 2016). DFO Pacific is divided into three major branches Conservation and Protection (C&P), Science, and Fisheries and Aquaculture Management (FAM). The science branch is further divided into five divisions. Groundfish assessment and research programs are embedded In the Stock Assessment and Research (StAR) Division. Following the 2016 reorganization John Holmes took over as StAR division manager. Other divisions in Science branch include, Canadian Hydrographic Service (Navigation products), Ocean Sciences (OSD, Oceanography), Aquatic Diagnostics, Genomics & Technology (ADGT, (fish health, aging lab, ROV operations), and a new division, Ecosystem Sciences headed by Eddy Kennedy. This new division is tasked with trying to achieve the marine conservation target objectives articulated by the Trudeau government in its mandate letter to the Fisheries minister to achieve the Aichi Biodiversity targets and implement ecosystem based science in fisheries assessment and management. Within groundfish science, Lynne Yamanaka has moved from groundfish to invertebrates, Dr. Dana Haggarty has taken over as head of the the inshore rockfish and Lingcod programs, Dr. Sean Anderson has recently joined the sections and is focused on data limited species, Norm Olsen heads up the surveys program (and database support), Rowen Haigh leads offshore rockfish assessment, Chris Grandin leads on Pacific hake. In fisheries management, Barry Ackerman has retired as the trawl coordinator and been replaced by Rob Tadey, Neil Davis has moved up to regional director of fisheries management, Adam Keiser is the new head of the Groundfish Management Unit (GMU), Shane Petersen joins the GMU as the Hook and Line Coordinator and Lindsay Gardner is the current Sablefish manager.

WDFW - Director Jim Unsworth stepped down after two+ years, Joe Stohr (long-time Deputy Director) is acting Director. Region 4 (N Puget Sound) Director Amy Windrope is acting Deputy Director - candidates for agency Director being interviewed now. Groundfish is still under Fish Management Division (Craig Burley). About 30 people in the groundfish unit (coastal, Puget Sound), Theresa Tsou oversees finfish, Dayv Lowry oversees Puget Sound group, Lorna Wargo oversees Coastal group, Michelle Culver heads intergovernmental management unit. Toxins unit (TBiOS) looks at Salish Sea organic/inorganic pollutants. Intent to fill NPFMC groundfish plan team seat in near future with Lisa Hillier. Also a new statewide marine forage fish lead - Phill Dionne from habitat group has taken that position.

NWFSC - There is a report, but no representative present at this meeting. Apparently timing of the annual meeting constrains their participation. Chair to contact them and discuss timing options.

ODFW - not a lot of changes, Marine Resources Program has finfish (and other) lead responsibility (part of Fish Division). Funding is stable, centered in Newport, satellite offices up and down coast (Astoria, Charleston, Brookings) and marine mammal folks in Corvallis. Little turnover- Caren Braby is program manager, new section lead - Justin Ainsworth- for technical and data services- still seeking marine mammal project leader. Steven Marx has taken over as the designated representative for the North Pacific Fishery Management Council.

CDFW - Marine Region has most groundfish management and research- reports to DD for Fish and Wildlife (currently open position), but not much change within the Marine Region. As of July 1 will transition to electronic reporting of all landings (one year transition period), will move entirely to e-tickets (PSMFC-led), so changes in statistical unit to deal with this change. Currently a bill in legislature for funding that would bring a large number of people to Marine Region - broad support from fisheries, NGOs, etc. Could increase staffing by as many as 38 positions, time will tell. (Noted that PFMC lost Kelly Ames position as staff, impacted GMT as she was very instrumental in GMT support).

SWFSC - HQ is in La Jolla, Fisheries Ecology Division (most groundfish assessment work, although FED has a salmon focus) in Santa Cruz - Kristen Koch was acting Director, now official Center Director. Toby Garfield remains acting Director of Center. FED habitat team changes - Mary Yoklavich retired recently, as did Susan Sogard (early life history team). Not clear if those positions will be replaced.

VIII. CARE Report

Reiterative report from last TSC meeting - CARE meets biennially
Summary - new people Kevin McNeel (ADF&G) is chair, Barbara Campbell (NWFSC) is vice chair, Nikki Atkins (NWFSC-PSMFC).

CARE Meeting held April 2017- executive summary given at last TSC meeting.

CARE Secretary coordinated agency updates to CARE minutes May 2017.

CARE 2017 Minutes draft finalized and waiting CARE member approval.

13 overall age structure exchanges initiated last year between ADF&G, AFSC, CDFW, NWFSC, MLML, and WDFW. These included blue/deacon rockfish, lingcod, Pacific cod, Petrale sole, rougheye rockfish, and yelloweye rockfish. In 2017, TSC to CARE recommendation was to review yelloweye rockfish age pattern criteria; performed 5 age structure exchanges in 2017 Some interest in promising new technology, near infrared spectroscopy methods to age otoliths. Committee members were interested in calibrating the machine to tag-recapture, known-age sablefish to produce age estimates much faster than traditional methods. AFSC has been working on evaluating the method for Walleye pollock and Pacific cod as well as sablefish and sole. Some hope is that this approach has more potential for some species, leaving more human resources available for more difficult to age species (e.g., rockfish). AFSC is only center with NIR machine on the west coast for automating the otolith reading

2017 Recommendation from CARE to TSC is that CARE recognized the TSC to CARE concern over storage media issue and developed the ad-hoc working group to address the issue. The 2017 TSC to CARE recommendation was to investigate yelloweye rockfish age determination criteria; CARE had five age structure exchanges, including bomb-radiocarbon validated specimens, among agencies since that time to compare criteria (including distribution of bomb-radiocarbon dated otoliths) to improve age determination efforts. It was proposed to add yelloweye rockfish criteria as a research priority to make it easier to study.

IX. Surveys

SWFSC - surveys include CalCOFI and pelagic juvenile rockfish surveys, several highlights include differences in larval community structure inside and outside of cowcod conservation areas in S. California Bight, and high diversity in the juvenile rockfish and pelagic forage assemblages observed in the pelagic midwater trawl survey during the large marine heatwave

CDFW - has been conducting ROV surveys since 2014 inside and outside state MPA network, currently working with researchers at UC Davis to develop and integrate spatial modeling techniques for MPA monitoring with this data. A PFMC methodology review on the survey work and methods, with potential applications for stock assessment, is planned for later this year. Commercial groundfish sampling survey - Port Samplers (with PSMFC) are exploring using voice recognition software for data collection.

WDFW - As usual, ratfish and English sole dominate in bottom trawl surveys - eulachon catches were higher, caught places where previously had not been seen, bocaccio also encountered (central Strait of Juan de Fuca - technically just outside the DPS boundary designation - looks like juveniles from recent settlement waves). More hake and pollock also seen in 2017 (less Pacific cod), more sandpaper skate in recent years, as well as dogfish and big skate. Ragfish caught in 2017 (included predation mark) and sablefish (first in trawl survey since 2011). Also caught an albino ratfish this year (second ever encountered, first was also from this survey - but a few leucistic and amelanistic specimens have been found), manuscript documenting this occurrence is in preparation. Have also been doing surveys for US Navy, part of ESA monitoring, but appear to be very few rockfish near naval facilities (toxin loads high proximate to bases, and past dredging has simplified habitat. These waters do not represent “de facto MPAs”).

With respect to forage conditions, herring abundance at Cherry Point has been at record low levels in recent years, and hit an all-time low in 2017. Successful spawning in some regions of southern Puget Sound has not observed over the past three years. Fishery management actions are currently under evaluation. However other stocks - e.g., Quilcene Bay - have been expanding in abundance and range in recent years.

Yelloweye rockfish survey on outer coast (setline supplement to IPHC survey) has been expanding in recent years. Encountered lots of canary, a few yelloweye, in most recent survey (not quite as much additional information as hoping for). Nearshore rod and reel survey (black rockfish survey for decades, expanded to include China, Quillback, etc.) has been ongoing, catches reported in agency report. Next steps to expand ROV surveys on outer coast.

Efforts ongoing to improve estimates of historical removals, trying to work back in time to best inform historical removals (as far back as the late 1800s). A large report/book on historical fisheries development and technology is in preparation, some unique challenges associated with historical species composition data for better informing catch estimates. Misreporting and non-reporting of bycatch represent significant problems, as does use of aggregate market categories.

ODFW - Recreational fisheries monitoring- sports catch monitoring is ongoing on lengths, weights, species compositions from all major, most minor ports. Ride-along at-sea sampler program is also continuing (focus on discards). Actively involved in the "RecFIN Revamp" - process is changing, trying to improve data that are served by RecFIN. On commercial side, no major changes in sampling. Working to include the fixed-gear logbook in PacFIN, similar to the trawl logbook (currently needs improvement). Tried to re-initiate shore and estuary boat survey (hole in recreational data), some funding to conduct a limited angler intercept survey, also trying to compare phone and mail surveys to pair with intercept surveys for total catch estimates for this sector, mail surveys included an incentive ($2), but also increased cost. Evaluation of electronic monitoring systems for port sampling is ongoing (Astoria samplers have explored use of new system, initial results suggest that the effort doesn't seem to save a lot of time in the field but does save considerable time back in the office, post-sampling). Did note some differences in length frequency data that are a little concerning with respect to the application of this system.

IPHC - Overview of standard grid and gear, new in 2017 is electronic data recording coastwide, has improved data quality and timeliness/availability (data goes to assessment team two weeks earlier). Wide range of secondary objectives (oceanographic data, genetics, condition, bird and mammal interactions, Pacific cod sampling ,shark sampling, rockfish sampling with numerous state and federal agencies). 2017 survey ran a little bit long- did 1499 stations, expansions are being rotated to areas outside of the typical grid, particularly high profile is the area 2A (WA, OR, Northern CA) expansion. Plans for 2018 include area 2B and 2C expansions in areas of concern (MPAs, RCAs). Discussions by TSC members included the explicit need for a fixed grid design (should not be explicit requirement if moving to a spatiotemporal model).

NWFSC - see report, includes reference to recent tech memo describing history of NWFSC bottom trawl survey.

DFO - include 8 surveys that are either conducted by DFO or in collaboration with industry and other entities. Program annually includes two bottom trawl surveys, one offshore synoptic hook and line survey, one coastwide sablefish trap survey, a small mesh trawl survey (formerly targeted shrimp, currently ecosystem survey), biennial Pacific hake acoustic survey, IPHC hook and line survey (enhanced rockfish sampling in BC waters). Bottom trawls and more recently

hook and line surveys include CTDs, all data fishing event, catch and biological data logged electronically while at sea. A broad suite of survey results was reported and discussed. Government of Canada has an open data portal - all of the DFO survey data are supposed to be on there by 2020; flat files will be available to download and data will also be mapped using open maps; indices will be available and cruise reports are available and published
DFO is using DLMtool for a suite of species and producing data synopses for all groundfish species to be publish in 2019.

ADFG - Westward region (Kodiak and to the west) has an annual large mesh bottom trawl survey, primarily to assess Tanner and King crab, although catches predominantly groundfish, mostly in state waters around Kodiak- every other year to E. Aleutian Islands. About 370 hauls per year on average, arrowtooth flounder, flathead sole dominate catches. 2016 was first year pollock was not in the top 4 of catches. Used as relative index of abundance, most flatfish fisheries are federally managed. Also some hydroacoustic surveys for black rockfish, east side Kodiak and Afognak Islands used to set guideline harvest levels. In central region, no long-running surveys for Cook Inlet (ROV survey was cut), there is a biennial large-mesh trawl survey in Prince William Sound- provides relative abundance index for numerous groundfish species. In 2017 decreases observed for a number of species. In the Southeast there are a number of surveys, sablefish longline survey in Clarence St. and Chatham St. (provides index of abundance), in northern SE is a mark-recapture survey using pot gear, will be repeated in 2018 (tracking a strong 2014 year class). Also a demersal shelf rockfish survey - rotational basis of management areas using an SUV. A hagfish survey has been tagged onto a shrimp pot survey, measured up to 1,000 hagfish in this effort, baseline information. Dockside sampling programs ongoing.

AFSC- RACE Division - Bottom trawl and acoustic surveys (pollock are conducted by the RACE Division in Alaskan waters to support the NPFMC fishery management system. Surveys typically end by mid-August and data are typically available to stock assessment scientists within six weeks of collection, survey reports published routinely at regular intervals following surveys. Summer acoustic surveys alternate between the Gulf of Alaska and the Eastern Bering Sea Shelf in a biennial basis. Winter acoustic surveys are conducted in Shelikof Strait and the Shumagin Islands every year. Summer bottom trawl and acoustic surveys were conducted in the Gulf of Alaska in 2017. Walleye Pollock resource appears to be recovering, increasing in the Gulf of Alaska (2012 recruitment a key driver). A number of trawl surveys- Chukchi (sporadic), N. Bering Sea (odd years), Odd patterns are emerging for pollock and cod in Bering Sea survey- pollock tended to inner shelf, northern domain in 2017 (outer shelf 2010), in 2017 Pacific cod were rarely encountered in usual spots along BS shelf, but were found primarily in north (response to warming conditions?). In GOA, a fairly substantial (80%) decline in Pacific cod abundance in the Gulf of Alaska, quite concerning (also seen in other surveys, data), resulting in substantial reduction in quota, hardships for industry. One thing done in 2017 GOA bottom trawl survey was to switch to random sampling (from stratified) for otolith collections, subject of ongoing discussion between assessment analysts, survey leads.

AFSC- Auke Bay - main survey is a longline (sablefish focus) survey, systematic design with fixed stations that are 50 nm apart, two sets per day (shallow, deep), 2017 was the 40th annual longline survey for this effort. Was about 12% increase in catch in 2017 associated with the 2014 year class. Tagging of sablefish and thornyheads, some satellite tagging of dogfish last year. Depredation events, Killer whales in Western Gulf, Sperm whales in eastern. Catch and effort data available on AFSC website, indices developed all the way to shallowest strata. Ecosystem surveys in Bering Sea, have tagged age 0 sablefish on high seas, brought some back to lag for recruitment studies- interesting information coming out on this species from these focused efforts.

X. Reserves

ADFG - nothing

DFO - New government set a mandate to protect 5% by 2017 and 10% of federal waters by 2020; Achieved 7.75 by end of 2017 (including Hecate strait, Offshore Pacific Seamounts and Vents closure, Sjaan Kingla, 164 rockfish RCAs); Historically, intertidal was provincial, and now all waters are federal with the fisheries act; Economic impact is minor for the fishery (sablefish);

WDFW - report promised last year should be out soon, systematic dives inside/outside a set of MPAs from 1995-2010 to look for signals of differences. Concluded that 15 years wasn't enough to see population signal for many species, though tantalizing hints of more, bigger fish were present for copper rockfish and lingcod.

ODFW - 5 marine reserve sites, implemented in staggered fashion (starting in 2012 and final reserve, Cape Falcon, started restrictions in 2016), scientific and economic monitoring, Marine Reserves program met with Scientific Advisory committee in 2017 to start planning for the program review in 2023; monitoring and research at 4 sites in 2017, inside and comparison areas with same biological and habitat characteristics, surveys tailored to each reserve and include hook and line, longline, scuba in cooperation with California, ROV, SMURFS, ocean acidification monitoring, seastar wasting disease recovery monitoring; Ecological and Monitoring plan updated in 2017; Human Dimensions Monitoring Plan updated in 2017; staff turnover in ecological monitoring reserves, completed pilot study using a stereo video system with the video lander surveys comparing fish length accuracy

CDFW - Has 124 MPAs statewide. CDFW has finished the baseline monitoring and is starting work on Phase 2, a Long Term Monitoring Action Plan which is in development, with a draft anticipated in August 2018. CDFW now has a framework in place to evaluate requests for Scientific Collecting Permits to sample in the MPAs.

SWFSC and NWFSC - nothing to report

NPFMC - Fishery closure areas in Alaska, permanent and seasonal

PFMC - adopted new EFH to remove RCAs

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

A. Hagfish

DFO - no activity in 2017; proponent working to develop a new proposal for a fishery

ADFG - commercial fishery prosecuted through commissioner's permit; until this year only 1 permit, now 2 permit holders; authorized 20,000 pounds per permit; 60,000 pounds per year limit; gear limited to barrel traps, 3,000 gallon barrel limit; 99% of catch is black hagfish; 1 buyer, frozen and marketed in Korea

WDFW - Mostly Pacific hagfish, mostly human consumption, can fish off Oregon and land in WA. 2017 harvest over half million pounds, lowest on record. Started tracking landings in 2009

ODFW - primarily catch Pacific hagfish, year-round and use buckets to catch them, 1.6 million pounds in 2017, 2016 lowest year on record since started tracking since 2010, only regulation is that when landings reach 1.6 million pounds a public meeting is to be held; no research

NWFSC and SWFSC - nothing to report

CDFW - Pacific hagfish, fishery has been active for some time and variable (demand from South Korea and other fishery openings), landings relatively stable for the last few years, CDFW implemented new regulations to define barrel traps that wasn't enforceable, and has since changed the definition. CDFW staff are using a count per pound method to monitor changes in size of hagfish in the fishery.

B. Dogfish and other sharks

DFO - Dogfish: collect length/sexual maturity on trawl survey, no assessment plans and none have been requested, fishery is in decline; no lead for elasmobranch program;

IPHC - working with Cindy to get tissue samples from sleeper sharks this year; taking spiny dogfish measurements

ADFG - nothing; primarily caught as bycatch and increased to 35%, no directed fishery but could be caught with a commissioner's permit;

AFSC - working with Julie Neilson to get geolocation from pop-up tags, placed 125 tags; some migrate far offshore and some migrate nearshore; can dive as deep as 450 m deep; Sharon Wilde got genetic samples from sleeper sharks and looks like there's 2 separate genetic lineages but mixed together and Greenland sharks have separated out completely; restructured observer program to get discard rates from halibut fishery; observers on smaller boats and getting a different picture (PWS - previous estimates low and now 67 tons in SE) getting more realistic estimates, all discarded; discard survival study starting in 2017 (blood samples from longline caught dogfish)

NPFMC - setting shark specifications consistent with assessments and plan teams

WDFW - Basking shark seen in southern Puget Sound off Olympia in September. In North Puget Sound the Lummi Tribe landed 87,000 pounds of dogfish in 2017. Catch is almost entirely composed of females and conservation concerns about fishing on pupping grounds have been raised. Published 2 books that spawned from grey literature, student theses, and reports associated with a biennial meeting that has grown to be the second largest elasmobranch-focused meeting in North America. Books cover systematics, ecology, genetics, fisheries, ecotourism, etc. and chapter authors come from management and research entities up and down the west coast. Co-editors are Dayv Lowry and Shawn Larson (Seattle Aquarium).

ODFW, NWFSC, CDFW, and SWFWC - nothing to report

C. Skates

DFO - One publication

ADFG - bycatch fishery, state waters fishery; PWS 2017 estimates up slightly for Bering skate; other at historic low lowered bycatch rate to 5%

AFSC - One research project led by Jerry Hoff looking at skate habitat; 8 skate nursery sites listed as habitat areas of marine concern by Council; NPRB project to predict skate nursery habitat; paper in review; observer look at eggs to see if the eggs are viable and trying to identify areas where they are viable (years to hatch)

NPFMC - ABC consistent with stock assessment and plan teams

WDFW, IPHC, ODFW, NWFSC, CDFW, and SWFSC - nothing to report

D. Pacific Cod

DFO - ongoing data collection through various monitoring programs both FI and FD, collecting tissue samples, 3 management units currently and researching how many there actually are - combine two; assessment in 2014 and one stock hasn't been assessed since 2003; survey trends in south flat or down and in north going up; full assessment planned for 2018

IPHC - down in every area except in 2C went up just a touch

ADFG - Several Gulf communities petitioned the governor for fishery disaster relief funds and it was sent to the Secretary of Commerce

AFSC - Several studies are occurring: collaborative grant with OSU to look at habitat related size at age in the Bering sea, inshore and offshore different habitat and different age length keys; Dr. Spies developed the genome for Pacific cod; using acoustic data from bottom trawl survey to re-examine the vertical availability of cod. A pending proposal is focused on cod in Aleutians where fishing for code occurs mostly on winter aggregations but the quota is based upon the summer bottom trawl survey abundance. The fishing industry thinks the survey isn't capturing the complete population of cod.

NPFMC - In the Gulf of Alaska, there was an 80% reduction in P cod ABC from 2017 (88,342 mt) to 2018 (18,000 mt). So far in 2018, fishery catches in the western GOA have not been as reduced as those in the CGOA. Survey catches of Pacific cod in the northern Bering Sea occurred and affected overall survey catches, eastern Bering Sea assessment a project; rather than take Plan Team advice for ABC the SSC couldn't find compelling evidence and recommended max ABC; Council took a conservation cut; discussion papers exploring stranded cod (not achieving the TAC in areas of the Gulf) and bottom line was that cod were available for harvest but choices made by the fisheries were to move towards more profitable targets. Exploration of moving the dates for cod A Season in beginning of the year some halibut bycatch occurs and proposed allocating catch from this season to later in the year.

WDFW - genetic research looking at isolation by distance patterns; found isolation by distance without clean breaks and publication out; Puget Sound cod adapted to deal with warmer waters and could be a better aquaculture stock, IF ever needed.

ODFW, CDFW, and SWFSC - nothing to report

E. Walleye Pollock

DFO - 2017 pollock assessment; separated population into 2 stocks due to differences in mean size; one north and one south, a delay-difference model was used; high degree of uncertainty in the assessments; northern stock likely contiguous with the AK stock that comes down to BC. Authors noted inconsistent aging between commercial and research sampling - can get additional details from report.

ADFG - state manages one population; only 40% of quota caught in PWS; some interest in developing a pollock seine fishery but no fishing has occurred

AFSC - A number of studies have occurred in the Bering Sea to understand recruitment dynamics: one focuses on prey dynamics finding that during cold years pollock feed on larger copepods with higher lipid content and but in warm years like 2014-16 pollock consume small copepods of low lipid content; another study looks at diets and the effect of warm years finding warm years might be good for pollock because they can switch diets; after 30 years of looking at the population and environment, environmental signals of good and bad recruitment are being identified.

NPFMC - Bering Sea assessment Tier 1, but plan team chose to base ABC on tier 3, 7 reasons in the report;

WDFW, IPHC, ODFW, CDFW, and SWFSC - nothing to report

F. Pacific Whiting (Hake)

DFO - assessed annually collaboratively with the U.S.; survey in 2017 showed high abundance of age-1 fish; SS3 model; new maturity ogive; 6 genetically distinct stocks; declining size at age in Strait of Georgia and fishery ended because fish not marketable for a number of years, and now 3 and 4 year old hake now large enough for market;

All other agencies - nothing to report

G. Grenadiers

AFSC - ecosystem component species, every 4 years monitor to see if anything they need to worry about

All other agencies - nothing to report

H. Rockfish – nearshore, shelf, and slope

DFO – inshore rockfish program head (Lynne Yamanaka) left last year; program includes hook and line surveys inshore and offshore; surveys are the only source of biological samples; commercial fishery monitored by EM; otoliths are aged annually; Fisheries managers and commercial fishers working to reduce TAC for yelloweye rockfish down to 100 mt; Recent science advice recommends descending devices; 2 pre-COSEWIC reports for yelloweye rockfish and canary rockfish recently and accepted; Shelf and slope rockfish: Rougheye/Blackspotted rockfish tissue samples collected and processed annually from surveys and ageing of sampled fish commenced last year; pre-COSEWIC reports for rougheye and blackspotted rockfish drafted; an assessment for Queen Charlotte Sound POP stock was completed in 2017.
IPHC - in coordination with DFO, 3rd sampler out on BC boats and collecting biologicals and otoliths; yelloweye whole haul counts

ADFG - began interdivisional (commercial and sport) process; started with a workshop and focused on yelloweye and black rockfish species; mined data across divisions to make initial recommendations to move forward; Board of Fisheries approved requirement for all marine sportfishing boats descending device for all deep-water fisheries and will be required as next year (CPFVs required); recompression research - 185 rockfish held at capture depths to look at survival and post-recompression survival was >84% and will be available as a report soon;

yelloweye rockfish for past couple years sampled for hormone info from operculum, need to ground truth; seeing spikes in progesterone that might suggest skipped spawning; shortraker/blackspotted/rougheye - investigating ways to ID species using otoliths, shape analysis, otolith size at age; shortraker rockfish response to climate using dendrochronology and radiocarbon.

AFSC - Studies at the Kodiak Laboratory are looking at density and productivity of 3 species of rockfish at two sites with 3 habitat types in the Gulf of Alaska finding that rockfish like rocks with biogenic habitats, no seasonal effect, and differences among habitat types, trying to tease out if coral and sponge habitat matter. Another study examines the maturity of rougheye and blackspotted rockfishes showing larger sizes at 50% maturity than previously shown, marked skipped spawning (esp. shortrakers). A genomic study on POP shows mixing as juveniles but separation as adults and signatures of natural selection. Another study is examining environmental DNA in surface vs deep water samples to see if untrawlable habitat can be sampled with eDNA. Gulf of Alaska assessments show that POP are now the most abundant species, shortraker trawl survey estimate lower but catches lower than quota.

NPFMC - species complex in the south that would be hard to split out and have area apportionments for some species; did a stock structure analysis and Council recommends step 2 be explored; 3 research priorities - maintain the survey, improve surveys in untrawlable habitat, genetics research on dusky rockfish and shortspine thornyheads

WDFW - Canary, yelloweye, bocaccio genetic studies to see if DPS matches the lines: canary not different, yelloweye was different inside/outside, bocaccio not enough samples. Published collaborative paper with NOAA as Andrews et al. 2018 in *Conservation Genetics*. ROV surveys throughout Puget Sound “proper” focused on habitats with high likelihood of yelloweye occurrence, as determined by a MaxEnt model. Yelloweye issue on the outer coast and trying to develop an index of abundance; federal recovery team participation for yelloweye and bocaccio and working on implementation; outreach and education; descending devices required as of 2017 and doing education and outreach and working with enforcement; working on relational database for scientific collection permits to allow better tracking of take, as opposed to monitoring permit status.

ODFW - Looking at nearshore/offshore components of the deacon population - offshore schools from 40-70fm of large deacon rockfish - little to no difference in nearshore/offshore population segments and preliminary analysis suggests that the population segments mix; Polly Rankin project looking at movements of acoustically-tagged deacon rockfish in the nearshore, tagged and monitored for a year, patterns in daily activity and depth distribution, definitive but small home ranges, hypoxic event caused fish to move out of the area and then they came back within the array; Blue/deacon assessment participation; nearshore commercial fishery primarily hook and line with small boats close to shore, there was an increase last year in limits and they came close to limits; recreational bottomfish fishery closed in 2017 due to attainment; ACL exceeded for black rockfish (delay in commercial crab season so they continued fishing groundfish until crab started); promoting longleader gear to target deeper mid-water rockfish; continuing to work on outreach to reduce bycatch mortality; mandatory to have a descending device but don't specify which device

CDFW - Collects fishery-dependent data for rockfish commercially and recreationally (cut back a year ago on the beach/bank mode). Working with party boat fleet to collect carcasses for age structures. Nearshore permits transfers provisions were eased to allow more transfers effective April 2018. CDFW is using some of its ROV data to develop a fishery-independent index of abundance for some rockfish species and plans to present this to the SSC next year for use in stock assessments.

SWFSC - Recruitment research, Stock assessments, etc.

I. Thornyheads

All agencies - Nothing to report

J. Sablefish

AFSC - A rearing experiment is being conducted with sablefish simulating environmental conditions in the wild--for otolith rings, hatching, rearing success, and developmental stages are being investigated.

Sablefish tagging program - 23% recovered tags were 10 + years old, greatest traveled -1500 nm.

Juvenile sablefish research in St. John Baptist bay.

Archival tags, 100 recoveries, diurnal movement, day/night. Vertical migration, different during winter/summer.

Sablefish macroscopic female age or maturity. Winter sampling difficult. Looking at Size of liver to body size to predict maturity.

Early life history YOY, 500 samples in lab, temperature range for optimal growth of sablefish, 12-16 degrees.

Stock Assessments - a lot of small sablefish around, 2014 year class -starting to show up in survey. Considered 'nuisance,' only 1 dollar per pound right now. Many fishermen are releasing them on their own.
Biggest year class in a long time. 2nd highest in time series. 5 or 6 yrs old potentially be recruited into fishery.

Whale Depredation in the fishery: trying to account for it in stock assessment.

NPFMC - Whale depredation lowers ABC but also raises bias through the survey - net increase in ABC; Council interested in requirement for retention, development of DMR (discard mortality rate), and minimum size and evaluation of benefits to the stock, economic value of sablefish, effects of observer sampling on modifying the retention rate (seeing large year class); no more than a 10% increase in ABC annually

ADFG - Board of fisheries meeting
SE Alaska. New regulations include: allowing a live market sablefish in Chatham and Clarence St., for Clarence St. the longline and pot seasons are now combined and pots require two 4 in. in diameter escape rings, personal use sablefish fishery now allows the use of pots, and the sport fishery established a limit for all of SE Alaska for non-residents which is 4 per day and 8 annually. 12% increase in the Clarence St. quota.

DFO - Research: change over in staff. New assessment biologist, Brendan Connors, not a lot of work done in 2017 aside from the survey and updating the harvest control rule.
Continuing trap mounted camera accelerometer on Bowie Seamount.

No new assessment, updated in 2017 to address model mis-specification. Removed the floor on the TAC. Reduced max harvest rate. Retained 55 cm size limit.

Management - objectives of fisheries re-evaluated every year, a few changes. Model (2017) suggested 20% increase in TAC, to enhance rebuilding of the stock and prolong harvest industry decided not to take the entire 20%. Experience with big 1999 year class tempered industry desire to ramp up TAC because the TAC had to be reduced quickly in 2008/9/10 after large increases in 2002/3/4. Industry wants want less variability in TAC. Work underway to look at a coast wide assessment.

CDFW – Noted that sablefish are landed live in California.

IPHC, WDFW, ODFW, NWFSC, and SWFSC - nothing to report

K. Lingcod

DFO - not much to report, due to staff changes. Ongoing data collection -compiling data, aging Looking to add lingcod sampling to their hook and line surveys, already sampled in trawl surveys.

IPHC - nothing to report - may start sampling

ADFG - ROV survey in PWS discontinued, no stock assessment but sample commercial and recreational dockside

WDFW - Fin ray spines best hard structure to use for ageing; collecting biological samples from recreationally caught fish; some genetic work and testing ability to get genetics from gill clips and looking at survivability (DNA and hormones); creating videos and guides to standardize methodology to sample lingcod; sampling fin rays on live fish and returning them

Suggested WDFW tag some fish that are released alive, Will evaluate feasibility.

ODFW - Continued management. Not approaching state harvest limits. Provided data for federal lingcod assessment.

NWFSC - demographic variation on a fine scale - genetic variation - lingcod San Francisco south have a different allele

CDFW - Lingcod stock assessment results not good CDFW will begin collecting carcasses and gonads from the recreational fishery for future stock assessment.

AFSC, SWFSC, and NPFMC - nothing to report.

L. Atka Mackerel

AFSC - NPRB funded research was carried on to examine whether fishery restrictions to set mitigate the take of Steller sea lion Prey are effective. A stereo drop camera was used to examine community characteristics of sea lion prey near and far from sea lions colonies.

NPFMC - Tagging research priority

All other agencies - nothing to report

M. Flatfish

DFO - ongoing data collection - published 2015 arrowtooth flounder assessment, ageing of Dover sole and Petrale sole near complete for an updated assessment.

ADFG - someone tested pot gear for flatfish with limited success

AFSC - Flatfish research projects include; how temperature affects yellowfin sole catchability and the availability in the Bering Sea to the trawl survey; in GOA, the connectivity and settlement effect of arrowtooth flounder recruitment in relationship to the subtle influence of eddies is being examined; prey distributions of juvenile flatfish are being studied in Bering sea where high condition factors and growth may be affected by temperature or prey availability and quality--new fish and prey samples from the northern Bering sea are being processed; and a tagging study of greenland turbot during longline survey is examining the vertical movement of this species. During the past year, CIE reviews of Bering Sea flatfish occurred.

An NPRB study in northern Bering Sea and for Alaska plaice looks like they grow slower in the northern Bering Sea - do they stay there or migrate? Year effect on growth for yellowfin sole - grow faster in warmer water- how this might affect the harvest control rule will be analyzed with IPCC future temperature scenarios. Recruitment prediction model for rock sole using wind direction and temperature - positively correlated with recruitment.

NPFMC - Gulf - arrowtooth flounder went with author recommendation and noted retrospective bias and bias in max age - decrease natural mortality

SWFSC - fecundity research of petrale sole-- determinate batch spawning, 1-2.5 million eggs, data will be fed into next assessment. Current fecundity based on 1 study from 1950s.

WDFW, IPHC, ODFW, and CDFW - nothing to report

N. Pacific Halibut & IPHC activities

DFO - nothing to report

IPHC - research projects
Reproduction - sex ratio of commercial catch, improved maturation estimates of spawning biomass, temporal changes in reproductive development, gene expression profiling of reproductive axis, 30 males and 30 females collected every month, update maturity and age estimates. Pilot study for sex marking, can assign genetic sex with >97.5% accuracy

Study possible causes for size at age; evaluate growth patterns and effects of environmental influences, can manipulate growth in the lab with juveniles

DMRs and survival assessment - trawl study completed, validation of the satellite tags and survival of halibut

Longline study - evaluate effects of handling practices on injuries and the physiological condition of the captured pacific halibut, survival, etc…

Migration - larval, juvenile and adult migrations; tagging all sublegal fish released, pilot last year for tail pattern recognition, reproductive and annual migration, larval migration and connectivity linking GOA and BS

Genomics - sequence the genome

ADFG - state manages the sport fishery and recommends annual management measures to the NPFMC to keep charter fishery harvest in 2C and 3 A within their allocations.

NPFMC - use of EM for longline fishery and intersects with management - account for dead discards from observers generating info, assess fish condition and gear used get assigned a discard mortality rate;

Tweaking halibut DMR on annual basis; no longer running 10 year average;
Have option of deck sorting
Abundance based management - move away from fixed halibut bycatch limits and would vary by gear
Control rules about the steepness of the slope of the increase
Latest charge from the Council includes 5 new alternatives
Joint IPHC/Council meeting summer 2017 and compared how research priorities done- suggest keeping this updated

WDFW - nothing to report

ODFW - high profile recreational fishery; 2017 increase in area 2A and managed under 3 subareas within the state; took 92% of quota, 99.7% attainment in central coast

CDFW - has been monitoring and managing recreational fishery closely the last 2-3 years and has developed an online tracking system for the public. In 2017, the recreational fishery closed early with 88% quota attained. The commercial fishery has 10 hour openers and not much commercial activity, with 3800 dressed pounds landed by a handful of vessels in 2017. California fishermen participated in the sex-marking study with IPHC.

SWFSC - nothing to report

O. Other groundfish species

DFO, IPHC, CWFW, SWFSC, and ADFG - nothing to report

AFSC - A number projects occurred involving groundfish including: Conservation engineering projects continue examining how to reduce the bycatch of salmon and halibut using artificial light to illuminate escape routes, helping fishers get the tools to reduce bycatch, developing new camera systems to put on nets to guide where they're going; using hydrographic survey data to reconstruct the bathymetry, showing seafloor rising in one part of the Aleutians; identifying untrawlable habitats; researching the acoustic dead zone; vision research on wavelengths that fish can see; developing tablets and applications for collecting length measurements and specimen data at sea, and identifying on cryptic species in Alaska and providing training to ID fish at sea.

WDFW - dogfish, lingcod, flatfish and rockfish study to get conversion values to convert historical data, especially "liver" landings, for catch reconstructions

Pacific herring - Salish Sea assessment of genetic stock structure, make management recommendations, expert opinion and data dump; should be completed in June 2018; not a formal recovery plan

ODFW - kelp greenling - commercial and recreational - increased in harvest guideline, 6% attained by commercial fleet, recreational catches down
Cabezon both commercial and nearshore, retention has been prohibited in mid-July in recent years, exceeded ACL and OFL; will be looking at management changes in the recreational fishery

XII. Ecosystem Studies

AFSC - refer to report - series of modelling efforts, Integrated Ecosystem Assessment, and the effects of the 2015 marine heat wave (The Blob).

DFO - framework to develop MSE using DLM tools

WDFW - assessed mid-water species composition and structure in 2016-17 - ecosystem assessment. Noted regional, sub-basin differences and saw Pacific pompano and shad (didn't expect to see them). Also conducting high resolution mapping in Puget Sound to better account for distribution of various groundfish species. Derelict gear retrieval still underway. Eulachon excluders on shrimp trawls using LED illumination in the outer coastal fishery.

ODFW - further development of a nearshore FI survey - assess effectiveness of visual and acoustic tool looking at semi-pelagic rockfish estimates, gather detailed data to assess how the combo of tools works and inherent bias in it, trying to match abundance estimates from PIT tag project and acoustic survey, evaluate known bias in the program; use ROV and video landers to compare size composition and sizes with acoustic data

Working on developing hand-held ROV

BioSonics MX - habitat echosounder to survey the white zone

CDFW - nothing to report

SWFSC - continuing underwater camera surveys in Southern California Bight with Habitat Ecology Team

XIII. Progress on Previous Year's Recommendations

A0. From TSC to CARE
CARE did not directly respond and will carry this recommendation on this year
Working group to standardize otolith storage

A. From TSC to Itself
Workshops/Western Groundfish Conference:
Have a TSC representative sit on the Western Groundfish Steering Committee - Jon Heifetz (AFSC) is nominating Cara Rodgveller from the AFSC for the 2020 meeting (being held in AK)..

Continue TSC sponsored workshops and/or session at the WGC (first session of conference worked well in 2018, future...workshop transition at end of day?)

The WGC steering committee this year suggested letting people know the topic as soon as the conference is announced and like the topic of cryptic species. Other suggested topics are species distribution modelling for assessments, EFH, etc., discard mortality rates

Can we get the number of visitors to the TSC site from the WGC - how many people visited?

TSC reports-- provide lots of a wealth of overview information, provide link for WGC for background baseline information (students, new hires, etc.). Better circulation, exposure.

Data sharing policies - Jon Heifetz (AFSC) international coastwide meeting for sablefish happening in April 2018 - success! TSC recommended this workshop take place and promoted it. TSC looks forward to seeing the results

B. From TSC to Parent Committee
Wayne Palsson will continue to do update the accomplishments document.

XIV. Current Year Recommendations

A. From TSC to CARE
Carryover the review of yelloweye ageing review.
Encourage use of otolith morphometrics to separate out cryptic species - expand the current working group to expand to other species
Encourage CARE to evaluate the machine reading of otoliths as a valid method (near infrared), concern is that suitable criteria are met

B. From TSC to Itself
Approach whoever is replacing Kelly Ames at the Pacific Fishery Management Council to join the TSC. Dayv and Stephen to follow up.

Provide a Pacific Fishery Management Council report to the TSC - come as participant with a management overview but don’t provide a report.

Contact DFO provide a management representative participate/attend and help fill in gaps in the report

US-Canada Border dispute Dixon Entrance -purely informational presented by Wayne Palsson The US and Canada identify different international boundaries in Dixon Entrance separating SE Alaska and northern British Columbia. The A-B Line established in 1903 to separate land masses between the two countries, but the line didn't necessarily demarcate the water boundary. The U.S. doesn't not recognize the A-B line as the boundary - U.S. uses the middle between the landmasses while Canada extends the A-B line westward through the water as the boundary. There are several impacts to this conundrum. AFSC includes the northern half of Dixon Entrance in its bottom trawl survey while in theory, DFO manages and assesses portions of the same territory. Canada is enforcing fishing vessel transit requirements in their claimed territory and questioned on of the US chartered fishing vessel in 2017 as to why it had active fishing gear on is decks. The IPHC does not take a side on this vague issue. Recommendation: Investigate and aware that there is a jurisdictional dispute - research agencies should seek recommendations on surveying these areas

TSC should develop guidelines for authors to shorten their reports

Work with staff at the NWFSC to get a representative here at the TSC meeting in late April.

C. From TSC to Parent Committee

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

XVI. Schedule time and location of the Next Meeting (selection of next Chair, if needed) XVII. Adjourn (12:00 noon Wednesday April 25th)

Dayv Lowry serve as Chair the 2019 meeting. Next meeting is set for Olympia, WA - April 23-24, 2019. 1200 Adjourn. Safe travels!

XIX. Parent Committee Minutes

Minutes of the 59th Annual Meeting of the
Canada-U.S. Groundfish Committee
(a.k.a. "Parent Committee")

A Call to Order

Mr. Stephen Phillips, PSMFC, represented the United States and Mr. Greg Workman, DFO, represented Canada. The meeting was called to order at 10:00am, April 25, 2018.

B The Agenda

The agenda, following the format of previous meetings, was approved.

C The 2017 Parent Committee meeting minutes

The 2017 Parent Committee meeting minutes were adopted as presented

D Progress on 2017 Parent Committee recommendations

1. The Parent Committee thanks Wayne Palsson of the TSC for updating the "Accomplishments" document and agrees it should be updated on an annual basis.

   No Action Needed

2. The Parent Committee thanks the TSC for reviewing the status of TSC working groups and endorses there recommendations in this regard.
   No Action Needed

3. The Parent Committee agrees with the TSC on facilitating wider distribution of the TSC agency document. This could be improved by completing the agency reports and final document in a timely manner and distributing it widely within agencies and posting links to the TSC on agency websites.

   Action: The 2017 report was finalized 12/20/17, which was earlier than the 2016 report (finalized on 2/7/17).

4. The Parent Committee thanks the TSC for considering the establishment of the groundfish tagging working group and proposing to focus on reviewing all agency Sablefish data that could contribute to a coastwide stock assessment.
   No Action Needed

E 2018 Parent Committee Recommendations

1. The Parent Committee once again thanks Wayne Palsson of the TSC for updating the "Accomplishments" document and agrees he should continue be in charge of updating this document on an annual basis.
2. The Parent Committee concurs with the TSC that a representative from the Pacific Fishery Management Council (Kelly Ames) should be invited to the 2019 meeting in Olympia; efforts should be made to get a Northwest Fisheries Science Center representative to the annual meeting; and DFO should provide a management representative to attend the annual meeting.

XX. Other Business

1. The Parent Committee thanks PSMFC for its ongoing support for the Annual TSC meetings.

2. The Parent Committee thanks John Field and Melissa Monk from the SWFSC for hosting the TSC meeting at the SWFSC in Santa Cruz, California.

3. The Parent Committee thanks John Field, Melissa Monk, and Rebecca Miller for acting as rapporteurs for the TSC meeting and recommends that at future meetings committee members take turns as rapporteurs during the meeting, similar to Council meetings, as members are familiar with the discussions at the table.

XXI. Selection of the next Chair, Schedule and Location of 2019 Meeting

Dayv Lowry of the WDFW will continue as Chair for the 2019 meeting to be held April 23-24, in Olympia, Washington hosted by the Washington Department of Fish and Wildlife.

XXII. The Parent Committee meeting was adjourned at 11:00 am, Wednesday April 25, 2018.

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

AGENCY REPORTS

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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

2017 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

April 2018

Compiled by Wayne Palsson, Tom Wilderbuer, and Jon Heifetz

VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2017

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). 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, posters 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-independent surveys and related research on groundfish and crab in Alaska. Our efforts are directed at supporting implementation of the U.S. Magnuson-Stevens Fishery Conservation and Management Act and other enabling legislation for the wise stewardship of living marine resources. Surveys and research are principally focused on species from the five large marine ecosystems of Alaska (Gulf of Alaska, Aleutian Islands, eastern Bering Sea, northern Bering and Chukchi Seas, Beaufort Sea). All surveys provide a rich suite of environmental data that are key to practicing an ecosystem approach to fishery management. In addition, the Division works collaboratively with Industry toto 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 regular surveys are used by Center stock assessment scientists to develop our annual Stock Assessment & Fishery Evaluation (SAFE) reports for 46 unique combinations of species and regions. Research by the Division increases our understanding of what causes population fluctuations. This knowledge and the environmental data we collect are used in the stock assessments, and in annual ecosystem status reports. The understanding and data enable us to provide to our stakeholders with strong mechanistic explanations for the population trajectories of particular species. RACE Division Programs include Fisheries Behavioral Ecology, Groundfish Assessment Program (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes Program (RPP), Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.

One of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish and crab 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). In 2017 three Alaskan bottom trawl surveys of groundfish and invertebrate resources were conducted during the summer by RACE Groundfish Assessment Program (GAP) scientists: the annual eastern Bering Sea Shelf Bottom Trawl Survey, the biennial Gulf of Alaska Bottom Trawl Survey, and a new northern Bering Sea shelf bottom trawl survey.
The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock and other pelagic fish abundance in the Gulf of Alaska (winter and summer). A collaborative cruise to test the efficacy of different types of travel excluders was accomplished, as well. The MACE and GAP are working jointly to design an acoustical-optical survey for fish in untrawlable grounds. Once implemented, the survey will reduce bias in our survey assessments of particular taxa such as rockfish.

RACE scientists from multiple programs will continue research in 2018 on essential habitats of groundfish including: identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, including the nearshore areas and early life history stages of fishes in Alaska's subarctic and arctic large marine ecosystems; estimating habitat-related survival rates based on individual-based models; investigating activities with potentially adverse effects on EFH, such as bottom trawling; determining optimal thermal and nearshore habitat for overwintering juvenile fishes; benthic community ecology, and juvenile fish growth and condition research to characterize groundfish habitat requirements.

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. ABL's Ecosystem Monitoring and Assessment Program (EMA), Recruitment Energetics and Coastal Assessment Program (RECA), Genetics Program also conduct groundfish-related research.

In 2017 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; 6) analysis of juvenile groundfish collected on AFSC surveys to assess their growth, nutritional condition and trophodynamics conducted by the RECA Program; and 7) tagging of a small number of age-0 sablefish in the Gulf of Alaska and capture of 500+ live age-0 fish for use in laboratory energetics experiments.

Ongoing analytic activities in 2017 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 Acting Laboratory Director Pete Hagen at (907) 789-6001 or Pete.Hagen@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 Jennifer Ferdinand, (206) 526-4194.

II. Surveys

2017 Eastern and Northern Bering Sea Continental Shelf Bottom Trawl Surveys – RACE GAP
The thirty-sixth annual standardized eastern Bering Sea (EBS) continental shelf bottom trawl survey was extended northward using the same standardized survey methods (Stauffer 2004) to include 144 additional stations in an area bounded by the Bering Strait, Norton Sound, and the U.S.–Russia Maritime Boundary

(Figure 1). The EBS shelf and "Northern Bering Sea" (NBS) bottom trawl surveys were conducted aboard the chartered commercial stern-trawlers F/V *Alaska Knight* and F/V *Vesteraalen*. The NBS extension of the survey is a fundamental part of the NOAA Fisheries Alaska Fisheries Science Center (AFSC) Loss of Sea Ice (LOSI) Research Plan, the primary purpose of which is to study the impacts of diminished sea ice on the marine ecosystem. The NBS is a region of critical importance for increased scientific monitoring because it is a transitional zone between the EBS and Arctic Ocean that is transforming with the changing climate. The scale and extent of fish and crab movements can vary from year to year in response to a variety of biological or environmental processes causing large scale changes in distribution that extend well beyond the standard EBS survey boundary. The 2017 survey represents the second sampling year for a new time series of the NBS that is planned to continue on a biennial basis. Results from the 2017 combined EBS and NBS survey will be valuable for comparing snapshots of fish and crab distributions with those from the 2010 survey that was conducted during the same time of year using identical gear, methods and sampling design to see how the various demersal macrofauna have responded to climate change.

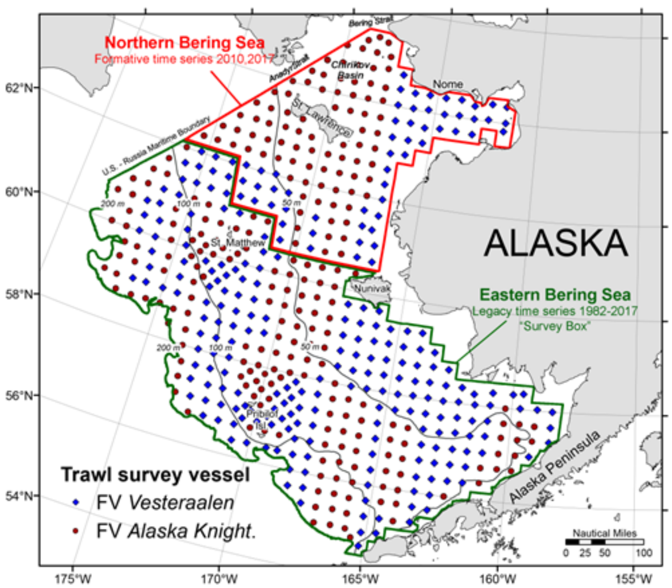

Fig. 1. Map showing survey stations sampled during the 2017 eastern and northern Bering Sea shelf bottom trawl survey.

After the completion of the EBS shelf survey, which started for both vessels in Dutch Harbor on 1 June 2017, both vessels transitioned into sampling survey stations in the southwest corner of the NBS survey region. The F/V *Vesteraalen* conducted sampling in the NBS from 01 August to 26 August, and the F/V *Alaska Knight* from 01 August to 2 September. A total of 520 stations in the combined EBS and NBS were successfully sampled in 2017, and there was a total of 111 fish taxa and 260 invertebrate taxa identified from bottom trawl catch samples.

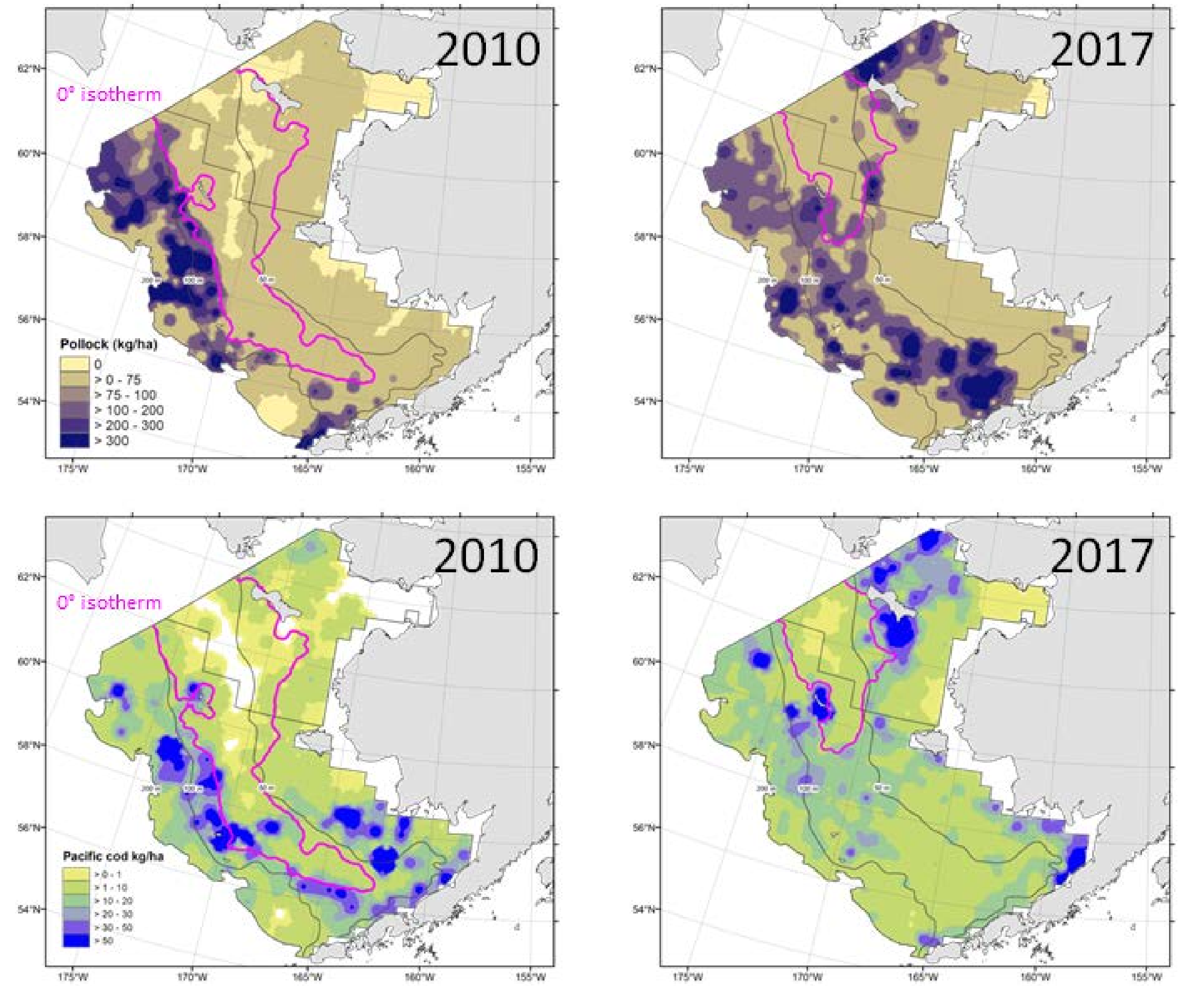

Fig. 2. Spatial distribution of large gadids, in terms of mean CPUE (kg/ha), observed during the 2010 and 2017 bottom trawl surveys of the EBS and NBS: Top left is walleye pollock in 2010, and top right is walleye pollock in 2017; bottom left is Pacific cod in 2010, and bottom right is Pacific cod in 2017. The pink line represents the 0°C isotherm.

The 2017 distributions of walleye pollock and Pacific cod were completely different than those observed in 2010. In 2010, pollock was mostly concentrated on the outer shelf at depths of 70–200 m north of 56°N (Fig. 2, top right). Pollock biomass was consistently low on the inner and middle shelf, and pollock were almost completely absent from the NBS. The total pollock biomass from the EBS was 3.74 million mt, while pollock biomass from the NBS was only 0.02 million mt.
In 2017, pollock biomass in the EBS was concentrated mostly on the middle shelf (Fig. 2, top right). In the NBS, there was a high concentration of pollock biomass to the north of St. Lawrence Island, and the total pollock biomass from EBS was 4.82 million mt, while pollock biomass from the NBS was 1.3 million mt.

In 2010, Pacific cod biomass in the EBS was concentrated in Bristol Bay and on the middle and outer shelf from the Pribilof Islands north to St. Matthew and cod biomass was low throughout the NBS (Fig. 2, bottom. left). Total cod biomass from the EBS was 860,000 mt, while biomass from the NBS was only 29,000 mt. In 2017, Pacific cod biomass was distributed differently (Fig. 2, bottom. right). Pacific cod were highly concentrated in only a few areas of the EBS and cod densities on the shelf were generally low, particularly on the middle and outer shelf in the southern parts of the survey area. In contrast, cod densities in the NBS were high both to the north and south of St. Lawrence Island. Total estimated cod biomass from the EBS was

644,000 mt, while biomass from the NBS was 283,000 mt. In both survey years, Pacific cod were concentrated in areas with bottom temperatures >0°C.

Survey estimates of total biomass in the EBS shelf (not including the NBS) for other major species in 2017 were 2.79 million mt for yellowfin sole, 1.33 million mt for northern rock sole, 424 thousand mt for arrowtooth flounder, and 126.7 thousand mt for Pacific halibut. Compared to 2016 levels, there was an overall general decrease in survey biomass for the major species: walleye pollock biomass decreased 2%, Pacific cod 35%, yellowfin sole 3%, northern rock sole 9%, arrowtooth flounder 11% and Pacific halibut 18%.

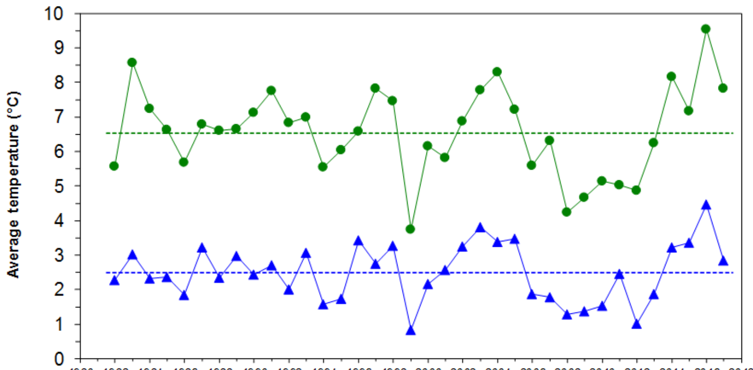

Fig. 1. Graph of mean annual surface and bottom temperatures for the eastern Bering Sea shelf bottom trawl survey.

Surface and bottom temperature means for the 2017 eastern Bering Sea shelf decreased from 2016 estimates, but both were still warmer than the long-term time-series mean (Fig. 3). The 2017 mean surface temperature was 7.8°C, which was 1.7°C lower than 2016 and 1.4°C above the time-series mean (6.5°C). The mean bottom temperature was 2.8°C, which was 1.7°C lower than 2016, but 0.4°C above the time-series mean (2.5°C). The 'cold pool', defined as the area where temperatures <2°C, extended from the northern-most port of the survey (latitude 62°N) south-east to latitude 54° N between 50 and 100 m bottom depth. This extent was significantly more developed than in 2016, when the cold pool was confined to the upper middle shelf, but was generally less extensive compared to 2007-2013 when overall temperatures were colder.

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

2017 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska – RACE GAP

The National Marine Fisheries Service Alaska Fisheries Science Center (AFSC) Resource Assessment and Conservation Engineering (RACE) Division chartered the fishing vessels *Ocean Explorer* and *Sea Storm* to conduct the 2017 Gulf of Alaska Biennial Bottom Trawl Survey of groundfish resources. This was the fifteenth 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 76 days. The cruise originated from Dutch Harbor, Alaska on May 23rd and concluded at Ketchikan, Alaska on August 8th. After the vessels were loaded and other preparations (*e.g.*, wire measuring, wire marking, and test towing) were made before the first survey tows were conducted on 26 May. The vessels surveyed from the Island of Four Mountains (170° W longitude) proceeded eastwards through the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern management areas (Figure 1). Sampled depths ranged from approximately 15 to 700 m. The cruise was divided into four legs with breaks in Sand Point, Kodiak, and Seward to change crews and re-provision.

A primary objective of this survey is to continue the data time series begun in 1984 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 2017 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 54 strata of depths and regions and applied to a grid of 5x5 km^2 cells. Stations that were previously identified as untrawlable were excluded from the sampling frame. 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 536 of 550 planned stations in the entire shelf and upper slope to a depth of 700 m. Biologists collected 161 fish taxa that weighed 251 mt and numbered 456,000 individuals. There were 468 invertebrate taxa collected that weighed a total of 5.7 mt. During the 2017 survey, biologists collected 152 taxa of fish and invertebrates as 313 vouchered lots for identification, permanent storage, or other laboratory studies. Other collected samples included over 11,200 otoliths for ageing, special collections for ecological studies, and others samples for life history characterization. A validated data set was finalized on 30 September (https://www.afsc.noaa.gov/RACE/groundfish/survey_data/data.htm), and final estimates of abundance and size composition of managed species and species groups were delivered to Groundfish Plan Team of the NPFMC. The survey data and estimates are also available through the AKFIN system (www.psmfc.org). The Plan Team incorporated these survey results directly into Gulf of Alaska stock assessment and ecosystem forecast models that form the basis for groundfish harvest advice for ABCs and TAC for 2017. Of particular note during this survey was an approximate 80% decline in the survey biomass estimate of Pacific cod. This result combined with others in the stock assessment led to substantial reductions in the amount of fish available for commercial fisheries in the Gulf of Alaska (see Pacific cod stock assessment below).

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

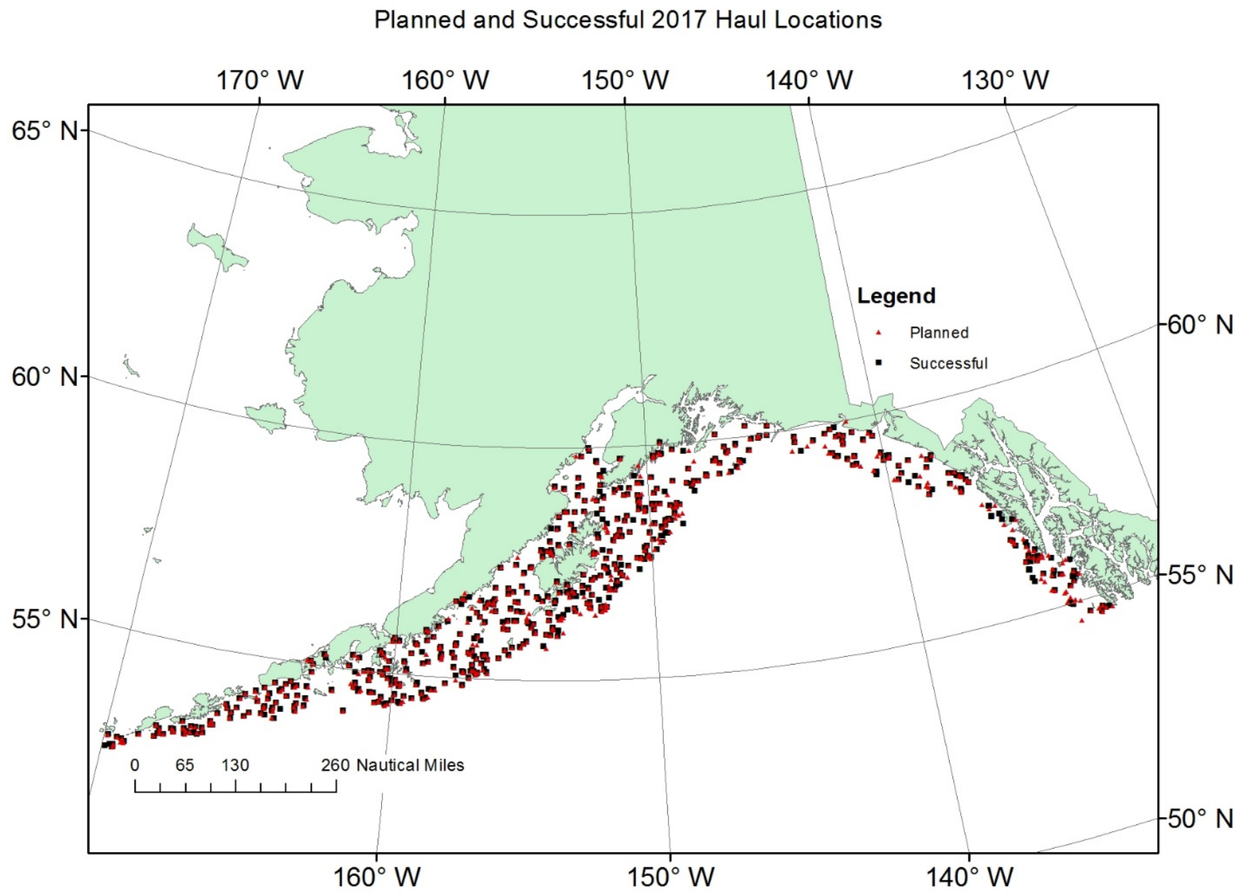

Figure 1. Planned and occupied stations during the 2017 Gulf of Alaska Biennial Bottom Trawl Survey.

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

Three cruises were conducted to survey several GOA walleye pollock (*Gadus chalcogrammus*) spawning areas in the winter of 2017. The first cruise (DY2017-01) surveyed the Shumagin Islands area (i.e., Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait; 8-11 February), Sanak Trough (11 February), Morzhovoi Bay (12 February), and Pavlof Bay (13-14 February). The second cruise (DY2017-02) covered the Kenai Bays (i.e., Port Dick, Nuka Bay, Nuka Passage, Harris Bay, Aialik Bay, Resurrection Bay, Auk Bay, Port Bainbridge, and Knight Passage; 2-5 March), PWS (5-7 March), and the outer PWS region (Hinchinbrook Trough and Middleton Island areas; 7-9 March). The third cruise (DY2017-03) covered the Shelikof Strait (18-24 March), Marmot Bay (14-15 and 26 March) and the Chirikof shelf break (24-25 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) and a a poly Nor'eastern (PNE) bottom trawl to estimate the abundance of walleye pollock. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multi-frequency 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 723 km (390.4 nmi) of transects. The survey transects were spaced 1.9 km (1.0 nmi) apart southeast of Renshaw Point and in the eastern half of Unga Strait, 3.7 km (2.0 nmi) apart in the western half of Unga Strait, 4.6 km (2.5 nmi) apart in Stepovak Bay and West Nagai 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 50 cm fork length (FL), with a predominant length mode at 42 cm FL, which is characteristic of age-5 walleye pollock, and suggests the continued success of the 2012 year-class. This size range accounted for 99.9% of the numbers and effectively 100% of the biomass of all pollock observed in this area. These walleye pollock were present in Unga Strait, near the mouth of Stepovak Bay, and in the Northern portion of West Nagai Strait. Although adult pollock > 45 cm FL have historically been detected off Renshaw Point, they were absent from this area in 2017. The majority of the pollock were scattered throughout the water column between 50-150m depth within 50m of the bottom, and occasionally formed small, very dense (i.e., “cherry ball”) schools. The maturity composition of males > 40 cm FL (n = 119) was 0% immature, 8% developing, 50% pre-spawning (mature), 40% spawning, and 3% spent. The maturity composition of females > 40 cm FL (n = 136) was 0% immature, 7% developing, 85% pre-spawning, 4% spawning, and 4% spent. The biomass estimate of 29,621 t (with a relative estimation error of 9.8%), based on data from acoustic transects and specimens collected from eight AWT hauls, is 43% greater than the 2016 estimate (20,706 t) and 39% of the historical mean of 75,901 t for this survey.

In Sanak Trough, acoustic backscatter was measured along 167 km (89.9 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 10 and 60 cm FL with a dominant length mode between 35 and 50 cm FL. This mode accounted for 95% of the numbers and 99.9% of the biomass of all pollock observed in Sanak Trough and likely represents age-5 fish. The majority of walleye pollock biomass was located in the southeastern portion of the surveyed trough and distributed throughout the water column below 50 m. The maturity composition for males > 40 cm FL (n = 22) was 0% immature, 0% developing, 77% pre-spawning, 14% spawning, and 9% spent. The maturity composition for females > 40 cm FL (n = 31) was 0% immature, 9% developing, 73% pre-spawning, 0% spawning, and 18% spent. The biomass estimate of 957 t (with a relative estimation error of 19.6%) is 27% of last year’s estimate of 3,556 t, and represents only 2% of the historic mean of 39,812 t for this survey.

In Morzhovoi Bay, acoustic backscatter was measured along 68 km (36.9 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 29 and 55 cm FL in Morzhovoi Bay, and accounted for 99% of the numbers and 99.9% of the biomass in this area. More adults > 50 cm FL were observed in Morzhovoi Bay than in the Sanak and Shumagins regions and accounted for 10% of the pollock biomass in this area. The majority of walleye pollock was located in the southern portion of the surveyed area and was scattered throughout the water column around 85 m from the surface. The maturity composition of males > 40 cm FL (n = 70) was 0% immature, 4% developing, 4% pre-spawning, 89% spawning, and 3% spent. The maturity composition for females longer than 40 cm FL (n = 24) was 0% immature, 17% developing, 58% pre-spawning, 4% spawning, and 21% spent. The biomass estimate of 3,932 t, based on data from acoustic transects and specimens collected from two AWT hauls (with a relative estimation error of 6.5%), is comparable to the biomass estimates generated between 2007 and 2013 (mean = 2,259 t; standard deviation = 397 t).

In Pavlof Bay, acoustic backscatter was measured along 65 km (34.8 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 10 and 60 cm FL with a dominant length mode between 35 and 50 cm FL. This mode accounted for 84% of the numbers and 99% of the biomass of all pollock observed in Pavlof Bay and likely represents age-5 fish. More pollock < 15 cm FL were detected in Pavlof than in any of the other areas, although very few of these presumed age-1 fish were seen during DY1701. This small size group represented 1% of the total number of fish caught in the DY1701 survey, and 0.4% of the biomass in Pavlof. The majority of walleye pollock biomass in Pavlof Bay was located in the NW portion of the surveyed area and was scattered throughout the water column between 40-100m from the surface. The maturity composition for males > 40 cm FL (n = 18) was 0% immature, 6% developing, 67% pre-spawning, 0% spawning, and 28% spent. The maturity composition for females > 40 cm FL (n = 22) was 0% immature, 9% developing, 77% pre-spawning, 0% spawning, and 14% spent. The biomass estimate of 2,228 t (with a relative estimation error of 14.7%) based on data from acoustic transects and specimens collected from two AWT hauls is very similar to the 2016 estimate of 2,130 t, and is the second estimate generated for this area. Surveys of Pavlof Bay were also conducted in 2002 and 2010, but an equipment malfunction and inclement weather, respectively, prevented trawling.

The Kenai Bays, specifically Port Dick, Nuka Passage, Nuka Bay, Harris Bay, Aialik Bay, Resurrection Bay, Day Harbor, Port Bainbridge, and Knight Passage, were surveyed from 2-5 March. Acoustic backscatter was measured along 552 km (298 nmi) of zig-zag transects. The walleye pollock in the Kenai Bays ranged between 35 and 55 cm FL, in a unimodal distribution with the mode at 42 cm FL, which is characteristic of age-5 fish, and shows the continued success of the 2012 year-class. The majority of the walleye pollock biomass (FL ≥ 30 cm) in the Kenai Region was located in Nuka Bay, Aialik Bay, Resurrection Bay (32%), and Port Bainbridge (17%). There was less than one ton of biomass estimated for fish < 30 cm. Most of the walleye pollock backscatter was located in schools in the upper water column, between 50 m and 150 m. The maturity composition for males > 40 cm FL (n = 266) was 0% immature, 2% developing, 72% pre-spawning, 26% spawning, and 0% spent. The maturity composition for females > 40 cm FL (n = 181) was 0% immature, 2% developing, 94% pre-spawning, 4% spawning, and 0% spent. The biomass estimate of 72,797 t based on data from acoustic transects and specimens collected from eleven AWT hauls is 10% less than the estimate from the winter 2015 survey (80,965 t), and 35% less than the winter 2010 survey estimate of 111,200 t. Neither the 2015 or 2010 estimates included Knight Passage.

Prince William Sound (PWS) was surveyed from 5-9 March. Acoustic backscatter was measured along 533 km (288 nmi) of parallel transects spaced 4.6 km (2.5 nmi) apart. The walleye pollock in the PWS ranged between 35 and 65 cm FL, with a primary mode at 42 cm FL (indicative of age-5 fish), and a few older fish. The majority of the walleye pollock biomass in PWS was distributed along the eastern side of the main channel. Most fish were detected around 350m deep and 100 m off bottom. The maturity composition for males > 40 cm FL (n = 241) was 0% immature, 0% developing, 26% pre-spawning, 74% spawning, and 0% spent. The maturity composition for females > 40 cm FL (n = 106) was 0% immature, 1% developing, 83% pre-spawning, 15% spawning, and 1% spent. The biomass estimate of 107,517 t (with a relative estimation error of 5.8 %) based on data from acoustic transects and specimens collected from seven AWT hauls is slightly less than the estimate from the winter 2010 GOA survey estimate of 111,200 t. Less than 0.5 t were attributed to fish < 30 cm.

Hinchinbrook Trough (i.e., S. of Hinchinbrook Island to GOA Shelf) and the shelf break near Middleton Island (collectively the Hinchinbrook region) were survey March 7-9. Acoustic backscatter was measured along 338 km (182 nmi) of parallel transects spaced 13.9 km (7.5 nmi) apart and along 151 km (82 nmi) of zig-zag transects. The walleye pollock in the Hinchinbrook region ranged between 38 and 57 cm FL with a mode at 42 cm FL (indicative of age-5 fish). The majority of the walleye pollock biomass in the

Hinchinbrook region was distributed along the western ends of the northern transects in Hinchinbrook Trough. A little biomass was also estimated east of Middleton Island in deep water. Most of the walleye pollock backscatter in Hinchinbrook was located between 100 m and 200 m deep. Pollock backscatter near Middleton Island was about 400 m deep, and between 200-300m off the bottom. The maturity composition for males > 40 cm FL (n = 115) was 0% immature, 1% developing, 42% pre-spawning, 56% spawning, and 2% spent. The maturity composition for females > 40 cm FL (n = 100) was 0% immature, 3% developing, 95% pre-spawning, 2% spawning, and 0% spent. The biomass estimate of 36,563 t (with a relative estimation error of 14.9 %) based on data from acoustic transects and specimens collected from six AWT hauls is the first for this region in the winter.

In the Shelikof Strait sea valley, acoustic backscatter was measured along 1510 km (815 nmi) of transects spaced 13.9 km (7.5 nmi) apart. The majority of walleye pollock in Shelikof Strait were between 35 and 50 cm FL with a length mode centered around 42cm FL (Fig. 41). This size range accounted for 90% of the numbers and 97% of the biomass of all pollock observed in this area. This size range indicates the continued success of the 2012 year class. Smaller fish (10-15cm) made up a very small portion of the biomass (0.23%) and numbers (10%), and large adults (≥ 51 cm) also contributed little (2.6%) to overall biomass in 2017. Walleye pollock were observed throughout the surveyed area and were most abundant in the central part of the surveyed area. They were detected in the midwater between 50 and 160 m depth, and as a thick, uniform layer around 210 m deep. Dense midwater pollock aggregations of 35-50 cm FL pollock were encountered throughout the survey area. Spawning aggregations, historically observed in the northwestern part of the Strait, were not seen in 2017 or in 2016, in contrast to previous years. The maturity composition of > 40 cm FL (n = 311) was 0% immature, 3% developing, 5% pre-spawning, 83% spawning, and 8% spent. The maturity composition of females > 40 cm FL (n = 404) was 0% immature, 5% developing, 63% pre-spawning, 7% spawning, and 26% spent. The biomass estimate of 1,489,723 t (with a relative estimation error of 4.3%), based on acoustic data and specimens collected from 16 AWT hauls and one PNE haul, is more than twice that observed in 2016 and more than twice the historic mean of 665,474 t. The 2017 biomass estimate approaches biomass values not seen since the mid-1980s.

In Marmot Bay, acoustic backscatter was measured along 322 km (174 nmi) of transects spaced 1.75 km (1.0 nmi) apart in inner Marmot Bay and Spruce Island Gully, and 3.7 km (2.0 nmi) apart in outer Marmot Bay. Inner Marmot Bay and Spruce Island Gully were surveyed 14-15 March, and outer Marmot Bay was surveyed 26 March. Walleye pollock ranged between 34 and 60 cm FL with a clear mode at 42 cm. This size range accounted for 99.9% of the biomass of all pollock observed in this area. Smaller fish (< 34 cm FL) made up a very small portion of the biomass (<0.1%). There were no age-1 pollock caught in Marmot Bay for the second year in a row, and no adults (> 60 cm) captured in 2017. The majority of walleye pollock biomass occurred in aggregations in Spruce Gully and on the first 2 transects of outer Marmot. These aggregations were near the bottom in deeper water and often included a diffuse mixture of pollock, juvenile herring, and eulachon. The maturity composition of males > 40 cm FL (n = 128) was 0% immature, 2% developing, 4% pre-spawning, 41% spawning, and 53% spent. The maturity composition of females > 40 cm FL (n = 93) was 1% immature, 2% developing, 61% pre-spawning, 8% spawning, and 28% spent. The biomass estimate of 14,259 t (with a relative estimation error of 7.9%), based on data from acoustic transects and specimens collected from five AWT hauls which was about a third of last year's estimate of 37,161.

Along the Chirikof Shelf Break, acoustic backscatter was measured on 307 km (166 nmi) of transects spaced 13.9 km (7.5 nmi) apart. Chirikof was surveyed 24-25 March. Walleye pollock ranged from 38 to 57 cm FL. No larger or smaller fish were observed the survey. The size range was narrower this year than in 2015. Walleye pollock schools composing the majority of pollock biomass in Chirikof were scattered sparsely along the shelf break, mainly in shallow waters (60-100m depth). The maturity composition of males > 40 cm FL (n = 15) was 0% immature, 60% developing, 7% pre-spawning, 13% spawning, and 20% spent. The maturity composition of females > 40 cm FL (n = 57) was 0% immature, 0% developing, 14% pre-spawning, 0% spawning, and 86% spent. The biomass estimate of 4,007 t (with a relative estimation error of 24.0%), based on data from acoustic transects and specimens collected from four AWT hauls, was less than a third of last year's estimate of 12,685 t.

Summer acoustic-trawl survey of walleye pollock in the Gulf of Alaska--MACE

The MACE Program completed a summer 2017 acoustic-trawl (AT) survey of walleye pollock (*Gadus chalcogrammus*) across the Gulf of Alaska (GOA) shelf from the Islands of Four Mountains eastward to Yakutat Trough aboard the NOAA ship Oscar Dyson. The summer GOA shelf survey also included smaller-scale surveys in several bays and troughs. Previous surveys of the GOA have also been conducted during the summers of 2003 (partial), 2005 (partial), 2011, 2013, and 2015 by MACE. Mechanical issues during the second leg of the summer 2017 survey required that the ship return to port early and plans for the third leg had to be altered to assure that the survey covered the entire shelf to Yakutat Trough. Altered plans included increased spacing of transects in Chiniak and Barnabas Troughs (from 3 nmi to 6 nmi) and dropping surveys of Kenai Peninsula Bays and Prince William Sound.

Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and on-bottom backscatter was sampled with a poly Nor'eastern (PNE) bottom trawl. A trawl-mounted stereo camera ("CamTrawl") was used during the survey to aid in determining species identification and size of animals encountered by the AWT at different depths. A Methot trawl was used to target midwater macro-zooplankton. Forty seven conductivity-temperature-depth (CTD) casts were conducted to characterize the physical oceanographic environment across the surveyed area. During nighttime operations small scale grid surveys were performed across the shelf based on the AFSC bottom trawl survey trawlability grid. Trawlable (n=16) and untrawlable (n=13) grids were surveyed using the EK60 acoustic system (18, 38, 70, 120, and 200 kHz) and a Simrad ME70 multibeam sonar to assess the trawlability designation of the grid. Grid sampling was augmented with lowered stereo-video camera deployments (n=76) to estimate species abundance and groundtruth bottom classification.

Large numbers of age-0 pollock were observed on CamTrawl images during fishing activities. They were present throughout the summer survey area, particularly around the vicinity of the Shumagin Islands, the surrounding shelf areas, and in Shelikof Strait. Age-0 pollock were often located in the water column along with larger pollock. Age-0 pollock are not included in our pollock biomass estimates because they are poorly retained by the large survey trawl so accurate estimations of abundance are not possible, though we do account for their acoustic contribution. All biomass estimates reported here are for age-1+ pollock.

The age-1+ biomass estimate for the entire survey area was 1,343,570 t. The majority of the walleye pollock observed during the survey were located on the continental shelf (84%), Shelikof Strait (5%), near Mitrofania Island (3%), and south east of Kodiak Island in Chiniak (2%) and Barnabas Troughs (4%). The vast majority (86%) of the biomass for the entire survey was from age-5 fish (38-56 cm fork length, mean 44 cm FL). Surface water temperatures across the GOA shelf averaged 11.6° C, overall approximately 0.6° C cooler than in 2015.

The survey of the GOA shelf and shelf break was conducted between 12 June and 14 August 2017 and consisted of 41 transects spaced 25 nautical miles (nmi) apart. Walleye pollock distribution was patchy across the shelf with areas of greatest density between Unimak Pass and Sanak Island in the Davidson Bank area, between the Shumagin Islands and Shelikof Strait south of Mitrofania Island, and east of Kodiak Island on the western portion of Portlock Bank. Based on catch data from 47 AWT, and 7 PNE hauls, a major length group of walleye pollock was observed on the GOA shelf ranging from 36 to 58 cm FL with a mode of 44 cm FL, and a smaller length group ranged from 17 and 23 cm FL with a mode of 20 cm FL. The walleye pollock biomass estimate for the GOA shelf of 1,125,801 t from the 1,785 nmi of trackline surveyed was approximately 84% of the total walleye pollock biomass observed for the entire survey and is roughly equivalent to the 2015 estimate.

Sanak Trough was surveyed 19 June along transects spaced 4 nmi apart. The sparse backscatter attributed to walleye pollock in Sanak Trough was patchy and scattered throughout the 47 nmi of transects surveyed. Pollock captured in the two AWT hauls in Sanak Trough were primarily 37 to 56 cm FL with a major mode at 42 cm FL, resulting in a biomass estimate of 3,710 t, approximately 20% higher than what was seen in 2015.

Morzhovoi Bay was surveyed 19-20 June along transects spaced 4 nmi apart. Backscatter in Morzhovoi Bay attributed to walleye pollock was light and evenly scattered throughout the bay. Walleye pollock captured in one AWT haul in Morzhovoi Bay ranged from 37 to 56 cm with a major mode at 47 cm FL. The biomass estimate for the 23 nmi of trackline surveyed in Morzhovoi Bay was 1,606 t, approximately one third of the amount that was seen in Morzhovoi Bay in 2015.

Pavlof Bay was surveyed 21 June along transects spaced 4 nmi apart. The acoustic backscatter attributed to walleye pollock in Pavlof Bay was light but evenly scattered throughout the survey area. Walleye pollock captured in Pavlof Bay from one AWT were predominately 36 to 50 cm FL, with a mode at 44 cm FL. The biomass estimate in Pavlof Bay from the 29 nmi of trackline surveyed was 1,397 t, approximately half of what was seen there in 2015.

The Shumagin Islands area was surveyed on 23-26 June along transects spaced 3.0 nmi apart in West Nagai Strait, Unga Strait, and east of Renshaw Point, and 6 nmi apart in Shumagin Trough. In the Shumagin Islands walleye pollock were most abundant in the Unga Strait and Shumagin Trough areas. Walleye pollock from 5 AWT hauls were divided between two major groups, one ranging from 13 to 19 cm FL and the other from 37 to 53 cm FL with respective modes at 16 and 43 cm FL. The biomass estimate for the Shumagin Islands along the 190 nmi of tracklines surveyed was 15,288 t, similar to the amount seen there in 2015.

Mitrofania Island was surveyed 25 June along transects spaced 8 nmi apart. The acoustic backscatter attributed to walleye pollock was relatively high on all transects in the Mitrofania Island area. Lengths of walleye pollock captured in the one AWT haul near the island were divided between two groups, one ranging from 13 to 19 cm FL and the other from 37 to 48 cm FL with respective modes at 16 and 43 cm FL. The biomass estimate in Mitrofania along the 32 nmi of tracklines surveyed was 41,996 t, approximately three times greater than in 2015 estimate for the area.

Shelikof Strait was surveyed from 3-10 July along transects spaced 15 nmi apart. Walleye pollock were predominantly distributed throughout the western and central area of Shelikof Strait from Portage Bay to Katmai Bay area. In the central portion of the Strait large aggregations of predominately age-1 pollock formed a dense layer in the midwater. Additionally, age-0 pollock were present throughout the entire Strait from the surface to depths as deep as 150 m in some areas. Lengths were obtained from nine AWT and two PNE trawls hauls and were divided between two groups, one ranging from 13 to 19 cm FL and the other from 29 to 58 cm FL with respective modes at 16 and 44 cm FL. The biomass estimate for the 533 nmi of trackline surveyed in Shelikof Strait was 70,152 t, is less than a quarter of the 2015 estimate, is the lowest estimate for this area in the summer survey time series, and only accounted for approximately 5% of the entire GOA summer survey pollock biomass.

Nakchamik Island was surveyed 9 July along transects spaced 8 nmi apart. Backscatter attributed to walleye pollock near Nakchamik Island was lightly distributed across the 25 nmi of surveyed transects. Walleye pollock captured in the one AWT haul near Nakchamik Island ranged from 37 and 48 cm with a mode of 43 cm FL. The biomass estimate for the Nakchamik Island area was 379 t, the lowest seen in this region in the summer survey time series and approximately only 4% of the 2015 estimate.

Alitak and Deadman Bays were surveyed 12-13 July along a zig-zag pattern into the narrow inner bay area. From one AWT and one PNE haul conducted in the area walleye pollock ranged in length predominantly from 39 to 58 cm FL with a major mode at 47 cm FL. The biomass estimate along the 40 nmi of trackline surveyed in Alitak/Deadman Bay area was 813 t, the lowest seen in this region in the summer survey time series and approximately only 11% of the 2015 estimate.
Chiniak Trough was surveyed 28-29 July along transects spaced 6 nmi apart. Patchy, dense aggregations of adult walleye pollock were detected primarily in the northern transects in Chiniak Trough. Walleye pollock caught in 4 AWT hauls in Chiniak Trough ranged in length predominantly from 39 to 57 cm FL, with a mode at 44 cm FL. The biomass estimate for the 55 nmi of trackline surveyed in Chiniak Trough was 30,156 t, 14% lower than the 2015 estimate.

Barnabas Trough was surveyed 14 to 15 July before mechanical issues required the ship to return to port before completing the survey. Once repairs were completed Barnabas Trough was completely surveyed from 31 July thru 1 Aug along transects spaced 6 nmi apart. Aggregations of adult walleye pollock were detected primarily in the central transects in Barnabas Trough. Walleye pollock caught in an initial three AWT and one PNE haul, and upon returning seven AWT trawls in Barnabas Trough ranged in length predominantly from 38 to 50 cm FL and were dominated by a single mode at 44 cm FL. The biomass estimate for the 151 nmi of trackline surveyed in Barnabas Trough was 49,846 t, approximately 4% of the entire GOA summer survey biomass estimate and almost half of the estimated biomass for this area in 2015.

Marmot Bay was surveyed 3-4 Aug. along transects spaced 2 nmi apart in the inner bay and Spruce Gully, and 4 nmi apart in the outer bay. Walleye pollock backscatter was light in Marmot Bay with the greatest amounts found in the outer bay. Walleye pollock predominately ranged in length from 37 to 56 cm FL with a primary mode at 40 cm FL. The biomass estimate for Marmot Bay along the 108 nmi of trackline surveyed was 2,426 t, the lowest estimate for this area in the summer survey time series and only approximately 5% of the 2015 estimate.

Summer 2016-2017 acoustic vessel of opportunity (AVO) index for midwater Bering Sea walleye pollock--MACE

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 from near surface to 3 m off bottom was used to develop an abundance index that was strongly correlated with the total estimated AT survey pollock biomass ($r2 = 0.90$, $p = 0.0011$, 2006-2014). 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 2016-2017. The 2016 AVO index decreased 19% from the 2015 index value, and 14% from 2014. The 2017 AVO index decreased slightly (6%) from 2016. Both estimates (2016, 2017) were similar to a number of previous years in the series (2006, 2010, 2012-2013) based on overlapping 95% confidence intervals. Most pollock backscatter appeared to be distributed broadly across the shelf between 50 and 200 m isobaths in 2016 and 2017. The percentage of pollock backscatter east of the Pribilof Islands (east of 170○ W longitude) in the AVO index was 22% in 2016 and 19% in 2017. This is much greater than the percentage in summers 2010-2012 (range 4-9%), slightly less than that observed in 2013 (26%) and 2015 (25%), and much less than that observed in 2014 (33%). After a sharp increase in 2013-2014, the relative and absolute biomass of midwater pollock east of the Pribilof Islands has been slowly declining. Because the AVO index did not increase in 2016 as did the AT survey time series, comparison of the AVO index and AT survey time series shows a reduced correlation for 2016 (r2 = 0.76, p = 0.015). Classification of AVO backscatter was more difficult in summer 2017 due to the presence of questionable backscatter (QBS) in some parts of the 2017 AVO index area, increasing the uncertainty in the 2017 AVO index.

The AT survey time series has historically measured the presence of walleye pollock found in midwater down to 3 meters off bottom ("historic" AT time series). In 2016, this time series was altered to include pollock found down to 0.5 m off bottom ("new" AT time series; Honkalehto et al. in press). Preliminary analysis indicates the AVO index is equally well correlated to the new AT time series (r2 = 0.76, p = 0.015).

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 2017. 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 2017, the fortieth annual longline survey of the upper continental slope of the Gulf of Alaska and Bering Sea was conducted. One hundred and fifty-six 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 18 km (9.7nmi) of groundline composed of 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 84,417 sablefish, with an estimated total round weight of 216,431 kg (477,149lb), were caught during the survey. This represents an increase of 10,278 sablefish over the 2016 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 2,261 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at two stations in the western Gulf of Alaska and eleven stations in the Bering Sea. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 18 stations in 2017. Sperm whales were observed depredating on the gear at one station in the western Gulf of Alaska, four stations in the central Gulf of Alaska, three stations in the West Yakutat region, and nine stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2017 longline survey. Satellite pop-up tags were deployed on spiny dogfish (*Squalus acanthias*) and blood samples were obtained in the Gulf of Alaska. Information from these tags and from the blood samples will be used to investigate discard mortality rates and stress response from capture events. Sperm whale observations and photo identifications were conducted in collaboration with a separate vessel at two stations during Leg 3. Yelloweye rockfish (*Sebastes ruberrimus*) samples were collected for a study developing hormone profiles in bony structures that may be used to reconstruct reproductive life histories. Finally, tissue samples from five groundfish species were collected for a stable isotope analysis.

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 the shallower 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 Pat Malecha at (907) 789-6415 or pat.malecha@noaa.gov or Chris Lunsford at (907) 789-6008 or chris.lunsford@noaa.gov.

Northern Bering Sea Integrated Ecosystem Survey – ABL

Auke Bay Labs has conducted surface trawling and biological and physical oceanography sampling in the Northern Bering sea annually since 2002. The Ecosystem Monitoring and Assessment program in partnership with the Alaska Department of Fish and Game, United States Fish and Wildlife Service and the AFSC Recruitment Processes Alliance will continue to conduct a the survey Aug 27 to Sep 20, 2018 aboard a chartered fishing vessel and include 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 are 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) sample collections within Region 2 of the Distributed Biological Observatory.

Physical and biological data are typically collected from 50 stations and oceanographic data are collected at 5 Distributed Biological Observatory stations annually. Headrope and footrope depth and temperature are monitored with temperature and depth loggers (SBE39) at each station.

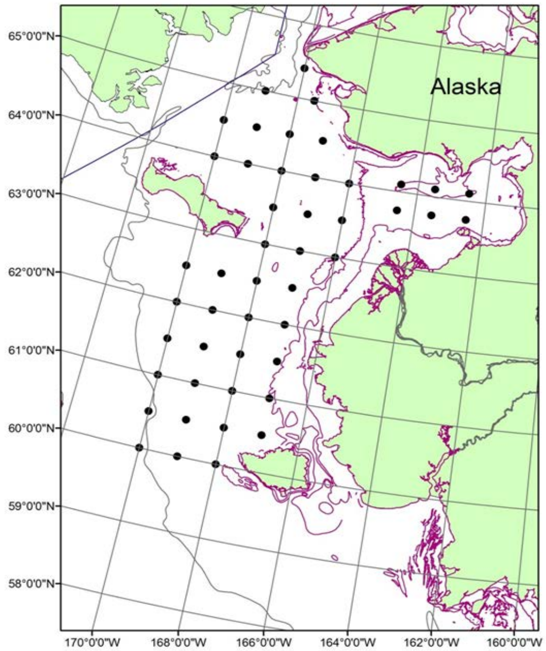

Figure 1. Stations planned to be sampled during the August 27 to September 20, 2018 integrated ecosystem survey in the northern Bering Sea.

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

Late-Summer Pelagic Trawl Survey (BASIS) in the Southeastern Bering Sea, August-September 2018

This survey was not conducted in 2017 therefore we provide plans for 2018. Scientists from the Recruitment Processes Alliance (RPA) of the Alaska Fisheries Science Center (AFSC) will conduct a fisheries-oceanographic survey in the southeastern Bering Sea (SEBS) during the early fall aboard the NOAA Vessel Oscar Dyson from August 20 to September 17, 2018. Prior to the RPA surveys, fisheries-oceanographic surveys were conducted annually (2002-2012, 2014-2016) as part of the Bering-Aleutian Salmon International Survey (BASIS) and the Bering Sea Project (BSP). The survey includes the SEBS shelf between roughly the 50 m and 200 m isobaths, from 160º W to 175º W (Figure 1). A surface trawl (top 20 m) and a midwater trawl towed obliquely (200 m maximum) will be conducted at each station. During this survey, trawl catch and ecosystem data is collected with a priority to provide a mechanistic understanding of the factors that influence recruitment of walleye pollock (*Gadus chalcogrammus*) and Pacific cod (*Gadus macrocephalus*).

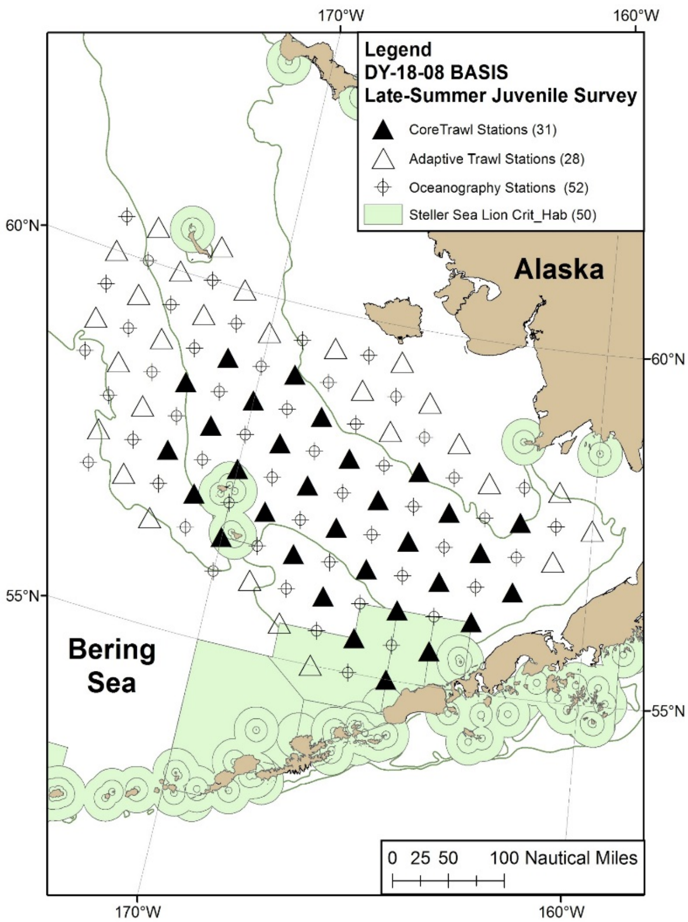

Figure 1. Station locations for the August to September 2018 southeastern Bering Sea integrated ecosystem survey also known as BASIS.

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 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.

<u>Full Coverage Category</u>

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.

Partial Coverage Category

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;
· no selection pool which contains two categories of vessels:
  o Fixed gear vessels less than 40 ft LOA and vessels fishing with jig gear.
  o Vessels that are voluntarily participating in EM innovation research.

Electronic Monitoring Program (EM Trip Selection Pool)

Vessels in the partial coverage category had the option to "Opt in" to a voluntary Electronic Monitoring (EM) Program for the year in 2016 and again in 2017. The overall goal of the two year 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 was used to implement a fully regulated EM Program.

On August 8, 2017, the final rule to integrate electronic monitoring into the North Pacific Observer Program published in the Federal Register. This represents a major milestone in transitioning from a voluntary, cooperative research effort to a fully operational and regulated program beginning January 1, 2018. It also represents a major new addition to the way in which the observer program collects and processes data for management in North Pacific groundfish and halibut fisheries. This is a "first-of-its-kind" approach of using EM to enumerate and identify retained and discarded species from fixed gear vessels and the data is provided to the Alaska Regional Office for catch accounting purposes.

A New FMA Director

Chris Rilling, FMA Director, retired on January 5, 2018. Jennifer Ferdinand was selected as the next Director of the Fisheries Monitoring and Analysis Division in December 5, 2017.

For more information on the North Pacific Observer Program contact Jennifer Ferdinand at (206) 526-4076 or Jennifer.ferdinand@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 tagging program for spiny dogfish was begun in 2009, with 183 pop-off satellite archival tags (PSATs) deployed between 2009 - 2013. Data were recovered from 153 of those tags, with eight tags physically recovered. The PSATs record depth, temperature, light levels and sunrise/sunset for geolocation. A subset of the data is transmitted to ARGOS satellites and any if any tags are physically recovered, the high resolution data can be downloaded. 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. Staff at ABL are working with a contractor (Julie Nielsen, Kingfisher Marine Research) to develop a Hidden Markov Movement model based on these tag data and incorporating environmental variables (e.g. temperature/depth profiles and sea-surface temperature).

In 2012 six spiny dogfish were tagged in Puget Sound, WA, with both PSATs and acoustic transmitters. The purpose of the double tagging was to use the acoustic locations as known locations and evaluate the accuracy and precision of the light-based geolocation data from the PSATs. A manuscript examining those tags is in preparation.

In 2016 staff at ABL began collaborating on a project examining stress physiology in spiny dogfish by collecting blood samples from captured animals. In 2017 we deployed three PSATs on the sampled fish and plan to deploy 18 more during the 2018 longline survey. Eight of the tags will be the same model as those previously used (for a total of 11 physiology study fish tagged) and 10 will be testing a new short-term mortality tag, that records data for only 96 days, but transmits high resolution behavior data once it surfaces. These tags may be used in the future for a skate discard mortality study in collaboration with UAF.

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.

Staff have been developing microsatellite markers, however, they are finding extremely low variability, and only three have been identified so far. The genetics lab at ABL has a new miSeq analyzer and plan to use the Pacific sleeper shark samples as the first project on it. They are exploring sibling and parentage relationships as well as continuing to search for any microsatellites with variability.

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. Beginning in 2017, many assessments adopted new schedules and the GOA shark assessment was delayed so that both shark assessments would be conducted in the same year. 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 most recent assessments (2016), 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 2017, but no assessment was conducted in 2017. The prior survey, 2015 is the most recent survey used in the assessment. The 2017 survey biomass estimate for spiny dogfish (53,979 t, CV = 19%) is about the same as the 2015 biomass estimate of 51,916 t (CV = 25%). Prior to that the biomass was nearly three times greater, and such variability in annual estimates is not unexpected due to the patchy distribution of this species. 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 2018 and 2019 (carried over from the previous assessment). Total catch of sharks in the GOA for 2017 was 1,632 t. Catch in inside waters is not managed by either federal or state agencies, but it is reported in the assessment. 2017 reported the largest catch in inside waters of the time series, 720 t, comprised mostly of Pacific sleeper shark.

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 185 t, which is not close to the ABC or OFL. Pacific sleeper shark are usually the primary species caught, however in 2017 salmon shark catch (114

t) was nearly double that of Pacific sleeper shark (60 t). These catch estimates incorporate the restructured observer program, but the impact appears to be minimal for BSAI sharks.

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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.

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2. Assessment

Bering Sea
The skate assessment for 2017 was a partial assessment in accordance with the new prioritization schedule. New information included: updated 2015 – 2017 catch data and 2017 Bering Sea shelf survey data. The 2017 biomass estimates from the EBS shelf survey for the aggregate skate complex increased from 4% from 2016. In the case of Alaska skates, survey biomass estimates decreased slightly from 2016, though variable, are basically trendless since species identification began in 1999.

No changes were made to the assessment model in the partial assessment. The projection model for Alaska skate was re-run with the most recent catch data. The 2017 EBS shelf survey data were presented in the chapter for informational purposes but were not used for status determination since the Tier 5 random effects model was not re-run for the ”other skates” component of the assemblage.
Model estimates of Alaska skate total biomass have declined for the last three years that the model covers (1992-2016). 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 the projected spawning biomass for 2018 (107,136 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 2018 and 2019 ABCs are 31,572 t and 29,447 t, respectively, and the Alaska skate portions of the 2018 and 2019 OFLs are 36,655 t and 34,189 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 2018 and 2019 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 2018 and 2019 total 46,668 t and 44,202 t, respectively, and ABCs for 2018 and 2019 total 39,082 t and 36,957 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 assessed on a biennial schedule with full assessments presented in odd years to coincide with the timing of survey data. A full assessment was completed for 2017. There were no changes in methodology but possible shifts in distribution were explored more thoroughly.

The 2017 survey biomass estimates for big skates declined substantially from 2015, there were fewer large-sized big skates encountered in the survey and fisheries with more small big skates in CGOA and fewer in EGOA. The biomass of the Other Skates declined also, mostly in the CGOA. The longnose skate biomass estimates increased from 2015 to 2017 with estimates increasing in the WGOA and CGOA. Fewer large-sized big skates were caught in the survey and in the fisheries during 2016 and 2017; the population is dominated by smaller individuals. Also, there may be shifts in abundance of big skates to the CGOA from EGOA. For longnose skates, they seem to have moved shallower in the water column. New inputs this year were the biomass estimates and length composition data from the 2017 GOA bottom trawl survey, updated groundfish fishery catch data, and fishery length composition data through 2017. The application of the RE model to the survey data for each skate category continues to provide reasonable results for biomass estimates.

The catches of big skates are substantially lower than in the years preceding 2014 (particularly 2009-2013). This decrease likely is due to prohibitions on retention of big skates in the CGOA (beginning in 2013), which discouraged "topping-off" behavior that resulted in high levels of catch, particularly for big skates in the CGOA. In January 2016, the Alaska Regional Office indefinitely reduced the maximum retainable amount for all skates in the GOA. Skates are managed in Tier 5. Applying M=0.1 and 0.75*M to the estimated biomass from the random effects models for each stock component, gives stock specific OFLs and ABCs. This approach was also used in the 2016 assessment. Catch as currently estimated does not exceed any gulf-wide OFLs, and therefore, none of the skate stocks are subject to overfishing. It is not possible to determine the status of stocks in Tier 5 with respect to overfished status.

The assessment continued the use of the random effects (RE) model to estimate survey biomass for each managed group and for each regulatory area. Big and longnose skates have area-specific ABCs and gulf-wide OFLs; other skates have a gulf-wide ABC and OFL.

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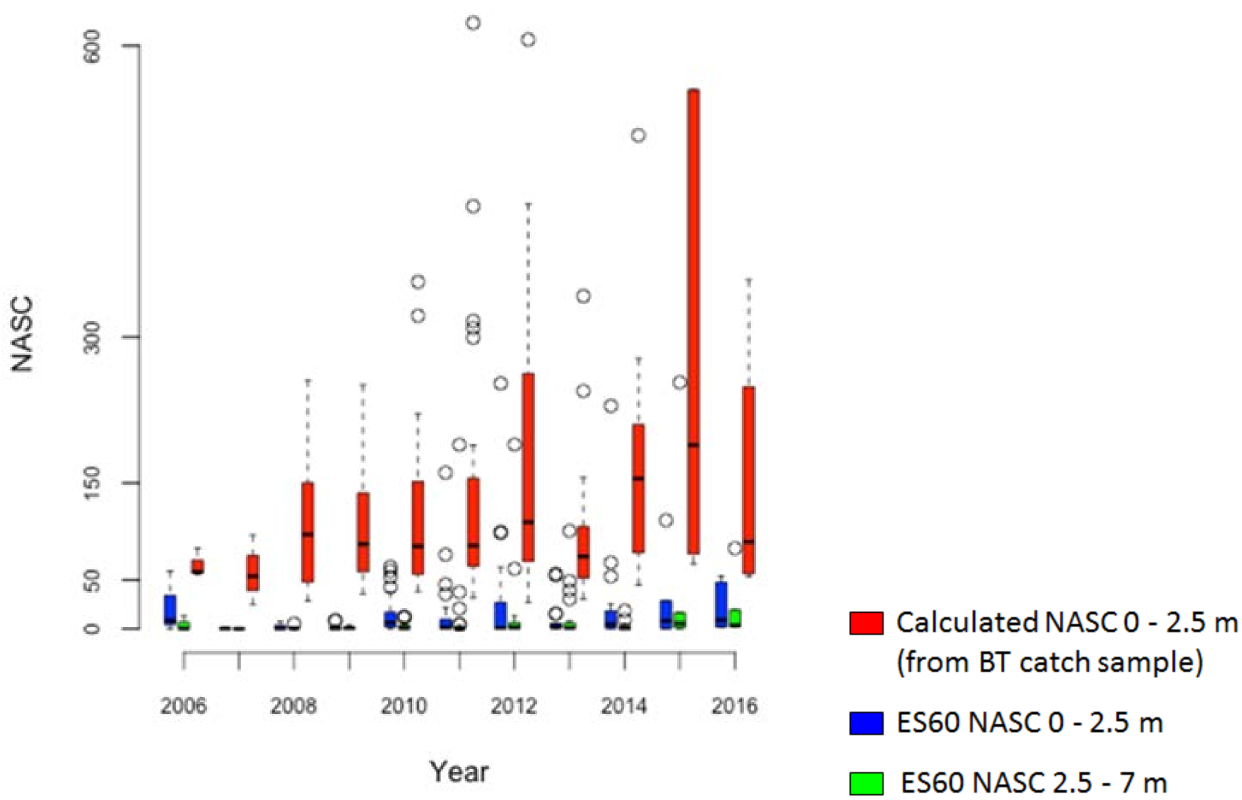
D. Pacific Cod

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.



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Climate Change and Location Choice in the Pacific Cod Longline Fishery-REFM/ESSR
Alan Haynie* and Lisa Pfeiffer
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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 2017 (346,693,000 fish) unexpectedly declined by 46% from 2016 (640,359,000 fish) and biomass in 2017 (598,260 t) was 37% less than in 2016 (944,621 t). In the 2016 assessment, the female spawning biomass was expected to increase. The following changes were made to the input data for the EBS Pacific cod assessment.

For the 2017 assessment, catch data for 1991-2016 were updated, and preliminary catch data for 2017 were incorporated. The commercial fishery size composition data for 1991-2016 were updated, and preliminary size composition data from the 2017 commercial fishery were incorporated. Size composition data from the 2017 EBS shelf bottom trawl survey were incorporated and the numeric abundance estimate from the 2017 EBS shelf bottom trawl survey were added (the 2017 estimate of 347 million fish was down about 46% from the 2016 estimate). Age composition data from the 2016 EBS shelf bottom trawl survey were incorporated. Age composition data from the 2013-2016 fisheries were also incorporated into some of the models.

Many changes have been made or considered in the stock assessment model since the 2016 assessment. Ten models were reviewed by the BSAI Plan Team Subcommittee on Pacific Cod Models at its June meeting, and seven models were presented in this year's preliminary assessment as requested at the conclusion of the June Subcommittee meeting. After reviewing the preliminary assessment, the BSAI Plan Team and SSC requested that a number of models from the preliminary assessment and one new model be presented in this final assessment. The model used in setting harvest specifications for 2018 and 2019 is unchanged from the previous year.

As estimated in the present model, spawning biomass is above $B_{40\%}$ and has been increasing since 2009 due to a number of strong year-classes beginning in 2006. However, spawning biomass is projected to begin declining again in the near future.

The Bering Sea Pacific cod stock is assigned to Tier 3a. The maximum 2018 ABC in this tier as calculated using the present model fit is 201,000 t, however, the Plan Team recommended the ABC be reduced to 188,000 t due to concerns related to the dramatic declines in the EBS shelf survey index, recent poor environmental conditions, lack of incoming recruitment, and recent small size-at-age of young Pacific cod . An ABC of 170,000 t was recommended for the preliminary 2019 ABC. The 2018 OFL from this new calculation is 238,000 t, which is less than the projected OFL from the previous assessment. The 2019 projected OFL is 201,000 t. The EBS Pacific cod stock is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Gulf of Alaska

Both the longline survey and trawl survey indices in 2017 had unexpected, steep declines. The 2017 trawl survey biomass estimate was the lowest in the time series and was 58% lower than the 2015 estimate. The longline survey RPN dropped 53% from 2016 to 2017. The 2016 assessment projected an 8% increase in female spawning biomass for 2017.

New information for the assessment included: The fishery catch data was updated for 2016 and 2017 (projected 2017 catch). Fishery size composition data were updated for 2016, preliminary fishery size composition were included for 2017, and weight and age at length and age compositions for the 2015 bottom trawl survey were included. The AFSC 2017 longline and bottom trawl survey indices of abundance and their corresponding length composition data were also included. Length composition data from ADF&G port sampling program were used to augment pot fishery catch composition data where observer data were not present.

The author evaluated several models and presented a subset of models that included the model configuration from 2016 with updated data. Model 17.08.35 was recommended by the author as it had the best fit to the data and had reasonable retrospective patterns. A major feature of this model that differed from last year's model was having natural mortality (M) estimated in two time blocks; 1) 1977-2014 and 2017 and 2) 2015 and 2016. This feature allowed the model to fit the recent steep declines in the longline and trawl survey indices of abundance that was likely due to temperature related mortality. The protracted warm conditions from 2014-2016 may have resulted in increased metabolic demands for Pacific cod that potentially lead to starvation and mortality. The estimate of M=0.49 during the 1977–2014 and 2017 block was similar to Model 17.08.25 (M=0.47). The estimate of M was 0.71 for the 2015-2016 block.

Another feature of this model was specifying the AFSC longline RPN index to be conditioned on water temperature. This feature allowed the model to be consistent with changing availability of small fish to the longline survey due to bottom temperatures. Smaller fish are encountered more frequently in this survey in warm years than in cold years.

The $B_{40\%}$ estimate was 67,433 t, with projected 2018 spawning biomass of 36,209 t. Recruitment was generally above average for the 2005-2012 period and below average for 2013-2016. Spawning biomass is expected to decline sharply in the near future.

This stock is in Tier 3b because the 2018 spawning biomass is estimated to be at B21%. The F35% and F40% values are 0.82 and 0.66, respectively. The Tier 3b FOFL and FABC values are 0.42 and 0.34, respectively. The OFL is 23,565 t and the maximum permissible ABC is 19,401 t. The authors recommended that the FABC value be reduced to 0.31 to help ensure that the stock stays above the B20% value. If the Pacific cod stock is projected to be equal to or below B20%, directed fishing is prohibited due to Steller sea lion regulations. The Plan Team concurred with the author's recommended ABC and OFL values. The recommended ABC is 18,000 t for 2018 which is an 80% decrease from the 2017 ABC of 88,342 t. The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

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E. Walleye Pollock

1. Research

Fall Energetic Condition of Age-0 Walleye Pollock Predicts Survival and Recruitment Success - ABL
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 in all years except 2015 when oblique (water column) trawls were used. 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 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.

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 SEBS 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 2007-2013 (i.e., cold conditions). Warm conditions returned in 2014 through late-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 25% of the variation in the number of age-1 recruits per spawner (Fig. 2). Strong year classes occurred in 2008 and 2012 and this indicator does not capture those events well. With 2008 and 2012 removed from the model, the AEC accounts for 59% of the variability in age-1 survival (Fig. 2).

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).

The full model (all years) indicates that the 2016 year-class is predicted to have above average survival to age-1, while the constrained model (2008 and 2012 removed) predicts intermediate survival comparable to that of the 2014 and 2015 year classes. The SEBS experienced warm conditions through late-summer 2016, although age-0 pollock in 2016 seem to have mitigated harsh environmental conditions by utilizing the cold pool (which may act as a thermal refuge) and consuming more lipid-rich euphausiid prey (Duffy-Anderson et al., 2017).

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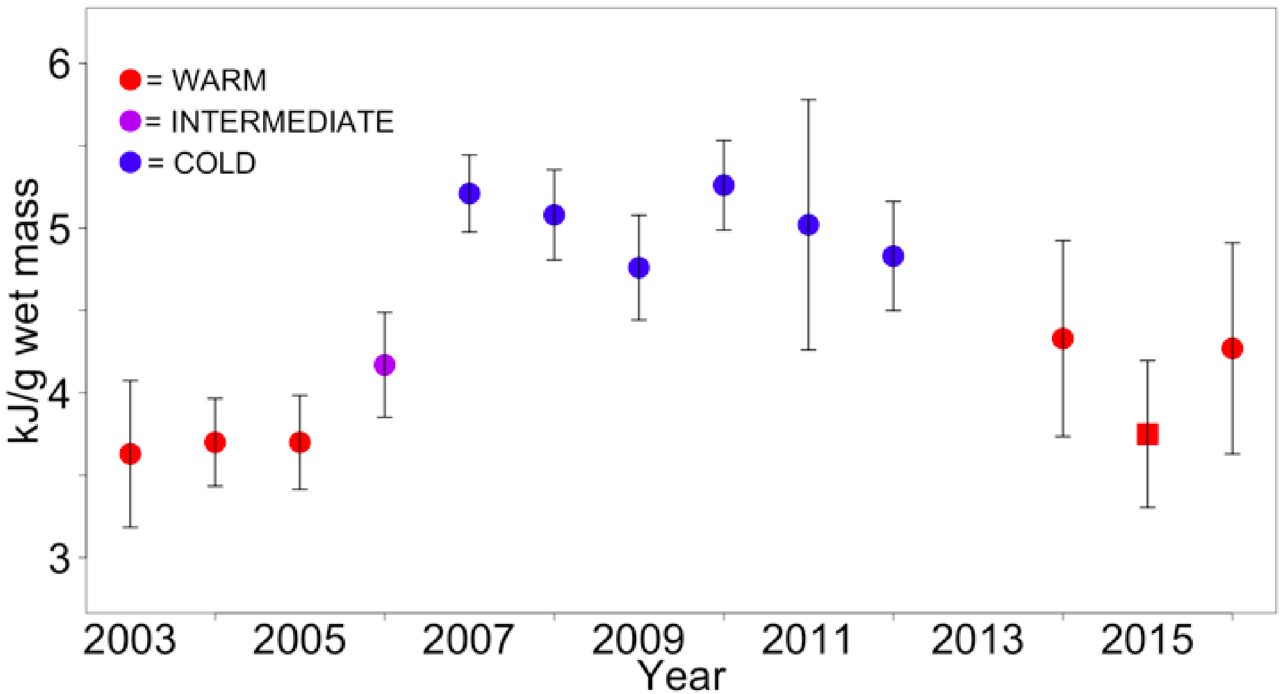

Figure 1. Average energy density (kJ/g) of age-0 Walleye pollock (*Gadus chalcogrammus*) collected during the late-summer BASIS survey in the eastern Bering Sea 2003-2016. Fish were collected with a surface trawl in all years except in 2015 when an oblique trawl was used.

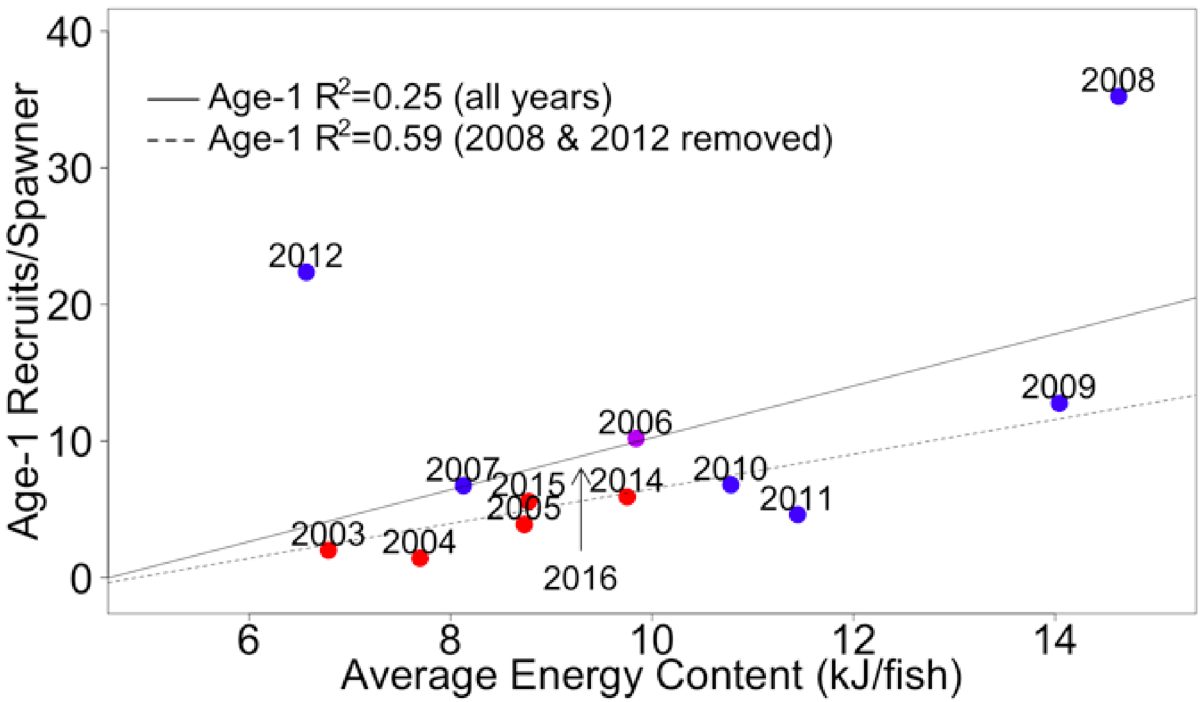

Figure 2. Relationship between average energy content (AEC) of individual age-0 Walleye pollock (*Gadus chalcogrammus*) and the number of age-1 recruits per spawner from the 2016 stock assessment (Ianelli et al., 2016). Fish were collected with a surface trawl in all years except in 2015 when an oblique trawl was used.

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Spatial Overlap of Age-0 Walleye Pollock and Foraging Landscapes Predicts Survival and Recruitmet Success - ABL

Age-0 Walleye pollock (*Gadus chalcogrammus*) abundance was estimated from the Bering-Arctic-Subarctic Integrated Survey (BASIS) conducted during late summer in 2003-2014. Zooplankton was sampled contemporaneously and provides information on available foraging landscapes. Year-, station-, and taxa-specific zooplankton biomass were weighted by year (or stanza)- and taxa-specific lipid values in order to determine spatially explicit estimates of prey availability.

The spatial overlap between age-0 pollock and prey availability was quantified using the Proportional Similarity Measure (Slobodchikoff and Schulz 1980) (Fig. 1). Index values range from 0-1, with higher values indicating greater proportion of overlap between age-0 pollock and lipid-rich zooplankton prey. This index of spatial overlap forecasts pollock cohort strength (as age-1 recruits per spawner; Ianelli et al. 2016) and indicates that different mechanisms may govern survival in warm versus cold years (Fig. 2).

The eastern Bering Sea experienced above-average (warm) conditions characterized by an early ice retreat and small or retracted cold pool between 2003-2005. Thermal conditions in 2006 were intermediate, indicating a transition, and ice retreated much later in the years 2007-2013 (i.e., cold conditions). Warm conditions returned in 2014. No clear pattern exists between the index of spatial overlap and thermal conditions (Fig. 1). However, a strong correlation between the overlap index and recruitment exists by climate stanza (warm versus cold years). In warm years (2003-2005, 2014), the overlap with lipid-rich prey accounts for 93% of the variation in the number of age-1 recruits per spawner. In cold years (2007-2012), overlap explains 68% of the variability (Fig. 2).

In the eastern Bering Sea, bottom-up processes shape foraging landscapes that ultimately determine the energetic condition and overwinter survival of age-0 pollock (Heintz et al., 2013). Additionally, timing of sea ice retreat and the spatial extent of the cold pool affect the distribution of age-0 pollock and also impact the distribution of adult pollock and other predators (e.g., Arrowtooth flounder, *Atheresthes stomias*) (Hollowed et al., 2013).

Multiple-year climate stanzas of warm conditions precipitate a trophic cascade that leads to a restructuring of the prey base, reduced energetic condition of age-0 pollock, and reduced overwinter juvenile pollock survival success (Duffy-Anderson et al., 2017). Under cold conditions, zooplankton prey are both larger and more lipid-rich; juvenile pollock are better provisioned going into winter; and have greater overwinter survival (Heintz et al., 2013). Therefore, survival (and subsequent recruitment) of age-0 pollock may be governed by different mechanisms in warm (bottom-up) and cold (bottom-up and top-down) years.

The spatial overlap of age-0 pollock and foraging landscapes helps to explain recruitment variability in the eastern Bering Sea. During periods of warm conditions, bottom-up processes affecting prey availability and condition (i.e., lipid content) appear to have a greater influence on survival and recruitment strength. Under cold conditions, bottom-up processes are important, while top-down processes that delineate the spatial overlap with predators also contribute.

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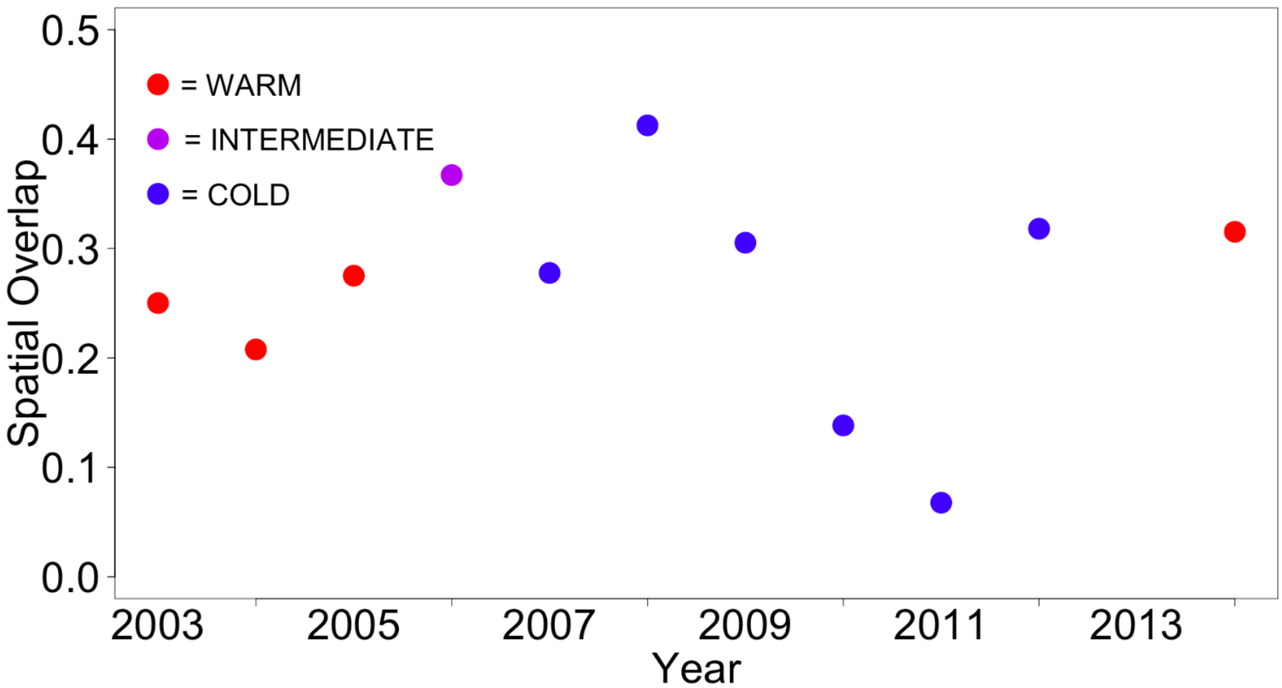

Figure 1. Index of spatial overlap for 2003 – 2014 (no survey in 2013). Values range 0-1 with higher values indicating greater proportion of overlap between age-0 Walleye pollock (*Gadus chalcogrammus*) and available zooplankton prey.

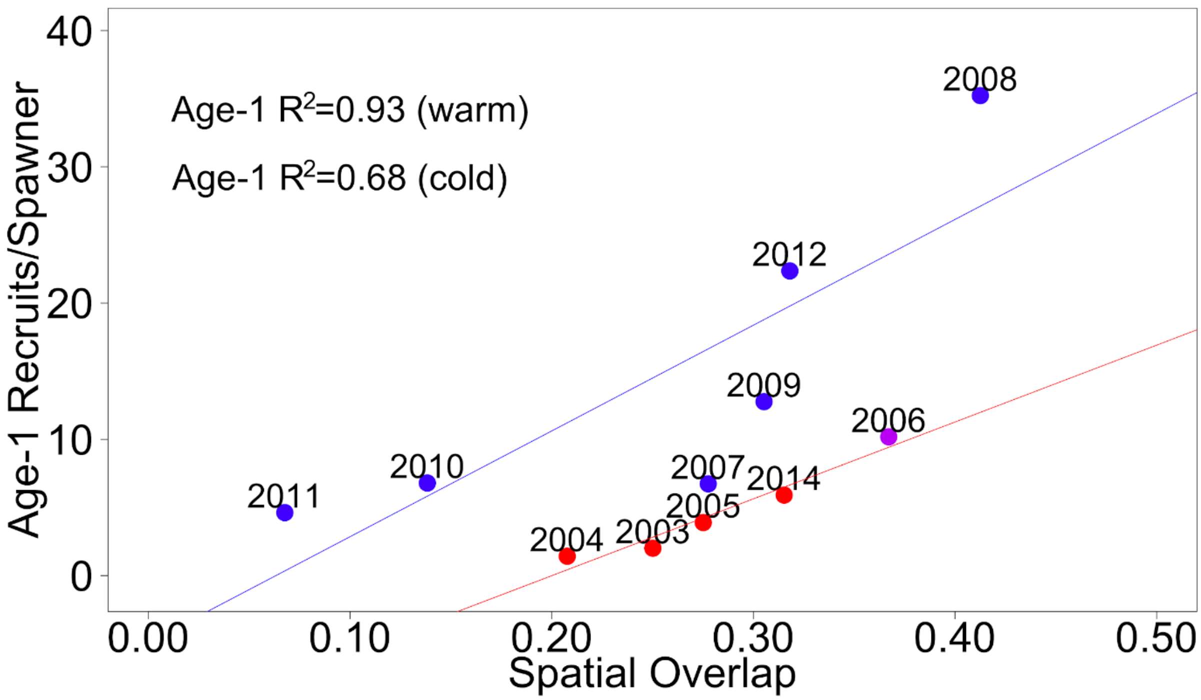

Figure 2. Relationship between the index of spatial overlap and the number of age-1 recruits per spawner from the 2016 stock assessment (Ianelli et al., 2016). The intermediate year (average thermal conditions; 2006) was not included in either relationship. No survey occurred in 2013.

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/cgi-bin/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 2017 TC index value is -6.16, lower than the 2016 TC index value of -3.19, indicating a decrease in conditions for pollock survival from age-0 and age-1 from 2016 to 2017, respectively. The decrease in expected survival is due to the larger difference in sea temperature from late summer (warmer) to the following spring (cooler). However, both the late summer sea surface temperature (13.0 °C) in 2016 and spring sea temperatures (6.4 °C) in 2017 were warmer than the long-term average of 9.7 °C in late summer and 5.1 °C in spring since 1949. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-4 from 1964 to 2016, but not significantly correlated for the shorter period (1995-2016).

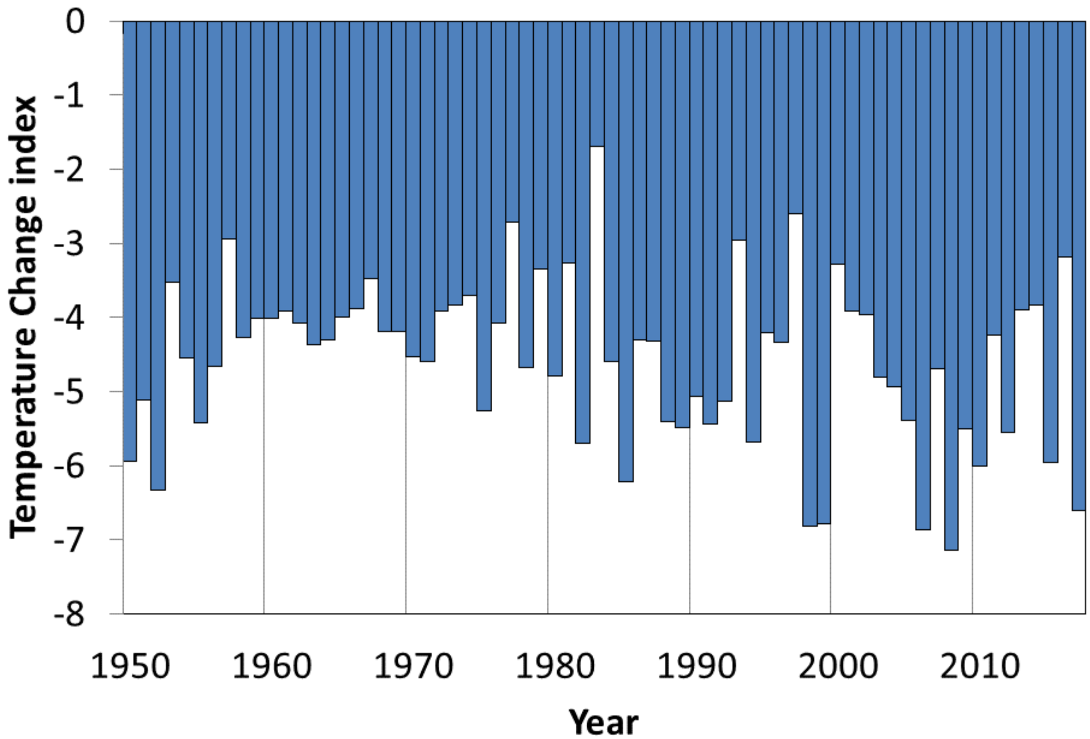

Figure 1: The Temperature Change index values from 1949 to 2017.

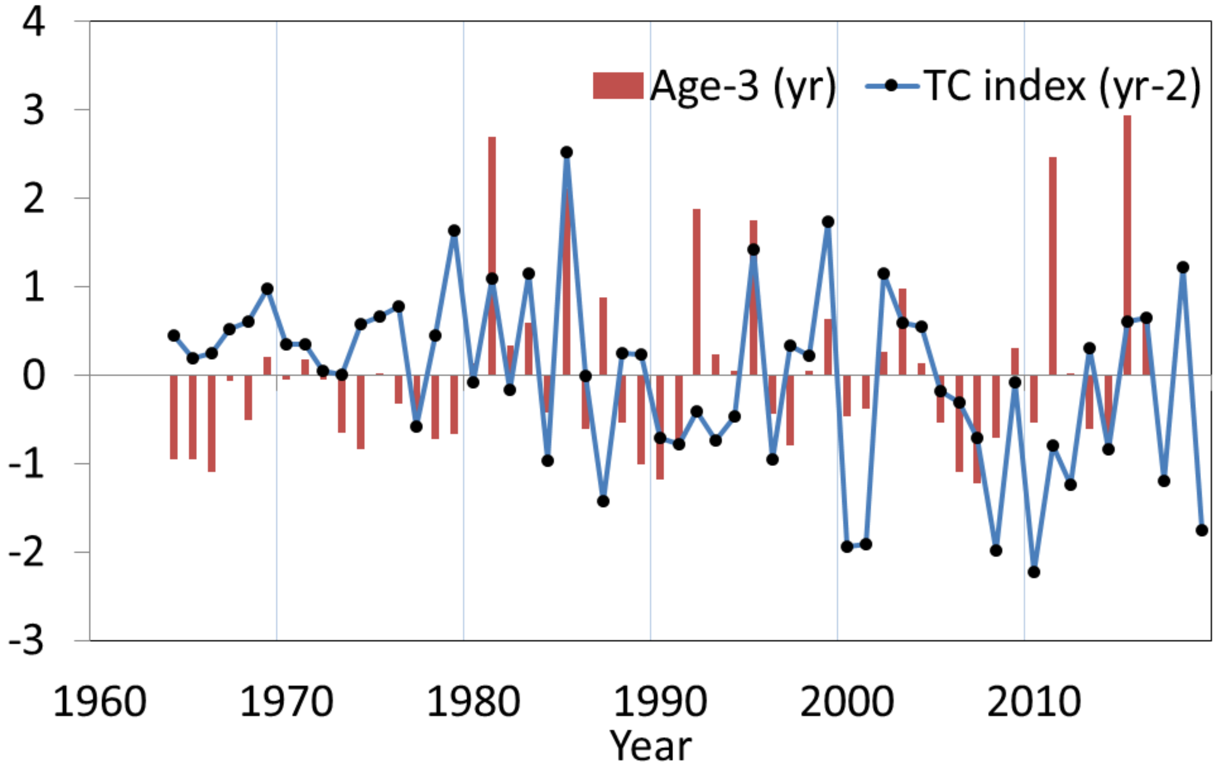

Figure 2: Normalized time series values of the temperature change index (t-2) from 1964-2019 indicating conditions experienced by the 1961-2016 year classes of pollock during the summer age-0 and spring age-1 life stages. Normalized values of the estimated abundance of age-3 walleye pollock in the eastern Bering Sea from 1964-2016 (t) for the 1961-2013 year classes. Age-3 walleye pollock estimates are from Table 1.30 in Ianelli et al. 2016. The TC index indicate above average conditions for the 2015 year class and below average conditions for the 2014 and 2016 year classes of pollock.

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	**0.34**	**0.34**	**0.32**	0.27	0.23	0.21
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. The 2016 year class of pollock experienced a warm summer during the age-0 stage and a cool spring in 2017 during the age-1 stage indicating poor conditions for over wintering survival from age-0 to age-1.

*Implications***:** The 2017 TC index value of -6.16 was below the long-term average of -4.61, therefore we expect lower than average recruitment of pollock to age-3 in 2019 from the 2016 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. The 2015 TC index value of -5.96 was below the long-term average, therefore we expect slightly below average recruitment of pollock to age-3 in 2017 from the 2014 year class.

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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 for the 2002-2014 year classes 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, 2014, and 2015 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 two warm years (2014 and 2015) using methods in Eisner et al. (2014). Zooplankton data was not available for 2013. Pollock abundance was available from the stock assessment report for the 2002-2015 year classes (Ianelli et al., 2016).

Status and trends: A positive significant (P = 0.002) linear relationship was found between mean abundances of large zooplankton during the age-0 stage of pollock and stock assessment estimates of abundance of age-1 pollock for the 2002-2015 year classes and age-3 pollock for the 2002-2013 year classes and of age-1 from Ianelli et al. (2016) (Figure 1).

For the prediction of age-1 pollock abundance, a model relating zooplankton abundance to the stock assessment estimates of the abundance of age-1 pollock for the 2002-2014 year classes () and large zooplankton abundance in 2015 (32.75) predicted 9,895 million (standard error =4,619 million) age-1 pollock in 2016 from the 2015 year class, below age-1 pollock abundance for the time series.
For the prediction of age-3 pollock abundance, a model relating zooplankton abundance (2002-2012) to the stock assessment estimates of the abundance of age-3 pollock in 2005-2015 for the 2002-2012 year classes () and large zooplankton abundance in 2014 (185) predicted 8,389 million (standard error =1,1816 million) age-3 pollock in 2017 from the 2014 year class, average abundance for the time series. The model and large zooplankton abundance in 2015 (32.75) predicted 2,704 million (standard error=1,188 million) age-3 pollock in 2018 from the 2015 year class, below average abundance for the time series.

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 fish that forage on these taxa. 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 decreases in the availability of large zooplankton prey during the first year at sea in 2015 were not favorable for age-0 pollock survival and recruitment to age 1 and 3. If the relationship between large zooplankton and age 3 (age 1) pollock remains significant in our analysis, the index was used to predict the recruitment of pollock three (one) years in advance of recruiting to age 3 (age 1), from zooplankton data collected three (one) 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).

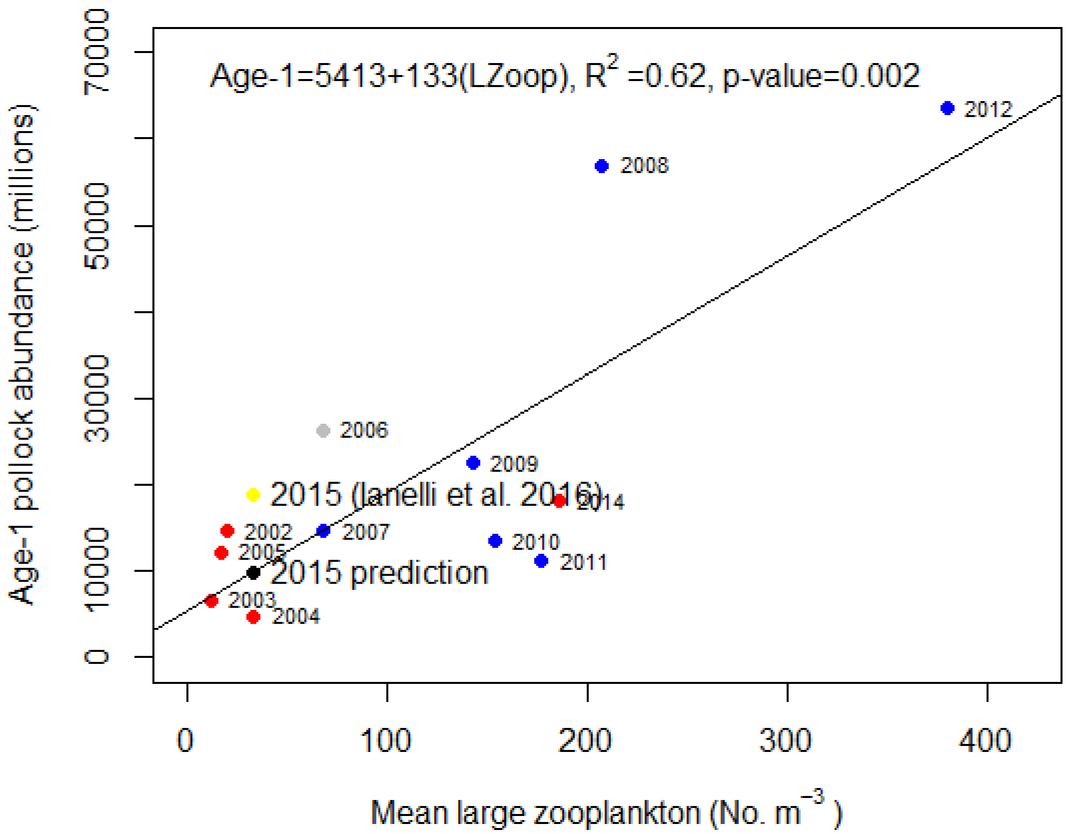

Figure 1. Linear relationships between mean large zooplankton abundance during the age-0 life stage of pollock and the estimated abundance of age-1 pollock abundance of the year class (2002-2015) from Ianelli et al. (2016). In the age-1 figure, the 2015 points are the "observed" stock assessment estimates of age-1 pollock from Ianelli et al. (2016) and the predicted numbers of age-1 pollock from our regression model and the large zooplankton values for 2015 (32.75). Points are labeled with year class. Red points are warm (low ice) years, blue are cold (high ice) years, gray is an average year and black is the predicted 2014 and 2015 year classes value from the model. No zooplankton data was available for 2013.

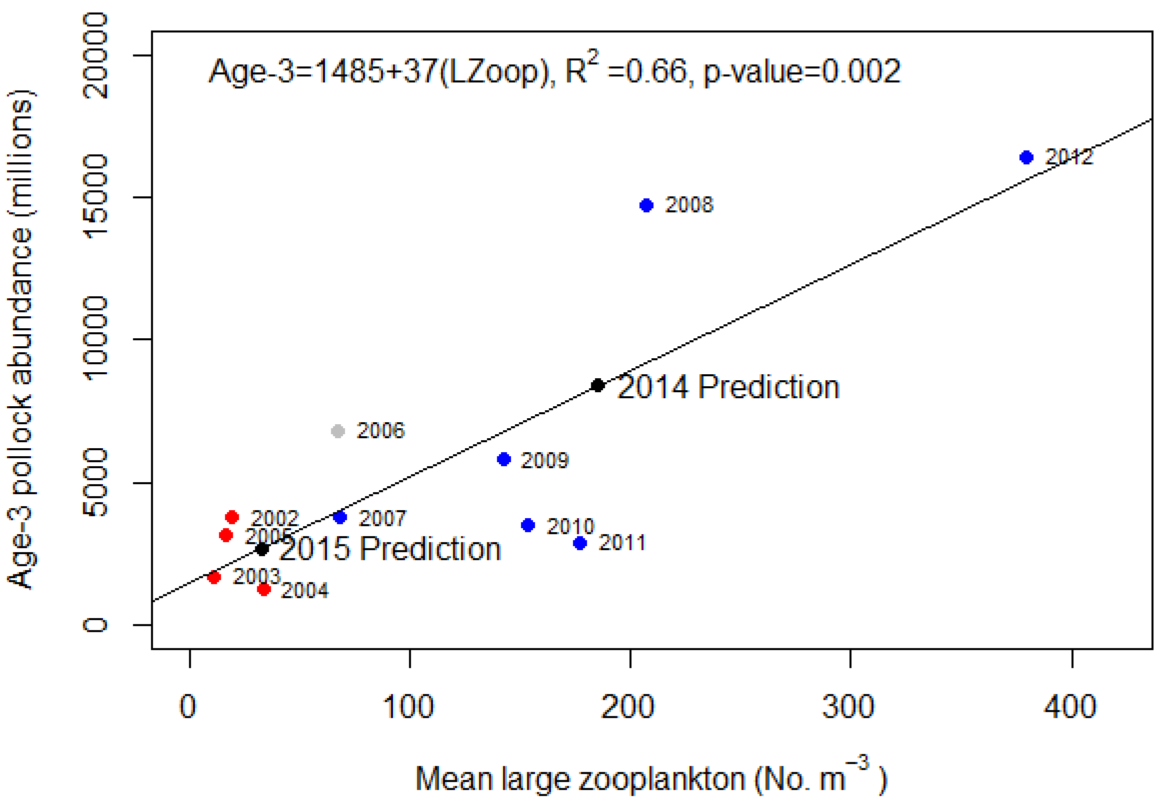

Figure 2. Fitted values and standard errors of the abundance of pollock estimated from the linear regression model relating the estimate pollock abundance from Ianelli et al. (2016) to the estimated abundance of large zooplankton the southeast Bering Sea during the age-0 life stage of pollock. Red symbols are stock assessment estimates of pollock abundance from Ianelli et al. (2016). Our regression models parameters and estimated abundance of large zooplankton in 2014 predicted an abundance of 9,805 million age-1 pollock with a standard error of 4,619 million for the 2014 year class and an abundance of 8,389 million age-3 pollock with a standard error of 1,116 million (blue) for the 2014 year class and 2,704 million age-3 pollock with a standard error of 1,188 million for the 2015 year class (blue).

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RACE Recruitment Processes Program (RPP)

The Recruitment Processes Program's (RPP) overall goal is to understand the mechanisms that influence the survival of young marine fish to 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 studied, we attempt to learn what biotic and abiotic factors cause or contribute to the observed fishery 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 used to better manage and conserve the living marine resources for which NOAA is the steward.

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Gulf of Alaska

Shifting Spawn Timing in Gulf of Alaska Walleye Pollock - RPP

Lauren Rogers and Annette Dougherty

The timing of spawning in marine fishes is key for delivering larval offspring to suitable habitats at a time when sufficient prey are available. While spawning time is relatively fixed in some species, others show flexibility depending on thermal conditions, as well as variation among individuals within a population. Such interannual and intrapopulation variation in spawn timing can have consequences for match or mismatch of first-feeding larvae with production of prey, and subsequent recruitment success. We used 30+ years of data from larval surveys to reconstruct timing of walleye pollock spawning in Shelikof Strait, the primary pollock spawning grounds in the Gulf of Alaska. We then considered potential climatic and demographic drivers of changes in spawn timing for this stock.

Ichthyoplankton surveys have been conducted by the NOAA AFSC EcoFOCI program on an annual or biennial basis since 1979, specifically targeting offspring of pollock spawning in Shelikof Strait, and focused in late-May. From these surveys, hatch dates of larvae were back-calculated by using information on larval size-at-age (from otoliths), larval length distributions, CPUE, and a mortality correction (Bailey et al. 1996) to account for different ages of larvae caught during the surveys. Spawn dates were back-calculated from hatch dates using temperature-dependent egg development rates (Blood, Matarese and Yoklavich 1994).

We found evidence that the mean date of spawning has varied by three weeks over the last three and a half decades. Most of the interannual variation in mean spawn date can be explained by mean age of the spawning stock and temperature during spawning, with an older spawning stock and warmer temperatures leading to early spawning. Duration of the spawning season also increased in warmer years and when the spawning stock was older, which has the potential to reduce recruitment variability through a portfolio effect (i.e. though a broader distribution of larval hatch dates). These results demonstrate that both climate conditions and demography influence spawn timing in walleye pollock, with further implications for the winter prespawning survey and the roe fishery.

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Otolith chemistry of juvenile walleye pollock *Gadus chalcogrammus* in relation to regional hydrography: evidence of spatially split cohorts - RPP

Matthew T. Wilson, Annette Dougherty, Mary Elizabeth Matta, Kathryn L. Mier, and Jessica A. Miller

Spatial and temporal variation in production is fundamental to the ecology and management of marine fish populations. Within populations, a cohort (year class) can be structured spatially into contingents that occupy different habitat and contribute differently to overall population productivity, stability, and resilience to environmental change. Spatial structure has been suggested within populations of walleye pollock, which support some of the world's largest fisheries. We demonstrate, using otolith microchemistry, that Age-0 juveniles from habitats that differ in exposure to the Alaska Coastal Current, within the western Gulf of Alaska, were separated for ≥3-7 weeks prior to collection (Figure 1). The duration of spatial separation explained demographic differences in growth rate and body size between the Kodiak and Semidi populations. We hypothesize that the existence of a Kodiak contingent buffers the western GOA population against losses due to density-dependent mechanisms in and downstream transport from the putative main nursery, which is inhabited by the Semidi contingent.

Wilson et al. (2018) Mar Ecol Prog Ser 588:163-178 (https://doi.org/10.3354/meps12425).

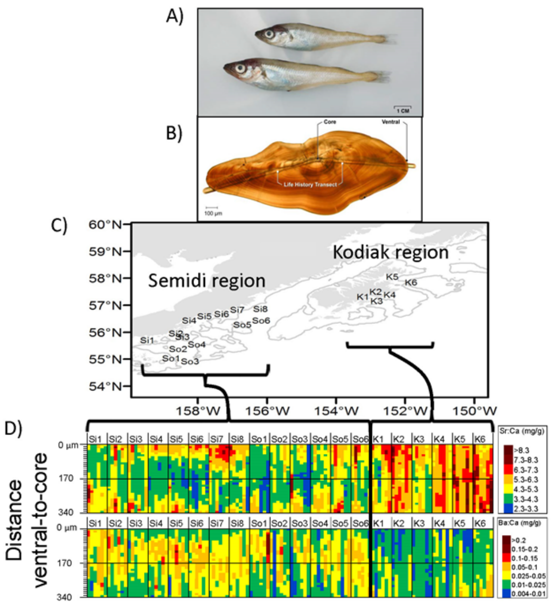

Figure 1. Age-0 walleye pollock (A) saccular otoliths (i.e. sagittae) (B) were collected from the western Gulf of Alaska during October 2011 (C) to examine element ratios along otolith life history transects. For Sr:Ca (D, top) and Ba:Ca (D, bottom), each column of pixels represents the ratios along a life history transect from the ventral edge inward 340 µm; "Semidi" fish had low Sr:Ca and high Ba:Ca relative to "Kodiak" fish.

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How regional differences in size, condition, and prey selectivity may have contributed to density-dependent regulation of 2013 year class of Walleye Pollock in the Western Gulf of Alaska - RPP
Jesse F. Lamb and David G. Kimmel

During the fall 2013 western Gulf of Alaska (WGOA) survey, age-0 walleye pollock (*Gadus chalcogrammus*) were found in high abundance compared to other years: an average of $0.42m^2$, compared to $0.06m^2$(2011) and $0.00087m^2$(2015). To assess the potential for density-dependent resource competition we are examining diet and condition of age-0 fish from the 2013 year class. We hypothesized that fish from different areas along the WGOA shelf may have had dietary differences that related to fish size and condition. We are testing this hypothesis by comparing fish size and condition in different regions of the WGOA to diets and prey distributions. Similar to previous studies, smaller, more numerous Pollock (n=503) were found southwest of Kodiak Island (Region A) and larger, less numerous Pollock (n=288) were found in the northeast WGOA, near Kodiak Island (Region B). We found pollock diet composition was similar in larger fish (60-80mm); however, differences in diet were found among the smaller fish (Fig 1, left). Using a measure of prey diet preference, the Prey-Specific Index of Relative Importance (PSIRI), we found significant overlap in the top five prey selected by pollock for both regions (Fig 1, right). Despite Region A having smaller fish than Region B, both regions shared the top two preferred prey items: large calanoid copepods and juvenile/adult euphausiids (Fig 1, right). Regional differences were found in the remaining selected prey items: pteropods and euphausiid calyptopis/furcilia stages in Region A compared to tunicates and anomuran crabs in Region B (Fig 1, right). These results may suggest density-dependent food limitation in Region A as higher quality prey may be been depleted by more numerous Pollock and this contributed to density-dependent mortality of the 2013 year class in the WGOA. We plan on examining pollock condition as well as finer scale spatial patterns in pollock diet composition moving forward.

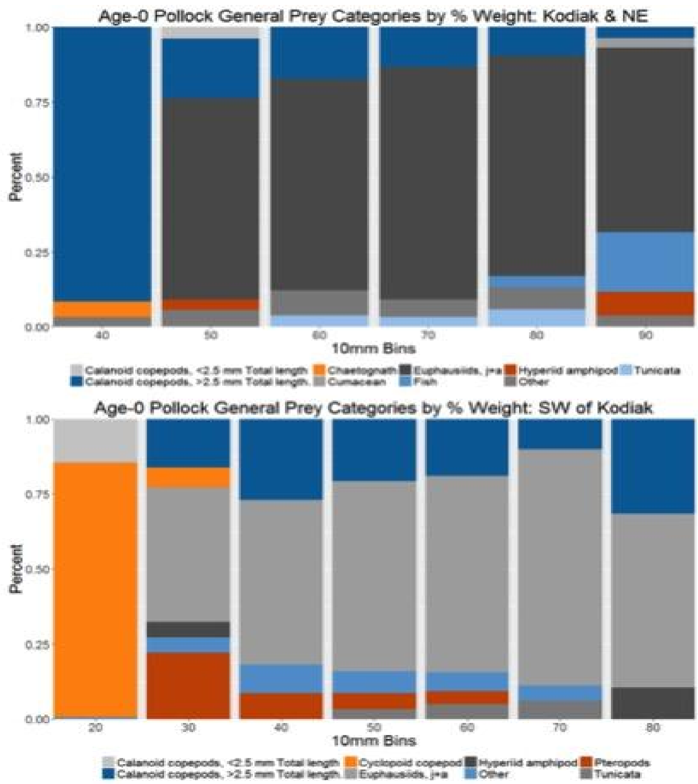

Figure 1. Age-0 pollock diet composition (percent weight) by 10mm length bins. The “Other” prey category was the sum total of prey categories that comprised less than 3% of the total prey weight in both regions.

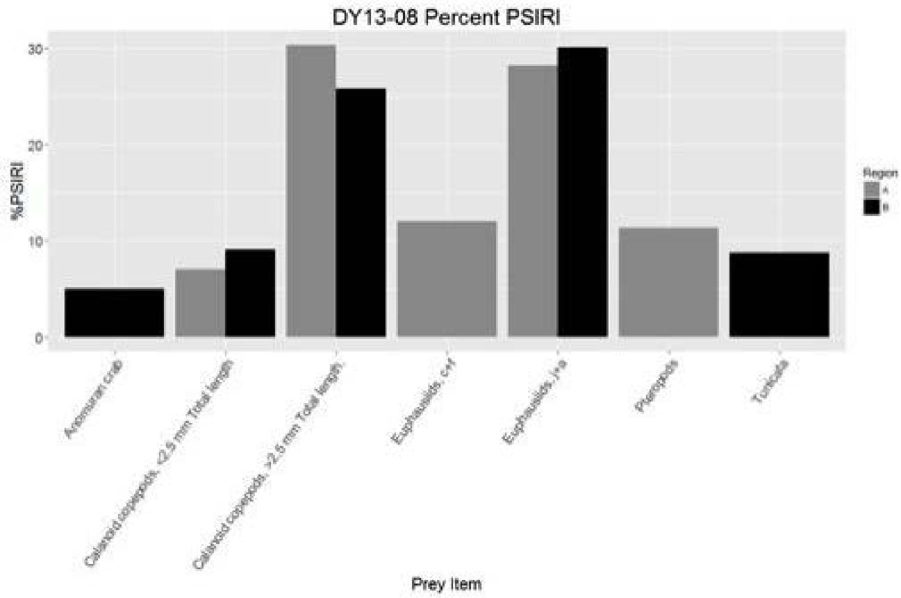

Figure 2. The top five selected prey taxa as determined by the PSIRIfor stations southwest of Kodiak Is. (Region A) and stations surrounding and to the northeast of Kodiak Is. (Region B).

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Bering Sea

Vertical Distribution of age-0 walleye pollock in the eastern Bering Sea - RPP

Adam Spear and Alex Andrews

As part of the Bering Arctic Subarctic Integrated Survey (BASIS), we analyzed acoustic –trawl (AT) survey data collected on the Oscar Dyson during routine research surveys over the SEBS shelf. A cold year (2012), an intermediate year (2011), and 2 warm years (2014-2016) were included in the analysis to compare the vertical distribution of age-0 walleye Pollock (*Gadus chalcogrammus*) during different temperature regimes. Surface, midwater, and oblique tows were conducted using the Cantrawl, Marinovich, and Nets-156 trawls. Age-0 pollock AT data collected during intermediate and cold years showed a deeper vertical distribution, while age-0 pollock AT data collected during warm years showed a shallower, more surface oriented distribution. Although not observed, shifts to deeper, colder water during warm years could provide a metabolic refuge from warm surface waters (see Duffy-Anderson et al., 2017), as well as an improved prey base as age-0 pollock follow the diel vertical migration patterns of major prey species (copepods, euphausiids) to promote continued vertical overlap with prey. Further studies will include depth specific changes in condition of fish to determine whether age-0 pollock in deeper waters during warm years have higher energy density.

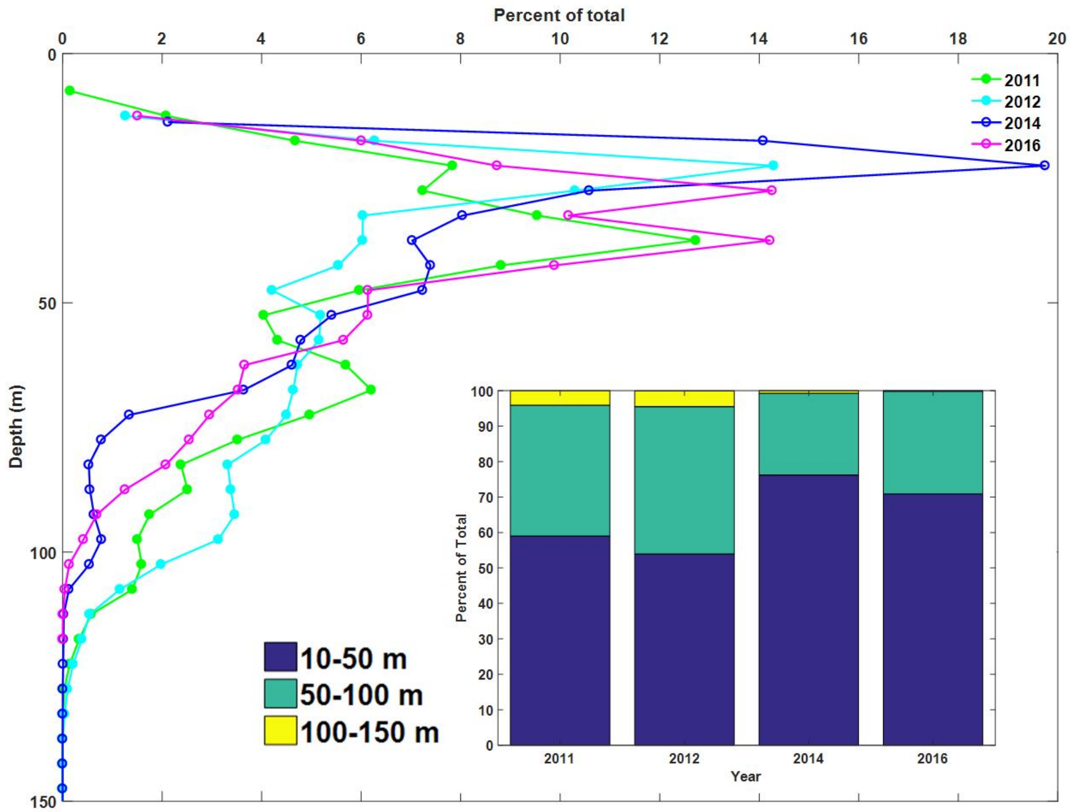

Figure 1. Depth distribution as percent of total abundance (fish nmi^{-2}) of age-0 pollock estimated by acoustic-trawl methods in 2011,2012, 2014,2016. Both plots show a shift in distribution towards the surface during warm years (2014, 2016). Colder years show a shift towards deeper waters.

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US Arctic

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

Chang Seung and James Ianelli*
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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.

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2. Stock Assessment

Gulf of Alaska – REFM

In 1998, the 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 unfished stock size, but declined to 39% by 2016. The spawning stock is projected to increase again in 2018 as the strong 2012 year class continues to increase in body size. Survey data in 2017 are contradictory, with acoustic surveys indicating large or increasing biomass, and bottom trawl surveys indicating a steep decline in recent years. These divergent trends are likely due to changes in the availability of pollock to different surveying methods, though additional research is needed to confirm this hypothesis.

The stock assessment model estimate of female spawning biomass in 2018 is 342,683 t, which is 57.5% of unfished spawning biomass (based on average post-1977 recruitment) and above the $B_{40\%}$ estimate of 238,000 t. The 2017 pollock assessment features the following new data: 1) 2016 total catch and catch-at-age from the fishery, 2) 2017 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2017 biomass and length composition from NMFS bottom trawl survey, 4) 2017 biomass and 2016 age composition from the ADFG crab/groundfish trawl survey, and 5) 2017 biomass and length composition from the summer GOA-wide acoustic survey.

The age-structured assessment model used for GOA W/C/WYAK pollock assessment was slightly modified from the 2016 assessment (Model 16.2). The 2017 assessment compared 4 models to the Model 16.2 with the new data:

Model 17.1—Age composition data reweighted using the Francis (2011) method.

Model 17.2—Same as model 17.1, but with random walks in survey catchability for the Shelikof Strait acoustic survey and the ADFG survey. This was the author's preferred model.

Model 17.3—Same as 17.2, but a smaller penalty on variation in catchability.

Model 17.4—Same as 17.2, but with an offset for natural mortality for the 2012 year class.

Model 17.1 explored using the Francis (2011) method in place of the McAllister and Ianelli method (1997) used since 2014. While this change reduced the effective sample size of age composition data by 46-86%, the model results did not appear to be particularly sensitive to the weighting method used.

Models 17.2 and 17.3 implemented a random walk process to estimate year specific catchability for the Shelikof Strait and ADF&G trawl surveys, as the proportion of total stock observed by these surveys could be expected to not be constant. Model 17.3 differs from 17.2 in that the penalty term for annual variation was increased, allowing greater change in year-to-year catchability estimates. Model 17.2 was chosen as being less likely to overfit the data given a

stronger constraint on change in catchability.
Model 17.4 implemented a cohort specific natural mortality for the 2012 year class, under the assumption that this may be lower given the dominance of this year class in the current surveys. A 26% reduction in M was estimated by the model, but the improvement in overall fit was negligible and therefore not recommended going forward.

Model 17.2 fits to biomass estimates follow general trends in survey time series. Fits to fishery age composition data were reasonable where 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. The model did not fit the most recent high Shelikof Strait acoustic survey biomass estimate, as this input was in contrast with the NMFS bottom trawl survey in 2017, which was substantially lower than previous years, and an age-structured pollock population cannot increase as rapidly as is indicated by this estimate. The model was unable to fit the extreme low value for the ADFG survey for 2015-2017, 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. Therefore the assessment author chose to use Model 17.2.

Because the model projection of female spawning biomass in 2018 is above $B_{40\%}$, the W/C/WYAK Gulf of Alaska pollock stock is in Tier 3a. The projected 2018 age-3+ biomass estimate is 1,124,930 t (for the W/C/WYAK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock dropping below $B_{20\%}$ is negligible (< 1 %) through 2022. For 2019, F_{ABC} was adjusted downward to $F_{47\%}$ based on the author's recommendation.

The 2018 ABC for pollock in the Gulf of Alaska west of 140° W longitude (W/C/WYAK) is 161,492 t which is a decrease of 21% from the 2017 ABC. The OFL is 187,059 t for 2018. The 2018 Prince William Sound (PWS) GHL is 4,037 t (2.5% of the ABC). For pollock in southeast Alaska (East Yakutat and Southeastern areas), the ABC for both 2018 and 2019 is 8,773 t and the OFL for both 2018 and 2019 is 11,697 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 1990-2017 bottom trawl survey biomass estimates in Southeast Alaska.

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

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.

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

Eastern Bering Sea - REFM

Spawning biomass in 2008 was at the lowest level since 1980, but has increased by 150% since then, although spawning biomass is projected to decline from the current high level in the near term. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent increases were fueled by recruitment from the very strong 2008, 2012, and 2013 year classes (126%, 152%, and 68% above average for the post-1976 time series, respectively), along with spawning exploitation rates in 2009-2017 that averaged 11% below the post-1976 time series average. Spawning biomass is projected to be 80% above B_{MSY} in 2018.

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

The 2017 NMFS bottom-trawl survey (BTS) biomass and abundance at age estimates were included.·The 2016 NMFS acoustic-trawl survey (ATS) biomass and abundance at age estimates were updated based on age data collected from the ATS sampling (in 2016 the BTS age-length key was used).

The ATS age data from 1994-2016 that includes the bottom layer analysis (0.5-3m from bottom) was completed and used in the base/reference model (last year the accompanying biomass time series for these data were evaluated but the full set of age data was unavailable). This is new to the assessment.

Two additional years of opportunistic acoustic data from vessels transiting the EBS shelf region were processed and the time series now extends from 2006-2017.

Observer data for catch at age and average weight at age from the 2016 fishery were finalized and included.

Total catch as reported by NMFS Alaska Regional office was updated and included through the 2017 fishing season. There were no changes to assessment methodology this year.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates of B_{MSY} and the probability density function for F_{MSY}. The updated estimate of B_{MSY} from the present assessment is 2.043 million t, down 6% from last year's estimate of 2.165 million t. Projected spawning biomass for 2018 is 3.679 million t, placing EBS walleye pollock in sub-tier "a" of Tier 1. As has been the approach for many years, 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 0.466, up 17% from last year's value of 0.398. The harvest ratio of 0.398 is multiplied by the geometric mean of the projected fishable biomass for 2018 (7.714 million t) to obtain the maximum permissible ABC for 2018, which is 3.598 million t, up 15% and down 4% from the maximum permissible ABCs for 2017 and 2018 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 seven reasons for doing so in the SAFE chapter.

During the period 2010-2013, ABC harvest recommendations were based on the most recent 5-year average fishing mortality rate. Beginning in 2014, however, stock conditions had improved sufficiently that an increase in the ABC harvest rate was appropriate. Specifically, the Team and SSC recommended basing the ABCs on the harvest rate associated with Tier 3, the stock's Tier 1 classification notwithstanding. The Team recommends continuing this approach for setting the 2018 and 2019 ABCs, giving values of 2.592 million t and 2.467 million t, respectively.

The OFL harvest ratio under Tier 1a is 0.622, 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 2018 determines the OFL for 2018, which is 4.797 million t. The current projection for OFL in 2019 given a projected 2018 catch of 1.390 million t is 4.592 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.

The appendix to the SAFE chapter describes a multi-species model ("CEATTLE") involving walleye pollock, Pacific cod, and arrowtooth flounder. The authors view this as a "strategic" model rather than a model that would be used for setting annual harvest specifications. Nevertheless, the 2018 "target" ABC values from CEATTLE are similar to the maximum permissible ABC value from the stock assessment (being 2% and 11% higher than the value from the stock assessment when CEATTLE is run in single-species mode and multi-species mode, respectively). Like the authors of the stock assessment, the authors of the CEATTLE appendix suggest setting the actual 2018 ABC at a significantly lower value (although based on a different harvest control rule than the Tier 3 rule).

Several of the concerns listed by the stock assessment authors in support of their ABC recommendation involve ecosystem considerations, specifically:

Because the environmental conditions in summer 2017 followed a warm period, precaution may be warranted, since warm conditions are thought to negatively affect the survival of larval and juvenile pollock. There is apparently a considerable amount of pollock showing up in the northern part of the shelf beyond the traditional EBS shelf survey area, approximately 1.3 million t in 2017. (The authors clarified during the Team meeting that this is a concern because, if it reflects a unidirectional migration and further such migrations occur in the future, this could reduce the biomass in the traditional EBS shelf survey area).

Pollock are an important prey species for the ecosystem and apparent changes in the distribution may shift their availability as prey. In particular, fur seal populations around the Pribilof Islands have had declines in pup production from 2014-2016. The extent that fishing intensity can allow for continued prey availability could be considered as a means to minimize further declines in the fur seal populations.

The CEATTLE model suggests that the B_{MSY} level is around 3.6 million t instead of the 2.3 million t estimated in the current assessment (noting that total natural mortality is higher in the multi-species model).

Aleutian Islands

This year's assessment estimates that spawning biomass reached a minimum level of about $B_{30\%}$ in 1999 and has since generally increased, with a projected value of $B_{38\%}$ 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 $B_{40\%}$ 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 $F_{35\%}$ as 0.42 and $F_{40\%}$ as 0.33. Under Tier 3b, with the adjusted $F_{40\%}$=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 $F_{35\%}$=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

In accordance with the approved schedule, no assessment was conducted for Bogoslof this year, however, a full stock assessment will be conducted in 2018. Until then, the values generated from the previous stock assessment are rolled over for 2018 specifications. Additional information listed below summarizes the 2016 assessment. 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 from which to make 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 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 assessment authors recommended using the biomass estimate based on the average of the three most recent surveys (228,000 t) for ABC.

The maximum permissible ABC value for 2017 is 97,428 t (assuming $M = 0.3$ and $F_{ABC} = 0.75 \times M = 0.225$ 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. The walleye pollock stock in the Bogoslof district 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.

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F. Pacific Whiting (hake)

G. Rockfish

1. Research

Pacific Ocean Perch Genomic Studies – ABL

DNA sequences are the result of the spatio-temporal dynamics in biological populations. With the advent of next generation sequencing techniques, we are now able to harness this information to test old hypothesis and pose new ones. We used Restriction Site Associated DNA sequencing (RAD-seq) technique to obtain 11,146 single nucleotide polymorphic (SNPs) sites from 401 POP young of the year collected during the 2014 (19 stations) and 2015 (4 stations) GOAIERP surveys in the Eastern Gulf of Alaska. Our results show that the collections represented four to seven distinct populations confirming the DisMELS model predictions of populations from various parturition locations mixing during larval dispersal.

We are also beginning to explore new questions that can be addressed with the genomic data. For example, a genome-wide association study where all the loci are tested for correlation against physiological and environmental gradients, revealed signatures of natural selection. And although only few of the selected loci were found in the NCBI (National Center for Biotechnology Information) database we were still able to make limited inference on which specific gene coding protein variants were selected for or against. Based on the represented loci, we found that POP young of the year condition and growth was associated with gene variants coding for cellular growth, duplication and membrane trafficking, and interestingly a gene variant coding for TAAR13c-expressing olfactory sensory neurons. The TAAR13c receptor is activated by low concentrations of cadaverine, a diamine emanating from decaying flesh. In laboratory studies, it was found that zebrafish exhibit a powerful and innate avoidance behavior to cadaverine (Hussain, Ashiq, et al. "High-affinity olfactory receptor for the death-associated odor cadaverine." Proceedings of the National Academy of Sciences 110.48 (2013): 19579-19584.).

Latitudinal gradient was also found to be associated with a set of annotated gene variants. Interestingly, these genes code for proteins that are linked to stress, especially heat and muscle regeneration. These findings imply that POP young of the year are facing various selection forces during their first year at sea. Hence each adult cohort DNA signature is a result of the environmental conditions experienced during their first year at sea. These findings support the idea of a selective sieve hypothesis where the strongest selection occurs during the initial larval and YOY stages in response to environmental conditions, food availability and predator abundances. By examining the DNA sequences of older fish cohorts, we may be able to reconstruct environmental pressures they experienced as young of the year.

In 2017, we were able to obtain YOY and adult DNA samples from the Eastern and Western Gulf of Alaska. Pending further funding, we plan to analyze them and verify the findings to date as well as elucidate new insights into POP biology.

For more information, contact Jacek Maselko (Jacek.Maselko@noaa.gov).

Alaska rockfish environmental DNA (eDNA) - ABL

BACKGROUND

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. polyspinis). By collecting water samples in areas of untrawlable habitat, we hope to better understand rockfish habitat utilization by identifying the presence of rockfish in areas inaccessible to typical sampling procedures. 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.

METHODOLOGY

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. DNA concentration was determined within the water samples and next generation sequencing analyses identified individual taxa within a subset of 10 samples.

RESULTS

Twenty-eight paired samples (56 samples total) from surface (10 m) and bottom waters, 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.

Laboratory processing of the filter membranes revealed that all contained DNA, except for the negative controls. A preliminary analysis of a subset of samples identified several broad categories of taxa present in the water samples including several fish (Figure 2). The semi-quantitative results demonstrated a distinct difference between the amount of DNA detected from surface and bottom samples, especially for groundfish species. Additional samples are currently being processed and further analyses may identify additional taxa, including crabs, shrimp, octopus, coral, sponge, otters, and whales. In subsequent analyses, we hope to further refine the results and relate DNA concentrations to habitat.

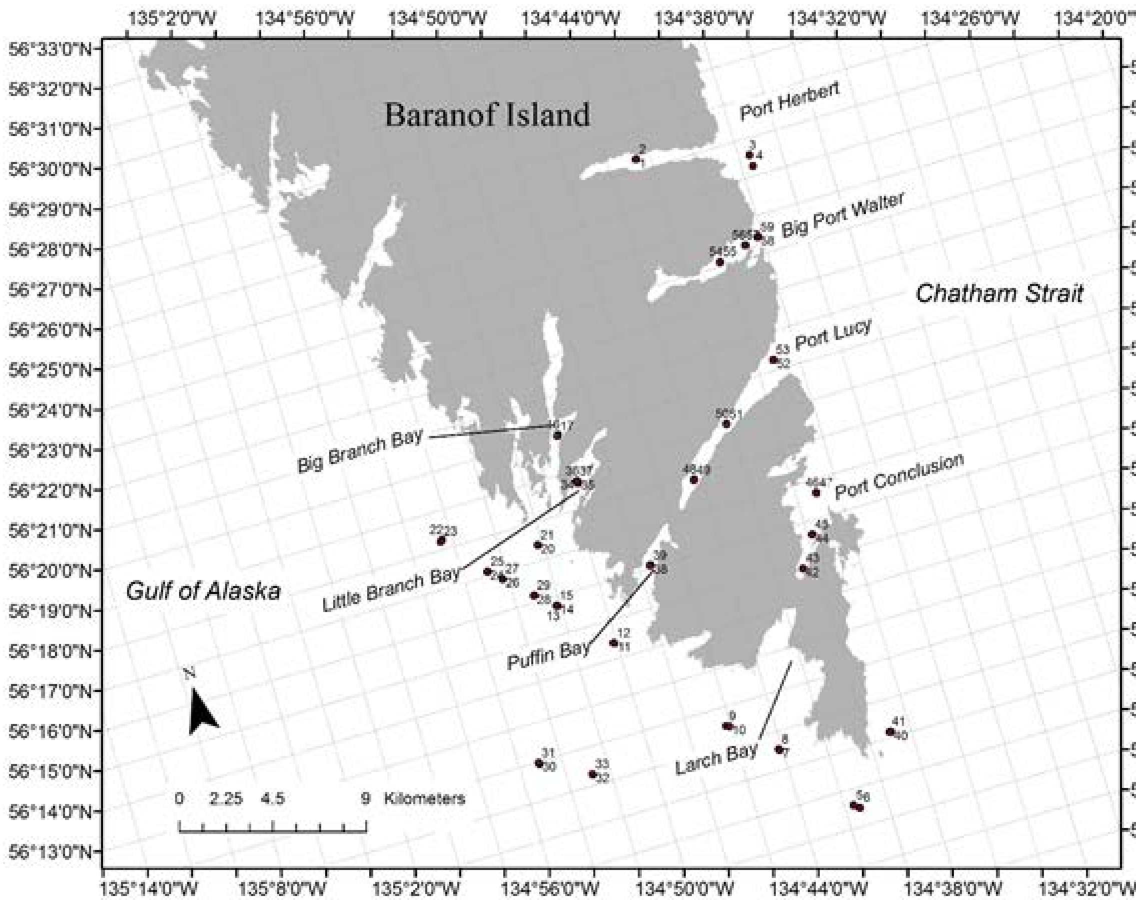

Figure 1. Map of eDNA sampling locations near southern Baranof Island.

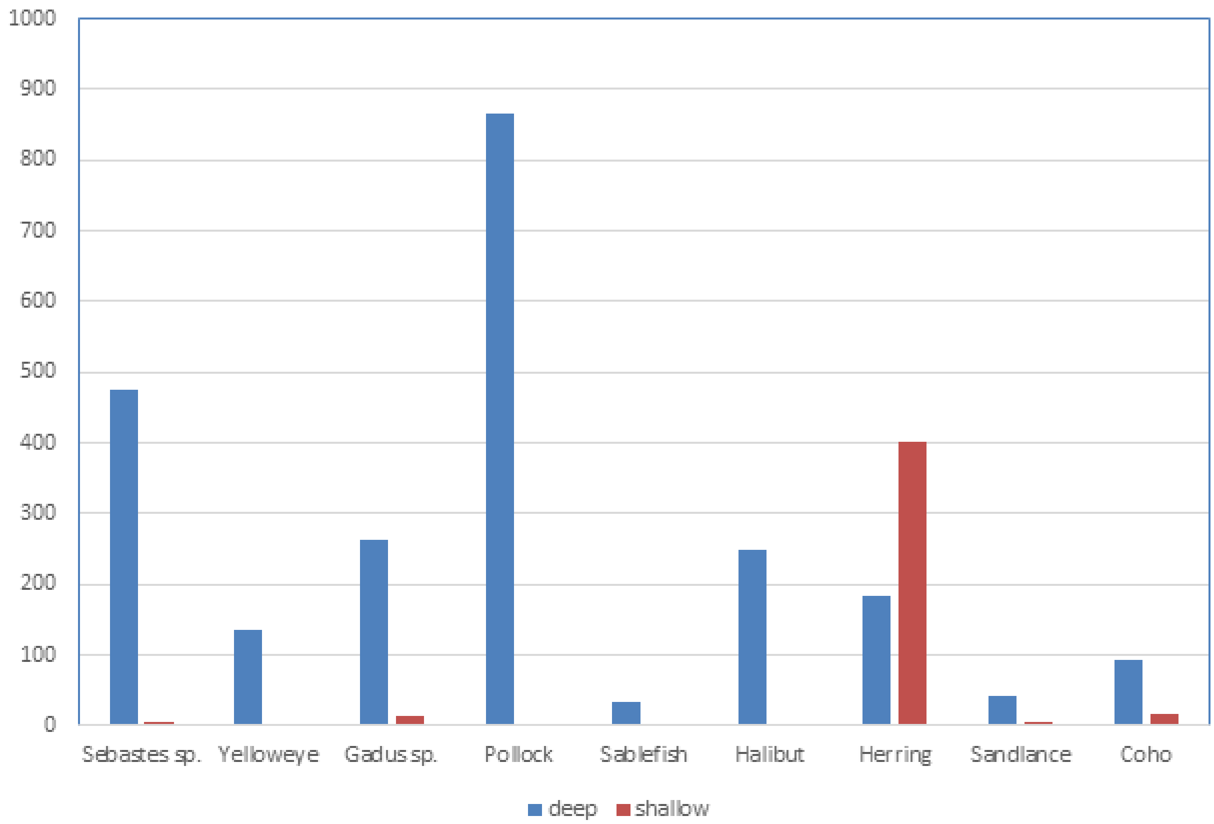

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Figure 2. Number of eDNA fragments aligned with reference DNA sequences by species and sampling depth from a subset of water samples collected near southern Baranof Island, Southeast Alaska.

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

The seasonal use of habitat by rockfishes within the Gulf of Alaska is not well understood and more research is needed to determine the relative importance of high relief habitats containing biotic structures to these species within this region. We examined the density and community structure of commercially important rockfishes in the Gulf of Alaska in three habitat types during three seasons. Low relief, high relief, and habitat containing structure forming invertebrates (biotic habitat) were sampled during spring, summer, and winter seasons at three sites (Portlock Bank, the 49 Fathom Pinnacle, and the Snakehead Bank) in the central Gulf of Alaska near Kodiak Island using stereo drop cameras (SDC) and bottom trawls. Stereo drop cameras were also used in several locations throughout the central and eastern Gulf of Alaska to determine if localized rockfish/habitat relationships were consistent over a broader region within this large marine ecosystem. The community structure within all three sites was dominated by dusky rockfish (*Sebastes variabilis*), northern rockfish (*S. polyspinis*), Pacific ocean perch (*S. alutus*), and harlequin rockfish (*S. variegatus*). Community structure and density between seasons were not significantly different but there were differences between sites and habitats within these sites. Stereo drop camera images showed that high relief and biotic habitats had higher rockfish densities and that rockfish densities were highest at the 49 Fathom Pinnacle site. Community structure differed between sites with the 49 Fathom Pinnacle site dominated by adult dusky, northern, and harlequin rockfish while the Snakehead Bank site was dominated by juvenile Pacific ocean perch, harlequin rockfish, and other small or juvenile rockfish. Within the Snakehead Bank site, the low relief habitat had a completely different community structure dominated by flatfish while the high relief and biotic habitats were dominated by rockfishes. The pattern of higher densities in high relief areas was also found in the camera transects throughout the broader central Gulf of Alaska for northern, dusky, and harlequin rockfish, but not for Pacific ocean perch. This research highlighted the role of complex habitat as Essential Fish Habitat for juvenile Pacific ocean perch and adult northern and dusky rockfish throughout the entire year.

Conrath, C. C. Rooper, R. Wilborn, D. Jones, and B. Knoth (in preparation) Seasonal habitat use and community structure of rockfishes in the Gulf of Alaska.

Conrath, C. (in preparation) Reproduction potential of dusky and northern rockfish related to habitat within the Gulf of Alaska.

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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 deep water rockfish species including: the rougheye rockfish complex (rougheye and blackspotted rockfish, *S. aleutianus* and *S. melanostictus*), and shortraker rockfish, *S. borealis*. 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 2021.

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. Initial analyses of rougheye rockfish collected during this later reproductive season indicate that the length at maturity values were similar to the earlier period but skipped spawning rates were about 15% lower for this species.

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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. Preliminary analyses of these samples indicate that the length at maturity values are similar to the earlier time period but rates of skipped spawning were about 15% lower.

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2. Assessment

Pacific Ocean Perch (POP) – Bering Sea and Aleutian Islands - REFM

The Pacific Ocean perch assessment for 2017 was presented as a “partial assessment” format because it was a scheduled “off-year” assessment under the new Stock Assessment Prioritization guidelines. Therefore, only the projection model was run, with updated catches. New data in the 2017 assessment included updated 2016 catch and estimated 2017 and 2018 catches. No changes were made to the assessment model. A new feature included in the “off-year” assessments was a figure describing exploitation rate (i.e., catch/biomass).

The survey biomass estimates in the Aleutian Islands were high in 2016 and the female spawning biomass is estimated at 1.5 times the $B_{40\%}$ level. New projections were very similar to last year's projections because observed catches were very similar to the estimated catches used last year. Spawning biomass is projected to be 305,804 t in 2018 and to decline to 295,593 t in 2019. Exploitation rates by area since 2004 appeared to be low in all areas.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 214,685 t, 0.082, and 0.101, respectively. Spawning biomass for 2018 (305,804 t) is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier "a" of Tier 3. The 2018 and 2019 catches associated with the $F_{40\%}$ level of 0.082 are 42,509 t and 41,212 t, respectively, and are the recommended ABCs. The 2018 and 2019 OFLs are 51,675 t and 50,098 t.

ABCs be set regionally based on the proportions in combined survey biomass as follows (values are for 2018): EBS = 11,861 t, Eastern Aleutians (Area 541) = 10,021 t, Central Aleutians (Area 542) = 7,787 t, and Western Aleutians (Area 543) = 12,840 t. The recommended OFL for 2018 and 2019 is not regionally apportioned. Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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Pacific Ocean Perch -- Gulf of Alaska - ABL

Pacific ocean perch total biomass has been increasing since the early 1980s (currently at 1.4 times the $B_{40\%}$ level). The stock assessment model estimates a 13% increase in spawning biomass from 2017 to 2018, and a 22% increase in ABC. The spawning stock biomass is projected to decrease by 1.4% from 2018 to 2019.

Changes to the input data include updated survey biomass estimates for 2017, survey age compositions for 2015, fishery age composition for 2014 and 2016, final catch for 2015 and 2016, and preliminary catch and projected catches for 2017-2019. The fishery length composition data was changed to 1 cm length bins with a plus group of 45 cm. The 1984 and 1987 bottom trawl survey biomass and age composition data were removed from the assessment.
Two changes to the 2015 assessment model were recommended for this year: 1) bottom trawl survey biomass is fit with a log-normal distribution; and 2) an additional fishery selectivity time period (2007-present) was added to accommodate the Central GOA rockfish program and the availability of older fish to the fishery.

The GOA Pacific ocean perch stock is in Tier 3a. The recommended model resulted in an estimated maximum permissible ABC of 29,236 t ($F_{ABC} = F_{40\%}$ of 0.094). The F_{OFL} is specified to be equal to the $F_{35\%}$ (0.113) and results in an OFL of 34,762 t. The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

The harvest apportionment for 2018 and 2019 is from the random effects model. Amendment 41 prohibited trawling in the Eastern GOA east of 140° W longitude. Trawling is allowed in the W. Yakutat (between 147° W and 140° W) portion of the Eastern GOA, and the proportion of Eastern GOA biomass is 0.58, smaller than the estimate of 0.61 from the 2015 assessment. The random effects model was not applied for the WYAK and EYAK/SEO split and the weighting method of using upper 95% confidence of the ratio in biomass between these two areas used in previous assessments was continued.

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Dusky Rockfish-- Gulf of Alaska -- ABL

In 2017, the scheduled frequency for some stock assessments was changed in response to the National Stock Assessment Prioritization effort. Prior to 2017, Gulf of Alaska (GOA) rockfish were assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. The new schedule sets full assessments for dusky rockfish in the 'off' survey years (even years) and partial assessments for the 'on' survey years (odd years). In 2017 a partial assessment consisting of an executive summary including recent fishery catch and survey results was conducted, and harvest levels for the 2018 and 2019 were recommended. Estimates of spawning biomass for 2018 and 2019 from the current year (2017) projection model are 21,559 t and 20,151 t, respectively. Both estimates are above the $B_{40\%}$ estimate of 19,707 t. The exploitation rate has been less than 6% every year since 1991.

There were no changes in the assessment methods. New data added to the projection model included updated 2016 catch and new projected catches for 2017-2019. The dusky rockfish stock is in Tier 3a and the recommended maximum permissible 2018 ABC of 3,957 t was from the updated projection model. This ABC is 8% lower than the 2017 ABC of 4,278 t.
The stock is not being subject to overfishing, is not currently overfished, nor is it approaching an overfished condition. The following table shows the recommended ABC apportionment for 2018 and 2019. The apportionment percentages are the same as in the last full assessment.

Area Apportionment	Western	Central	Eastern	Total
2018 Area ABC (t)	146	3,502	309	3,957
2019 Area ABC (t)	135	3,246	287	3,668

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

Northern Rockfish – Bering Sea and Aleutian Islands - REFM

This chapter was presented in a "partial assessment" format because it was a scheduled "off-year" assessment under the new Stock Assessment Prioritization guidelines. Therefore, only the projection model was run, with updated catches. New projections were slightly different from last year's projections because observed catches were quite different from the estimated catches used last year. Spawning biomass is projected to be 106,486 t in 2018 (1.6 times the $B_{40\%}$ level) and to decline to 104,699 t in 2019. Exploitation rates by area since 2004 appeared to be low in all areas in most years.

New data in the 2017 assessment included updated 2016 catch and estimated 2017 and 2018 catches. No changes were made to the assessment model. A new feature included in the "off-year" assessments was a time series of exploitation rate (i.e., catch/biomass). It has been determined that reliable estimates of $B_{40\%}$,

$F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying northern rockfish for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 65,870 t, 0.065, and 0.80, respectively. Spawning biomass for 2018 (106,486 t) is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier "a" of Tier 3. The 2018 and 2019 catches associated with the $F_{40\%}$ level of 0.065 are 12,975 t and 12,710 t, respectively, and are the authors recommended ABCs. The 2018 and 2019 OFLs are 15,888 t and 15,563 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

For Gulf of Alaska northern rockfish in 2017, a partial assessment was presented to recommend harvest levels for the next two years. The 2018 spawning biomass estimate (28,017 t) is just above $B_{40\%}$ (27,983 t) and projected to decrease to 26,512 t (below $B_{40\%}$) in 2019. Total biomass (2+) for 2018 is 74,748 t and is projected to decrease to 73,814 in 2019.

There were no changes in assessment methodology. New data added to the projection model included updated catch data from 2015 (3,944 t) and 2016 (3,437 t), and new estimated catches for 2017-2019. The 2018 spawning biomass estimate (28,017 t) is above $B_{40\%}$ (27,983 t) and projected to decrease to 26,512 t in 2019. Total biomass (2+) for 2018 is 74,748 t and is projected to decrease to 73,814 in 2019.

Northern rockfish are estimated to be in Tier 3a in 2018 and 3b in 2019. The assessment authors recommended to use the maximum permissible 2018 ABC and OFL values of 3,685 t and 4,380 t, respectively. This stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

Area apportionments of northern rockfish ABC's for 2018 and 2019 are based on the random effects model applied to GOA bottom trawl survey biomass estimates through 2015 for the Western, Central, and Eastern Gulf of Alaska resulting in the following percentage area apportionments: Western 11.40%, Central 88.50% and Eastern 0.01%. Note that the small northern rockfish ABC apportionments from the Eastern Gulf are combined with other rockfish for management purposes. 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

In accordance with the approved schedule, no assessment was conducted for shortraker this year, however, a full stock assessment will be conducted in 2018. Until then, the values generated from the previous stock assessment (below) will be rolled over for 2018 specifications. Additional information listed below summarizes the 2016 assessment.

2016 was a full assessment for this Tier 5 stock; there were no changes in the assessment methodology. 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 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 CVs at 0.23 and 0.26, respectively. According to the random effects model, 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 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.

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 biomass estimate was based on the random effects model. The Team recommended setting F_{ABC} at the maximum permissible level under Tier 5, which is 75 percent of *M*. The accepted value of *M* for this stock is 0.03 for shortraker rockfish, resulting in a $maxF_{ABC}$ value of 0.0225. The ABC is 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. For 2018, the biomass estimate was updated with 2017 survey data. Estimated shortraker rockfish biomass is 38,361 t, which is a decrease of 33% from the previous estimate in the 2015 assessment. Catch data were updated as well.

Shortraker rockfish has always been classified into “tier 5” in the North Pacific Fishery Management Council’s (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, we continue the use of a random effects model applied to the trawl survey data from 1984 – 2017 to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2018 fishery. Estimated shortraker biomass is 38,361 mt, which is a decrease of 33% from the 2015 estimate. This is the first substantial decline in biomass since seeing a progressive increase in biomass since 1990. The NPFMC’s “tier 5” ABC definitions state that FABC ≤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 863 t for the 2018 fishery. Gulfwide catch of shortraker rockfish was 776 t in 2016 and estimated at 547 t in 2017. Shortraker rockfish in the GOA 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.

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Blackspotted/rougheye Rockfish Complex – Bering Sea and Aleutian Islands - REFM

This chapter is a partial assessment and update of the 2016 full assessment and used the Tier 3 age-structured model applied to the BSAI whereas previously the model was only used for the AI portion of the assessment. Spawning biomass for BSAI blackspotted/rougheye rockfish in 2018 is projected to be 8,208 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 AI (2016) increased substantially from the low estimate in 2014. New data included updated catch for 2016 and estimated catches for 2017 - 2019.

For the BSAI, this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$. Because the projected female spawning biomass for 2018 of 8,208 t is less than $B_{40\%}$, (8,311 t) the stock qualifies as Tier 3b but is projected to be in Tier 3a in 2019 and the adjusted $F_{ABC} = F_{40\%}$ values for 2018 and 2019 are 0.044 and 0.045, respectively. The maximum permissible ABC for the Aleutian Islands is 501 t, which is the recommendation for the AI portion of the 2018 ABC. The apportionment of 2018 ABC to subareas is 239 t for the Western and Central Aleutian Islands and 374 t for the Eastern Aleutian Islands and Eastern Bering Sea. The recommended overall 2018 ABC of 613 t and a 2018 OFL of 749 t. It is unknown if the blackspotted and rougheye rockfish complex is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

Given on-going concerns about fishing pressure relative to biomass in the Western Aleutians, the SSC requested that the apportionment by sub-area be calculated and presented. The maximum subarea species catch (MSSC) levels within the WAI/CAI for 2018, based on the random effects model, are as follows: Western Aleutians = 35 t, Central Aleutians = 204 t.

Blackspotted/rougheye Rockfish Complex – Gulf of Alaska - 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. In accordance with the new assessment schedule frequency, a full assessment was conducted for RE/BS in 2017.

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.

A full assessment was completed for these species in 2017. Data input changes included the following: Updated catch estimates for 2016, new catch estimates for 2017-2019, new fishery ages for 2014 and 2016, new fishery lengths for 2015, a new trawl survey biomass estimate for 2017, new trawl survey ages for 2015, and new longline survey relative population numbers (RPN) and lengths for 2016 and 2017. There were no changes to the assessment methodology.

Model results indicate that the 2018 projected spawning biomass estimate (15,059 t) is 1.7 times the $B_{40\%}$ estimate (8,998 t) but is projected to slightly decrease to 14,972 t in 2019. The rougheye/blackspotted complex qualifies as a Tier 3a stock. For the 2018 fishery, the Plan Team accepts the authors' recommended maximum permissible ABC of 1,444 t ($F_{ABC} = F_{40\%} = 0.04$) and OFL of 1,735 t ($F_{OFL}=F_{35\%} = 0.048$).

This stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. The apportionment percentages have changed with the addition of the 2017 trawl survey biomass. In past assessments, apportionment was based on a 4:6:9 weighted average of the proportion of biomass in each area from the three most recent bottom trawl surveys. The Plan Team and SSC have requested that the random effects model be applied to the bottom trawl survey data. However, the RE/BS model includes the longline survey in the model. Rather than switching to another apportionment method, the authors continue to recommend status quo until the Survey Averaging Working Group can provide recommendations on what apportionment to use for stocks with multiple surveys and regional variability in the sampling error. Area apportionments based on the three-survey weighted average method are as follows for 2018: Western GOA = 176 t, Central GOA = 556 t, and Eastern GOA = 712 t.

Gulfwide catch of rougheye and blackspotted rockfish remains relatively stable in all areas, with some decrease in the central GOA and slight increase in the eastern GOA in 2017. The majority of the RE/BS rockfish catch remains in the rockfish and sablefish fisheries. The 2017 bottom trawl survey increased by 16% from the 2015 survey and is now near average for the time series. The 2017 longline survey abundance estimate (relative population number or RPN) increased about 50% from the 2016 estimate and well above the long-term mean. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished.

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H. Thornyheads

1. Research

2. Stock Assessment

Gulf of Alaska - ABL

Rockfish have historically been assessed on a biennial stock assessment schedule to coincide with the availability of new trawl survey data (odd years). In 2017, the Alaska Fisheries Science Center participated in a stock assessment prioritization process. It was recommended that the Gulf of Alaska (GOA) thornyhead complex remain on a biennial stock assessment schedule with a full stock assessment produced in even years and no stock assessment produced in odd years. However, we performed a partial stock assessment for this year because the allowable biological catch (ABC) has been exceeded in the past in the western GOA, and because the biomass estimates provided by the GOA trawl surveys have at times displayed extreme variability between surveys. For 2018, the biomass estimate was updated with 2017 survey data. Estimated thornyhead rockfish biomass is 90,570 t, which is an increase of 4% from the previous estimate in the 2015 assessment. Catch data were updated as well.

Gulf of Alaska thornyheads (*Sebastolobus* species) are assessed as a stock complex under Tier 5 criteria in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, we continue the use of a random effects model applied to the trawl survey data from 1984 – 2017 to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2018 fishery. Estimated thornyhead biomass is 90,570 t, which is an increase of 4% from the 2015 estimate. 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 FABC ≤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 2,038 t for the 2018 fishery. Gulfwide catch of thornyhead rockfish was 1,119 t in 2016 and estimated at 1,012 t in 2017. 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.

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I. Sablefish

1. Research

Sablefish (*Anoplopoma fimbria*) reared in the laboratory to verify age, growth, and development for comparison to wild caught larvae from the western Gulf of Alaska - RPP

Annette Dougherty, Steven Porter, and Alison Deary

We conducted a pilot study of sablefish larvae rearing with the following objectives:

1. Validate daily increment formation in otoliths using alizarin complexone (ALC) staining to determine if field-collected larvae may be correctly aged for growth studies.

2. Document early-life development (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 at Manchester, Washington provided eggs and milt. Gametes were transported to the Alaska Fisheries Science Center larval fish rearing laboratory in Seattle, Washington. Eggs and yolk-sac larvae were kept in the dark at 5.6°C until first feeding at which time the temperature was raised to 6.8°C and a light cycle started to emulate larvae rising into the surface water. A sub-set of eggs/larvae were kept isolated in a smaller rearing tank and immersed in a 25 mg/l alizarin complexone (ALC) solution to validate the periodicity of increment formation. Skeletal development was assessed using a clearing and staining technique modified from Taylor and Van Dyke (1985). In this technique, calcified elements stain red and un-calcified structures stain blue.

Results
<u>Development at 5.6°C</u>
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>

Figure 1. Hatch: large yolk, no body or eye pigment, mouth not formed, well defined hatch mark on otoliths

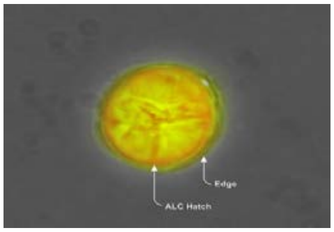

Figure 2. Result of 6 hour immersion of larva in 25 mg/l ALC solution. Sagitta otolith removed from a 5.2 mm larva preserved 3 days after hatch (ALC hatch mark, 1 increment, and edge).

8 days after hatch: eyes pigmentation begins, larvae reactive to touch and short bursts of swimming observed, gut apparent

15 days after hatch: cartilage of lower jaw forms

16 days after hatch: eyes fully pigmented (may be functional at this time)

17 days after hatch: first elements of gills form

19 days after hatch: first and second gill arch present, pectoral fin supported by a single element (cleithrum)

22 days after hatch: mouth apparent but not functional, cartilaginous elements that form muscle attachment points for functional mouth opening and closing first develop

27 days after hatch: first feeding, yolk still present

28 days after hatch: precursor to maxilla of the upper jaw formed

30 days after hatch: larvae attracted to light and swim to the surface

Figure 3. Sablefish larva (9.04 mm SL) 38 days after hatch. Yolk depleted.

43 days after hatch: all elements of ventral gills present but not ossified

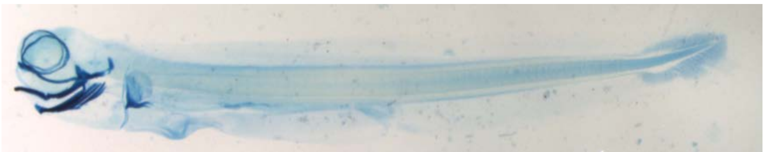

Figure 4. Lateral view of cleared and stained Sablefish larva (~8.59 mm notochord length (NL)) 43 days after hatch.

45 days after hatch: skeletal development begins in caudal region

49 days after hatch: ossification of cleithrum

59 days after hatch: hemal arches begin to form in caudal region; caudal fin supports develop

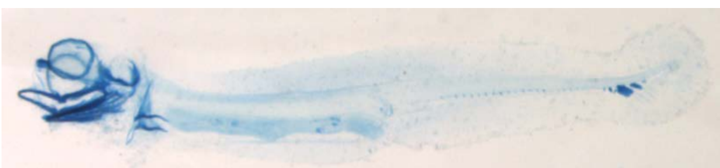

Figure 5. Lateral view of cleared and stained Sablefish larva (9.31 mm NL) 59 days after hatch.

Sablefish have a prolonged period of yolk-sac retention after hatching of approximately 5 weeks in comparison to walleye pollock (*Gadus chalcogrammus*), which reach yolk depletion about 2 weeks after hatching. Since sablefish spawning may begin as early as January in the Gulf of Alaska, this prolonged yolk-sac retention may prevent starvation in wild sablefish since the peak in zooplankton production does not occur until spring. ALC staining validated that a well-defined increment is deposited on the otoliths at hatch (defines day 1 for fish ageing), but otoliths from older larvae that had been marked several times throughout the rearing experiments suggest that daily increment deposition does not continue or is beyond the resolution of a the microscope at 1000X (<1 µ). Further samples will be analyzed to determine if daily or non-daily increment deposition continues throughout larval development. The laboratory reared fish will serve as validation specimens to aid in the interpretation of otolith increments and condition of the larvae from the field.

During this study, we also conducted the first examination of the internal anatomy of sablefish and have identified some potential bottlenecks related to the developmental state of feeding and swimming structures. First feeding was observed at 27 days post-hatch after several cartilaginous structures developed that provided muscle attachment and necessary leverage to open and close the lower jaw. Although the maxilla was present in the upper jaw, it remains rudimentary throughout the sizes examined, suggesting that only elements of the lower jaw were involved in feeding by the end of the study (59 dph). Feeding is likely accomplished by a combination of suction and ram feeding, where pre-flexion sablefish overtake prey in the water column while using some suction pressure to overcome the viscosity of the water. Ossification is delayed in sablefish, relative to other species such as walleye pollock, with only a single element in the pectoral fin being ossified by the end of the study period (59 days after hatch). By examining development at a fixed temperature in laboratory-reared specimens, we have assembled an early developmental series that can be used to assess the developmental state and functional abilities of field-collected specimens.

For more information please contact Annette Dougherty at: Annette.Dougherty@noaa.gov

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 2017. Total sablefish tag recoveries for the year were around 715. Twenty three percent of the recovered tags in 2017 were at liberty for over 10 years. About 36 percent of the total 2017 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 37 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 39 years, and the greatest distance traveled of a 2017 recovered sablefish tag was 1,544 nm. Six adult sablefish and five juvenile sablefish tagged with archival tags were recovered in 2016. First reports describing the vertical movement (using collected depth data) of adult sablefish from these electronic tags are currently in review.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye rockfish are also maintained in the Groundfish Tag Database. Eighteen thornyhead (17 conventional and 1 electronic) and 1 Greenland turbot were recovered in 2017.

Releases in 2017 on the groundfish longline survey totaled 3,322 adult sablefish, 877 shortspine thornyheads, and 9 Greenland turbot. Pop-up satellite tags (PSAT) were implanted on 3 spiny dogfish. An additional 164 juvenile sablefish were tagged during a juvenile sablefish tagging cruise in 2017.

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

Juvenile Sablefish Studies – ABL

Juvenile sablefish tagging studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2017. A total of 164 juvenile sablefish were caught and tagged and released in St. John Baptist Bay and Silver Bay near Sitka, AK over 4 days (July 9 – July 12) with 91 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 1.96 sablefish per rod hour fished. This was down significantly from 2016 (9.72), and the lowest since 2014 (1.04). Overall CPUE had been increasing since around 2006, but 2017 did not follow that trend. The mean length of sablefish was slightly higher than in 2016 but still lower than the recent average for the same time of year. Notably, the sablefish near the hatchery were much larger than last year and larger than the fish in SJBB, probably as a result of the much lower density encountered this year.

For more information contact Dana Hanselman at dana.hanselman@noaa.gov

Sablefish Archival Tagging Study - ABL

Archival tags were implanted into 599 adult sablefish (*Anoplopoma fimbria*) to study their diel vertical migration (DVM). Of these tags, 98 were recovered with usable depth data that we used to identify DVM and to classify DVM into 1 of 2 types, Type 1 DVM (rise from bottom during nighttime) and Type 2 DVM (rise from bottom during daytime). Our study demonstrates 3 important attributes of DVM for sablefish. First, DVM occurred widely. Nearly all tagged sablefish (97%) exhibited DVM. Although widespread, the occurrence of DVM was intermittent (12% of days). Second, bottom depth for Type 1 DVM was about 130 m shallower than for Type 2 DVM. Third, for both DVM types, one high and one low in the occurrences of both DVM types were observed each year, but their timing was mismatched.The occurrence of Type 1 DVM was highest in fall and lowest in spring, whereas the occurrence of Type 2 DVM was observed about 3 months later. The most probable explanation for Type 1 DVM by sablefish is that they move to follow vertically migrating prey. Type 2 DVM more commonly occurs during winter, likely representing an increase in foraging during the daytime to compensate for decreased pelagic resources in winter.

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

A comparison of methods for classifying female sablefish maturity– ABL

For sablefish, the spawning season is estimated to peak in February. Typically, sampling platforms, such as the NMFS longline survey in Alaska, occur from June through August (Figure 1). This encompasses the time in the reproductive cycle when fish are either resting or beginning to develop. The goal of this study was to determine if maturity classifications collected during summer surveys in Alaska could be used to accurately predict if fish would spawn in the coming winter and whether histology was required to accurately classify ovarian development. The maturity classification methods included 1) macroscopic classification at-sea by scientists that varied throughout the survey period, 2) macroscopic classification after the survey from photographs by a single experienced scientist (standardized macroscopic), and 3) a microscopic evaluation of ovarian structures from histological slides by the same scientist as in 2.

On the latter two legs of the survey in August, particularly leg 7, there were a greater proportion of fish in later stages of vitellogenesis than on earlier legs of the survey (Figure 2). This indicates that observations on later legs of the survey will provide more accurate predictions of whether a fish will spawn. Overall, the at-sea macroscopic method resulted in earlier estimates of age or length at maturity. The magnitude of the effect varied by survey leg. The standardized macroscopic and microscopic methods yielded very similar results. Because sampling ovaries, processing histological slides, and analyzing ovarian structures is a more expensive and time consuming method of classifying ovarian development than macroscopic methods, our results demonstrate that the standardized macroscopic method may be practical to use in place of microscopy when there are time and fiscal constraints.

For more information contact Cara Rodgveller (cara.rodgveller@noaa.gov).

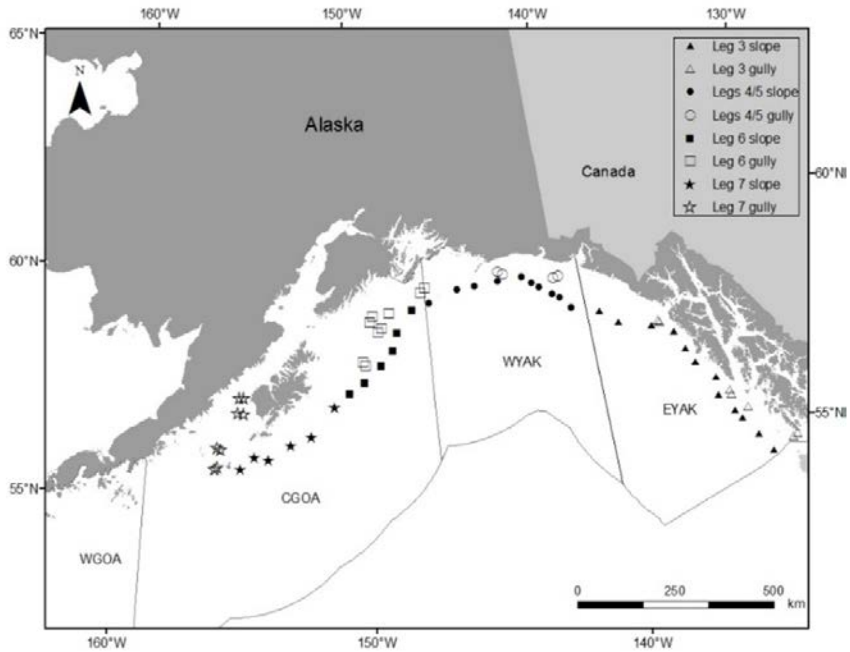

Figure 1. Map of AFSC longline survey stations sampled on survey legs 3-7. Leg 3 is sampled in early July and the vessel heads westward, ending at the western side of the central Gulf of Alaska at the end of August.

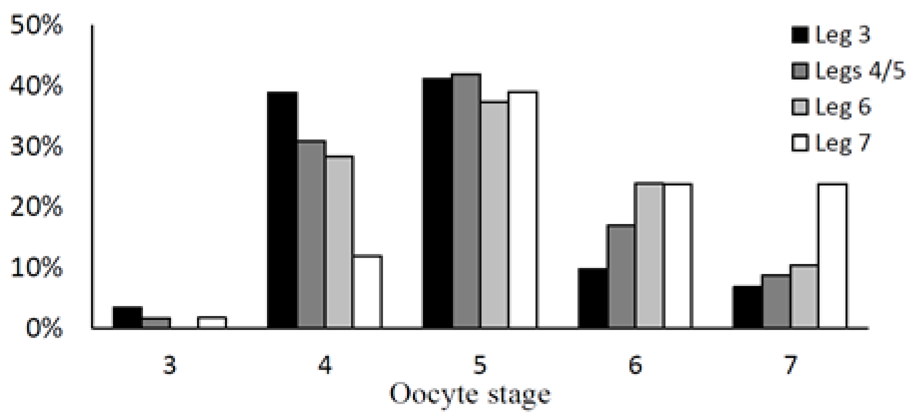

Figure 2. Frequency of each oocyte development stage by leg of the Alaska Fisheries Science Center longline survey in July and August, where the developmental stage is the most advanced oocyte stage in the ovary. Stages 3 through 7 are progressively later stages of vitellogenesis.

The utility of relative liver size and body condition for predicting maturity and fecundity of sablefish – ABL

Female sablefish were sampled on four survey legs during a summer longline survey in July (legs 3 through 5) and August (legs 6 through 7) 2015 and during a winter survey in December 2015, which is 1 to 3 months prior to spawning in the Gulf of Alaska. The body condition and liver size relative to body size (hepatosomatic index, HSI) increased throughout the summer and by the end of the summer were similar to winter measurements (for HSI see Figure 1). There were significant differences between immature and mature fish HSI and body condition during most sampling periods. Fecundity and relative fecundity were significantly related to body condition and HSI. Increasing or decreasing these measures of condition by 1 standard deviation in a model of fecundity, which also included length, resulted in an estimated decrease in fecundity of 32% or an increase or 47%. This indicates that incorporating condition into measures of productivity may give a more accurate measurement of total egg production than solely spawning biomass. In models that utilized summer condition and liver weight, as well as length and age, to predict whether a fish was immature or would spawn, predictions later in the summer (on legs 6 and 7) produced maturity at age models that were similar to those that used the maturity designations from histology slides (Figure 2).

For more information contact Cara Rodgveller (cara.rodgveller@noaa.gov).

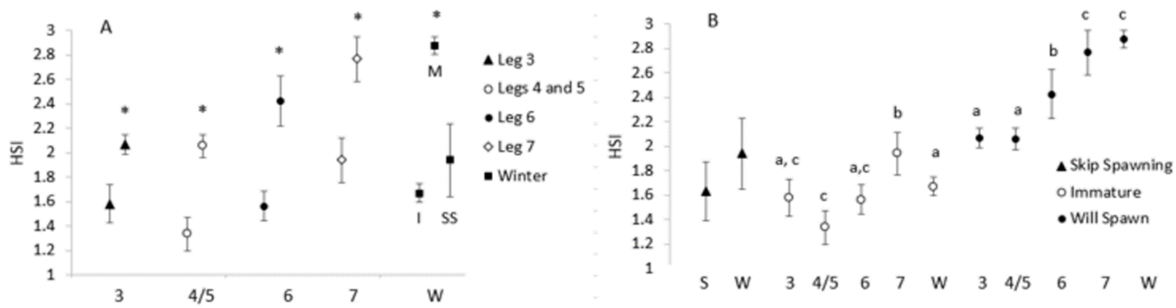

Figure 1. Hepatosomatic index (HSI) for sablefish collected on legs 3 through 7 of the summer longline survey or in winter. Immature (I), mature (M), and skip spawning (SS) fish are labeled for the winter because skip spawning must be differentiated from the other two groups. In Panel A, on every survey leg the mean for immature fish is lower than the mean for fish that will spawn. An * represents a significant difference between maturity categories during that sampling period. Panel B includes much of the same data in panel A, except that each maturity category is presented together and significant differences between sampling periods are denoted by a different letter. In Panel B, SS samples are pooled for all of summer (N = 11) and compared to those collected in the winter (N = 16).

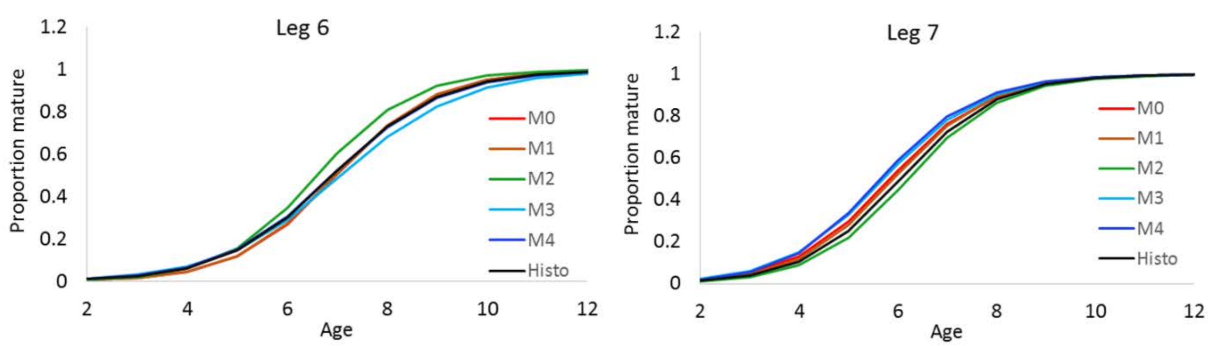

Figure 2. Logistic curves of maturity at age when maturity was determined using histology slides (Histo) or predicted with models (M0 through M4) for legs 6 and 7 of the NMFS Alaska summer longline survey.

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

Description of indicator: Biophysical indices from surveys in 2016 and salmon returns in 2017 were used to predict the recruitment of sablefish to age-2 in 2017 and 2018 (Yasumiishi et al. 2015a). Biophysical indices were collected during the southeast coastal monitoring (SECM) survey. The SECM survey has an annual survey of oceanography and fish in inside and outside waters of northern southeast Alaska since 1997 (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 at the Alaska Fisheries Science Center in Juneau, Alaska. 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: We modeled age-2 sablefish recruitment estimates from 2001 to 2016 (Hanselman et al. 2016) as a function of sea temperatures during 1999-2014, chlorophyll a during 1999-2014, and adult pink salmon returns in 2000-2015. The model with the lowest Bayesian information criterion (108) described the stock assessment estimates of age-2 sablefish abundance as a function of late August maximum chlorophyll *a* during the age-0 stage, late August maximum sea temperature during the age-0 stage, and pink salmon returns during the age-1 life stage of these sablefish (Figure 1; Table 1). A regression model indicated positive coefficient for the predictor variables chlorophyll a, sea temperature, and pink salmon returns were positively in the sablefish model (R^2 = 0.7667, Adjusted R^2 = 0.7084, F-statistic: 13.15 on 3 and 12 DF, p-value: 0.0004224).

Based on 2016 environmental data, the high levels of 10.83 chlorophyll a (10.83), warm waters (13.4 °C) and good forecast for pink salmon returns (43 million) in 2017, we predict above average abundance of age-2 sablefish (68 million) in 2018 (2016 year class). Based on 2017 environmental data, low chlorophyll a (1.12) in 2015, average sea temperatures (12 °C), and low pink salmon returns in 2016 (17,820,985), we predict below average abundance of age-2 sablefish in 2017 for the 2015 year class.

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: Our 2017 model indicates that we should expect a weak 2015 year class and a strong 2016 year class of sablefish.

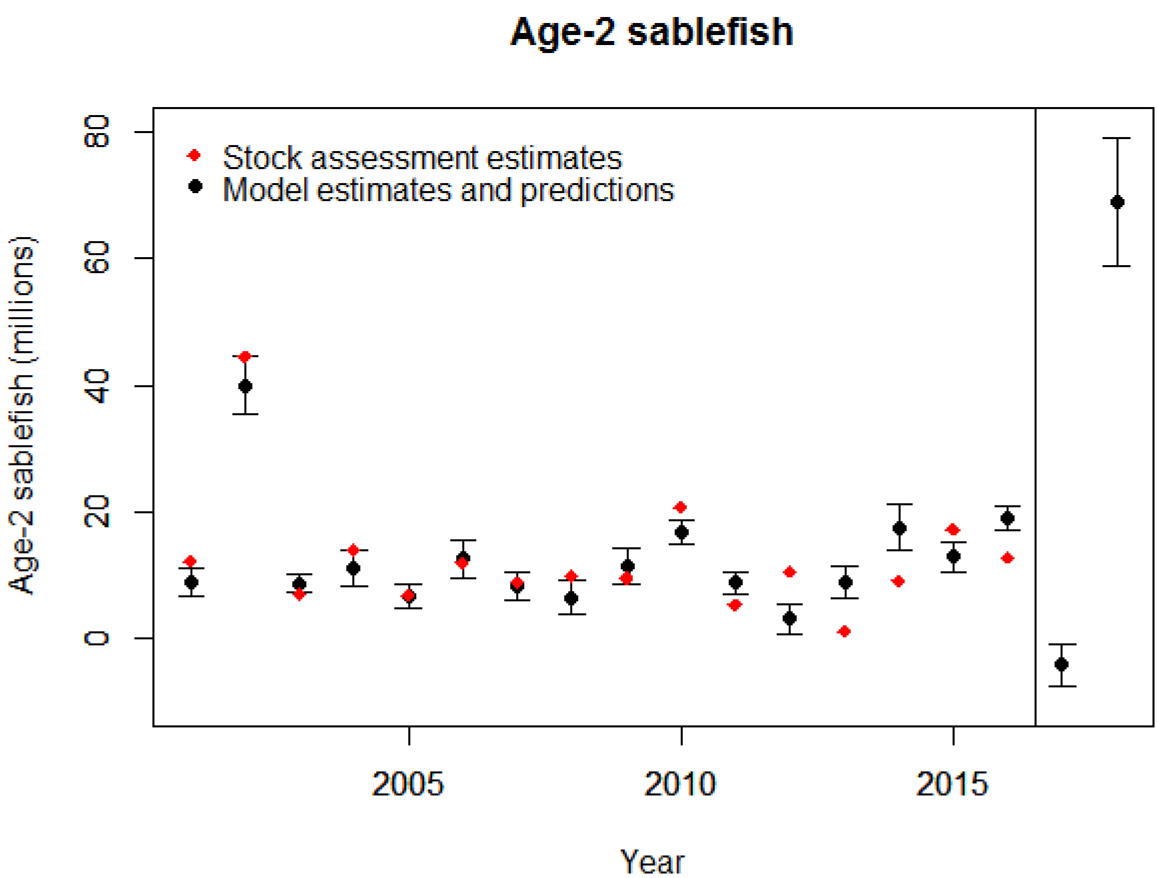

Figure 1. Stock assessment estatimes, model estimates, and the 2017 and 2018 prediction for age-2 Alaska sablefish. Stock assessment estimates of age-2 sablefish were modeled as a function of late August chlorophyll *a* levels and late August sea temperatures in the waters of Icy Strait in northern southeast Alaska during the age-0 stage (*t*-2), and the returns of age-1 pink salmon (*t*-1). These predictors are indicators for the conditions experiences by age-0 sablefish. Stock assessment estimates of age-2 sablefish abundances are from Table 3.14 in Hanselman et al. 2016.

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Table 1. Nearshore survey data fit to the stock assessment estimates of age-2 sablefish (millions of fish) from Hanselman et al. (2016). Table shows the 2017 model fitted (2001-2016) and forecast (2017, 2018) estimates and standard errors for age-2 sablefish, and the predictor variable from 1999-2015 used to estimate (2001-2016) and predict (2017, 2018) the stock assessment estimates of age-2 sablefish. Gray shaded cells indicate predicted values based on the 2017 Model and environmental indices from 2016 and 2017.

	Estimates	Fitted and forecast		Predictor variables		
Year	Sablefish (t)	Estimates	Standard error	Chlorophyll a (t-2)	Sea temperature (t-2)	Pink salmon (t-1)
2001	12.2	8.95	2.067	2.15	13.4	31009547
2002	44.5	40	4.56	6.08	12	85654226
2003	7.1	8.79	1.55	1.63	12.8	61929924
2004	14	11.16	2.72	2.64	10.7	72431623
2005	6.8	6.77	1.81	1.22	13.1	60965661
2006	12	12.61	2.94	1.05	14.5	79033917
2007	8.9	8.38	2.25	2.68	12.5	21848850
2008	9.9	6.56	2.75	2.15	10.8	62435599
2009	9.6	11.54	2.8	2.33	14.2	25406377
2010	20.7	16.84	1.88	3.59	11.7	50695114
2011	5.4	8.91	1.78	2.52	12.3	35196281
2012	10.6	3.13	2.51	0.55	12.7	73123947
2013	1.2	8.86	2.51	3.06	11.2	32320595
2014	9.2	17.63	3.58	1.58	12.7	119898191
2015	17.2	12.98	2.33	1.92	14.2	50944432
2016	12.9	19.07	1.94	3.73	12.4	46306393
2017		-4.11	3.3	1.12	12	17820985
2018		68.72	10.08	10.83	13.4	43000000

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YOY Sablefish Growth and Consumption Study - ABL

Effects of temperature on growth and consumption rates of YOY Sablefish (218 – 289 mm TL) were measured in laboratory trials with fish held over 5 temperature treatments (5°C, 8°C, 12°C, 16°C and 20°C) and maintained on *ad libitum* ration for 3 weeks. Growth, consumption, and body condition of fish were compared between treatments. Specific growth rate (SGR; % wet weight gain (g) d^{-1}) was used to derive a temperature-dependent growth model, and consumption rates were used to calculate species specific parameters for the consumption function of a Wisconsin-type bioenergetics model. Daily growth in length varied from 0.13 mm d^{-1} to 1.74 mm d^{-1} and SGR ranged from 0.52 to 2.31. SGR peaked at 15.4°C, remained high at 12°C and 16°C, and steadily declined as temperatures shifted outside this range. Residuals of length-weight regressions showed YOY Sablefish condition was positive at 12°C and 16°C, and negative at 5°C, 8°C, and 20°C. Consumption rose sharply with temperature, peaking at 18.6°C. The narrow thermal range of positive condition and optimal SGR indicates YOY Sablefish growth and development may be dramatically influenced by relatively small shifts in water temperatures. Further, when compared to similar studies of smaller sized Sablefish, we observed a shift with size in thermal performance with larger fish performing better at colder temperatures compared to smaller fish. A secondary growth study was conducted to test the reliability of the growth and consumption models from our main study. Observed growth and consumption rates matched well with model estimates and provide important information linking temperature-dependent physiological response through early development. The shift in thermal performance with size is an important consideration for future management initiatives. While traditional recruitment models rely heavily on information from a single life-stage, resource use and physiological requirements often change with development. Given the widespread occurrence of anomalous thermal events in the GOA, a life-stage specific understanding of the effects of varying temperatures is crucial.

Analysis of body composition revealed an energy allocation strategy across all temperature treatments strongly emphasizing protein synthesis relative to lipid storage, i.e. somatic growth over energy storage. Fish across all treatments had ~8% total-body lipid, while protein linearly increased with temperature. Conversion efficiency of fish (a measure of food consumed relative to instantaneous growth rate) showed highest conversion efficiencies between 12°C and 16°C. RNA/DNA ratios (an instantaneous cellular growth index) were lowest at 16°C, and was coupled with highest growth, suggesting the presence of an optimal growth efficiency window between 12°C and 16°C, further emphasizing that growth/condition of these fish could be affected by even small variations in temperature. The emphasis on heightened somatic growth in YOY sablefish relative to energy storage suggests that the benefit of growth outweighs the potential costs, i.e., risk of starvation. The benefits could include predator avoidance and/or prey capture in a new benthic environment. While YOY sablefish were able to survive the relatively wide range of temperature treatments in our study, the reduced growth at temperatures outside the growth efficiency window could have implications for survival of these fish once they settle to the benthic habitat.

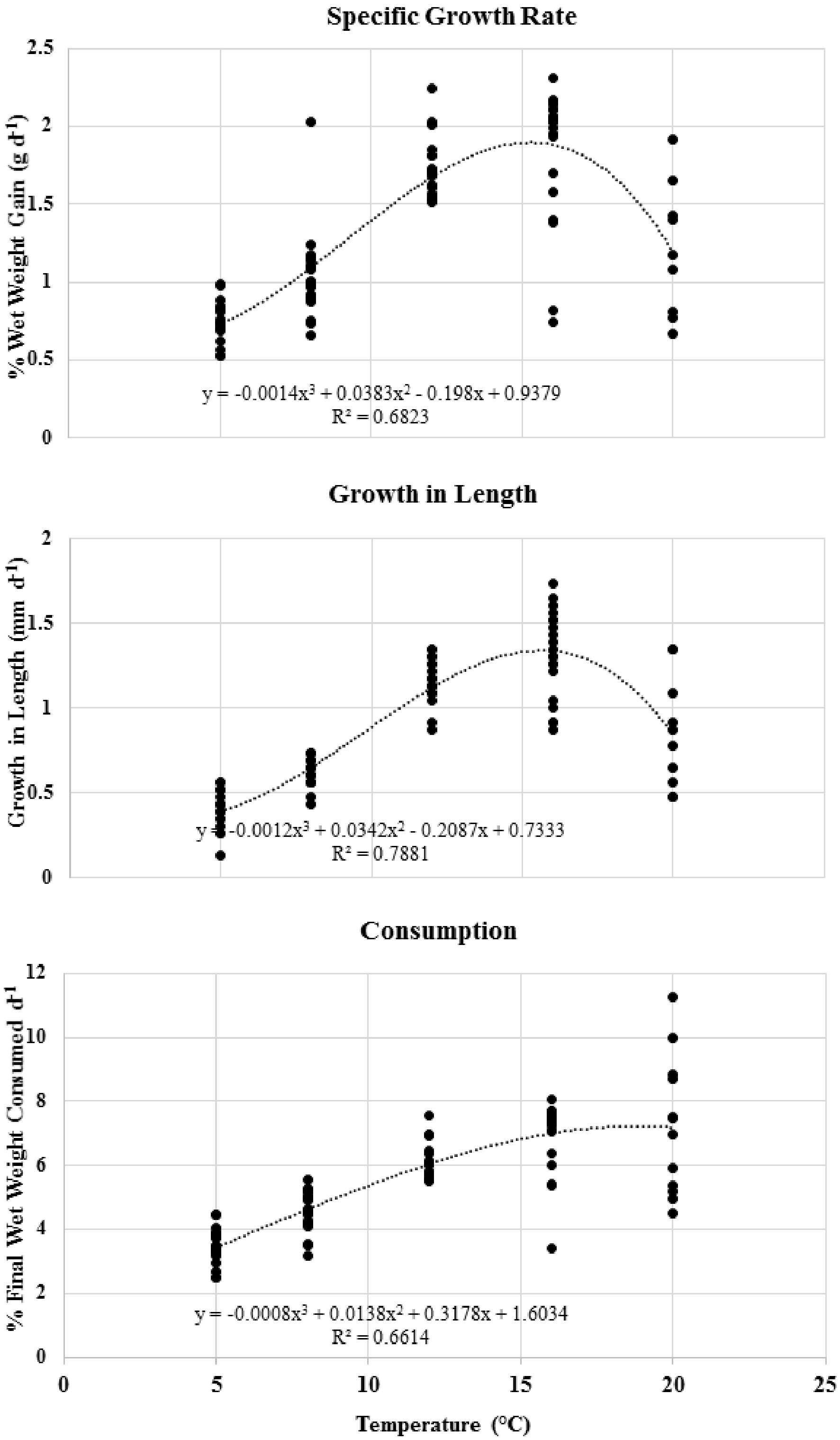

Fig. 1. Temperature-dependent specific growth rate (SGR), growth in length, and consumption, for YOY Sablefish (218 - 289 mm TL). Values are based on individual values of fish from each temperature treatment following 3 weeks of growth at each temperature. A third-order polynomial function describing the temperature-dependent physiological response of each parameter is given.

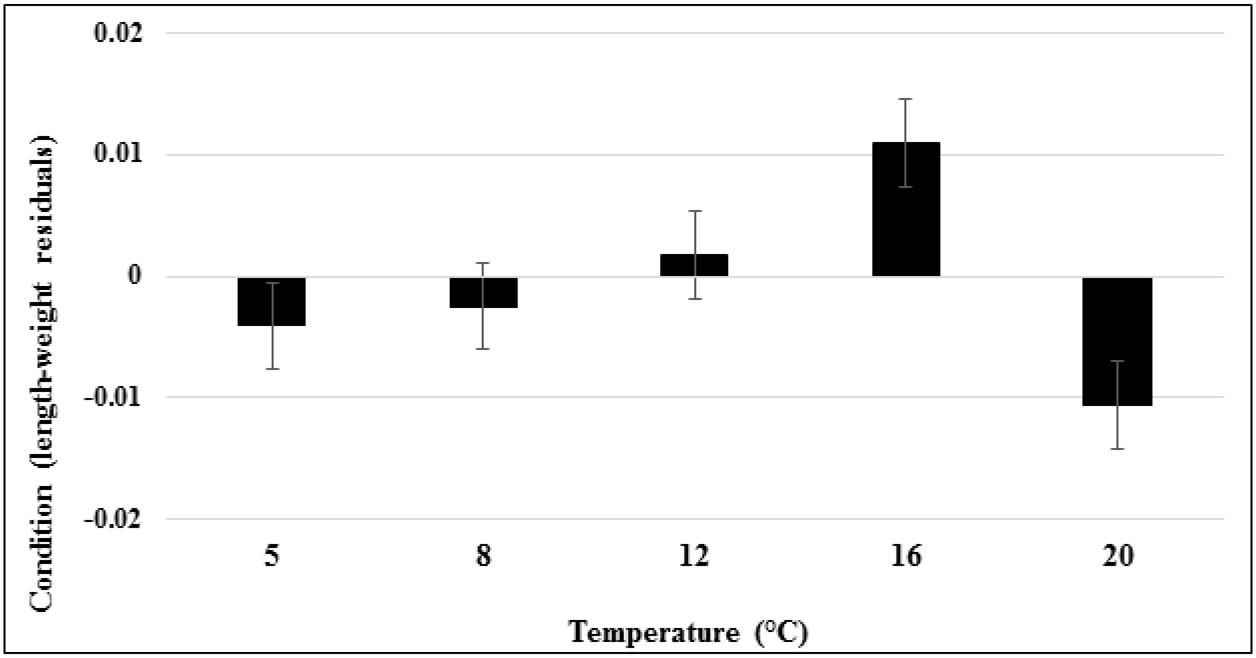

Fig. 2. Temperature-dependent condition factor of YOY Sablefish (218 – 289 mm TL). Condition is based on the length-weight residuals of fish following 3 weeks of growth at each temperature. Mean (± SD) values are based on individuals from duplicate tanks at each temperature.

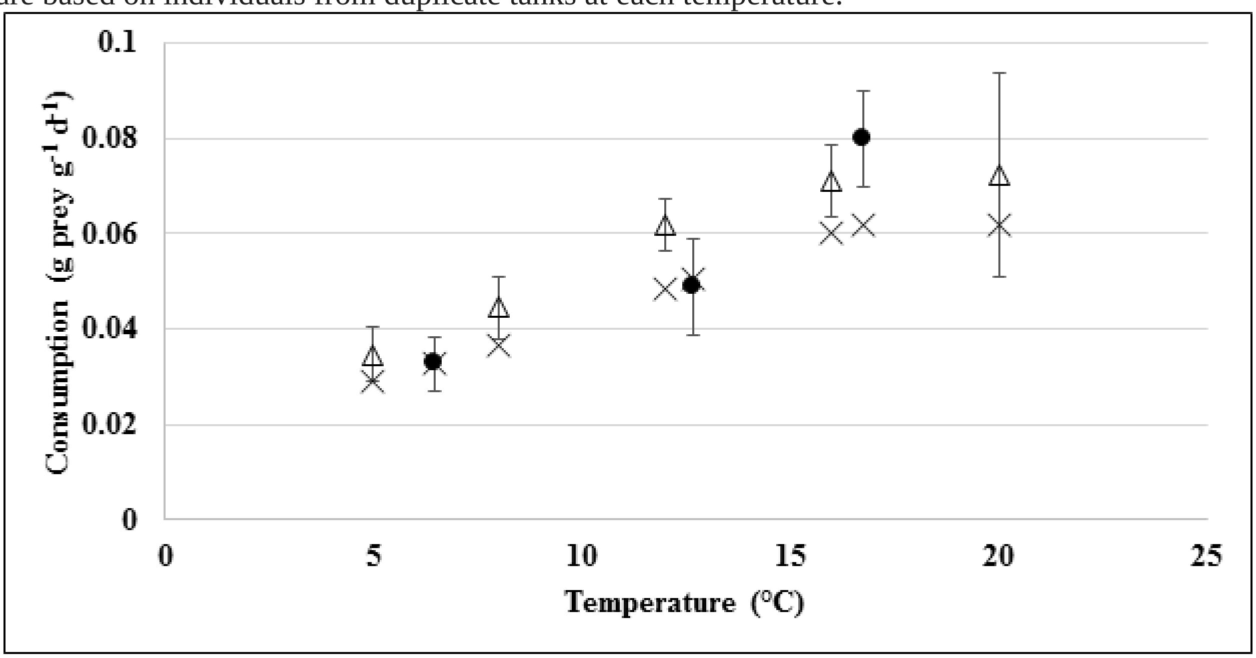

Fig. 3. Mean (± SD) prey consumption rates from 2016 (hollow triangles) and 2017 (black dots) trials for YOY Sablefish during laboratory experiments and estimates of consumption rates calculated using the consumption function of the bioenergetics model (X).

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2. Stock Assessment

Bering Sea, Aleutian Islands, and Gulf of Alaska - ABL

A full sablefish stock assessment was produced for the 2018 fishery. New data included in the assessment model were relative abundance and length data from the 2017 longline survey, relative abundance and length data from the 2016 fixed gear fishery, length data from the 2016 trawl fisheries, age data from the 2016 longline survey and 2016 fixed gear fishery, updated catch for 2016, and projected 2017 - 2019 catches. Estimates of killer and sperm whale depredation in the fishery were updated and projected for 2017 - 2019.

The longline survey abundance index increased 14% from 2016 to 2017 following a 28% increase in 2016 from 2015. The lowest point of the time series was 2015. The fishery abundance index decreased 23% from 2015 to 2016 and is the time series low (the 2017 data are not available yet). There was a new Gulf of Alaska (GOA) trawl survey in 2017 which increased 89% from 2015 to 2017. Spawning biomass is projected to increase rapidly from 2018 to 2022, 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, but the recent 2014 year class should rapidly move the stock above it's target.

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.

Instead of maximum permissible ABC, we recommended a 2018 ABC of 14,957 t, which is 14% higher than the 2017 ABC. The maximum permissible ABC for 2018 is 89% higher than the 2017 ABC of 13,809 t. The 2016 assessment projected a 1% increase in ABC for 2018 from 2017. The author recommended ABCs for 2018 and 2019 are lower than maximum permissible ABC for two important reasons.

First, the 2014 year class is estimated to be 2.5 times higher than any other year class observed in the current recruitment regime. Tier 3 stocks have no explicit method to incorporate the uncertainty of this new year class into harvest recommendations. While there are clearly positive signs of strong incoming recruitment, there are concerns regarding the lack of older fish and spawning biomass, the uncertainty surrounding the estimate of the strength of the 2014 year class, and the uncertainty about the environmental conditions that may affect the success of the 2014 year class. These concerns warrant additional caution when recommending the 2018 and 2019 ABCs. It is unlikely that the 2014 year class will be average or below average, but projecting catches under the assumption that it is 10x average introduces risk knowing the uncertainty associated with this estimate. Only one large year class since 1999 has been observed, and there is only one observation of age compositions to support the magnitude of the 2014 year class. Future surveys will help determine the magnitude of the 2014 year class and will help detect if there are additional incoming large year classes other than the 2014 year class.

Projections that consider harvesting at the maximum ABC for the next two years, if the 2014 year class is actually average, results in future spawning biomass projections that are very low, where depensation (reduced productivity at low stock sizes) could occur. Recommending an ABC lower than the maximum should result in more of the 2014 year class reaching spawning biomass and achieving higher economic value. Because of these additional considerations, we assume that the recent recruitment is equal to the previous highest recruitment event in the current regime for projections (1977, which is still 4x average.) This results in more precautionary ABC recommendations to buffer for uncertainty until more observations of this potentially large year class are made. Because sablefish is an annual assessment, we will be able to consider another year of age compositions in 2018 and adjust our strategy accordingly.

Second, we also recommend a lower ABC than maximum permissible based on estimates of whale depredation occurring in the fishery in the same way that as recommended and accepted in 2017. Because we are including inflated survey abundance indices as a result of correcting for sperm whale depredation, this decrement is needed to appropriately account for depredation on both the survey and in the fishery. This ABC is still 14% higher than the 2017 ABC.

Survey trends support this moderate increase in ABC relative to last year. There was a substantial increase in the domestic longline survey index time series, and a large increase in the GOA bottom trawl survey. These increases offset the continued decline of the fishery abundance index seen in 2016. 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 2015 estimate in 2016, up 5% from 2015. The 2008 year class showed potential to be large in previous assessments based on patterns in the AFSC survey age and length compositions; this year class is now estimated to be about 13% above average. There were preliminary indications of a large incoming 2014 year class, which were evident in the 2016 longline survey length compositions and now are extremely dominant in the 2016 age compositions. This year class appears to be very strong, but year classes have sometimes failed to materialize later and the estimate of this year class is extremely uncertain.

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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 (Hanselman et al. 2018).

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 (Peterson and Hanselman 2017). 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.

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Coastwide research discussions for sablefish – ABL

Sablefish stock assessments are conducted independently for the US West Coast (California-Oregon-Washington), Canada, and both Alaska State and Alaska 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. In late April 2018, scientists from DFO, NWFSC, Alaska Department of Fish and Wildlife and AFSC will meet to discuss ongoing sablefish research, sablefish assessment models, and opportunities for collaboration. 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. We hope this project will help foster communication and collaboration across management areas.

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J. Lingcod

K. Atka Mackerel

1. Research

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).

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2. Stock Assessment

Spawning biomass reached an all-time high in 2005, then decreased continuously through 2017 (the spawning biomass is estimated to be roughly 50% of what it was in 2005). It is projected to decrease further, at least through 2018. The 1998-2001 year classes were all very strong, and the 2006 and 2007 year classes were above average. The addition of the 2016 fishery and survey age compositions information impacted the estimated magnitude of the 2011 year class which increased 14%, relative to last year's assessment, and the magnitude of the 2012 year class which increased 32% relative to last year assessment. The 2012 year class is now estimated to be slightly above average. The projected female spawning biomass for 2018 (139,300 t) is still above $B_{40\%}$ (122,860 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 2016 year-end catch was updated, and the projected total catch for 2017 was set equal to the 2017 TAC.
- The 2016 fishery age composition data were added.
- The 2016 Aleutian Islands survey age composition estimates were added.

Methodological changes included the following:

- Refinements to the time-varying fishery selectivity inputs were made using the same statistical weighting ("Francis") method for the time-varying fishery selectivity variance term that was used for the survey age composition data.
- In the projection model:
    - Catches for 2018 and 2019 were assumed to equal 75% of the BSAI-wide ABC, based on the effect of the revised Steller Sea Lion Reasonable and Prudent Alternatives that were implemented in 2015 (it was 62% 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 2018 yield (ABC) at $F_{40\%}$ = 0.38 is 92,000 t, up 5% from the 2017 ABC and up 8% from last year's projected ABC for 2018. The projected 2018 overfishing level at $F_{35\%}$ = 0.46 is 108,600 t, up 5% from the 2017 OFL and up 8% from last year's projected OFL for 2018.

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 2018 are 36,820 t for Area 541 and the Bering Sea region (a 5% increase from 2017), 32,000 t for Area 542 (a 5% increase from 2017), and 23,180 t for Area 543 (a 5% increase from 2017). Atka mackerel is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.
As requested, this section was significantly expanded and updated. Temperature anomaly profiles from the 2016 Aleutian Island survey data appear to be some of the warmest on record. Temperature may affect recruitment of Atka mackerel and availability to the bottom trawl survey. Atka mackerel is the most common prey item of the endangered western Steller sea lion throughout the year in the Aleutian Islands. Steller sea lion (SSL) surveys indicate slight population increases, except in the western Aleutians (area 543).

Regulations implemented in 2015 significantly adjusted SSL management measures that were in place from 2011-2014 and re-opened area 543 to directed fishing for Atka mackerel (but with a maximum TAC of 65% of the area ABC), removed the TAC reduction in area 542, and re-opened areas in 541 and 542 that had been closed to directed Atka mackerel fishing. Prior to 2011, a "platoon" system was in place that restricted the timing of fishing effort in the AI.

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

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L. Flatfish

1. Research

Availability of yellowfin sole to the eastern Bering Sea trawl survey and its effect on survey biomass--GAP
Availability of yellowfin sole *Limanda aspera* to the eastern Bering Sea trawl survey, rather than trawl sampling efficiency, is proposed as the primary reason for relatively high annual variability of biomass estimates in this region, including most recently, a 48% increase from 2015 to 2016. The main hypothesis presented here is that temperature-mediated differences in the timing of spring-summer spawning migrations to unavailable nearshore spawning grounds, affect survey biomass estimates. Colder bottom temperatures delay both migrations and spawning, causing higher proportions of mature individuals to reside in the unavailable nearshore grounds at the time of annual survey (June-July). Indicators of this scenario include decreases of mature fish proportions and decreases in mean overall fish lengths during colder years when biomass was less than expected. Further evidence includes differences in spatial distribution between warm and cold years, and spatial shifts away from nearshore areas between early June and July-August sampling during which catch per unit effort (CPUE) increased and proportion of females increased. That neither of these spatial shifts nor temperature-CPUE relationships occurred for northern rock sole *Lepidopsetta polyxystra*, a species of similar morphology and abundance, and overlapping spatial distribution, suggests

that temperature-mediated trawl sampling efficiency was not a major contributing factor for yellowfin sole. We have also found a positive relationship between survey biomass estimates and survey start times, reinforcing that availability is a function of timing. The addition of survey start time to the catchability (*q*) parameter within the current stock assessment model significantly improved model fits to survey biomass.

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Connectivity, cross-shelf transport, and the delivery of larval arrowtooth flounder (*Atheresthes stomias*) to suitable nursery habitats in the Gulf of Alaska - RPP

Esther D. Goldstein, Janet T. Duffy-Anderson, Jodi L. Pirtle, William T. Stockhausen, Matthew T. Wilson, Mark Zimmermann, and Calvin W. Mordy

Arrowtooth flounder (ATF: *Atheresthes stomias*) is an ecologically important predator and the most abundant groundfish species in the Gulf of Alaska (GOA) throughout the past few decades (Spies and Turnock, 2013). The shift toward high abundance and biomass of arrowtooth flounder in recent years in the GOA has led to concern regarding potential predation pressure on the juvenile stages of commercially important species such as walleye pollock (*Gadus chalcogrammus*; Gaichas et al., 2011; Hollowed, 2000) and highlighted the need for increased understanding of the processes and that influence arrowtooth flounder survival and recruitment.

Arrowtooth flounder spawn along the continental slope in water depths of ~300-600 meters, and after a pelagic larval duration that spans multiple months, late-stage larvae settle to obligate juvenile nursery habitats in shallower water on the continental shelf (Stockhausen et al. *in revision*). Like many marine fish with ontogenetic habitat requirements, arrowtooth flounder recruitment is dependent upon spatial and temporal coupling between life-stage transitions and access to suitable habitats. The successful transition between the pelagic larval stage and benthic-associated juvenile stage is substantially influenced by two processes: 1) along-shelf and cross-shelf transport of larvae that is driven by oceanography and hydrology, and 2) delivery of larvae to high quality nursery habitats. We hypothesize that inter-annual oceanographic variability will influence the degree to which larvae are successfully transported from offshore environments to suitable nursery habitats, and that successful recruitment of arrowtooth flounder may be enhanced by submarine canyons that act as conduits of cross-shelf transport for larvae.

We utilized an Individual-Based Biophysical Model (IBM) developed using the DisMELS modeling framework (Stockhausen et al. *in revision*) in combination with a juvenile habitat suitability model using a Maximum Entropy modeling approach to identify coupling between transport and delivery to suitable nursery habitats for the years 2000-2011 in the GOA. Based on habitat suitability models and coupled IBM results habitat requirements restrict the amount of nursery habitat available for settlement-stage arrowtooth flounder, and subsequently, decrease expected survivorship and recruitment. The majority of suitable habitat is located in the western GOA, and accordingly, successful delivery to suitable habitats is associated with particle trajectories that extend to the western GOA and primarily along the continental shelf in comparison to trajectories that deliver larvae to low quality habitats (Fig. 1a, b). Inter-annual oceanographic variability influences the degree to which settlement-stage arrowtooth flounder are successfully delivered to suitable habitats, by up to a two-fold increase in recruitment in some years. Particularly, recruitment success was enhanced by transient, retentive, oceanographic features such as eddies. For larvae that are advected offshore, cross-shelf transport to and delivery to suitable nursery habitats via canyons was lower than non-canyon routes of transport. However, routes of cross-shelf transport and the efficacy of submarine canyons as conduits of shelf-ward movement is substantially influenced by the presence and location of eddies (Fig. 2). These findings suggest that in the heterogeneous GOA, connectivity, survival, and recruitment of arrowtooth flounder is enhanced by eddies that promote retention, and mediated by the interaction between persistent topographic features and transient oceanographic processes.

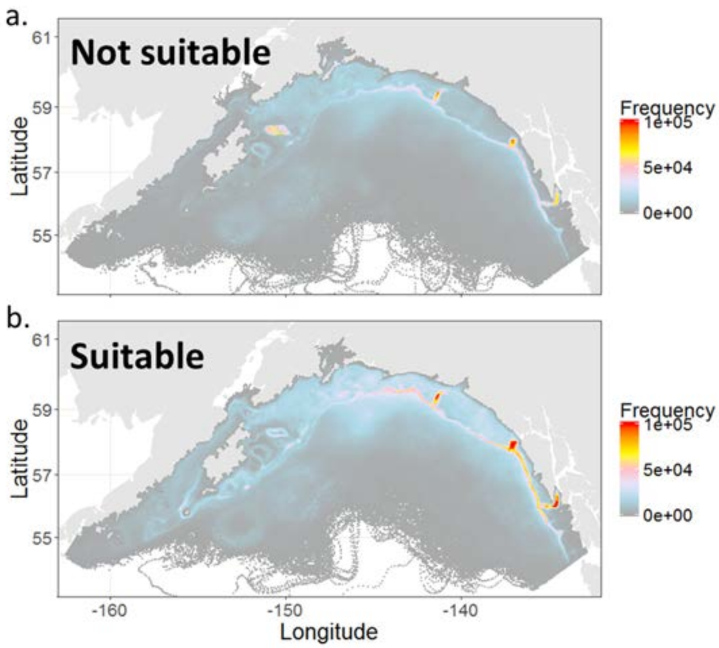

Figure 1. Arrowtooth flounder Individual-based Biophysical Model (IBM) output paired with the habitat suitability model from 2000-2011. The color scale shows the number of modeled larval particles that traversed a 3 km x 3 km grid cell and the values were averaged across the 12 year study period. The panels show the transport trajectories of individuals that were delivered as settlement-stage larvae to a) nursery habitats that are not suitable and b) suitable nursery habitats.

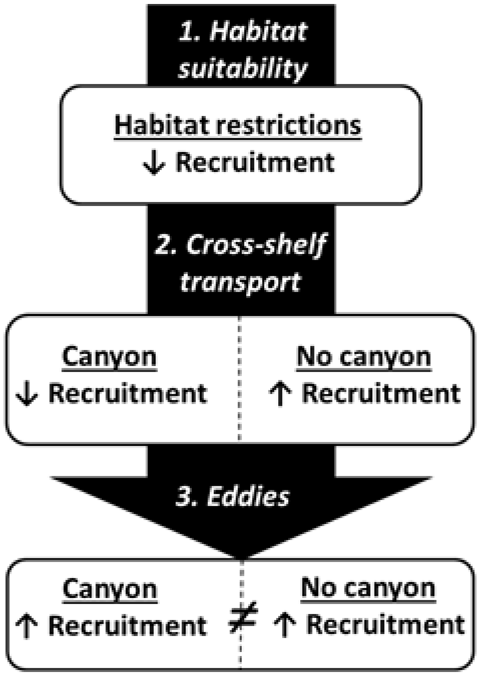

Figure 2. Schematic representation of the processes that influence recruitment for arrowtooth flounder in the Gulf of Alaska focusing on 1) habitat suitability, 2) cross-shelf transport, and 3) eddies. 1) Habitat suitability requirements enhance habitat restrictions and decrease recruitment. 2) Successful recruitment associated with cross-shelf transport through canyons is lower than non-canyon routes. 3) Transient eddy feature enhance recruitment regardless of the route of cross-shelf transport but the timing and location of eddies influences the relative importance of cross-shelf transport via canyons and other routes.

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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 habitats of juvenile yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS), particularly on how habitat may be impacted by the multi-year warm-cold thermal shifts and the long-term warming trend in the EBS.

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 distribution was concentrated in the south in the Bristol Bay area ("south" habitat). Whether YFS juveniles also followed a similar pattern is currently being investigated. Larval transport is most likely the key determinant of the distribution of juveniles over the habitat range.

Results from this research so far showed that the north and south habitats both had high prey abundance and similarly high summer bottom temperature during the latest warm thermal phase, which began circa late 2013. It appeared that both habitat areas were comparable in critical habitat qualities. However, the body condition of juveniles was higher in the south. This difference may be attributed to higher prey quality in the south, and more favorable thermal environment in the winter months for growth (Yeung and Yang, In review). Diets may also be different between the north and the south areas for both NRS and YFS. Juveniles of both species may consume more polychaetes on average in percentage weight in the south than in the north, and more clams in the north than in the south. A difference in diets could contribute to difference in condition and growth. Otolith analysis showed that NRS in the south were much larger than those in the north at the same age, as was first annulus size. Overall, the results indicate that juvenile NRS grows faster in the south than in the north.

In 2017, juvenile flatfish habitat investigations were extended into the northern Bering Sea (NBS) with the extension of the bottom trawl survey. Juveniles (≤15 cm total length) were collected along the coast in waters mostly ≤ 25 m deep from Bristol Bay in the south to Norton Sound in the north to examine the spatial variation in their body condition. Fish specimens are collected at 15 stations in the NBS, and 6 stations in the EBS (the working definition of the NBS and EBS divide being 60oN). Specimens are being analyzed for stomach contents, lipids biochemistry, and otolith age. As in 2016, very high abundances of juvenile NRS and YFS were observed in the bottom-trawl survey. Colder bottom water temperatures have returned to the EBS in 2017 following a record high in 2016. The continuation of this research will enable the comparison of juvenile condition between a cold and a warm thermal phase.

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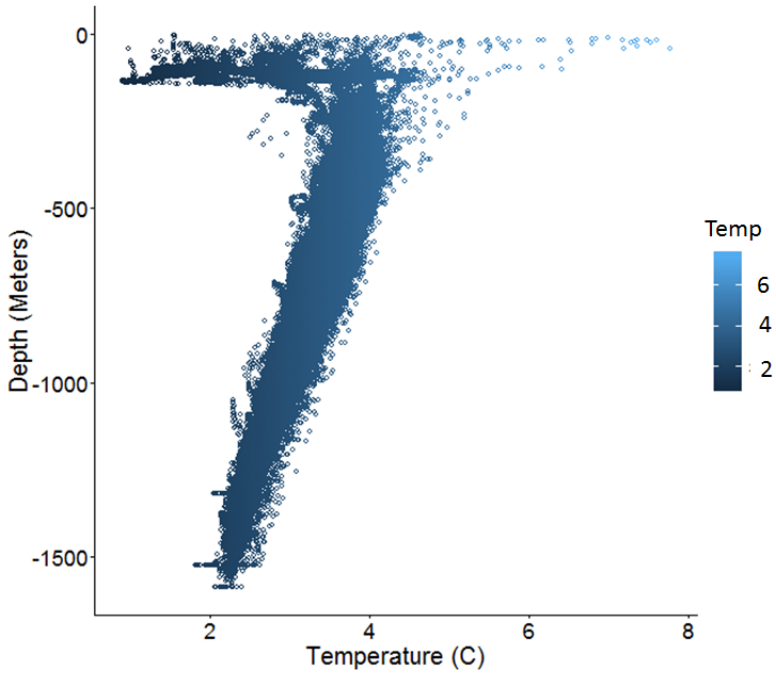
Yeung, C., Yang, M.S., In review. Spatial variation in habitat quality for juvenile flatfish in the southeastern Bering Sea. Journal of Sea Research.

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.



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Flatfish biology in the Bering Sea: examining spatial and temporal effects on maturity and growth across the eastern and northern Bering Sea continental shelves

Funded by NPRB, the overarching goal of this project is to provide life history information for flatfishes that is essential for their management and conservation. This study has the following main objectives:
1) Identify maturity schedules for flatfishes in the NBS (yellowfin sole and Alaska plaice) and update maturity schedules in the EBS (Greenland turbot and Bering flounder);
2) Incorporate new maturity-at-age estimates for the above species into their respective age-structured models for estimation of spawning stock biomass;
3) Analyze spatial and temporal variation in maturity for yellowfin sole and Alaska plaice under environmental conditions by examining the utility of linear and non-linear modeling;
4) Estimate the relationship of NBS yellowfin sole and Alaska plaice growth to environmental conditions.

Field collections for yellowfin sole and Alaska plaice were conducted during the annual eastern Bering Sea

(EBS) and an extension to the survey area into the northern Bering Sea (NBS). Ovaries from female specimens were collected as part of the standard otolith collection on these surveys. Processing of ovary samples and age determination of otoliths is being finalized for histological review and subsequent maturity-at-age estimates, and potential for spatial and temporal variation. An effort will be made to collect additional females from the 2018 EBS survey for yellowfin sole.

Non-linear Modeling with Aspects of Reproduction and Covariates
We've begun to explore the use of non-linear techniques through generalized additive models, with maturity data used in this project for the final models that involve examining spatial and temporal components of flatfish reproduction. Once all the maturity collections are processed and analyzed histologically, final models will be constructed on the full suite of samples, both spatially and temporally. The 1993 EBS yellowfin sole maturity collections was initially explored because of its large spatial coverage and sample size. GAM construction may involve testing the fit for multiple error distribution types (e.g. Poisson, Negative Binomial, Tweedie, Binomial), depending on the type of model used. Results from a single output, with setting gamma=1.4 with a quasi-Poisson error distribution using the *mgcv* package in R, show significance of smooth terms from selected variables used. For this model, maturity code was used as a proxy for oocyte development stages, based on five assigned stages: Maturity development stage ~ s(Latitude, Longitude) + s(Bottom temperature) + s(Depth) + s(Fish Length). The plots show that fish at a more advanced level of oocyte development (vitellogenesis or have spawned, exhibiting post-ovulatory follicles) are larger and occur shallower on average during the spawning season where the bottom temperature is warmer.

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2. Assessment

Yellowfin sole Stock Assessment - Bering Sea - REFM

The 2017 EBS bottom trawl survey resulted in a biomass estimate of 2.78 million t, compared to the 2016 survey biomass of 2.859 million t (a 3% decrease). 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 (1.9 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 the second strongest as any observed since 1983 and the 2006-2009 year-classes also are estimated to be a bit above average as future contributors to the reservoir of female spawners. The 2017 catch of 132,300 t represents the largest flatfish fishery in the US and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

Changes to the input data include: 1) 2016 fishery and survey age compositions, 2) 2017 trawl survey biomass and point estimate and standard error, 3) estimate of the discarded and retained portions of the 2016 catch composition, 4) estimate of total 2017 catch, 5) and updated weight at age for survey and fishery. No changes were made to the assessment model. The projected female spawning biomass estimate for 2018 is 895,000 t, which is 1.9´B_{MSY}. This is a 15% increase from last year's 2017 estimate (778,600 t). Although there has been a general decline that has prevailed since 1993, there is now some indication of a slow increase over the past three years.

This stock is in the Tier 1 management category since 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 456,000 t, and projected spawning biomass for 2018 is 895,000 t, meaning 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 biomass estimates) 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 0.109. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.12. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2018 biomass estimate produced the 2018 ABC of 277,500 t, and the corresponding product using the OFL harvest ratio produces the 2018 OFL of 306,700 t. For 2019, the corresponding quantities are 267,500 t and 295,600 t, respectively. Yellowfin sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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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 2017 bottom trawl survey resulted in a biomass estimate of 1.33 million t, a 9% decrease from the 2016 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 catch has averaged 40,000 t from 1975 – 2017.

The 2017 assessment was presented in a "partial assessment" format because it was a scheduled "off-year" assessment under the new Stock Assessment Prioritization guidelines. Due to unforeseen technical complications involved with extending the projection range in the Tier 1 assessment model from 2 to 3 years, the authors retained last year's 2018 projection values and computed the 2019 projection values by assuming that the percentage change from 2018 to 2019 would equal the percentage change from 2017 to 2018. The authors anticipate that the technical complications will be overcome before the next partial assessment is conducted. New data in the 2017 assessment included updated 2016 catch and estimated 2017 catch. No changes were made to the assessment model. A new feature included in the "off-year" assessments was a time series of exploitation rate (i.e., catch/biomass).

Spawning biomass was at a low in 2008, but until recently has continuously increased since then. The 2001-2005 year classes are all estimated to be above average; however, the spawning biomass has peaked and is now projected to be declining. The stock assessment model projects a 2018 spawning biomass of 472,200 t. The projected spawning biomass for 2019 is 413,300 t. Northern rock sole qualifies for management under Tier 1 due to reliable estimates of B_{MSY} and the pdf of F_{MSY}. Spawning biomass for 2018 is projected to be well above the B_{MSY} estimate of 257,000, placing northern rock sole in sub-tier "a" of Tier 1. The Tier 1 2018 ABC harvest recommendation is 143,100 t (F_{ABC} = 0.155) and the 2018 OFL is 147,300 t (F_{OFL} = 0.160). The 2019 ABC and OFL values are 132,000 t and 136,000 t, respectively. Recommended ABCs correspond to the maximum permissible levels. This is a stable fishery that lightly exploits the stock. 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.

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Northern Rock Sole – Gulf of Alaska Shallow Water Complex - REFM

A full assessment for shallow water flatfish was completed for 2017. The complex total biomass estimate for 2018 is 339,152 t, a 13% increase from the 2017 value of 299,858 t. This increase is due primarily to a higher model estimate for both northern and southern rock sole and 2017 survey estimates that were higher than 2015 for yellowfin sole, starry flounder, sand sole, and Alaska plaice (estimated from the random effects model). The random effects model estimates for 2017 biomass of butter sole and English sole were smaller than estimated in 2017. On the whole, the random effects model estimated an increase in biomass in 2017 compared to 2015 for the complex combined.

Age structured assessment models are used for northern and southern rock sole, and the random effects model is used for the remaining tier 5 species in the shallow water flatfish complex (as well as for apportionment). The northern and southern rock sole assessment model was updated with data through 2017, including updated 2016 catch and estimated 2017 catch, 2017 trawl survey biomass, 2017 fishery length composition, 2017 trawl survey length composition, and 2015 trawl survey conditional-age-at-length (CAAL). The random effects model was updated with 2017 trawl survey biomass.

The author's recommended change to the rock sole assessment models for 2017 incorporated the time series of trawl survey length compositions and removed the age compositions. The age data from the trawl survey is employed within the CAAL framework.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. The GOA Plan Team agrees with authors' recommended ABC for the shallow water flatfish complex which was equivalent to 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 54,688 t and OFL of 67,240 t for 2018.

Information is insufficient to determine stock status relative to overfished criteria for the complex as a whole. For the rock sole species, the assessment model indicates they are not overfished nor are they approaching an overfished condition. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

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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 2017 shelf trawl biomass estimate increased 22% from 2016 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. Model results indicate the Age 3+ biomass has declined slowly since the mid 1990's (20% overall), but show a steady increase since 2016. Estimates for 2019 show continued increases are likely.
The 2017 assessment was presented as a "partial assessment" format because it was a scheduled "off-year" assessment under the new Stock Assessment Prioritization guidelines. Therefore, only the projection model was run, with updated catches. New data in the 2017 assessment included updated 2016 catch and estimated

2017 and 2018 catches. No changes were made to the assessment model. A new feature included in the "off-year" assessments was a time series of exploitation rate (i.e., catch/biomass). Changes to the input data in this analysis include:

- 2017 catch biomass was added to the model
- 2016 catch biomass was updated to reflect October – December 2015 catches

Flathead sole are designated in Tier 3 since 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 2018 (214,124 t) is above $B_{40\%}$, flathead sole is in Tier 3a. ABCs for 2018 and 2019 was set at the maximum permissible values under Tier 3a, which are 66,773 t and 65,227 t, respectively. The 2018 and 2019 OFLs under Tier 3a are 79,862 t and 78,036 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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Gulf of Alaska

The 2018 spawning biomass estimate (85,765 t) is 2.3 times $B_{40\%}$ (36,620 t) and is projected to be stable through 2019. Total biomass (3+) for 2018 is 281,635 t and is projected to slightly increase in 2019. Flathead sole are assessed on a biennial schedule and for 2017 a full assessment was conducted without any new changes to the assessment methodology. The 2015 assessment model was updated with the most recent fishery catch and length data (2015-2017), 2017 bottom trawl survey biomass and length compositions, and 2015 bottom trawl survey conditional age-at-length data.

Flathead sole are determined to be in Tier 3a. For 2018 the author recommended to use the maximum permissible ABC of 35,266 t, a level nearly identical to the 2017 ABC of 35,243 t. The F_{OFL} is set at $F_{35\%}$ (0.40) which corresponds to an OFL of 43,011 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 2018 and 2019 are based on the random effects model applied to GOA bottom trawl survey biomass in each area. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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Greenland Halibut (Turbot)

The projected 2018 female spawning biomass is 58,035 t, which is a 15% increase from last year's 2017 estimate of 50,461 t. Female spawning biomass is projected to increase to 61,878 t in 2019. 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 2018 predict an increase in spawning biomass as these year classes grow and mature.

This chapter was presented in a "partial assessment" format because it was a scheduled "off-year" assessment under the new Stock Assessment Prioritization guidelines. Therefore, only the projection model was run, with updated catches. New data in the 2017 assessment included updated 2016 catch and estimated

2017 and 2018 catches. No changes were made to the assessment model. A new feature included in the "off-year" assessments was a time series of exploitation rate (i.e., catch/biomass).

Changes to the input data include: 1) Updated 2016 and projected 2017 catch data, 2) 2017 EBS shelf trawl survey estimates, 3) 2017 ABL longline survey estimates, and 4) 2017 EBS shelf survey and ABL longline survey length composition estimates.

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 2018 female spawning biomass was at 58,035 t, well above the estimate of $B_{40\%}$ (41,239 t). Because the projected spawning biomass in year 2018 is above $B_{40\%}$, Greenland turbot ABC and OFL levels are determined at Tier 3a of Amendment 56. The maximum permissible value of F_{ABC} under this tier translates into an OFL of 13,148 t for 2018 and 13,540 t for 2019 and a maximum permissible ABC of 11,132 t for 2018 and 11,473 t for 2019.

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 Team's recommended 2018 and 2019 ABCs in the EBS are 9,718 and 10,016 t. The 2018 and 2019 ABCs for the AI are 1,414 and 1,457 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.

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Arrowtooth Flounder – Bering Sea and Aleutian Islands- REFM

The projected age 1+ total biomass for 2018 is 785,131 t, a 2% increase from the value of 772,153 t projected for 2018 in last year's assessment. The projected female spawning biomass for 2018 is 490,663 t which is an increase from last year's 2018 estimate of 464,066 t and is over twice the $B_{40\%}$ level. The stock has remained at a high level for the past 20 years and is subject to light exploitation.

The 2017 assessment was presented in a "partial assessment" format because it was a scheduled "off-year" assessment under the new Stock Assessment Prioritization guidelines. Therefore, only the projection model was run, with updated catches. New data in the 2017 assessment included updated 2016 catch and estimated 2017 and 2018 catches. No changes were made to the assessment model. A new feature included in the "off-year" assessments was a time series of exploitation rate (i.e., catch/biomass).

The total catch for 2017 estimated by calculating the proportion of catch between January 1st and September 21st from the previous five years (2012-2016), 90.2%. The total year's catch was extrapolated from the catch through September 21, 2017, for an estimated total of 5,698 t. We note that the actual catch is slightly higher as of November 9, 2017. The 2018 catch was estimated as the average catch over the past four years, with the average catch from 2014-2016 from AKFIN, and the full year's catch estimate for 2017, for a 2018 estimate of 11,797 t. There has been a decreasing trend in ATF catch and the years selected for the 2018 catch estimate capture that trend.

Since reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Arrowtooth flounder 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 well-above $B_{40\%}$, so ABC and OFL recommendations for 2018 were calculated under sub-tier "a" of Tier 3. F_{ABC} was set at the $F_{40\%}$ level, which is the maximum permissible level under Tier 3a, resulting in 2018 and 2019 ABCs of 65,932 t and 64,494 t, respectively, and 2018 and 2019 OFLs of 76,757 t and 75,084 t. Arrowtooth flounder is a lightly exploited stock in the BSAI. Arrowtooth flounder is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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 in the current model have decreased relative to the projection model estimates in 2016, but are still at a high level. The projected spawning biomass for 2018, assuming fishing mortality equal to the recent 5-year average, was 873,789 t. This was 24% lower than the projected 2018 biomass from the 2016 assessment of 1,154,310 t. The projected estimate of total biomass for 2018 of 1,421,306 t was 32% lower than the estimate from the 2016 projection model.

There were several changes from the previous assessment. The length-age conversion matrix was estimated from length at age data from 1984-2013, and the weight at age was re-estimated. An ageing error matrix was added, and the age and length and age composition information was weighted with the Francis (2011) method.

The 2018 ABC of 150,945 t was 11% lower than estimate from the 2016 projection model. Arrowtooth flounder is estimated to be in Tier 3a, and assessment recommended ABC and OFL were adopted. This stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

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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.

Deep-water flatfish - REFM GULF OF ALASKA

The deepwater flatfish complex is comprised of Dover sole, Greenland turbot, and deepsea sole. This complex is assessed every fourth year and was last assessed in 2015 and will be assessed again in 2019. In non-assessment years, such as 2017, an executive summary is completed to recommend harvest levels for the next two years.

For Dover sole, a single species projection model was run using parameter values from the accepted 2015 assessment model and using updated catch information for 2015-2017. Greenland turbot and deepsea sole are Tier 6 stocks, and accordingly, ABCs and OFLs are based on historical catch levels and these quantities were not updated. ABCs and OFLs for the individual species in the deepwater flatfish complex are determined and then summed for calculating complex-level OFLs and ABCs.

Dover sole is a Tier 3 stock and is assessed using an age-structured model. The single species projection model was run using parameter values from the accepted 2015 Dover sole assessment model. The 2018 and 2019 Dover sole ABCs are 9,202 t and 9,316 t, respectively, and 2018 and 2019 OFLs of 11,050 t and 11,187 t, respectively.

For the Tier 6 species in the complex, 2018 and 2019 OFL (average catch from 1978–1995) is 244 t, and ABC (75%OFL) is 183 t. The combined ABC and OFL for the deepwater flatfish complex for 2018 and 2019 gives the maximum permissible ABC of 9,385 t and OFL of 11,294 t for the deepwater flatfish complex, and a 2019 maximum permissible ABC of 9,499 t and OFL of 11,431 t.

Gulf of Alaska 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 deepwater flatfish complex they are 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.

The random effects model is used to determine area apportionment for Dover since 2016. The Greenland turbot and deepsea sole portion of the apportionment is based on the relative proportion of survey biomass of these species found in each area, averaged over the years 2005-2015. The ABC by area for the deepwater flatfish complex is then the sum of the species-specific portions of the ABC.

M. Pacific halibut

1. Research

N. Other Groundfish Species

CONSERVATION ENGINEERING (CE)

Evaluation of salmon behaviour to reduce bycatch in the Bering Sea pollock fishery--CE

The Conservation Engineering (CE) group of the NMFS Alaska Fisheries Science Center (AFSC) (Noelle Yochum, lead) conducts cooperative research with Alaska fishing groups and other scientists to better understand and mitigate bycatch, bycatch mortality, and fishing gear impacts to fish habitat. In 2017, CE research focused on projects concerning salmon bycatch (primarily chum, Oncorhynchus keta, and Chinook, O. tshawytscha) in the Bering Sea walleye pollock ("pollock", Gadus chalcogrammus) trawl fishery. Because salmon are considered a prohibited species for the pollock fishery, allowable bycatch is restricted (Fissel et al. 2016). To avoid exceeding the bycatch limit, since 2003, members of the fishing and conservation engineering communities have worked to develop and improve upon bycatch reduction devices that permit salmon to escape out of the trawl after capture and before entering the codend (an 'excluder'; Gauvin, 2016; Gauvin et al., 2015, 2013, 2011; Gauvin and Gruver, 2008; Gauvin and Paine, 2004). Some fishermen have added artificial light around the escapement portal with the expectation that it attracts or guides salmon towards the exit. Increased escapement rates of Chinook salmon in the Pacific hake (Merluccius productus) midwater trawl fishery have been reported with the use of blue lights near the escapement portal (Lomeli and Wakefield 2012, 2014a, 2014b, 2016), and Bering Sea pollock industry representatives report that salmon escapement seems to increase with bright white artificial lights (Ed Richardson, At-sea Processors Association, personal communication). Through the evolution of the salmon excluder in the pelagic pollock trawl net, salmon escapement has been variable among tows, trials, vessels, and fisheries (Gauvin et al. 2013, 2015). Research is ongoing to improve the salmon excluder design. Similarly, while results have been inconsistent with respect to the efficacy of utilizing artificial light to attract or guide salmon to an escape portal, lights continue to be used in this fishery with the goal of increasing escapement. To contribute to this on-going research, in 2017 CE conducted projects (1) to evaluate salmon behavior in response to artificial lights in the trawl; and (2) to collaborate on an industry driven project evaluating salmon behavior around excluders.

Salmon Response to Artificial Light--CE

Between 24 August and 11 September 2017, CE conducted a research cruise to evaluate salmon behavior in a commercial pollock trawl net in the presence and absence of artificial light, and with a barrier to water flow. The chartered cruise was aboard the F/V Pacific Explorer, a 155 ft catcher vessel trawler in the Bering Sea pollock fishery. The net used was made by Hampidjan, had headrope and footrope lengths of 140 m and 314.4 m (respectively), and steel trawl doors. The intermediate section was untapered, 30 meshes long, with 114 mm (4.5 in) stretch mesh (measured between knots). The trawl was towed in a way to mimic commercial fishing operations. The one exception was that, in over half of the tows, the codend was opened so that no fish would be captured. A 4' x 4' reinforced vinyl square (a 'parachute') was attached in the front of the codend to simulate it being closed and filling with fish. This was done to avoid retaining fish and, therefore, the need to either discard at sea or offload. For all tows, fishing location was determined by the captain, with guidance from the 'rolling hot spot' locations, with the goal of 'catching' a mix of pollock and salmon (targeting 30-100 salmon per approximately two hour tow). This was done to ensure that, during a tow, sufficient numbers of salmon would experience the experimental lights, and that conditions were representative of commercial fishing operations.

During the charter, the behavior trials were conducted in the straight, intermediate section of the trawl (i.e., between the net and codend, or 'stuffing tube'). On the port and starboard sides of the net, halfway between the top and bottom riblines, lights were attached facing towards the net opening. The lights, housed in pressurized acrylic tubes, were synced so that they would turn on for 15 minutes, then off for 15 minutes, in repeating, alternate cycles until the lights were manually turned off at the end of the tow. White LED lights were used, both strobing and not (at different times). The light was covered with a 'sconce' to direct the illumination up the net rather than bleeding across to the other side. We also tested a green Wesmar light (one that is currently being applied by some fishermen and scientists to guide salmon towards an escape portal) at full intensity, and without strobe. During separate trials, this green light was placed only on one side of the net at a time. Wildlife Computer TDR-MK9 archival tags were used to record light quantity (i.e., photosynthetically active radiation, PAR) in 30 s intervals. During six of the tows, a 4’ x 4’ ‘parachute’ was attached to the four riblines in the intermediate, opening 8 ft behind the experimental area to observe salmon and pollock behavior near the lights with the addition of something that slowed the water flow down near the experimental area. An acoustic sounder (DIDSON by Sound Metrics), and low light cameras with infrared illumination were used to observe the behavior of pollock and salmon as they passed by the lights.

Analysis of the video footage and DIDSON data collected during this research cruise is currently underway (winter 2018). This includes (1) scanning the footage to select clips when salmon are present in the field of view, (2) quantifying presence of salmon in each side of the net and linking that to when the experimental lights were on or off, and (3) analyzing behavior of the salmon in the presence of the illuminated and non-illuminated lights with respect to intentional movements in any direction.

Collaboration on Industry Led Excluder Research--CE

In August 2017, John Gauvin (North Pacific Fisheries Research Foundation, NPFRF) proposed an Exempted Fishing Permit (EFP) research project to iteratively, over 3 years, develop and test salmon excluder designs for the different trawl vessel size classes fishing for Bering Sea pollock. The project is a collaborative effort with John Gruver of United Catcher Boats Association, Ed Richardson of At-Sea Processors Association, the Amendment 80 fleet, other members of the pollock fishery, and the AFSC CE group. During several workshops in 2017, project collaborators came together to discuss salmon excluders that have been and are being used, and new, innovative ideas for modifying salmon excluders. Models of the new designs and those successfully being used were taken to a flume tank at the Marine Institute in St. John’s, Newfoundland (November 2017). Together, fishermen, net makers, industry representatives, the CE lead, and collaborators on this project observed the model excluders in the flume tank and worked together to improve the designs. Based on what was learned at the flume tank, three of the most promising excluder designs were selected for sea trials that are currently taking place (winter 2018). The EFP includes three seasons of testing (winters of 2018, 2019, and 2020). The overall goal is for the trials to culminate in an excluder design that effectively and reliably allows for salmon escapement, and, through the process, to gain a better understanding of what variables affect the efficacy of the design elements. The design modifications will focus on the location of the escapement portal, the design of the ramp to the portal, the number of portals, and the design of the trawl section around the excluder section. As a collaborator, CE has supported this research by being involved in the initial workshops for this project to discuss excluder designs and attending the flume tank workshop in November 2017. CE has also provided edits and feedback to the EFP proposal and the RFP for boat owners to bid on the opportunity to conduct the research on their vessel. CE also led the proposal review of the vessels that bid. CE continues to support the research by being involved in the on-going sea trials, and will be involved in data evaluation, and planning next steps.

Support of Industry Innovation--CE

In addition to the research, in 2017 CE continued efforts to support innovation and collaboration with the fishing industry and conservation engineering community. To do this, CE hosted a workshop, in collaboration with industry and scientific partners, held in Seattle, WA to (1) present research being done by CE and other scientists focusing on Alaska fisheries; (2) provide an opportunity for industry members to present on ways they are innovating; (3) provide information that supports industry innovation; (4) facilitate a discussion about industry bycatch concerns and potential solutions; and (5) get feedback from industry members, NGOs, managers, and other scientists about needed research for Alaskan fisheries with respect to bycatch and habitat impacts, and how CE can support industry led innovation. There were ~40 people in attendance and 10 presentations. At the completion of the workshop, there was a brief discussion about steps moving forward. It was agreed that an annual workshop would be beneficial.

In addition to the CE annual workshop, in 2017, CE 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. These cameras support better understanding of fishing gear operation and facilitate timely improvements. The current systems have been in use for over 5 years now, and have seen some changes and improvements over the years. In 2017, CE continued to maintain, upgrade, and expand the loaner pool of underwater cameras to further facilitate and encourage industry-driven innovation.

Technology to Observe Fish Behavior--CE

Through technological advancements in the salmon behavior study (described above), CE continued its work on the research and development of underwater imaging specific to bycatch mitigation in commercial fishing gear. Specifically, CE worked to develop technology to observe fish behavior in a trawl net without the use of visible camera lights. For the salmon behavior study, rather than using traditional underwater cameras that illuminate the field of view with white light, we imaged with low light cameras and near infrared (NIR) light. We used a Stanford Photonics intensified charge-coupled device (ICCD) camera with a Gen III intensifier, which was sensitive to both infrared (IR) and visible light. The camera was connected to a titanium underwater housing that contained a digital video recorder (DVR), battery, and depth activated power control. The camera was illuminated by off-the-shelf security infrared light emitting diode (LED) arrays in pressure tolerant potting epoxy. Additional, low-light charge coupled device (CCD) cameras, with the infrared light cut out filter removed, were used. These were housed in pressurized acrylic tubes. Next to each camera were independent infrared LED arrays housed in aluminum pressure housings with clear acrylic ports, and connected to a titanium underwater housing that contained a battery and depth activated power control. These lights provided a minimum of 100 degree angle wide illumination. The wavelength distribution of the infrared LEDs used for both camera set ups was centered at 840 nm, and had a range of approximately 1 meter in situ. In addition to the cameras, during the 2017 field work, a DIDSON acoustic sonar was used to determine its efficacy in visualizing fish behavior compared to cameras, given the greater range of the sonar, but limited resolution.

Evaluating Trawl Footrope-Seafloor contact in the Bering Sea Pollock Fishery--CE

In 2017, CE collaborated on a study with Alaska Pacific University professor Dr. Brad Harris and his master’s student Brianna King to develop technology and discern best practices for quantifying and evaluating seafloor contact of a pelagic trawl footrope during commercial fishing operations. This work is being done in response to ambiguity that surrounds rate of contact for the Bering Sea pollock fishery. Currently, a range of 20% - 90% is used for the North Pacific Fishery Management Council fishing effects model. These rates of contact are based on conversations with the industry and expert opinions rather than empirically derived data. During the 2017 research charter to evaluate salmon behavior (described above), Brianna’s objective was to determine reliable methods for collecting data on footrope-seafloor contact. Various bottom contact sensors were attached along different parts of the footrope to determine an effective way to measure contact. These sensors are accelerometers placed in a housing with a steel rod extending downward. As the net approaches the seafloor, the steel rod begins to tilt as it lays down on the bottom, and the accelerometer records these angles (e.g., 90 degrees is off the bottom, whereas 0 degrees is on the bottom), which can then be trigonometrically translated into a height off bottom. Brianna is currently (winter 2018) analyzing these data.

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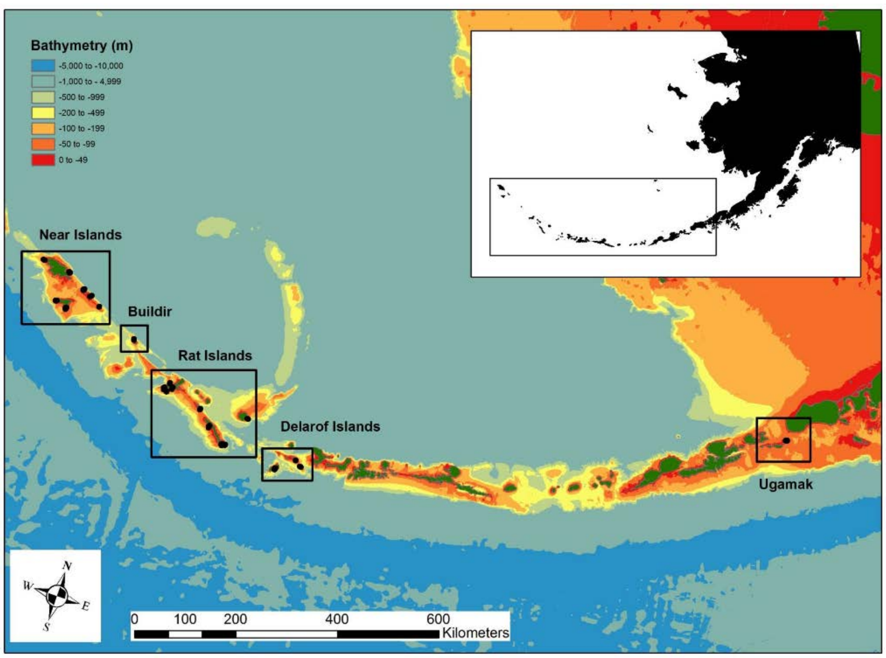
For more information, contact MACE Program Manager, Chris Wilson, (206) 526-6435.

GROUNDFISH ASSESSMENT PROGRAM

Opportunistic nearshore underwater camera survey in the Aleutian Islands-GAP

The availability of fish resources in nearshore shallow areas in the Aleutian Islands remains poorly understood because traditional bottom trawl surveys conducted by NOAA's Alaska Fisheries Science Center (AFSC) cannot sample the prevalent rocky, nearshore habitats and lack precision for specific localized areas. We attempted to overcome these sampling challenges by opportunistically deploying a towed underwater stereo camera system near SSL rookeries and haulouts during the NOAA AFSC Marine Mammal Laboratory ship-based population survey of SSL in 2016 and 2017. A total of 63, 15-minute transects were conducted in depths ranging from 20-100m. Transects were analyzed using software developed at the AFSC which allowed for fish and associated habitat to be identified, quantified, and measured. Camera transects encompassed substrates ranging from sand to high-relief boulder fields, and we found that higher fish abundance was associated with rocky terrain. Substrates and associated fish abundances varied widely over small (10-100 m) spatial scales, suggesting that nearshore survey activities should be structured to account for extreme spatial variability. The relatively low cost of our camera system, combined with its ability to be deployed quickly during available vessel time, make it a promising tool for future fish surveys of nearshore and untrawlable habitat.

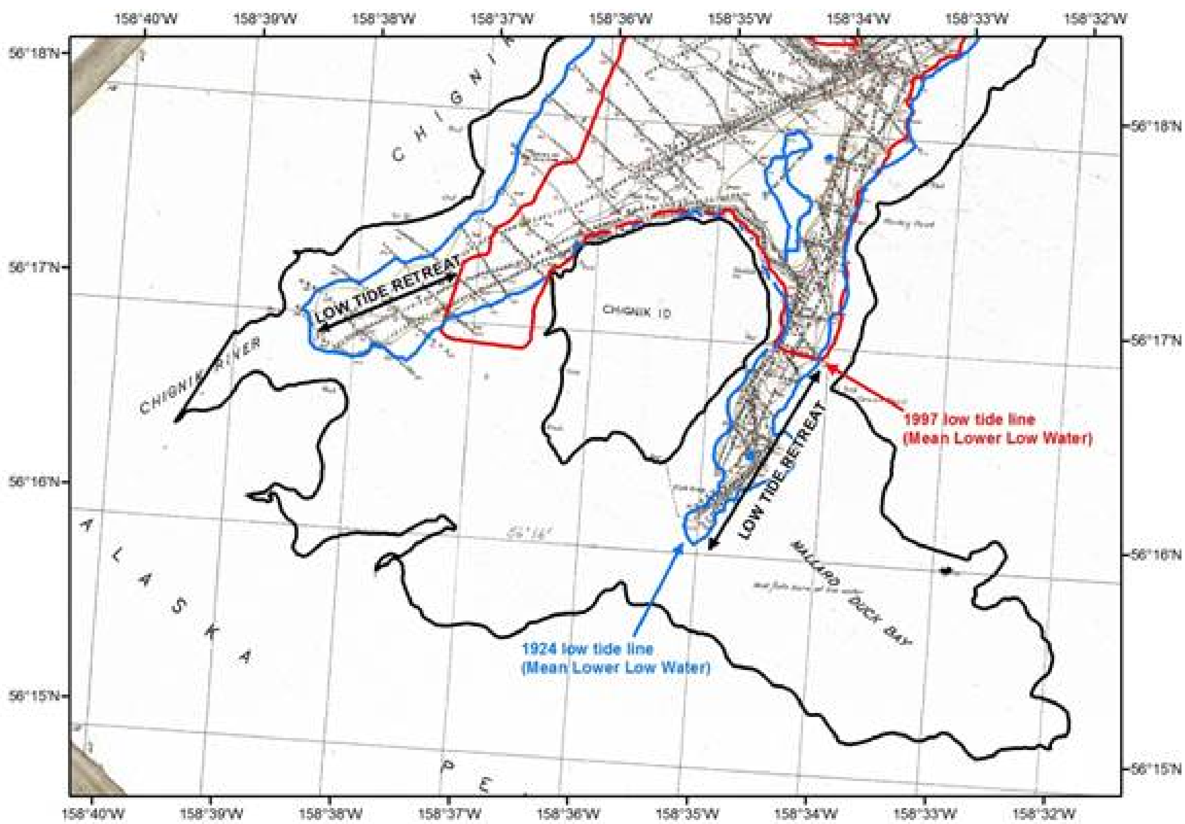
For more information, contact Susanne McDermott at Susanne.McDermott@noaa.gov.



Camera tow locations during the opportunistic underwater camera survey in the Aleutian Islands.

Inshore shallowing at Chignik, in the western Gulf of Alaska - RACE GAP

We quantified the shallowing of the seafloor in five of six bays examined in the Chignik region of the Alaska Peninsula, confirming National Ocean Service observations that 1990s hydrographic surveys were shallower than previous surveys from the 1920s. Castle Bay, Chignik Lagoon, Hook Bay, Kujulik Bay and Mud Bay lost volume as calculated from Mean Lower Low Water (Chart Datum) to the deepest depths and four of these sites lost volume from Mean High Water to the deepest depths. Calculations relative to each datum were made because tidal datum records exhibited an increase in tidal range in this region from the 1920s to the 1990s. Our analysis showed that Mud Bay is quickly disappearing while Chignik Lagoon is being reduced to narrow channels.



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Research on surveying untrawlable habitats-RACE MACE & GAP

Bottom-trawl and acoustic surveys conducted by the AFSC have been the main source of fishery-independent data for assessing fish stocks in Alaska. But bottom trawls cannot sample in steep, rocky areas ("untrawlable" habitats) that are preferred by species such as Atka mackerel and rockfishes. Untrawlable areas make up to about 20% of the federally managed area where surveys have been attempted in the Gulf of Alaska and up to about 54% of the federally managed area in the Aleutian Islands. A number of commercially important rockfish species including dusky, northern, harlequin, and yelloweye rockfishes strongly prefer these untrawlable habitats. Many species of rockfishes are long-lived and reproduce late in life, making them particularly vulnerable to overfishing. Managers need accurate stock assessments to keep these fisheries sustainable. Unfortunately, assessments based on surveys of trawlable areas are highly uncertain for species that live mainly in untrawlable habitat.

The problem of assessing fish stocks in untrawlable habitat is not limited to Alaska. Developing new methods to sample in rock, reef, and other untrawlable habitats is a nationwide NOAA effort. NOAA's Untrawlable Habitat Strategic Initiative (UHSI), has been conducting several pilot projects for developing methodologies that can be used to sample untrawlable habitats. Many methods are being explored, and most involve acoustic or optical technologies (underwater cameras).

In Alaska, previous research has combined large-scale acoustics and optical sampling. A sampling plan for assessing fish in untrawlable habitats in the Gulf of Alaska is being developed for future implementation. In this planned survey bottom trawl samples will be replaced with high resolution photos from which fish species and sizes can be identified. Stereo cameras lowered from ships or moored near or on the seafloor will be used where each will be most effective. The Gulf of Alaska untrawlable survey design will be based on prior studies by the Alaska Fisheries Science Center and other researchers, including:

- Acoustic-optics studies
- Experiments with stationary triggered cameras
- Mapping and habitat classification efforts
- Remotely operated vehicle surveys
- Studies of fish response to camera equipment and movement
- A study of fish visual spectrum sensitivity
- Research into computer automated image analyses

Research on untrawlable habitats will continue to be important for producing the most accurate stock assessments possible for species such as rockfishes that prefer these inaccessible areas.

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Multispecies Acoustic Dead-zone Correction and Bias Ratio Estimates Between Acoustic and Bottom-trawl Data--GAP

In this study, we extended the original work of Kotwicki et al. (2013) to jointly estimate the acoustic dead-zone correction, the bias ratio, and the gear efficiency for multiple species by using simultaneously collected acoustic and bottom-trawl data. The model was applied to cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) in the Barents Sea and demonstrated a better or similar performance compared with a single species approach. The vertical distribution of cod and haddock was highly variable and was influenced by light level, water temperature, salinity, and depth. Temperature and sunlight were the most influential factors in this study. Increase in temperature resulted in decreasing catch and fish density in the acoustic dead zone (ADZ), while increasing sun altitude (surrogate for light level) increased the catch and fish density in the ADZ. The catch and density of haddock in the ADZ also increased at the lowest sun altitude level (shortly after midnight). Generally, the density of cod and haddock changed more rapidly in the ADZ than in the catch (from bottom to the effective fishing height) indicating the importance of modelling fish density in the ADZ. Finally, the uncorrelated variability in the annual residual variance of cod and haddock further strengthen the conclusion that species vertical distribution changes frequently and that there are probably many other unobserved environmental variables that affect them independently.

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

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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.

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.

Determination of Parameters for an Underwater Camera System that Maximizes Available Light for Analysis While Minimizing Visual Detection by Demersal Fishes Associated With Untrawlable Habitats--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 of species distributed to depths where the ambient light environment is too dim for optical systems. 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, groupers, or other mesophotic fishes) necessitating the addition of a color component to aid in species identification. To develop an underwater camera and lighting system for assessing deepwater fish 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 is being addressed by: (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?

So far, this need has addressed for deep-water rockfishes in Southern California, where 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 in review. Currently, similar studies are being proposed for Alaskan rockfishes, nearshore rockfishes along the west coast, groupers in the Gulf of Mexico, and for mesophotic fishes in the Pacific Islands region.

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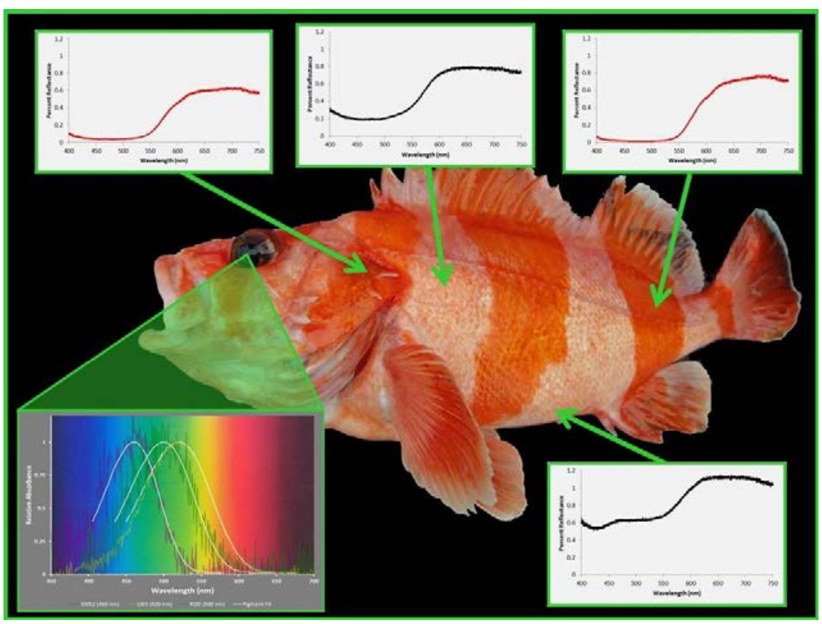
Species	**Common Name**	**Max Depth***	**ROD[†]**	**LWS[†]**	**SWS2/RH2[†]**
S. chlorostictus	Greenspotted Rockfish	363	486	493	442
S. goodei	Chilipepper Rockfish	325	486	488	454
S. rosenblatti	Greenblotched Rockfish	491	489	493	438
S. elongatus	Greenstriped Rockfish	250	490	497	446
S. emphaeus[‡]	Puget 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.

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 2017. 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 and western Pacific. Similarly, they are collaborating on a study of capelin and in particular on the taxonomic status of the Gulf of Alaska populations. 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 study of the developmental osteology of the bathymasterid *Ronquilus jordani* (Stevenson, with Hilton and Matarese); and a partial revision of the agonid genus *Pallasina* (Stevenson). Work on the molecular phylogenetics and morphology of the pectoral girdle of snailfishes (Orr, Stevenson, Spies, with UW) was completed, as well as a partial systematic revision of the lumpsucker genus *Eumicrotremus* (Stevenson et al., 2017). Descriptions of new species, based on morphology and genetics, from Alaska and Canada continues.

In addition to taxonomic revisions, descriptions of new taxa, and guides, the description and naming of a new snailfish, 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), *Bathyraja spinosissima* (Orr, Hanke, Stevenson, 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) now in press. Stevenson recently completed a study documenting the reliability of species identifications in the North Pacific Observer Program (Stevenson, 2018), co-authored the data report from the 2014 eastern Bering Sea shelf survey (Conner et al., 2017), and is working on a comparison of fish distributions in the northern Bering Sea (Stevenson and Lauth, in prep) as well as a study documenting fishery interactions with skate nursery areas in the Bering Sea (Stevenson et al., in prep).

Orr and Stevenson have also conducted work with invertebrates. On-deck guides have been synchronized with the nomenclature of our 2016 *Checklist of the Marine Macroinvertebrates of Alaska*. 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 2017:

Stevenson, D. E. 2018. Documenting the reliability of species identifications in the North Pacific Observer Program. Fisheries Research 201:26–31.

Stevenson, D. E., C. W. Mecklenburg, and Y. Kai. 2017. Taxonomic clarification of the *Eumicrotremus asperrimus* species complex (Teleostei: Cyclopteridae) in the eastern North Pacific. Zootaxa 4294(4):419–435.

Conner, J., D. E. Stevenson, and R. R. Lauth. 2017. Results of the 2014 eastern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-350, 154 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.

Pietsch, T. W., and J. W. Orr. In press. Fishes of the Salish Sea: Puget Sound and the Strait of Georgia and Juan de Fuca. University of Washington Press, Seattle, 1505 MS pp + 350 figs.

V. Ecosystem Studies

Ecosystem Socioeconomic Profile (ESP) – AFSC

Ecosystem-based science is an important component of effective marine conservation and resource management; however, the proverbial gap remains between conducting ecosystem research and integrating with stock assessments. A main issue involves the general lack of a consistent approach to deciding when to incorporate ecosystem and socio-economic information into a stock assessment and how to test the reliability of this information for identifying future change. Our current national system needs an efficient testing ground and communication tool in order to effectively merge the ecosystem and stock assessment disciplines.

Over the past several years, we have developed a new standardized framework for operationalizing the integration of ecosystem and socioeconomic factors within the NOAA Fisheries' stock assessment system (Shotwell et al. 2017). These ecosystem and socioeconomic profiles (ESPs) 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. We use Alaska groundfish as a case study and data collected from a large variety of national initiatives was first synthesized for all stocks. A four-step process was then used to generate a set of standardized products that culminate in a focused, succinct, and meaningful communication of potential drivers on a given stock. We combine a priority-based data gap analysis with a graded metric panel and a Bayesian model selection process to test potential indicators on data-limited to data-rich stocks. The resulting ESP report is effectively a synthesis of ecosystem and socioeconomic factors that can be distilled into several different formats to communicate with the scientific community, stakeholders, and the public. The standardized process/product framework allows for comparison across stocks and provides the necessary building blocks to move toward an ecosystem-based approach to fisheries management.

These baseline ESPs can then be enhanced with new information from process studies (e.g. IERPs, FATE) continued ecosystem monitoring (e.g. standard surveys, remote sensing), laboratory experiments (e.g. early life history development, energetics studies), or integrated modeling (e.g. habitat suitability models, individual based models, multi-species models). The ESPs 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., B. Fissel, and D. Hanselman. 2017. Ecosystem-Socioeconomic Profile of the Sablefish stock in Alaska. Appendix 3C *In* Hanselman, D., C. Rodgveller, C. Lunsford, and K. Fenske. 2017. Assessment of Sablefish stock in Alaska. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea Aleutian Islands and Gulf of Alaska. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@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 objective of this study was to collect plankton samples inside and outside of coral habitat to determine whether these habitats were preferentially chosen for spawning by rockfish species. The study was carried out over 2 days in conjunction with Leg 1 of the 2017 bottom trawl survey of the Gulf of Alaska. Only a single tow during Leg 1 of the survey captured rockfish that were close to extruding larvae. So an alternative study design that focused on known areas of coral habitat was employed. Thus, stations were chosen within GOA slope closed areas (HAPC closures) at Sanak Bank and in previously studied juvenile Pacific Ocean perch nursery habitat near Samalga Pass. Stations included coral, sponge and bare habitats that were previously surveyed (with a couple exceptions).

This study implemented a new design that had not been tested before, so there was a unique opportunity for proof of concept in addition to collecting larval fish. As a pilot project, there were several opportunities for modifying and improving the larval fish pump design in situ. Improvements were immediately made to the deployment gear after the first deployment to prevent the pump from opening during ascent and emptying its contents. In addition, initial flow rates were set using a programmed thruster and based on tank studies that didn't take into account a swift benthic current. Therefore, Plankton Pump Deployments (PD) #2 - #11 had thruster speeds that were potentially inadequate for collecting more active zooplankton, such as larval fish and chaetognaths. Battery problems, as well as a few camera and door activation issues also occurred, but ultimately, the pump worked autonomously at depths where coral and sponge occurred and in regions where rockfish were spawning. The final four samples were collected with appropriate thruster speeds and no malfunctions, and resulted in an abundant and diverse array of zooplankton, including a larval rockfish. The autonomous pump design used for this project to sample larval fish may be useful for other important data collection such as examining benthic prey fields and energetics of near-bottom fishes in a variety of deep-water habitats.

Data are still in the process of being summarized for analysis. Some of the habitat classifications of study sites have not been matched with existing camera survey data (listed as NA in Table 1). The zooplankton community was dominated by copepods in all habitat types (Figure 1). Barnacle nauplii, amphipods and euphausiids were also important components of the zooplankton communities. It is of interest to note that the one larval rockfish was found in rocky, coral habitat, which was also the station with the highest count of zooplankton.

Table 1. Station identification of 15 plankton pump deployments (PD), habitat type (sponge, coral, bare rock), substrate type (unconsolidated or rocky), depth, surface current, invertebrate counts, and diversity.

Station ID	*Habitat Type*	*Substrate Type (Unconsolidated=U, Rocky=R)*	*Depth (m)*	*Surface Current ($cm\ s^{-1}$)*	*Total Invertebrate Count*
PD1	*NA*	*NA*	*123.1*	*1.5*	*NA*
PD2	*Sponge*	*U*	*122.8*	*1.2*	*12*
PD3	*NA*	*NA*			*NA*
PD4	*Bare*	*U*	*120*	*1.7*	*36*
PD5	*NA*	*NA*	*120*	*1.5*	*170*
PD6	*NA*	*NA*			*NA*
PD7	*Bare*	*R*	*88*	*0.0*	*146*
PD8	*Coral*	*U*	*80*	*0.5*	*3*
PD9	*NA*	*NA*	*98*	*0.5*	*127*
PD10	*Sponge*	*U*	*92*	*0.75*	*70*
PD11	*Sponge*	*U*	*94*	*0.5*	*31*
PD12	*Sponge*	*U*	*105*	*0.5*	*157*
PD13	*Sponge*	*U*	*105*	*0.5*	*137*
PD14	*Coral*	*R*	*93*	*0.5*	*531*
PD15	*Sponge*	*U*	*90*	*0.5*	*278*

Figure 1. Percent composition of invertebrates identified at 3 different habitat types (sponge, coral, and bare rock).

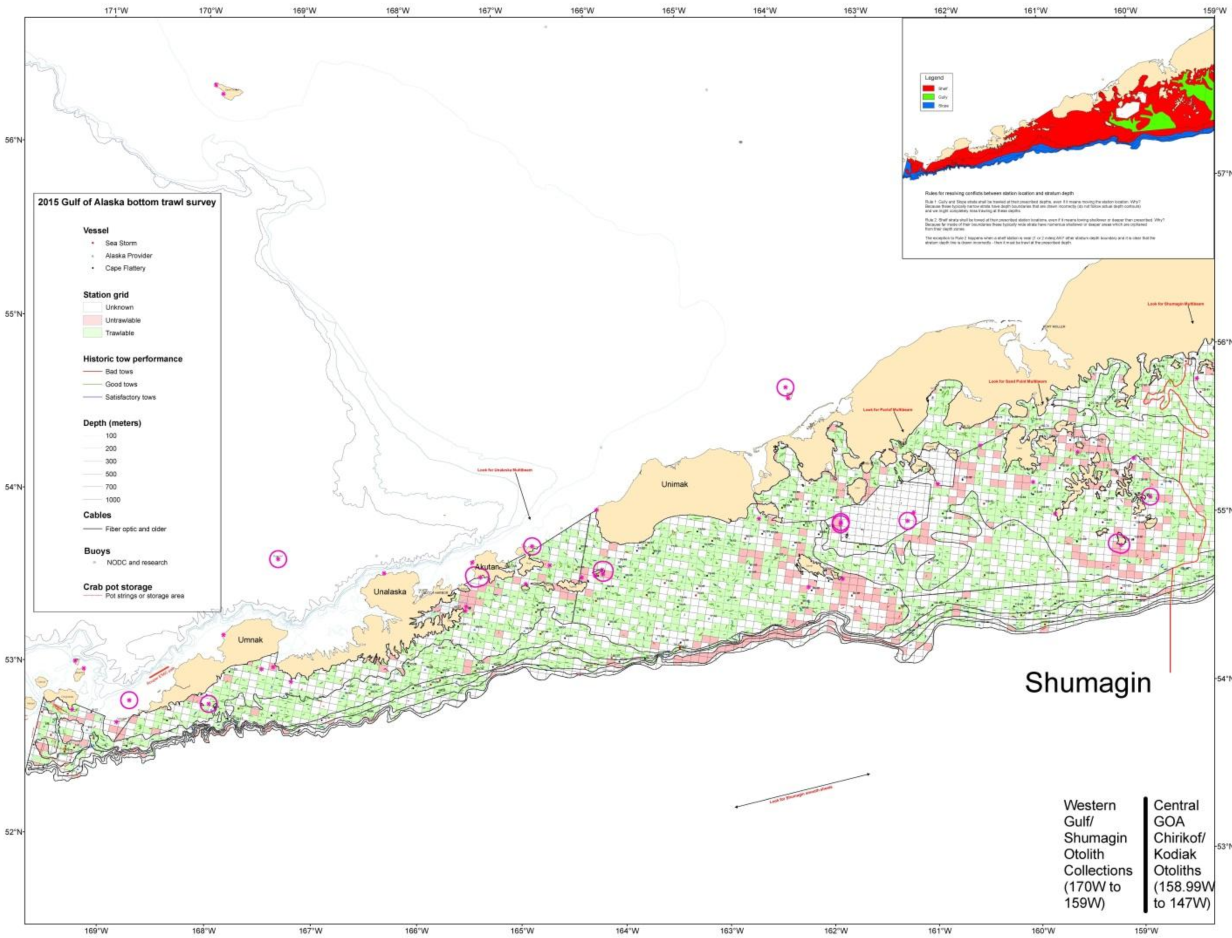


Figure 2. Map of 2015 western Gulf of Alaska bottom trawl survey stations from the Islands of Four Mountains to the Shumagin Islands as an example of the station pattern for the study. One of the survey vessels will conduct the study at its assigned stations.

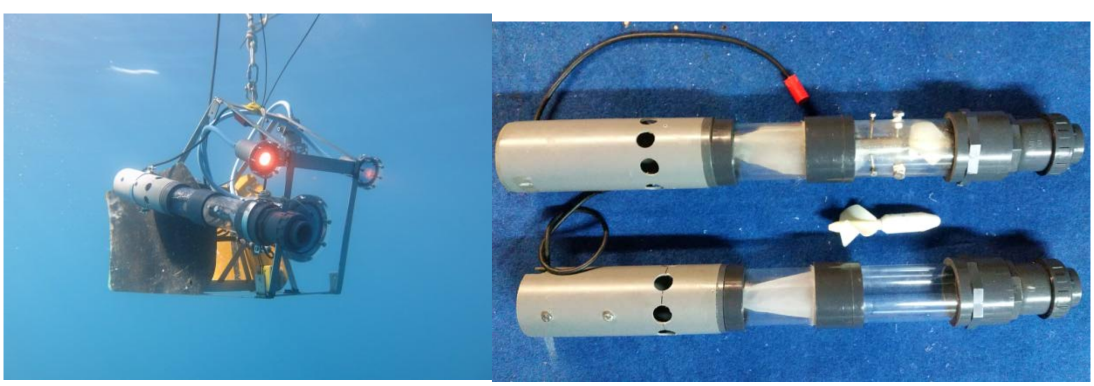


Figure 3. Plankton pump and deployment system with camera and lights. Images courtesy of ShelfReCover

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.

Using ichthyoplankton time series data form California to Alaska to identify ecosystem changes - RPP

Jens M. Nielsen, Lauren A. Rogers, J. Anthony Koslow, Richard D. Brodeur, Andrew Thompson, and Janet T. Duffy-Anderson

Ecological indicators can be used to track ecosystem change and assess impacts from natural and human mediated pressures. Ichthyoplankton data are particularly useful for assessing temporal ecosystem changes as they respond quickly to environmental variability and furthermore may provide a link to fish recruitment dynamics. However, what has so far only been tentatively explored is the use of multispecies larval indices as ecological indicators of ecosystem dynamics. We combine ichthyoplankton time-series from long-term monitoring programs ranging from California to Alaska, to identify if ichthyoplankton data can be used as ecological indicators for tracking and predicting marine ecosystem dynamics. Specifically, we analyzed ichthyoplankton time series data from the Gulf of Alaska (33 years) and the northern and southern California Current (Vancouver 16 years, Oregon 20 years, California 63 years). Dynamic factor analysis (DFA) and chronological clustering analysis were used to assess common trends in the ichthyoplankton time series data. First, we assessed if there are shared or divergent responses to environmental changes among ichthyoplankton assemblages from different regions. Second, we explored the relationship between trends in fish larvae dynamics and recruitment of commercially important species. Because early life stages of single species often exhibit high variability, we focus on multispecies analyses to assess how fish larvae can be used as a leading indicator of future recruitment dynamics of fishes of economic importance.

Preliminary analyses using the multi species approach show that the common trend of 40 ichthyoplankton species (estimated using DFA) corresponds closely to the common trend of recruitment estimates from 12 species in the Gulf of Alaska (Fig. 1). Similarly, there seem to be some co-variation between the winter PDO, used as a proxy for climatic perturbations, and the common trend of the ichthyoplankton data. Similar analysis will be conducted with data from the Vancouver, Oregon and California regions.

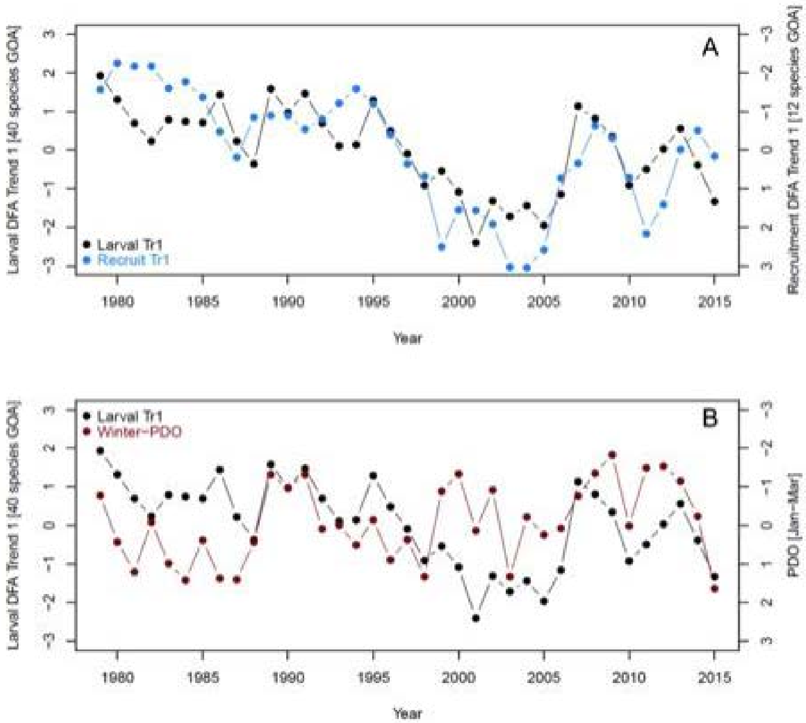


Fig 1: Temporal dynamics of **A**) the common DFA trend 1 of 40 ichthyoplankton species (black) and the DFA trend 1 of recruitment estimates of 12 adult species (blue), and **B**) the common DFA trend 1 of 40 ichthyoplankton species (black) and the winter PDO index (Jan-Mar, red) from the Gulf of Alaska. Note that the second y-axes were inverted.

By combining extensive time-series data from multiple regions the complementary multispecies approaches can help categorize species synchronies within sub-regions and between large marine ecosystems along the US west coast.

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Chukchi Sea Integrated Ecosystem Survey Beam Trawl Sampling - RPP
Libby Logerwell and Dan Cooper

The goal of NPRB's Arctic Integrated Ecosystem Research Program (IERP) (https://www.nprb.org/arctic-program/about-the-program/) is to better understand the mechanisms and processes that structure the Arctic marine ecosystem and influence the distribution, life history, and interactions of biological communities in the Chukchi Sea. A major field component of the Program is the Arctic Integrated Ecosystem Survey (IES), a multi-disciplinary survey that covered the US Chukchi Shelf in August – September 2017. A second survey is planned for 2019.
Benthic fish and invertebrates were sampled with a 3-m plumb staff beam trawl at 60 grid stations from the

Chukchi slope south to Bering Strait (Fig. 1).

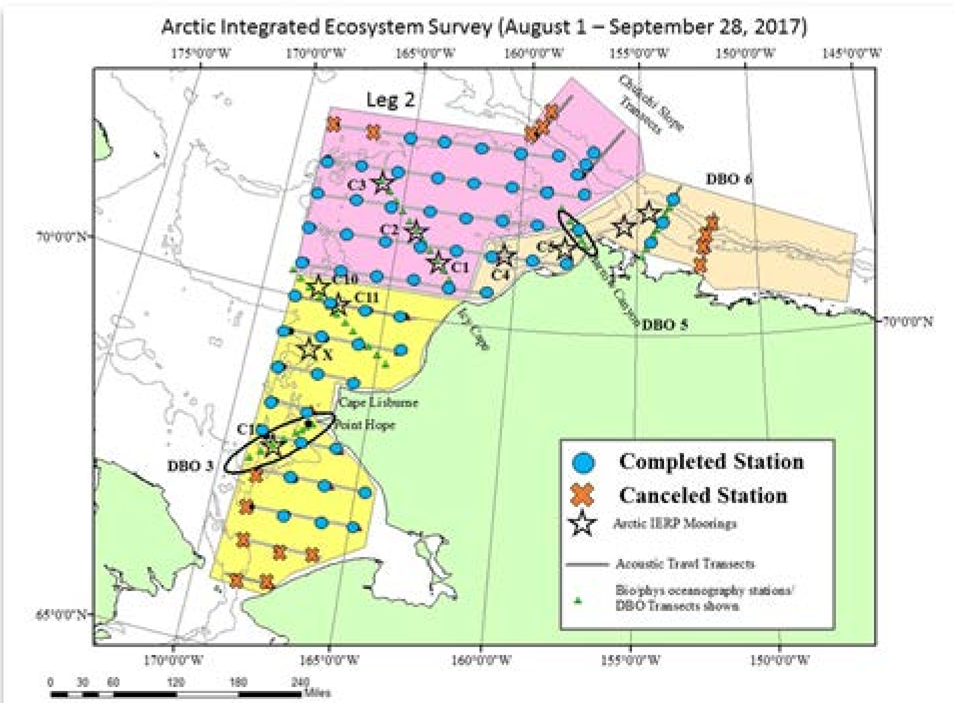

Figure 1. Stations sampled during the 2017 Arctic Integrated Ecosystem Research Program (IERP) Integrated Ecosystem Survey (IES) in the Chukchi Sea

Epibenthic invertebrates dominated the beam trawl catch, making up 94% of the total catch weight. The top 10 invertebrate taxa caught (by biomass) were brittlestars, Psolus sp. (Holothuroidea), snow crab, starfish, clams, sponges, and tubeworms. The most abundant fish taxa were Arctic cod, sculpin, eelblennies, eelpout and flatfish (Table 1). Pacific cod and walleye pollock were also caught, but were much smaller than the size caught in the commercial fishery, and were likely immature (mean 7.5 and 12.5 cm length, respectively). Similarly, snow crab were smaller than the legal limit for commercial harvest (mean 25 cm carapace width), although ovigerous females were caught.

Table 1. Total catch of snow crab and fish from beam trawl sampling during the 2017 Arctic Integrated Ecosystem Research Program (IERP) Integrated Ecosystem Survey (IES) in the Chukchi Sea. CPUE = catch-per-unit effort

Scientific name	Common name	CPUE kg/ha	CPUE No./ha
Chionoecetes opilio	Snow crab	296.17	33,621.35
Boreogadus saida	Arctic cod	22.269	22,575.12
Gymnocanthus tricuspis	Arctic staghorn sculpin	16.551	4,605.90

Myoxocephalus scorpius	Shorthorn (Warty) sculpin	16.197	5937.89
Lumpenus fabricii	Slender eelblenny	12.910	3,761.39
Lycodes turneri	Polar eelpout	10.014	1,998.42
Lumpenus medius	Stout eelblenny	8.172	2,754.45
Ammodytes sp.	sand lance unid.	5.836	1,645.61
Lumpenus sagitta	Snake prickleback	5.670	2,391.45
Hippoglossoides robustus	Bering flounder	4.514	429.05
Artediellus scaber	Hamecon	3.650	1,564.53
Limanda aspera	Yellowfin sole	2.417	193.41
Gadus chalcogrammus	Walleye pollock	1.893	132.59
Eleginus gracilis	Saffron cod	1.852	690.90
Stichaeus punctatus	Arctic shanny	1.613	472.31
Lumpenus sp.	Lumpenus sp.	1.237	1,879.34
Gadus macrocephalus	Pacific cod	1.083	362.71
Icelus spatula	Spatulate sculpin	1.062	295.64
Lycodes polaris	Canadian eelpout	0.941	552.52
Ulcina olrikii	Arctic alligatorfish	0.694	829.79
Lycodes sp.	Lycodes sp.	0.616	49.05
Lumpenus maculatus	Daubed shanny	0.518	128.64
Lycodes mucosus	Saddled eelpout	0.509	83.95
Liparis sp.	Liparis sp.	0.486	818.61
Gymnelus sp.	Gymnelus sp.	0.474	143.57
Triglops pingeli	Ribbed sculpin	0.429	191.80
Pleuronectiformes	Flatfish unident.	0.405	65.59
Liparis tunicatus	Liparis tunicatus	0.399	57.04
Mallotus villosus	Capelin	0.372	173.72
Lycodes palearis	Wattled eelpout	0.317	195.27

Nautichthys pribilovius	Eyeshade sculpin	0.309	130.63
Limanda proboscidea	Longhead dab	0.295	133.81
Lycodes raridens	Marbled eelpout	0.280	330.62
Hexagrammos stelleri	Whitespotted greenling	0.140	18.90
Gymnelus hemifasciatus	Gymnelus hemifasciatus	0.131	56.32
Podothecus sp.	Podothecus sp.	0.130	60.05
Liparidinae	Snailfish unident.	0.111	110.43
Gymnocanthus galeatus	Armorhead sculpin	0.093	6.64
Clupea pallasi	Pacific herring	0.093	11.61
Chirolophis snyderi	Bearded warbonnet	0.086	6.64
Eumesogrammus praecisus	Fourline snakeblenny	0.082	10.37
Gymnelus viridis	Fish doctor	0.073	5.61
Myoxocephalus polyacanthocephalus	Great sculpin	0.072	48.43
Enophrys sp.	Enophrys sp.	0.066	6.64
Limanda sakhalinensis	Sakhalin sole	0.062	5.13
Cottidae	Sculpin unident.	0.053	160.16
Myoxocephalus sp.	Myoxocephalus sp.	0.039	22.86
Aspidophoroides bartoni	Aleutian alligatorfish	0.031	34.76
Hypsagonus quadricornis	Fourhorn poacher	0.029	28.85
Trichocottus brashnikovi	Bullhorn sculpin	0.015	30.51
Ammodytes hexapterus	Arctic Sand Lance	0.015	7.29
Podothecus veternus	Vetrans poacher	0.013	13.04
Pleuronectiformes larvae	Flatfish larvae unident.	0.006	6.43
Liparis gibbus	Variegated snailfish	0.006	11.96
Icelus sp.	Icelus sp.	0.006	5.84
Gadus chalcogrammus Age 0	Walleye pollock age 0	0.005	10.49

Arctic cod were caught at nearly all stations over a range of water temperatures (Fig. 2). In contrast, saffron cod were found only in the southern half of the survey area, in relatively warm waters (Fig. 2). Walleye pollock were found over a fairly wide range of latitudes in the survey area, whereas Pacific cod were found only in warmer waters in the southern portion of the survey (Fig. 3). Snow crab were caught at nearly all stations. Female snow crab with eggs (ovigerous) were found in the northwestern area of the survey (Fig. 4). Bering flounder were most abundant in relatively cool waters at stations furthest from shore and associated with muddy substrates (Fig. 5).

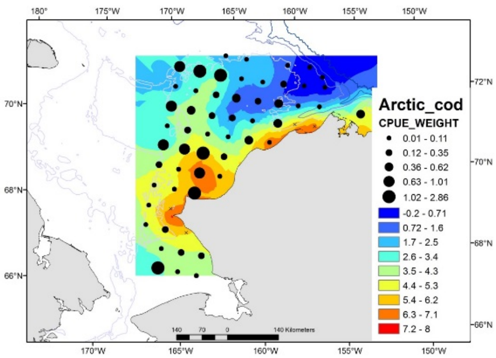

Figure 2. The distribution of Arctic cod and saffron cod overlaid on near-bottom water temperature (temperature data from CTD casts conducted at each station, courtesy of Ryan McCabe, Pacific Marine Environmental Laboratory).

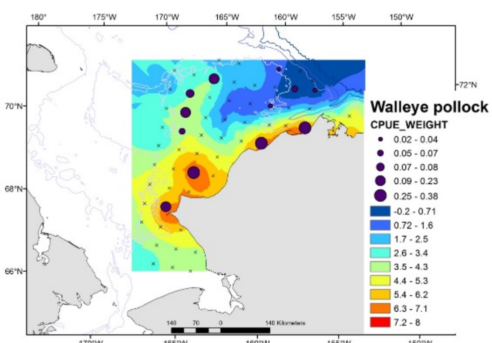

Figure 3. The distribution of walleye pollock and Pacific cod overlaid on near-bottom water temperature (temperature data from CTD casts conducted at each station, courtesy of Ryan McCabe, Pacific Marine Environmental Laboratory).

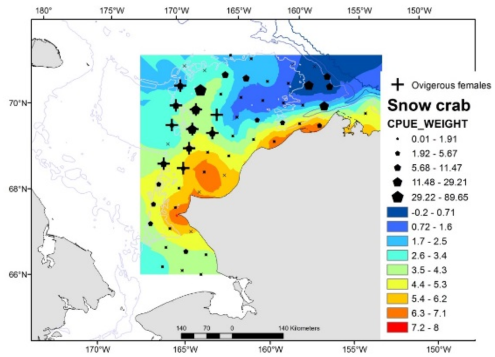

Figure 4. The distribution of snow crab overlaid on near-bottom water temperature (temperature data from CTD casts conducted at each station, courtesy of Ryan McCabe, Pacific Marine Environmental Laboratory). The presence of ovigerous females is indicated by a cross.

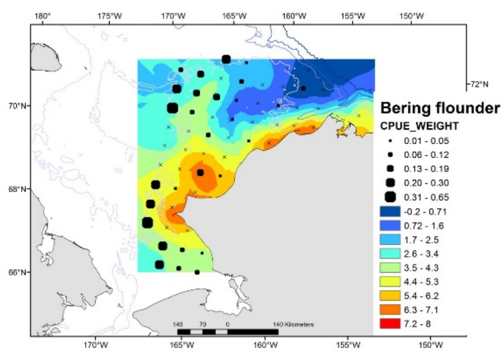

Figure 5. The distribution of Bering flounder overlaid on near-bottom water temperature (temperature data from CTD casts conducted at each station, courtesy of Ryan McCabe, Pacific Marine Environmental Laboratory).

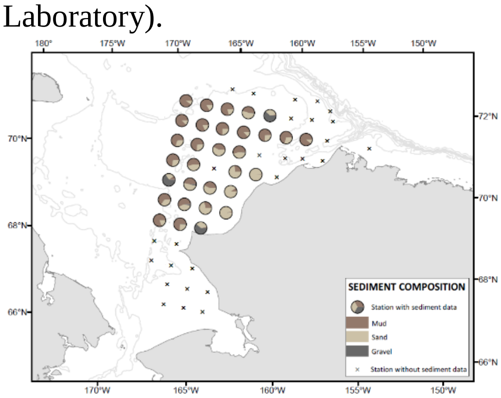

Figure 5. Sediment composition at each station is from benthic grab samples collected during the IES survey (data courtesy of Staci McMahon, University of Washington).

For more information please contact Libby Logerwell at: Libby.Logerwell@noaa.gov

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.

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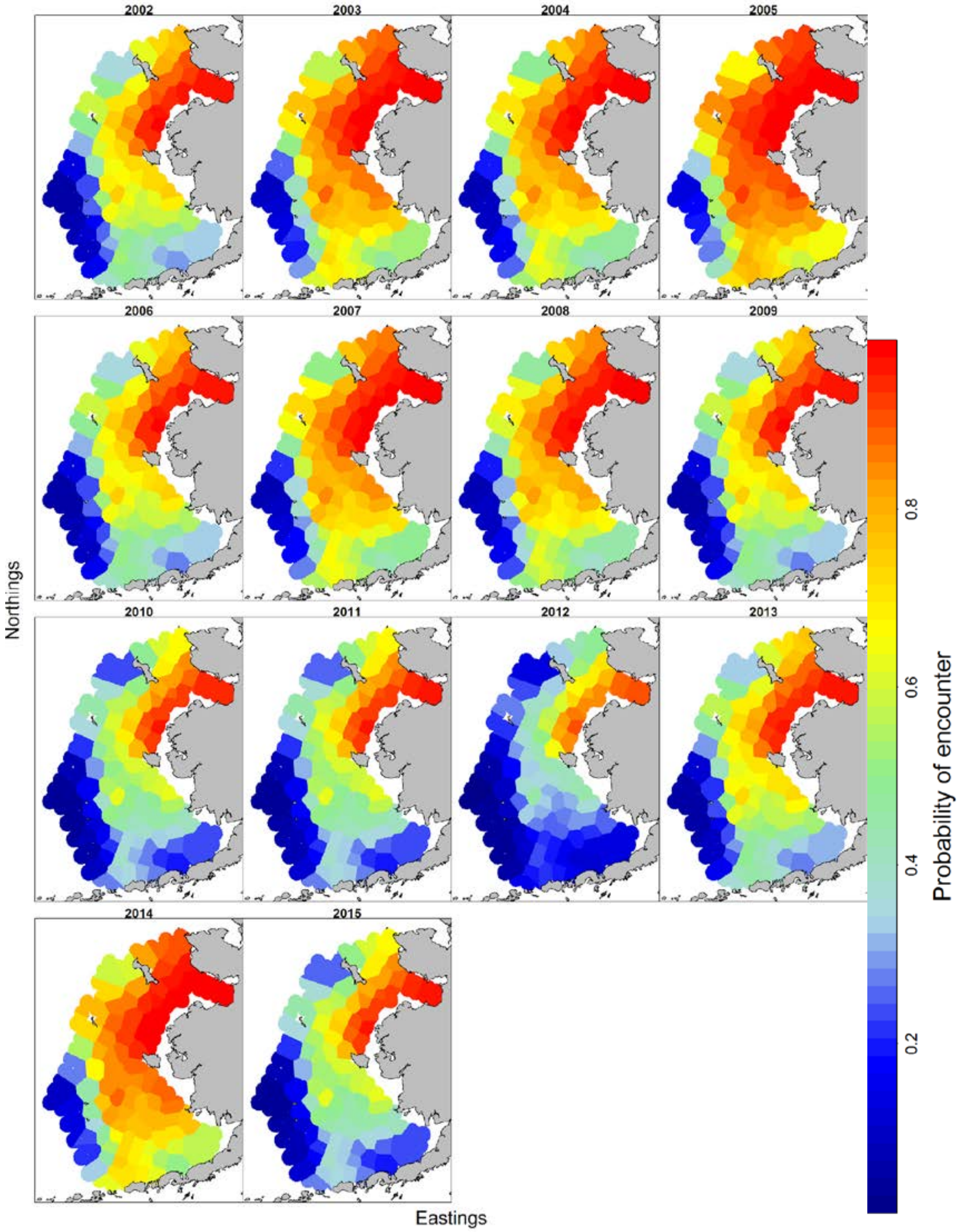

Figure 1. Density of Pacific herring in the eastern Bering Sea during late summer, 2002-2015. Densities were estimated using the geostatistical delta-generalized linear mixed model from Thorson et al. (2015).

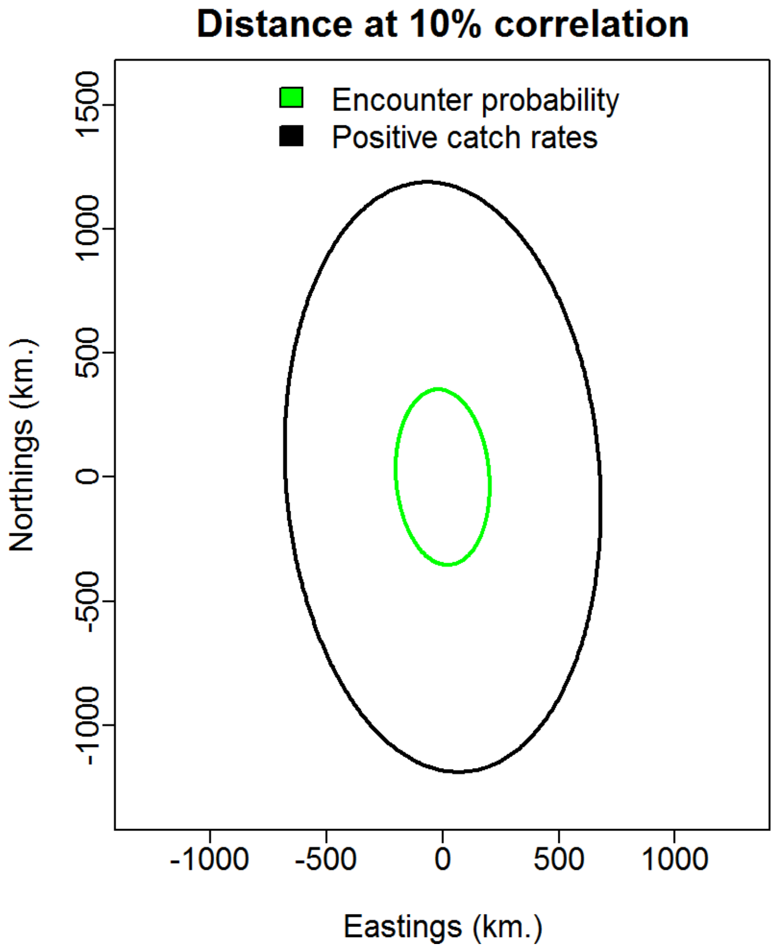

Figure 2. Geometric anisotropy plots for encounter probability of Pacific herring on the eastern Bering Sea shelf during late summer, 2002-2015.

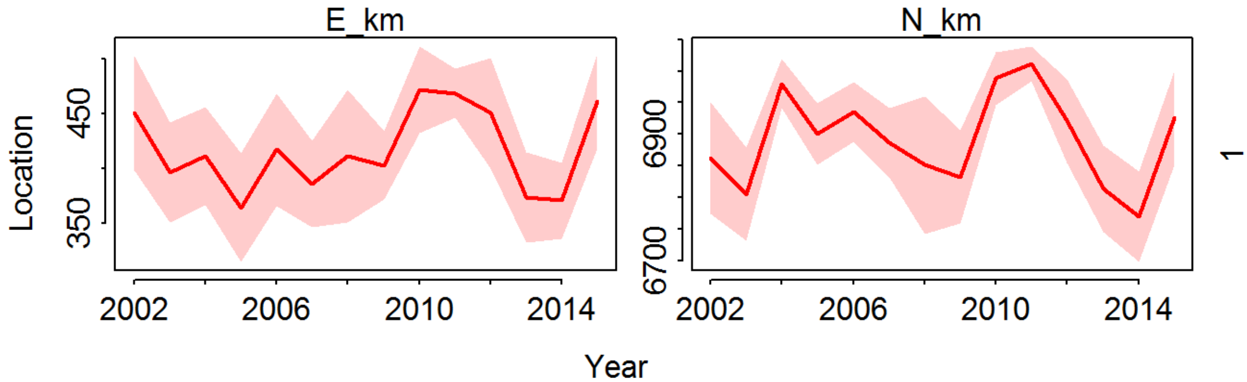

Figure 3. Northward and eastward center of gravity (distribution) in units of km for Pacific herring on the eastern Bering Sea during late summer, 2002-2015.

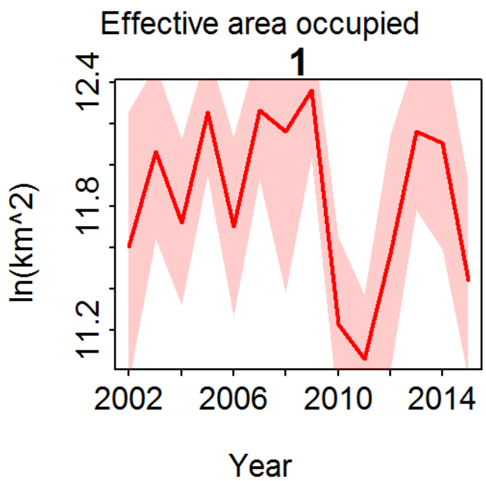

Figure 4. The effective area ($\ln(km^2)$) occupied by Pacific herring on the eastern Bering Sea shelf during late summer, 2002-2015.

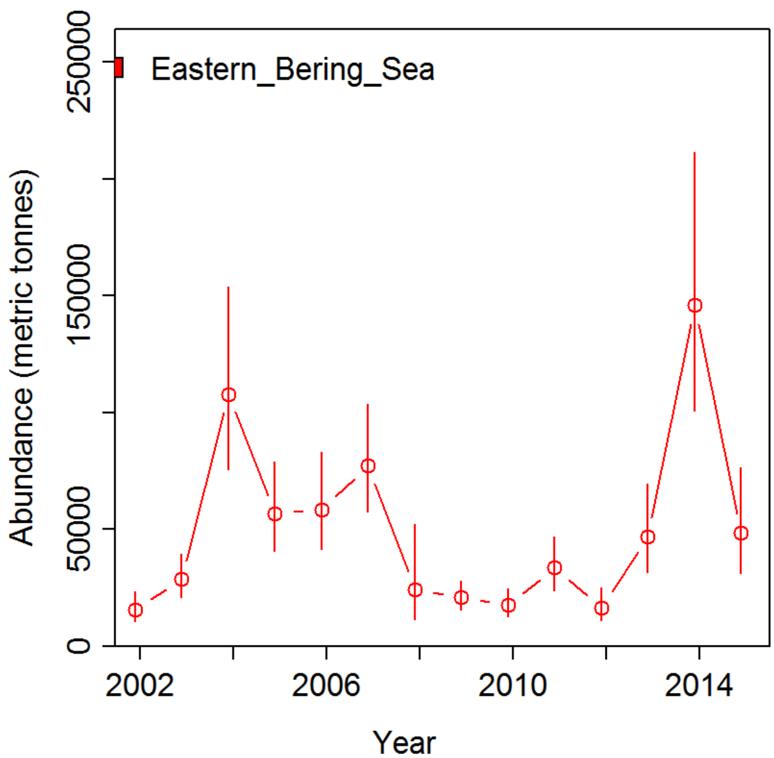

Figure 5. Estimated index of abundance with 95% confidence intervals for Pacific herring in the eastern Bering Sea during late summer, 2002-2015. Abundance was estimated using the geostatistical delta-generalized linear mixed model from Thorson et al. (2015).

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

Spatial and temporal trends in the abundance and distribution of groundfish in pelagic waters of the eastern Bering Sea during late summer, 2002-2016 -ABL

Description of index: Pelagic fish and jellyfish were sampled using a trawl net towed in the upper 20 m of the eastern Bering Sea during the Alaska Fisheries Science Centers' Bering Arctic Subarctic Integrated Surveys (BASIS) during late summer, 2002-2016. Stations were approximately 30 nautical miles apart and a trawl was towed for approximately 30 minutes. Area swept was estimated from horizontal net opening and distance towed.

Fish catch was estimated in kilograms. Surveys were not conducted in the south (<60 °N) during 2013 and 2015 and north (≥60 °N) during 2008 but fish densities in these areas were estimated using geostatistical modeling methods (Thorson et al. 2015). Four species were commonly caught with the surface trawl: age-0 Pacific cod (*Gadus macrocephalus*), age-0 pollock (G*adus chalcogrammus*), Atka mackerel (*Pleurogrammus monopterygius*), and yellowfin sole (*Limanda aspera*). Biomass was calculated for each species and compared across species and oceanographic domains on the Bering Sea shelf.

Abundance and distribution (center of gravity and area occupied) were estimated for each jellyfish species using the VAST package for multispecies version 1.1.0 (Thorson 2015; Thorson et al. 2016a, b, c) in RStudio version 0.99.896 and R software version 3.3.0 (R Core Team 2016). The abundance index is a standardized geostatistical index developed by Thorson et al. (2015, 2016a, 2016b, 2016c) to estimate indices of abundance for stock assessments. We specified a gamma distribution and estimated spatial and spatio-temporal variation for both encounter probability and positive catch rate components at a spatial resolution of 100 knots. Parameter estimates were within the upper and lower bounds.

Abundance and distribution (center of gravity and area occupied) were estimated for using the VAST package for multispecies version 1.1.0 (Thorson 2015; Thorson et al. 2016a, b, c) in RStudio version 0.99.896 and R software version 3.3.0 (R Project 2017). The abundance index is a standardized geostatistical index developed by Thorson et al. (2015, 2016) to estimate indices of abundance for stock assessments. We specified a gamma distribution and estimated spatial and spatio-temporal variation for both encounter probability and positive catch rate components at a spatial resolution of 100 knots. Parameter estimates were within the upper and lower bounds and final gradients were less than 0.0005.

Status and trends: Temporal trends in the estimated abundance of these groundfish species indicated a decline in the productivity of groundfish in pelagic waters of the eastern Bering Sea in 2016 (Figure 1-5, Table 1). Juvenile age-0 pollock were the most abundant juvenile pelagic groundfish species in our survey areas followed by yellow fin sole, Atka mackerel, and then Pacific cod (Table 1).

Distribution of groundfish in pelagic waters varied among species and years (Figure 2-5). Age-0 P. cod were distributed on the southern Bering Sea shelf near the Unimak Pass (Figure 2). Age-0 pollock were the most widely distributed species and primarily on the southeastern Bering Sea middle domain (50-100 m bottom depth) but distributed farther north during warm years (Figure 3). Atka mackerel were captured primarily in the outer domain of the southeastern Bering Sea shelf (Figure 4). Yellowfin sole distributed in the southern inner and middle domains of the southeastern Bering Sea shelf (Figure 5).

Temporal trends in the distribution (center of gravity) that age-0 pollock were distributed farther north during recent warm years (Figure 6). No warm and cold year trends was observed in the distribution of age-0 P. cod, yellowfin sole. Atka mackerel were generally distributed farther north during warm stanzas and farther south during the cold stanza (Figure 6). Area occupied indicated that pollock had an expanded range during warm years relative to cold years (Figure 7).

Factors causing trends: Lower abundances of groundfish in pelagic waters during 2016, third consecutive warm year, indicate poor environmental conditions for the growth and survival in the eastern Bering Sea during summer or movement out of the survey area. Age-0 pollock appeared to respond to warming with an expansion in their range and a distribution farther north. Movement of age-0 pollock and Atka mackerel farther north during warm years indicate a response to warming by their changing distribution.

Implications: Lower abundances of groundfish in surface waters during 2016 indicate a change in productivity in pelagic waters. The age-0 pollock distributed primarily in the southeastern Bering Sea middle domain, but were farther north during warm years during higher population densities possibly in search of food during years of low lipid-rich prey such as large zooplankton (Coyle et al. 2011).

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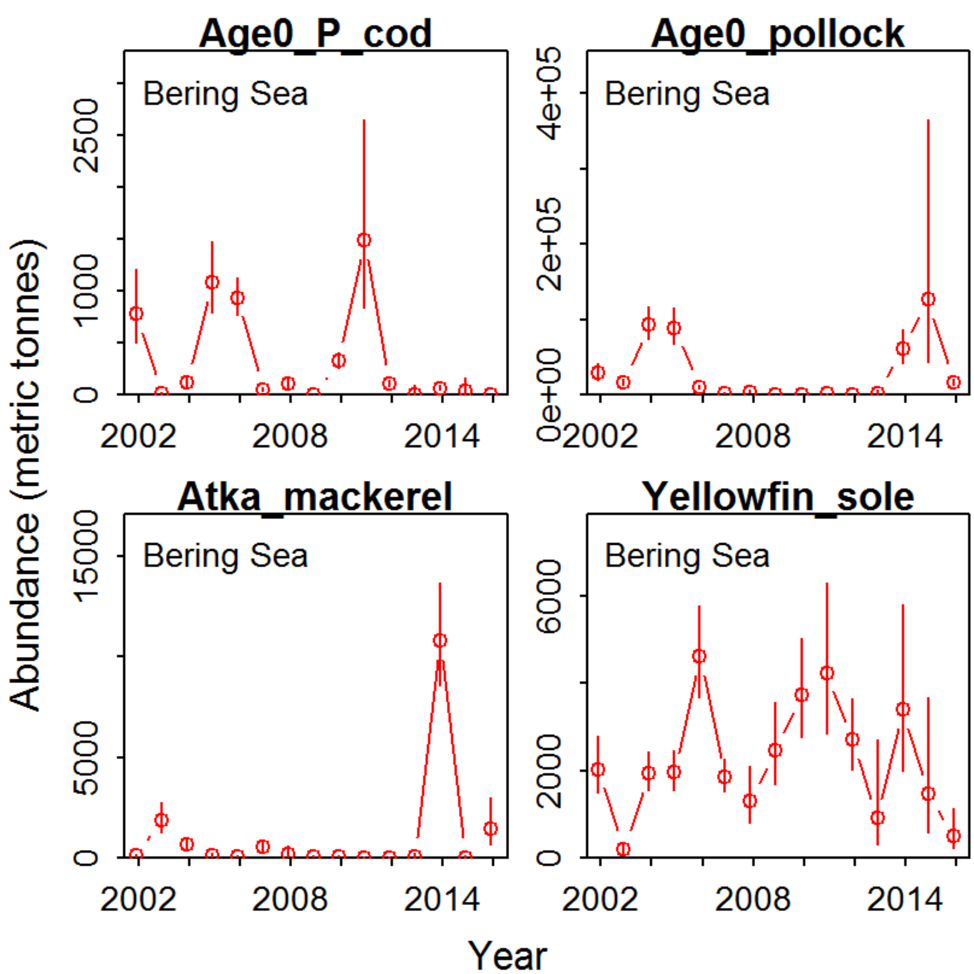

Figure 1. Index of abundance (metric tonnes) plus/minus 1 standard error for groundfish species in pelagic

waters of the eastern Bering Sea during late summer, 2002-2016.

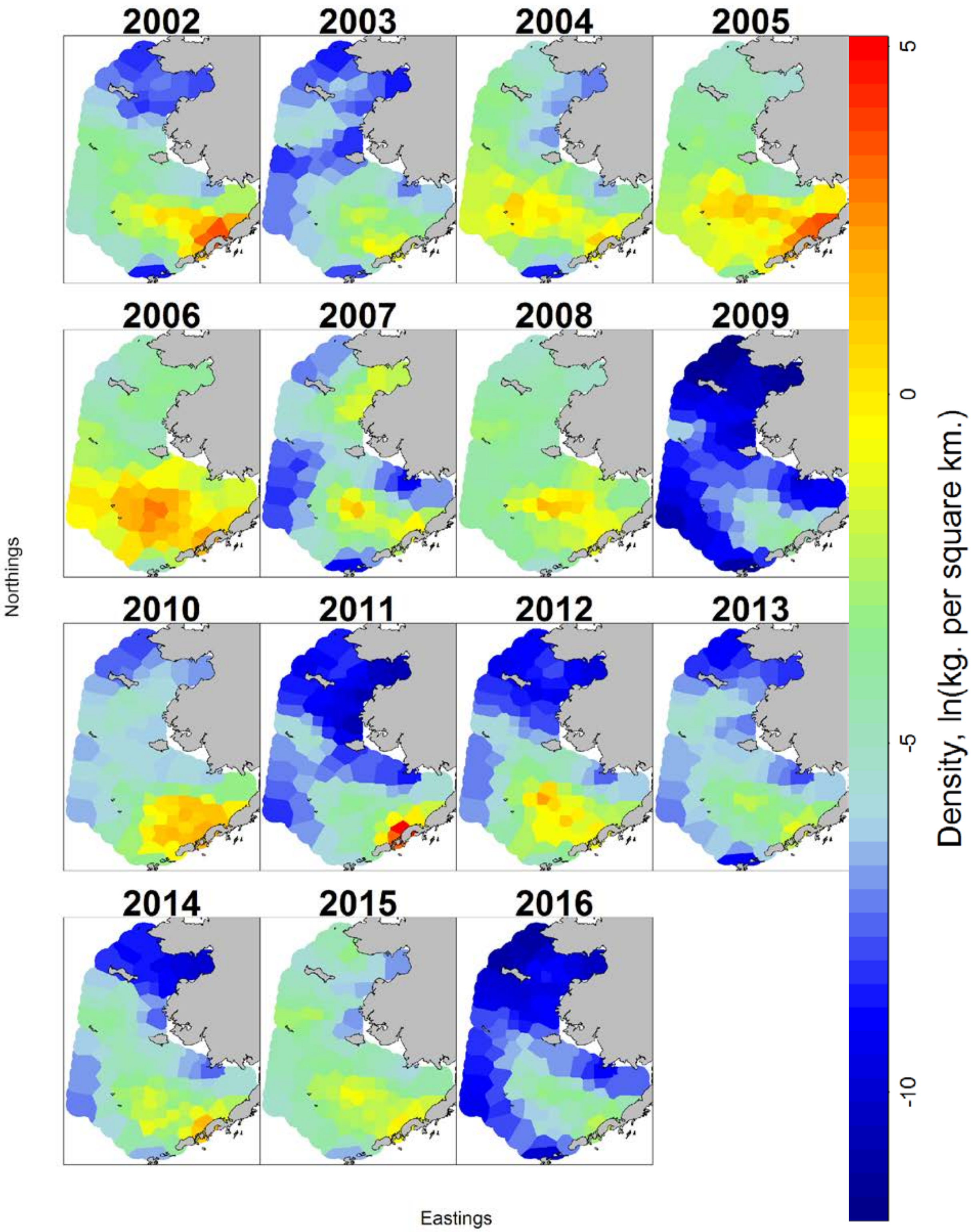

Figure 2. Predicted field densities of age-0 Pacific cod in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

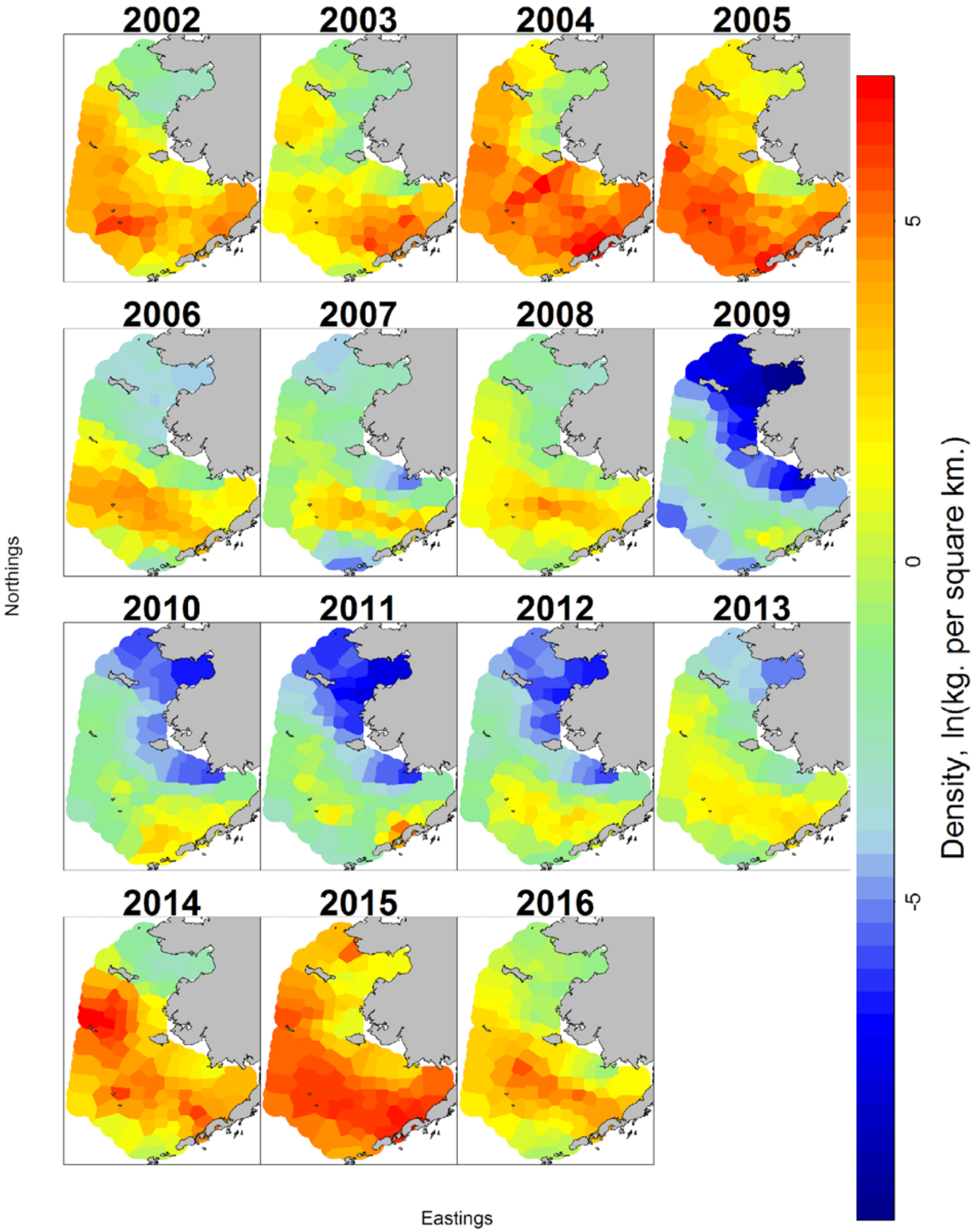

Figure 3. Predicted field densities of age-0 pollock in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

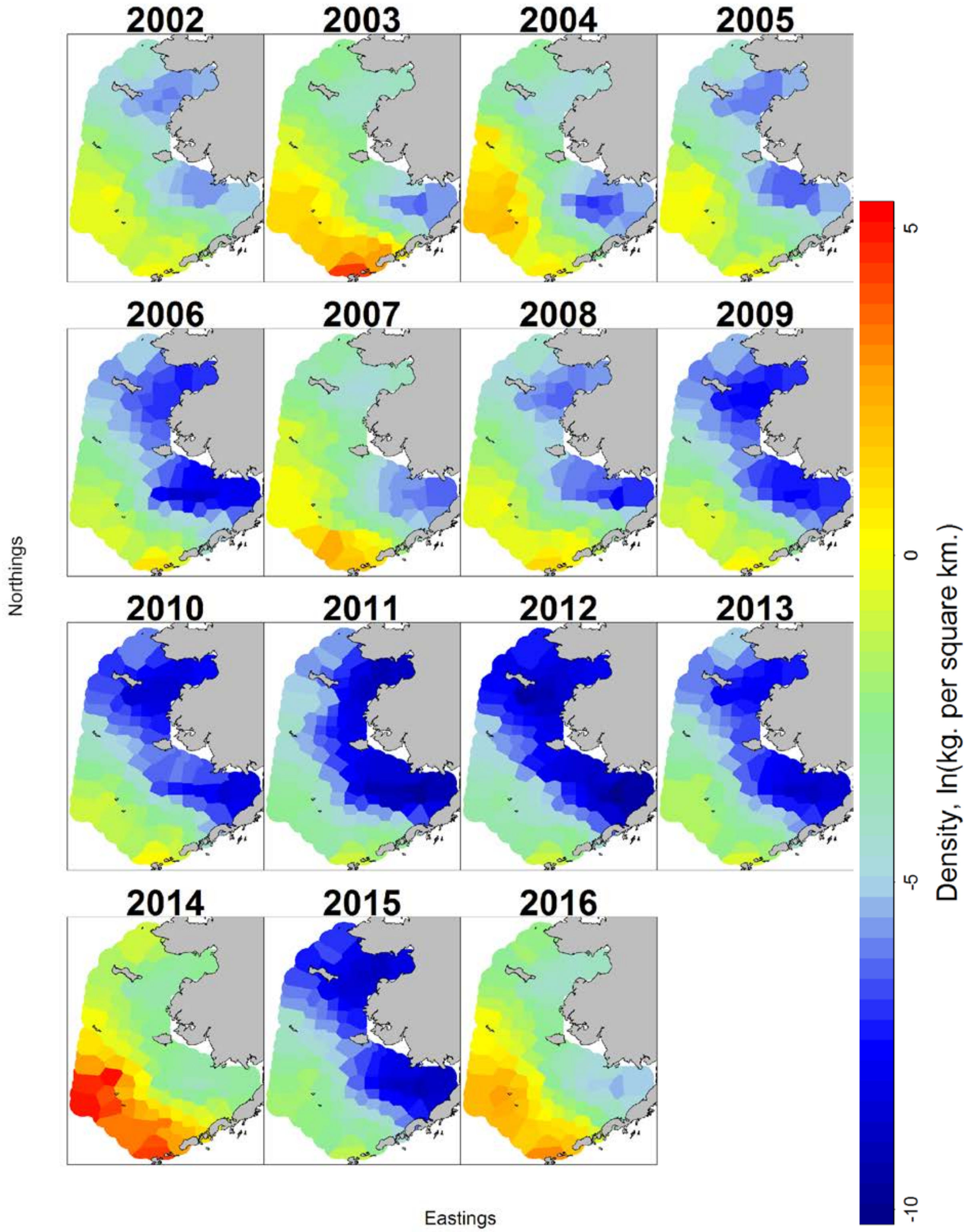

Figure 4. Predicted field densities of Atka mackerel in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

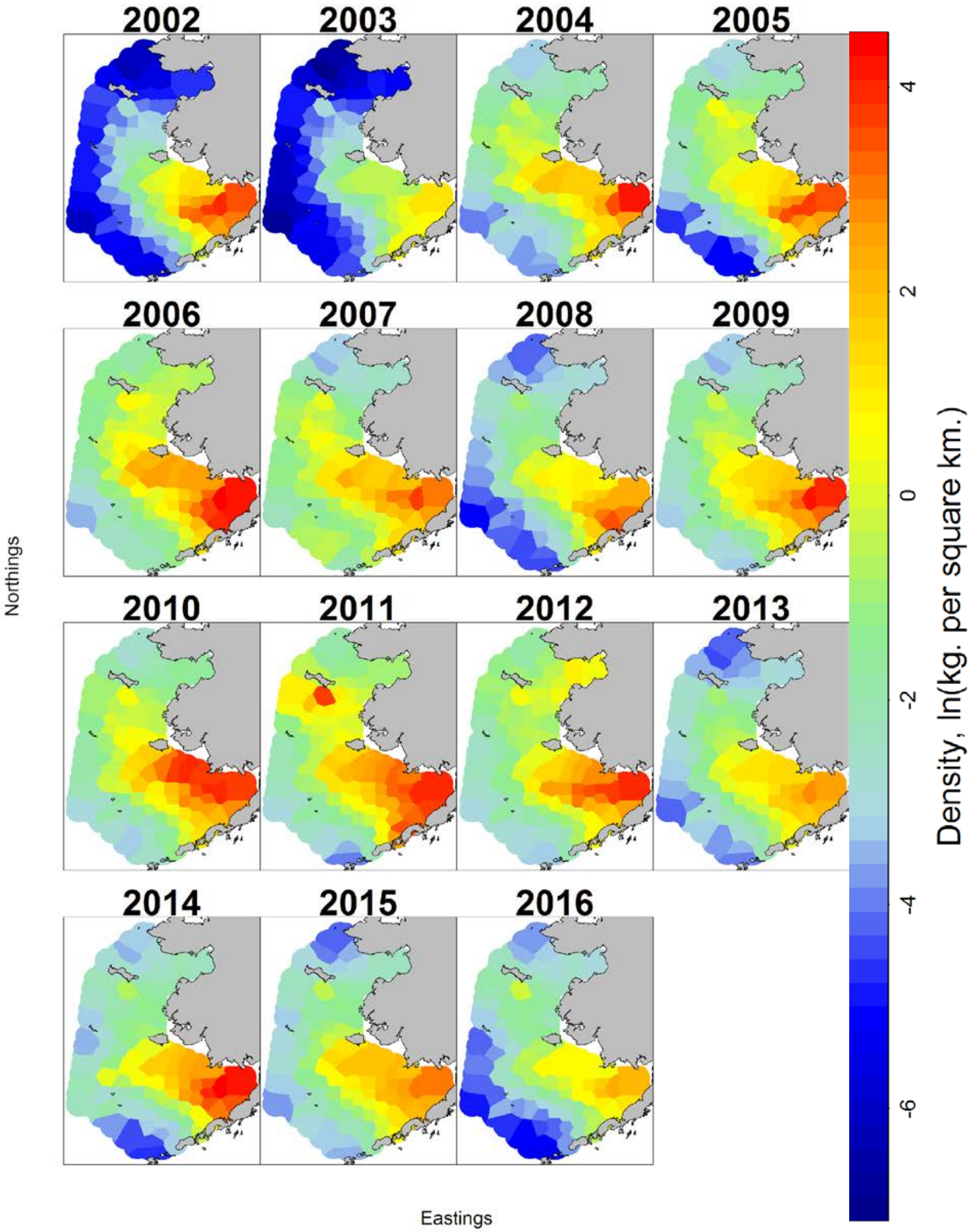

Figure 5. Predicted field densities of yellowfin sole in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

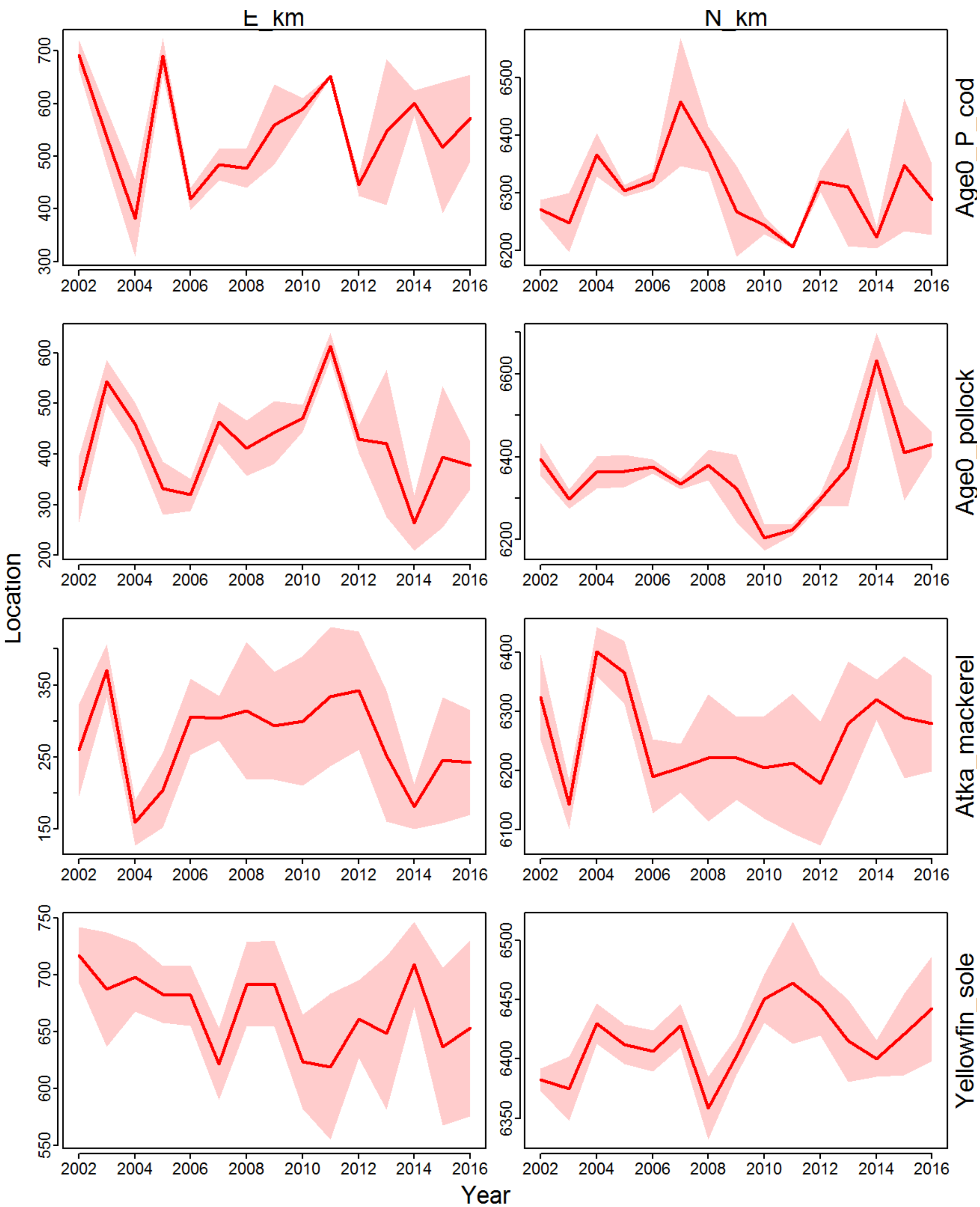

Figure 6. Center of gravity indicating temporal shifts in the mean east-to-west and north-to-south distribution plus/minus 1 standard error in UTM (km) for groundfish in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

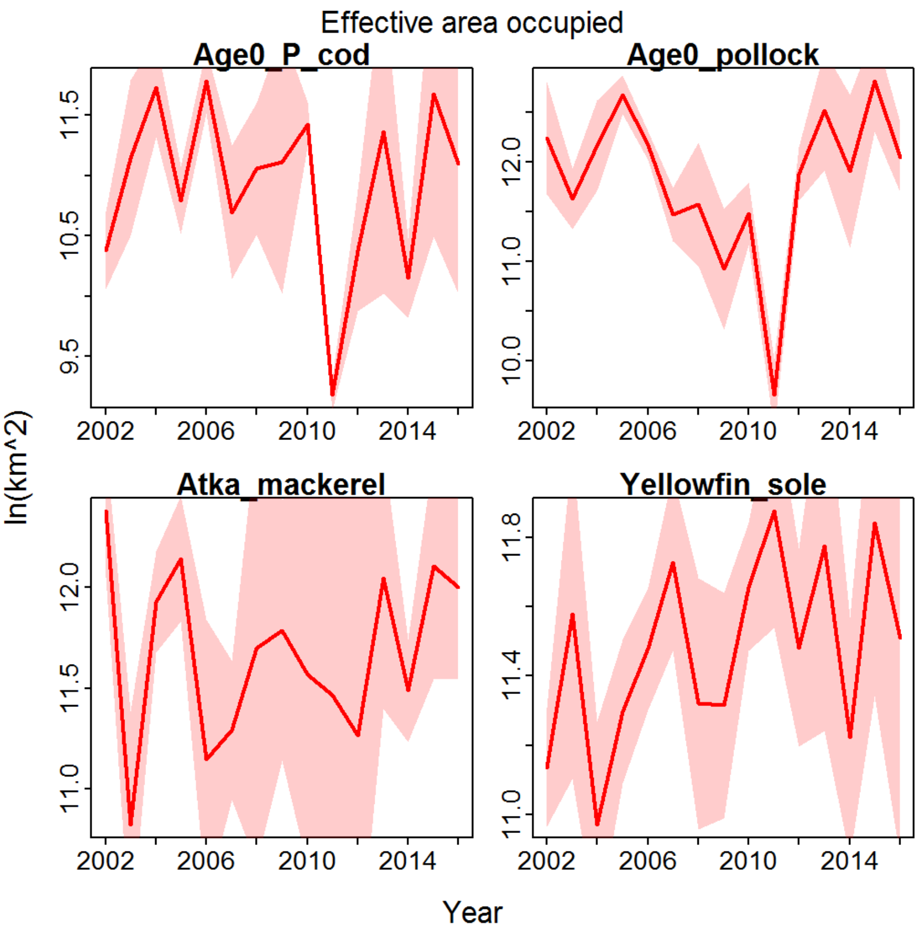

Figure 7. Effective area occupied (ln(km^2)) indicating range expansion/contraction plus/minus 1 standard error for groundfish in pelagic waters of the eastern Bering Sea shelf during late summer, 2002-2016.

Table 1. Index of abundance (metric tonnes) plus/minus 1 standard error (SE), and the coefficient of variation (%) for groundfish in pelagic waters of the eastern Bering Sea during late summer, 2002-2016.

	Age-0 P. cod			Age-0 pollock			Atka mackerel			Yellowfin sole		
	Estimate	S.E.	C.V.	Estimate	S.E.	C.V.	Estimate	S.E.	C.V.	Estimate	S.E.	C.V.
2002	776	345	44%	28,989	10,705	37%	113	61	54%	2,028	644	32%
2003	15	10	69%	16,866	4,027	24%	1,857	733	39%	194	104	53%
2004	122	37	31%	92,590	21,439	23%	638	270	42%	1,928	439	23%
2005	1,086	335	31%	88,836	23,511	26%	125	65	52%	1,956	455	23%
2006	937	179	19%	10,371	2,076	20%	79	37	46%	4,608	1,042	23%
2007	51	15	28%	2,325	547	24%	529	193	36%	1,860	368	20%
2008	105	39	37%	4,254	1,587	37%	156	215	138%	1,308	623	48%
2009	1	1	118%	82	41	51%	72	47	66%	2,448	913	37%
2010	324	80	25%	809	259	32%	53	38	72%	3,724	1,107	30%
2011	1,490	856	57%	1,562	924	59%	15	18	122%	4,231	1,685	40%
2012	110	29	26%	751	150	20%	12	13	108%	2,706	815	30%
2013	9	21	238%	1,565	2,139	137%	29	63	221%	922	994	108%
2014	66	24	36%	60,583	22,268	37%	10,831	2,537	23%	3,393	1,820	54%
2015	36	54	152%	126,858	134,018	106%	18	33	181%	1,464	1,347	92%
2016	3	3	86%	16,437	4,358	27%	1,432	1,063	74%	493	407	83%
Mean	342	135	67%	30,192	15,203	44%	1,064	359	85%	2,218	851	46%

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Small Neritic Fishes in Coastal Marine Ecosystems: Late-Summer Conditions in the Western Gulf of Alaska - RPP

Matthew T. Wilson and Lauren A. Rogers

The Ecosystems & Fisheries Oceanography Coordinated Investigations (EcoFOCI) Program monitors and researches small neritic fishes to improve our understanding and management of the Gulf of Alaska ecosystem and fisheries. Small neritic fishes include the juvenile stages of economically and ecologically important species (e.g., walleye pollock, Pacific cod, Pacific Ocean perch and other rockfishes, sablefish, and arrowtooth flounder). They also include species managed exclusively as forage fishes (e.g., capelin and eulachon) that support the fishes, seabirds, and marine mammals that characterize the piscivore-dominated GOA ecosystem. Longstanding objectives of EcoFOCI late-summer field work in the western Gulf of Alaska are to extend a time series of age-0 walleye pollock abundance estimates, monitor the neritic environment including zooplankton and abiotic conditions, and collect samples for research (e.g., trophic and spatial ecology, bioenergetics, age and growth).

During 21 August -15 September 2017, the NOAA vessel Oscar Dyson sampled the western Gulf of Alaska. The survey grid west of the Shumagin Islands was truncated due to weather. At each of 130 stations, water temperature and salinity were profiled, zooplankton were sampled, and target midwater fishes were collected using a Stauffer trawl (aka anchovy trawl) equipped with a small-mesh (2x3 mm) codend liner towed obliquely to a maximum depth of 200 m. Time series of abundance for age-0 pollock and for capelin were constructed based on catches from late-summer surveys since 2000 (only odd years since 2001) for the consistently sampled region between Kodiak Island and the Shumagin Islands. Mean catch per unit area was calculated using an area-weighted mean. Due to significant differences in catches of capelin during day versus night, mean CPUE for the night stations only is also shown.

Age-0 pollock were particularly abundant through Shelikof Strait and to the east of Kodiak Island (Figure 1). The mean CPUE estimate for 2017, which does not include the stations near Kodiak, suggests the second highest abundance of age-0 pollock in our time series (Figure 2), averaging 380,000 age-0 pollock per square kilometer (0.38 fish/m^2). This high abundance reflects the number of surviving larvae from spawning in the spring and survival processes through the summer. Pollock densities tapered off towards the Shumagin Islands in the southwest. This spatial distribution is in contrast to a previous high abundance year (2013) when catches were highest southwest of the Shumagin Islands (Figure 1). The observed spatial distribution of pollock may result from transport processes and/or reflect production from different spawning groups. This late-summer survey also provides an assessment of the abundance, size, and condition of young-of-year pollock before entering their first winter, giving an early indicator of potential year class strength. Strong catches of juvenile pollock, together with previously observed high larval abundance, suggest a return to productive conditions in the Gulf of Alaska following the \Blob" warm anomaly in 2014-2016.

Capelin abundance remained low in 2017, continuing a trend of low abundance since 2011. However, in Figure 2, note that no sampling occurred in even years and the time series estimate does not include catches from near Kodiak, where capelin catches are typically higher. Investigations into factors driving changes in the spatial distribution and abundance of capelin and juvenile pollock are underway.

This section is a slightly modified excerpt from Ecosystem Considerations 2017: Status of the Gulf of Alaska marine ecosystem, which is available at
https://www.afsc.noaa.gov/REFM/Docs/2017/ecosysGOA.pdf

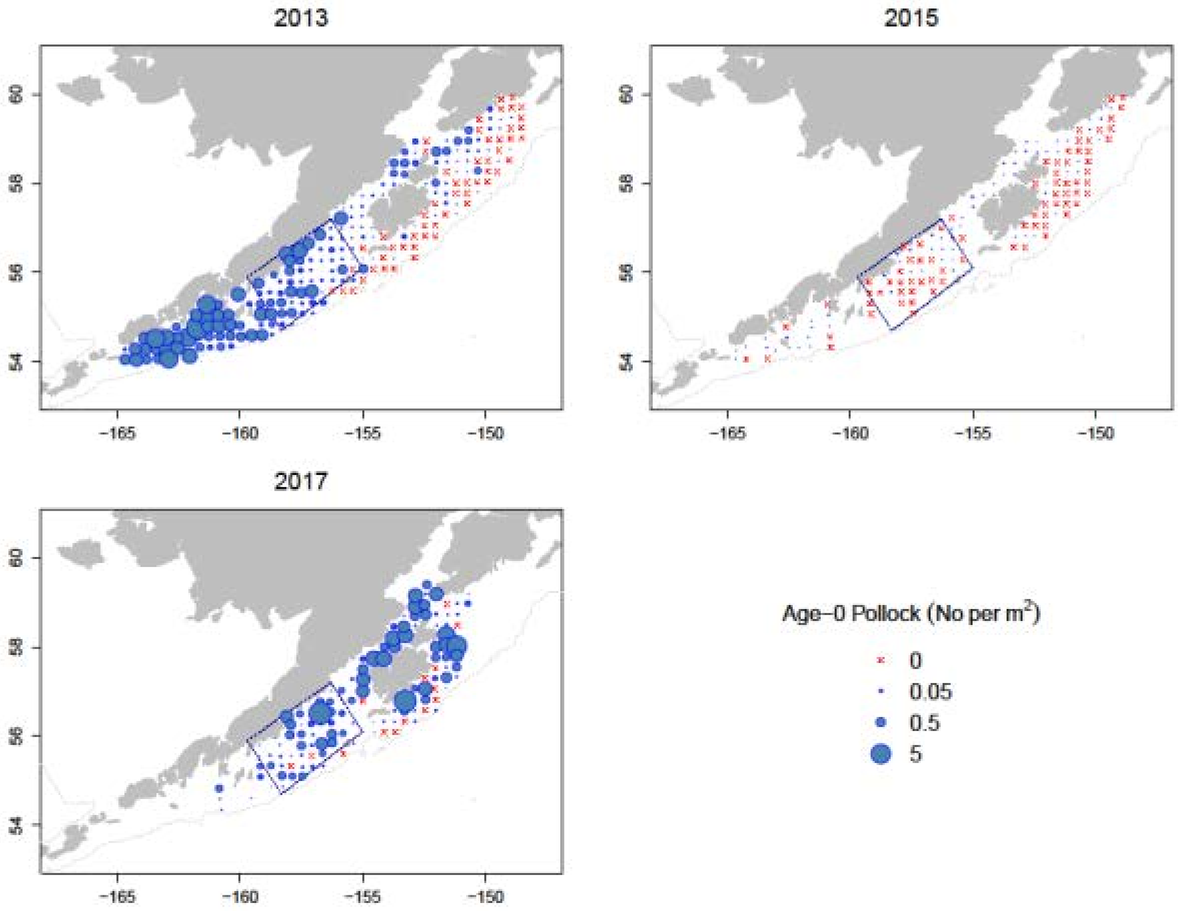

Figure 1. Catches of age-0 walleye pollock in the EcoFOCI late-summer small-mesh trawl survey for 2013, 2015, and 2017. The area in the blue dashed box indicates the region most consistently sampled since 2000 and includes the stations used to develop CPUE time series.

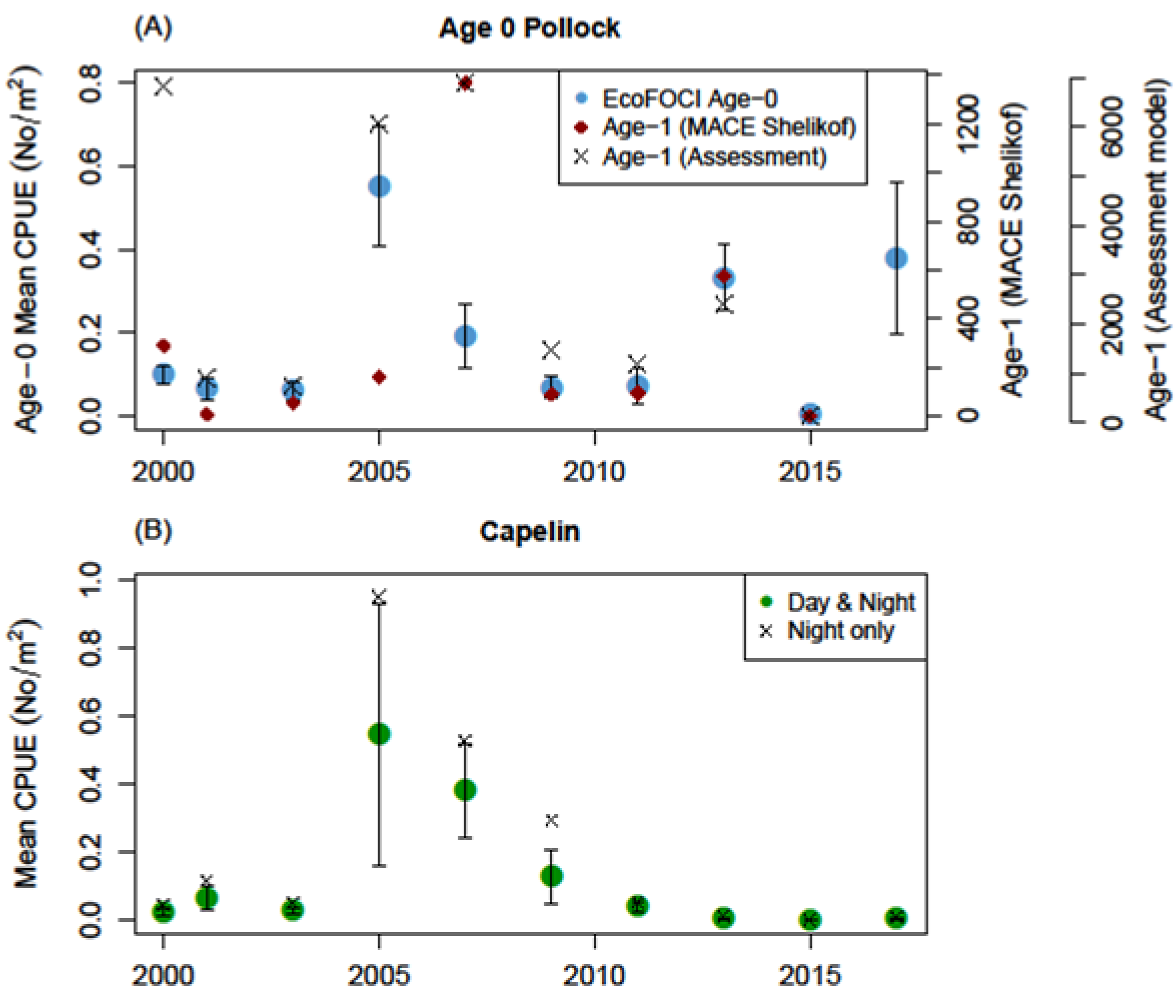

Figure 2. Mean catch per unit effort (CPUE) of age-0 walleye pollock (top) and capelin (bottom) in the EcoFOCI late-summer small-mesh trawl survey for 2000 - 2017. Mean CPUE is based on data from a consistently sampled region (see Fig. 1 dashed blue box).

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Marine Fishes Caught in the Southeast Coastal Monitoring (SECM) Survey - ABL

Jordan T. Watson, Andy Gray, Emily Fergusson, James M. Murphy

Description of indicator: The Southeast Coastal Monitoring (SECM) program has collected fish, zooplankton, and oceanographic samples in southeast Alaska since 1997 (Fergusson et al. 2013; Orsi et al. 2014; Orsi et al. 2015). Sampling has been focused most consistently in Icy Strait, the primary northern migratory pathway to the Gulf of Alaska for juvenile salmon originating from over 2000 southeast Alaska streams and rivers. Research objectives of the SECM program are to provide insight into the production dynamics and early ocean ecology of Southeast Alaska salmon.

Surface trawls (0-20m) are used to sample epipelagic fish species, including all five commercial species of Pacific salmon (*Oncorhynchus* sp.) in southeast Alaska. Juvenile pink salmon (*O. gorbuscha*) are, on average, the most abundant species in the epipelagic habitat in SECM surveys. In addition to juvenile salmon, SECM surveys catch a suite of non-salmonid fish species, including occasional large numbers of walleye pollock (*Gadus chalcogrammus*), capelin (*Mallotus villosus*), and Pacific herring (*Clupea pallasii*). We provide summaries of the annual catch rates for the five salmon species (pink; coho *O. kisutch*; sockeye, *O. nerka*; chum, *O. keta*; and Chinook, *O. tshawytscha*; Figure 1) and the three important ground and forage fish species (Figure 2).

Status and trends: In 2017, juvenile salmon catch rates were among the lowest of the time series for all five salmon species. Meanwhile, adult chum salmon catch rates continued an upward trend, though these rates remain nearly an order of magnitude lower than those of adult pink salmon.

Although catch rates for groundfish and forage fish are typically low during the SECM surveys, record catches of capelin, pollock, and herring have occurred in recent years. Herring was the only species with above average catch rates in 2017, with the second highest catch rate of the time series.

Factors influencing observed trends: Ocean conditions in 2017 were preceded by several anomalously warm years. Warm ocean conditions are likely to have influenced recruitment patterns through multiple years of altered community structure and stock dynamics. We continue to seek relationships between observed trends and environmental covariates (e.g., sea surface temperature).

Implications: Understanding recruitment processes of fish stocks is an important aspect of managing fish stocks, particularly during periods of substantial climate change. Juvenile abundance and oceanographic data collected during SECM have provided reliable forecasts of pink salmon returns to Southeast Alaska (Orsi, et al. 2015) and are used for pre-season fisheries management decisions in the purse seine and drift gillnet fisheries of Southeast Alaska (Wertheimer et al., 2015). By extending the application of SECM fish catches beyond pink salmon, we are poised to better resolve the relationships between other salmon and groundfish species and ecosystem indicators that help to describe their production dynamics. Furthermore, as SECM surveys continue annually, they fill a valuable gap in data that occurs during off-years for the Gulf of Alaska Ecosystem Surveys.

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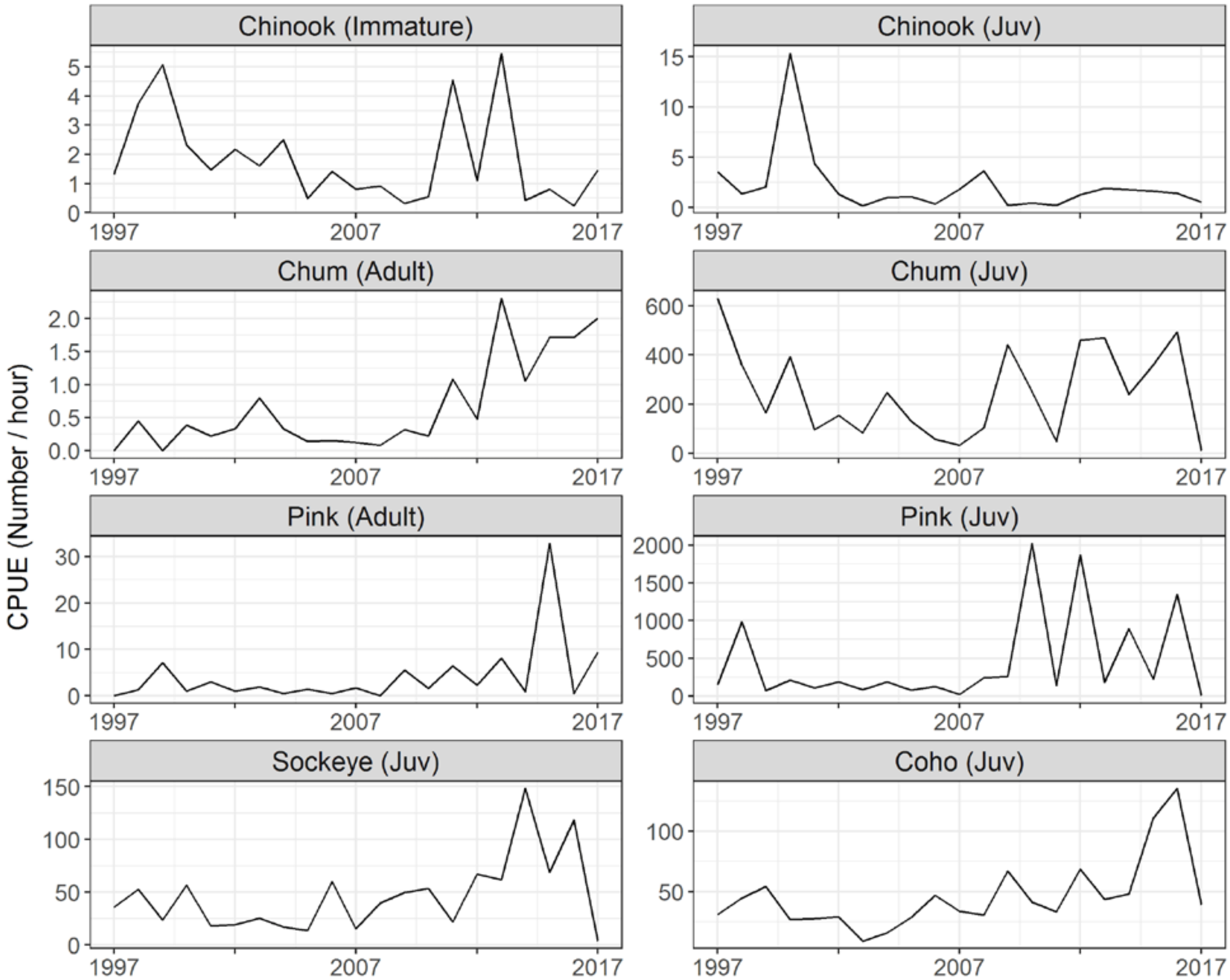

Figure 1. Time series of juvenile, immature (Chinook only), and adult salmon catch rates (number of fish per hour) during SECM surveys from 1997 – 2017.

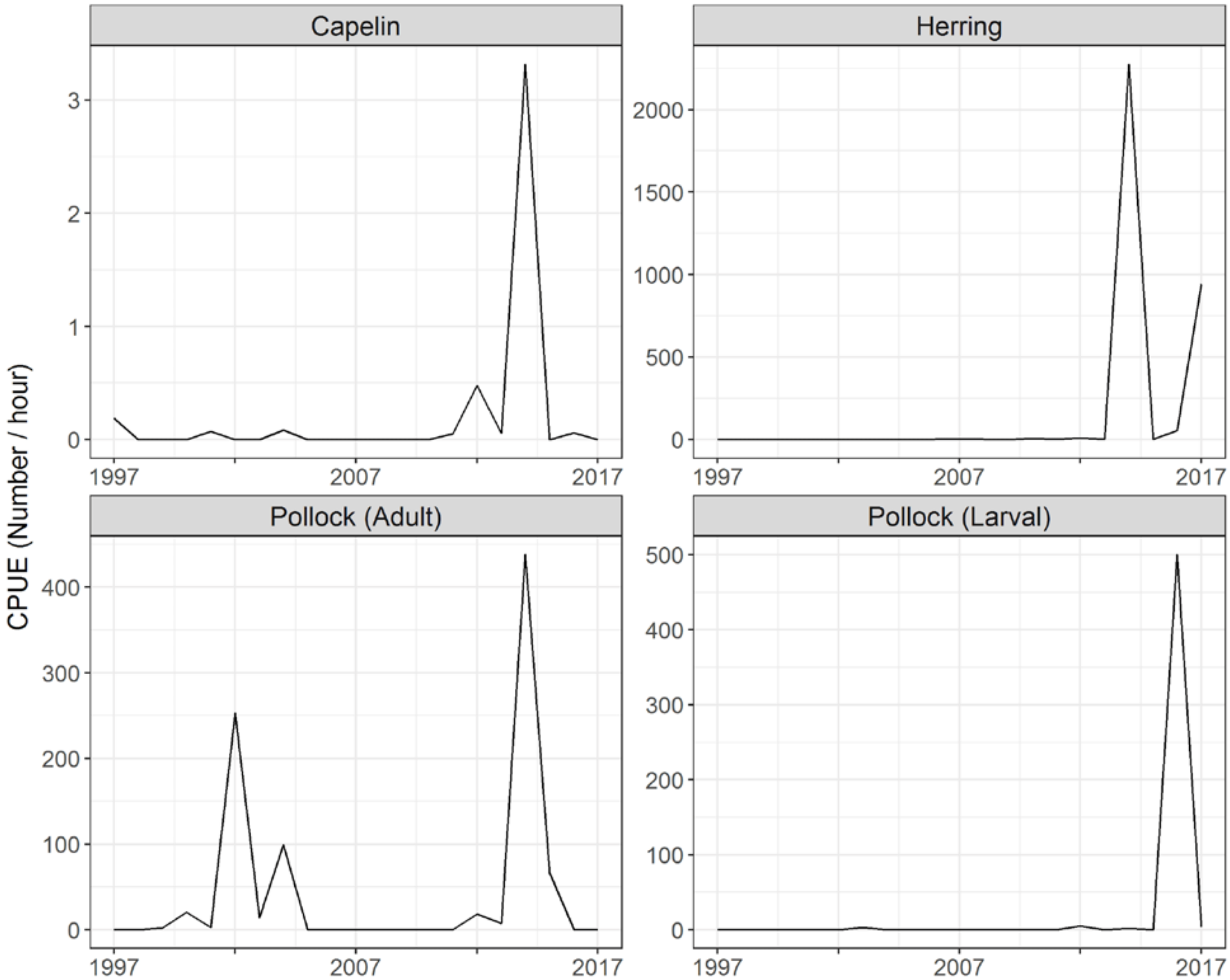

Figure 2. Time series of the most common non-salmonid fishes catch rates during SECM surveys from 1997 – 2017.

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

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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

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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*.

2017, 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 2017, AFSC personnel analyzed the stomach contents of 33 species sampled from the eastern Bering Sea, Gulf of Alaska and Aleutian Islands regions. The contents of 16,177 stomach samples were analyzed in the laboratory in addition to 3,073 stomach samples analyzed at sea during the Gulf of Alaska groundfish survey. This resulted in the addition of 56,554 records to AFSC's Groundfish Trophic Interactions Database. In addition, bill-load and diet samples from 1,155 seabirds were analyzed for the U.S. Fish and Wildlife Service, and 22 benthic grab samples were analyzed for an Essential Fish Habitat study. New information was added to the Stomach Examiner's Tool including 413 new images to aid in prey identification.

Collection of additional stomach samples was accomplished through resource surveys, research surveys, and sampling during commercial fishing operations. About 8,240 stomach samples were collected from large and abundant predators during bottom trawl surveys of the eastern Bering Sea continental shelf and the northern Bering Sea. Over 1,500 stomach samples were collected from the Gulf of Alaska to supplement the 3,073 stomach contents that were analyzed at sea during the bottom trawl survey in that region. Fishery Observers continued collection of stomach samples from Alaskan fishing grounds in 2017, resulting in 194 additional samples. REEM worked with FMA to design and implement new procedures for vessel assignment and specimen selection to broaden the temporal and spatial dispersion of the collected stomach samples from Pacific cod, walleye pollock and arrowtooth flounder.

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 2017: The Status of Alaska's Marine Ecosystems Completed and Posted Online

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. There are separate reports for each of four ecosystems: the eastern Bering Sea, Aleutian Islands, Gulf of Alaska, and the Arctic. In 2017, new information became available to update the reports for the eastern Bering Sea 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

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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
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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.

Literature Cited
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.

Literature Cited

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

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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

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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.

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Fissel, B. and B. Gilbert. 2014. "Technology Shocks and Capital Investment in the Commons", under revision at *Environmental and Resource Economics*.

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FishSET: a Spatial Economics Toolbox to better Incorporate Fisher Behavior into Fisheries Management-REFM/ESSR

Alan C. Haynie* and Corinne Bassin
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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

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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

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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).

Literature Cited
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
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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.*

Literature Cited

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

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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.

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Tools to Explore Alaska Fishing Communities-REFM/ESSR

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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

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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.

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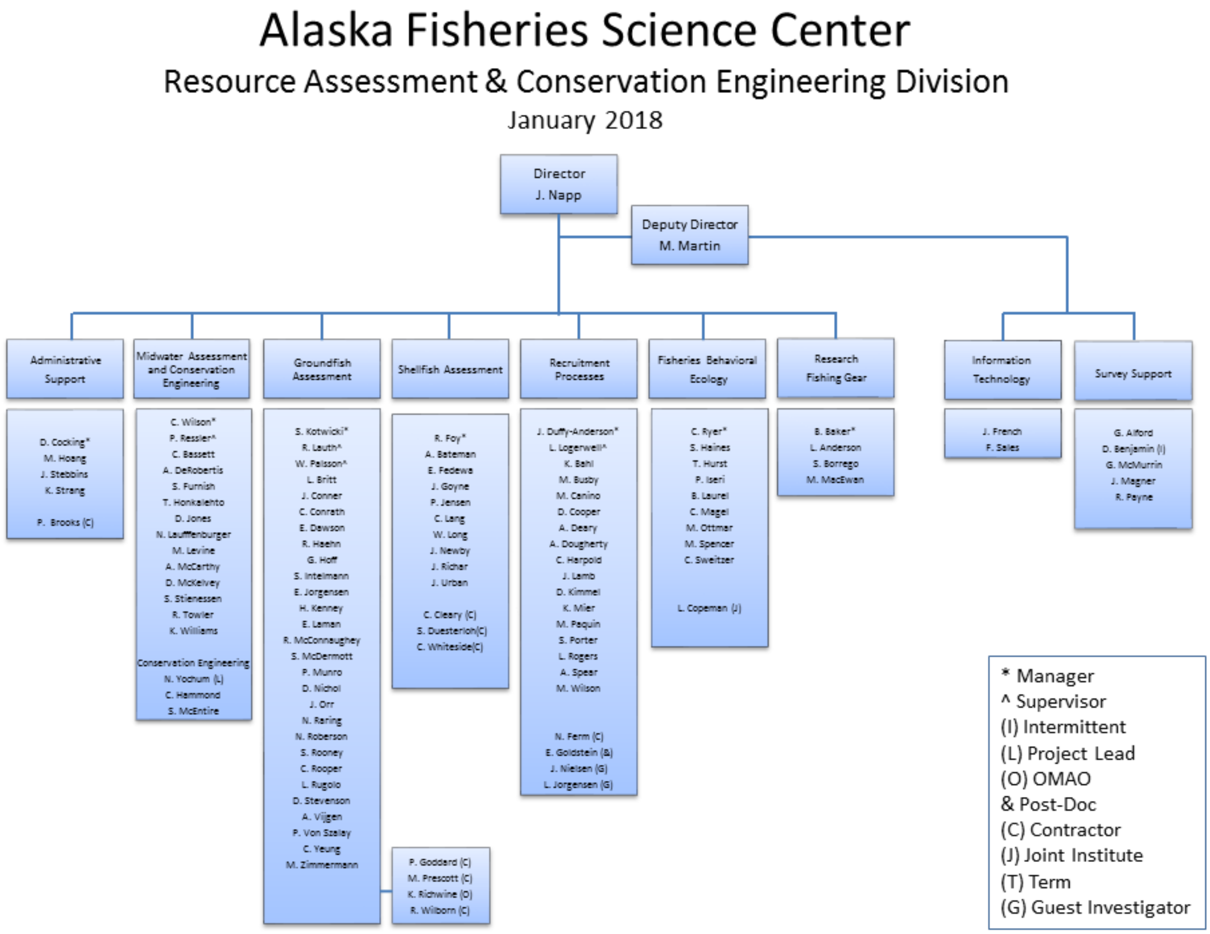
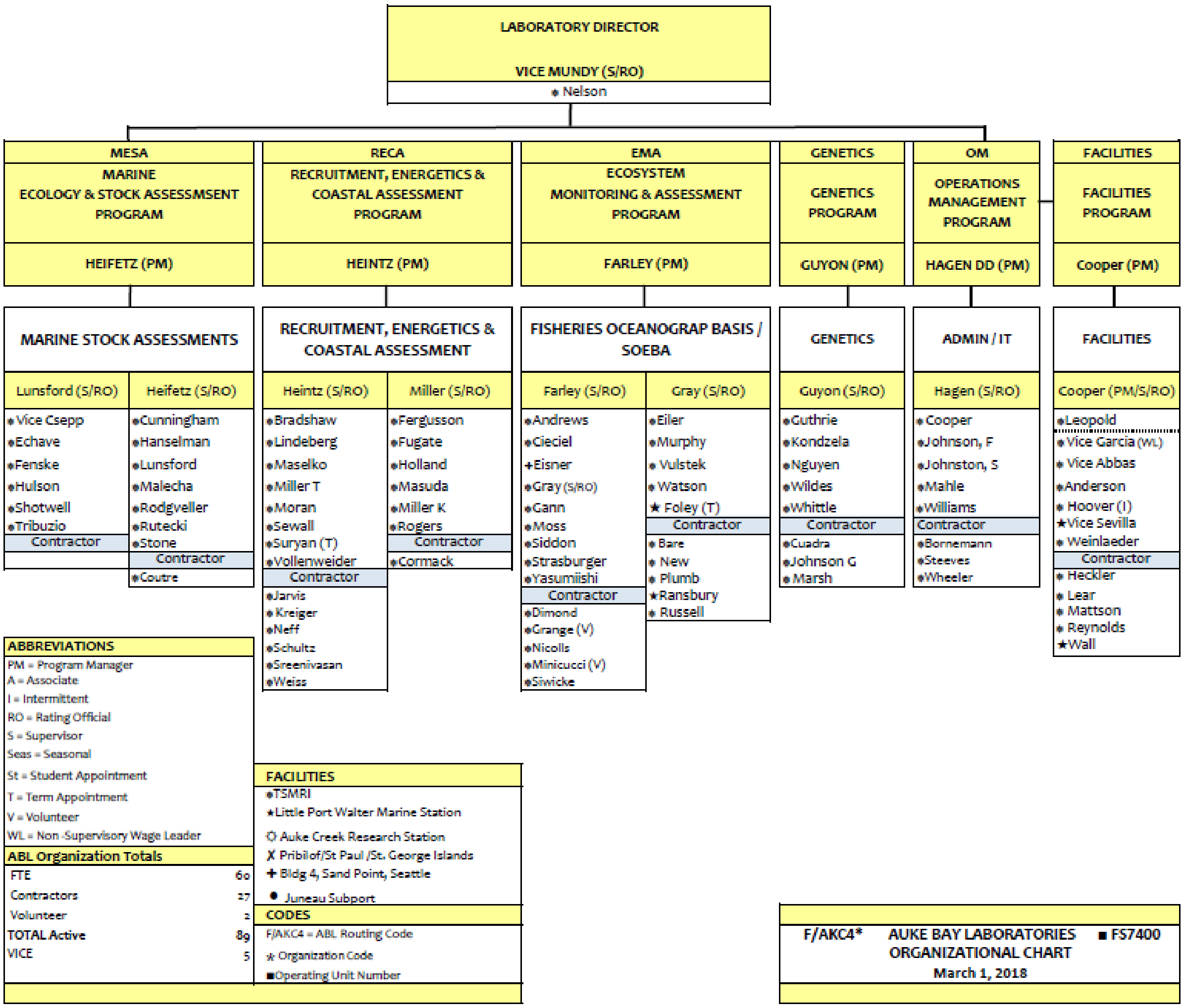
APPENDIX I. RACE ORGANIZATION CHART

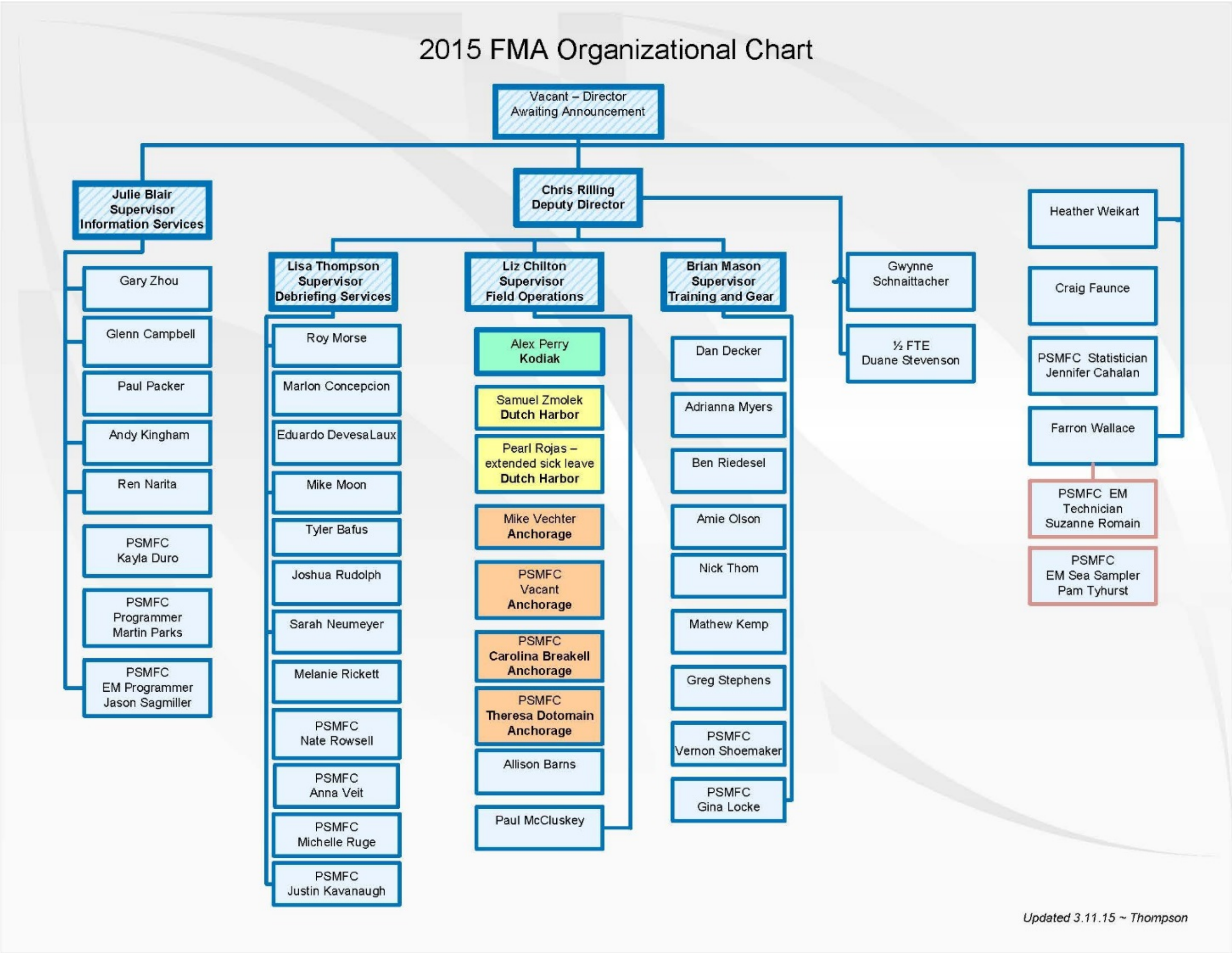


APPENDIX II. REFM ORGANIZATION CHART

APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART



APPENDIX IV – FMA ORGANIZATIONAL CHART



CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2017

April 2018

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I. 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
Stock Assessment and Research	Dr. John Holmes

Section Heads within the Stock Assessment and Research Division (StAR) are:

Groundfish	Mr. Greg Workman
Marine Invertebrates	Ms. Lynne Yamanaka
Quantitative Assessment Methods	Dr. Robyn Forrest
Fisheries and Assessment Data	Mr. Bruce Patten
Salmon Assessment	Ms. Mary Thiess

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 Stock Assessment and Research Division (StAR), 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 Groundfish, Fisheries and Assessment Data, and Quantitative Methods Sections within StAR. 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 2016 West Coast Vancouver Island Synoptic Bottom Trawl Survey. Subsequent failures of key vessel systems resulted in decommissioning of the ship in December 2017. The replacement vessel for the *W.E. Ricker,* the *Sir John Franklin* is currently under construction with delivery anticipated in the spring of 2019. At sea operations for groundfish surveys during 2018 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 StAR 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 (SAR) 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 2017 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. Collaborative Agreements were developed for 2017-18 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 2018-19.

II. Surveys

A. Groundfish Surveys Program Overview

The Fisheries and Oceans, Canada (DFO) Groundfish section of the StAR Division includes a surveys program. The cornerstone of the surveys program is a suite of surveys using bottom trawl, longline hook, and longline trap gear that, in aggregate, provide comprehensive coverage for all offshore waters of Canada's Pacific Coast (Figure 1). All the surveys follow random depth-stratified designs and 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 Collaborative Agreements. In addition to these surveys, the Groundfish section conducts an acoustic assessment of Pacific Hake and collects additional information from a DFO Small-Mesh Bottom Trawl Survey and the International Pacific Halibut Commission (IPHC) Setline Survey (Figure 2).

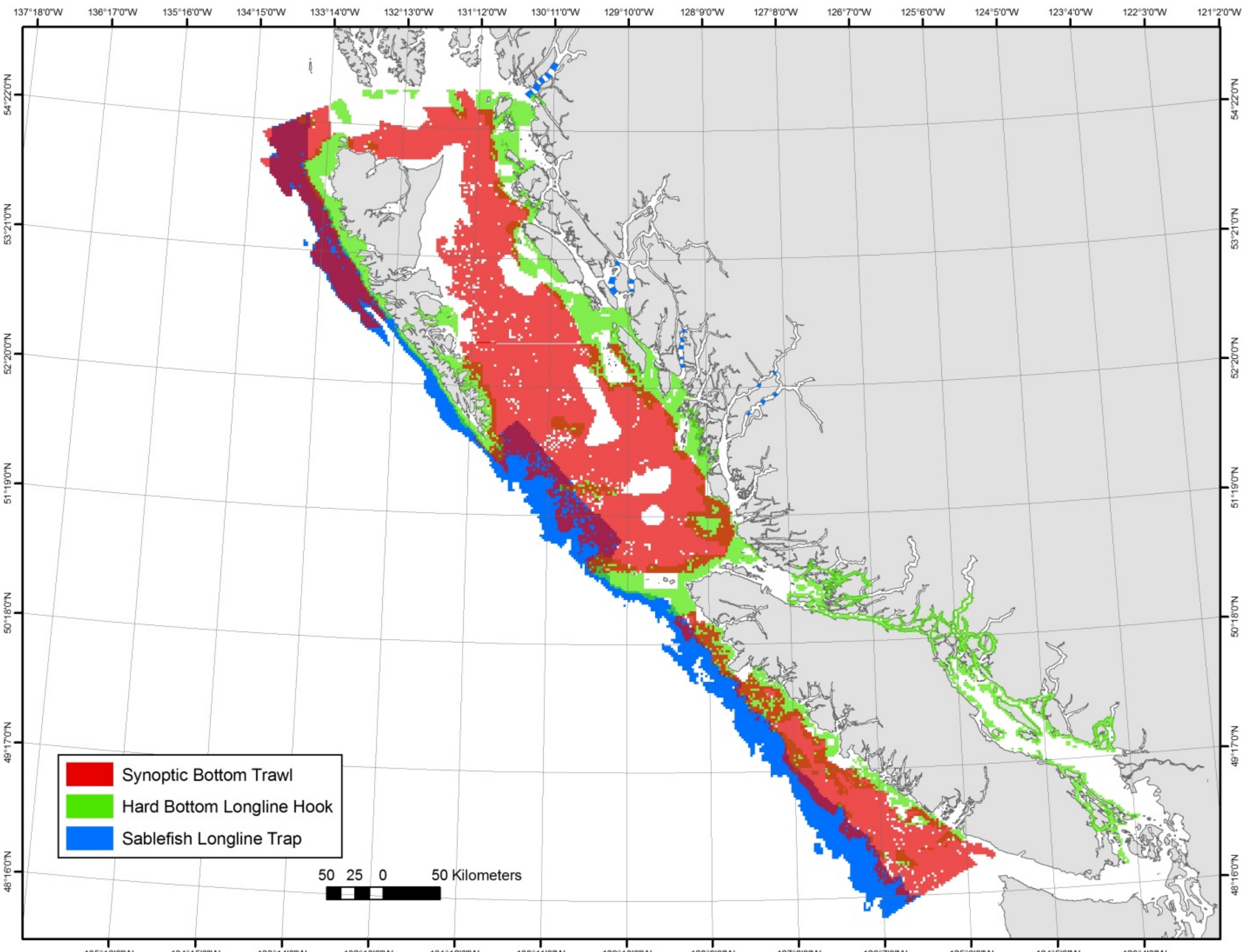

Figure 1.Random depth-stratified survey coverage.

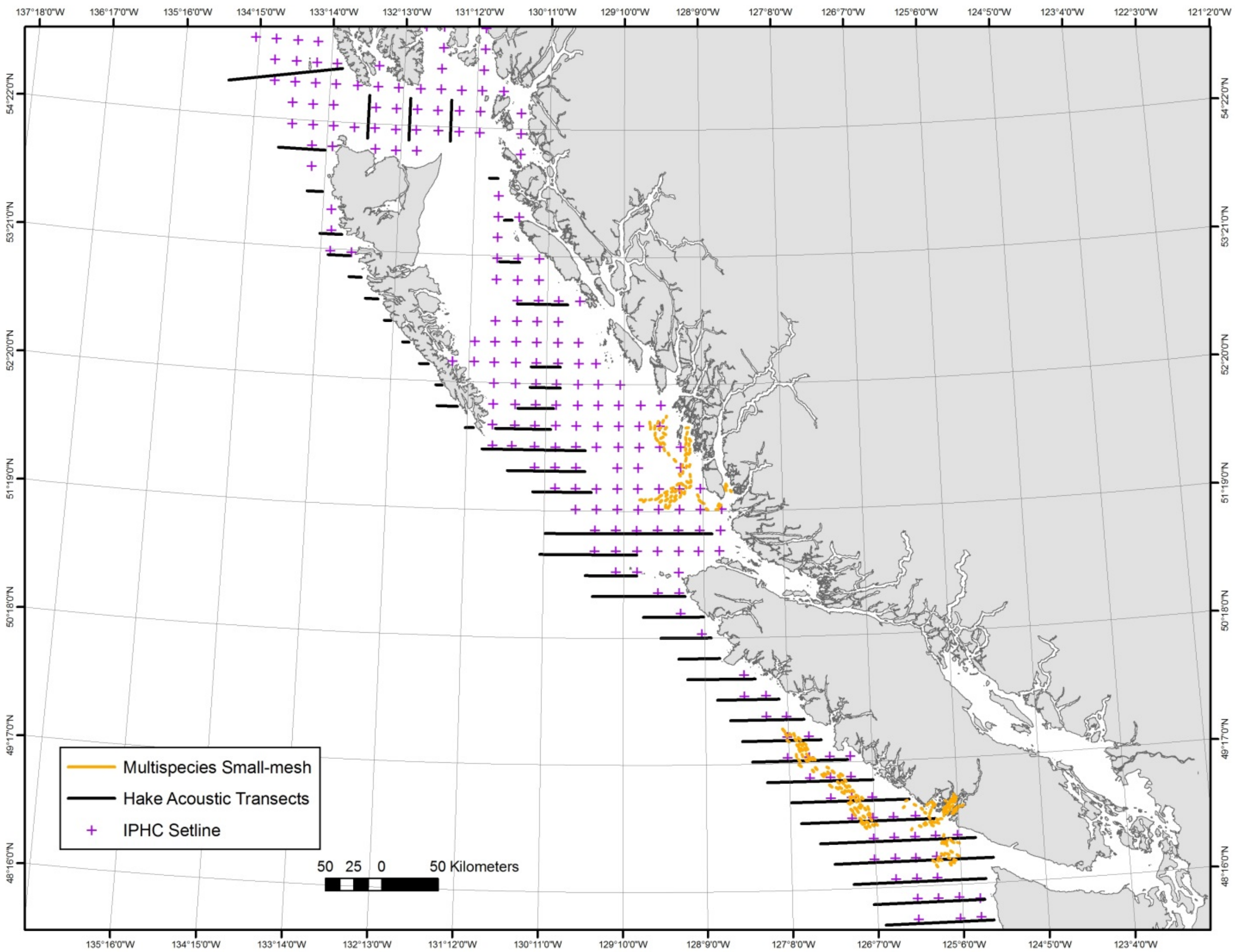

Figure 2. Other non-random-depth-stratified surveys that form part of the Groundfish survey program including the Multispecies Small-mesh Bottom Trawl Survey, the Pacific Hake Acoustic Survey, and the International Pacific Halibut Commission (IPHC) Setline Survey.

Each year two or three area-specific random depth-stratified bottom trawl surveys are conducted in collaboration with the commercial fishing industry. We call these surveys the Multispecies 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.

In addition to the annual bottom trawl surveys, each year two area-specific random depth-stratified longline hook surveys are conducted in collaboration with the commercial fishing industry. We call these surveys the Hard Bottom Longline Hook (HBLL) 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.

In addition to the bottom trawl and hook and line 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.

In addition to the bottom trawl, hook and line, and trap surveys an annual 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, Groundfish section staff also participate in a fixed-station survey of commercially important shrimp grounds onboard the Canadian Coast Guard research trawler. We call this survey the Multispecies Small Mesh Bottom Trawl Survey. Groundfish program staff participate in the survey to provide assistance in enumerating the catch while also collecting biological samples from selected fish 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.

This report summarizes the 2017 surveys (Figure 3) including the Multispecies Synoptic Bottom Trawl surveys conducted in Hecate Strait and Queen Charlotte Sound, the Hard Bottom Longline Hook Survey conducted in the northern part of “outside” waters, the coast-wide Sablefish Research and Assessment Survey, the Multispecies Small Mesh Bottom Trawl Survey off the west coast of Vancouver Island, and the IPHC setline survey. The Hard Bottom Longline Hook Survey of “inside” waters was not conducted due to vessel crewing limitations. The results of the Pacific Hake Acoustic Survey are not included in this report. For details on the surveys conducted in 2017, please see

Appendix 1.

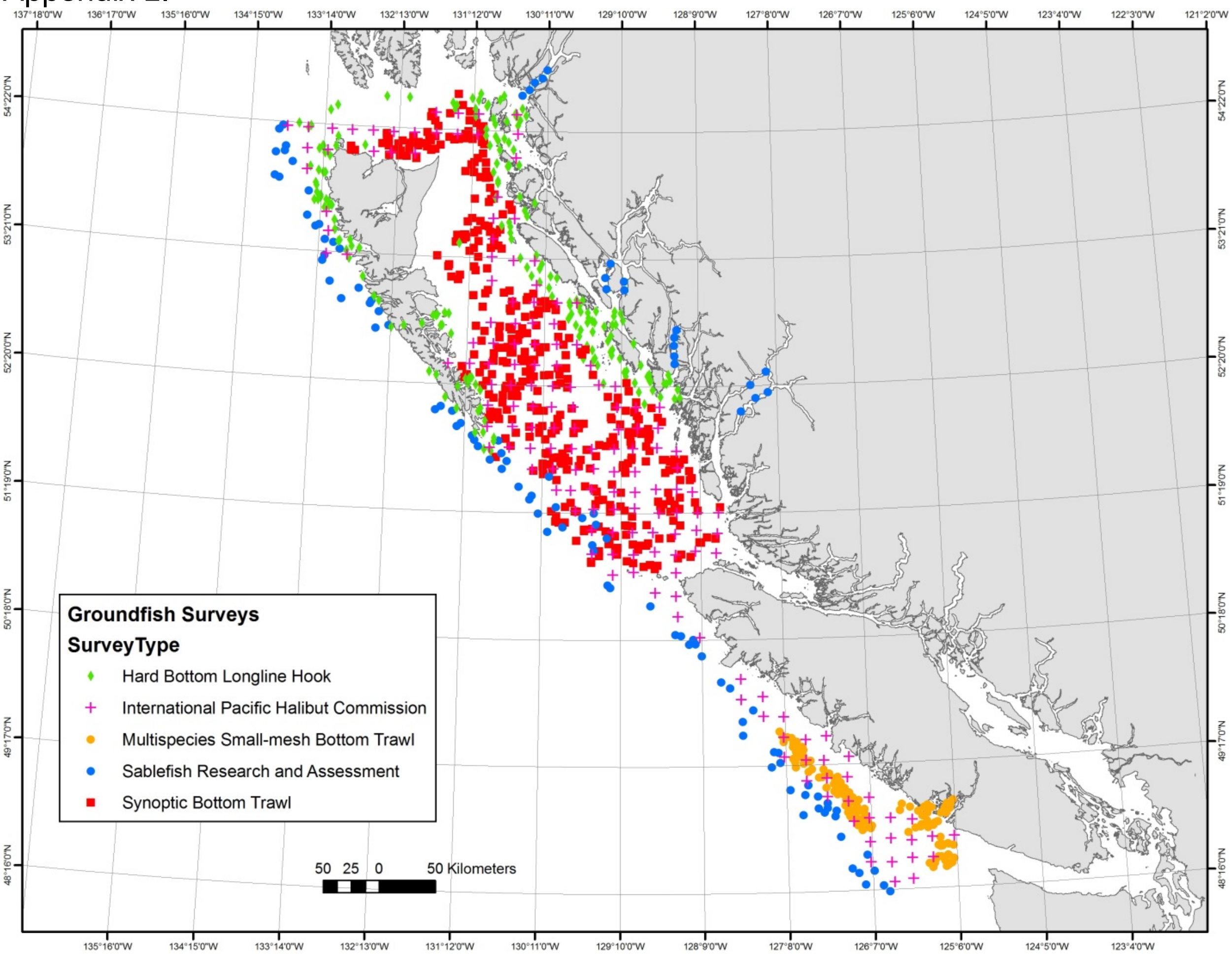

Figure 3. Fishing locations of the 2017 Groundfish surveys.

B. Multispecies Synoptic Bottom Trawl Surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive multispecies 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 (Figure 4).

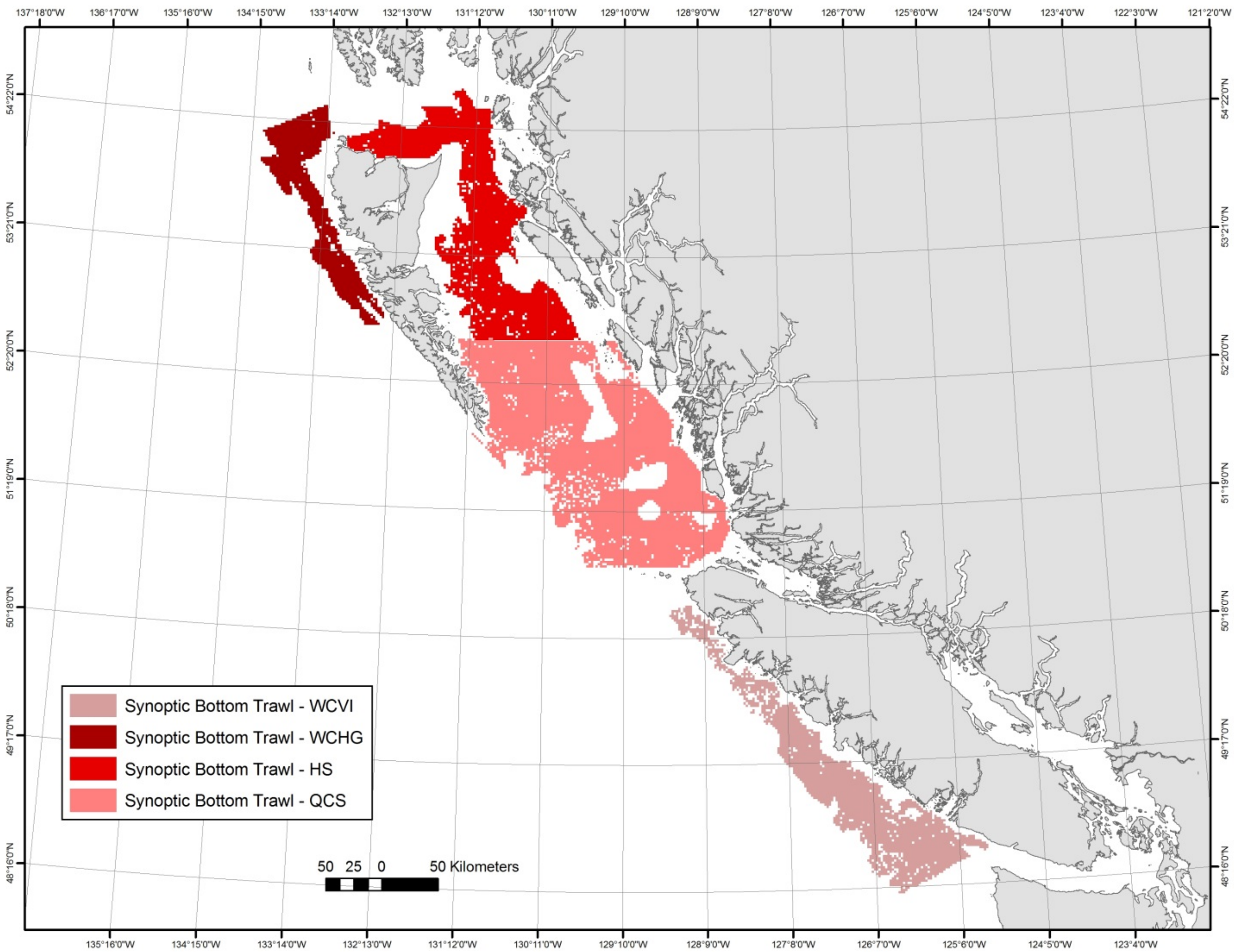

Figure 4. Multispecies Synoptic Bottom Trawl Survey coverage.

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. As such, the intent was to conduct a survey in March of 2017 and continue biennially, in odd numbered years. Unfortunately the research vessel was not operational in 2017 and the survey is now on hiatus due to staffing constraints.

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 2017 the Hecate Strait and Queen Charlotte Sound surveys were conducted. Both surveys were conducted on chartered commercial vessels because the Canadian Coastguard research trawler W.E. Ricker was not operational.

C. Hard Bottom Longline Hook Surveys

The 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 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 Hard Bottom Longline Hook program includes a survey of outside waters funded by the Pacific Halibut Management Association of BC (PHMA) and a survey of inside waters funded by DFO. Each year, approximately half of each survey area is covered and alternates between northern and southern regions year to year.

The “outside” area covers the entire British Columbia coast excluding inlets and the protected waters east of Vancouver Island. The northern region of the outside survey area includes the mainland coast north of Milbanke Sound, Dixon Entrance, and both sides of Haida Gwaii while the southern region includes the mainland coast south of Milbanke Sound, Queen Charlotte Sound, and the north and west coasts of Vancouver Island. The northern region of the outside area was surveyed during even numbered years from 2006 to 2012 and the southern region 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 region. The current schedule is to survey the northern region in odd numbered years and the southern region in even numbered years.

The “inside” area includes waters east of Vancouver Island. The northern region of the inside area includes Johnstone Strait and the Broughton Archipelago while the southern region includes Desolation Sound, the Strait of Georgia and the southern Gulf Islands. The survey has been conducted annually since 2003 excluding 2006. Currently the northern region is surveyed in even numbered years while the southern region is surveyed in odd numbered years.

The Hard Bottom Longline Hook surveys follow a 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 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 2017 the northern region of the outside area was surveyed. The intent was to survey the southern region of the inside area but unfortunately, due to crewing limitations, the inside survey was not conducted.

D. 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 5). 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.

The 2017 Sablefish research and assessment survey was comprised of two main components:

1. 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.
2. An Inlets Program that releases tagged Sablefish from fixed-stations at four mainland inlet localities (Figure 6). 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.

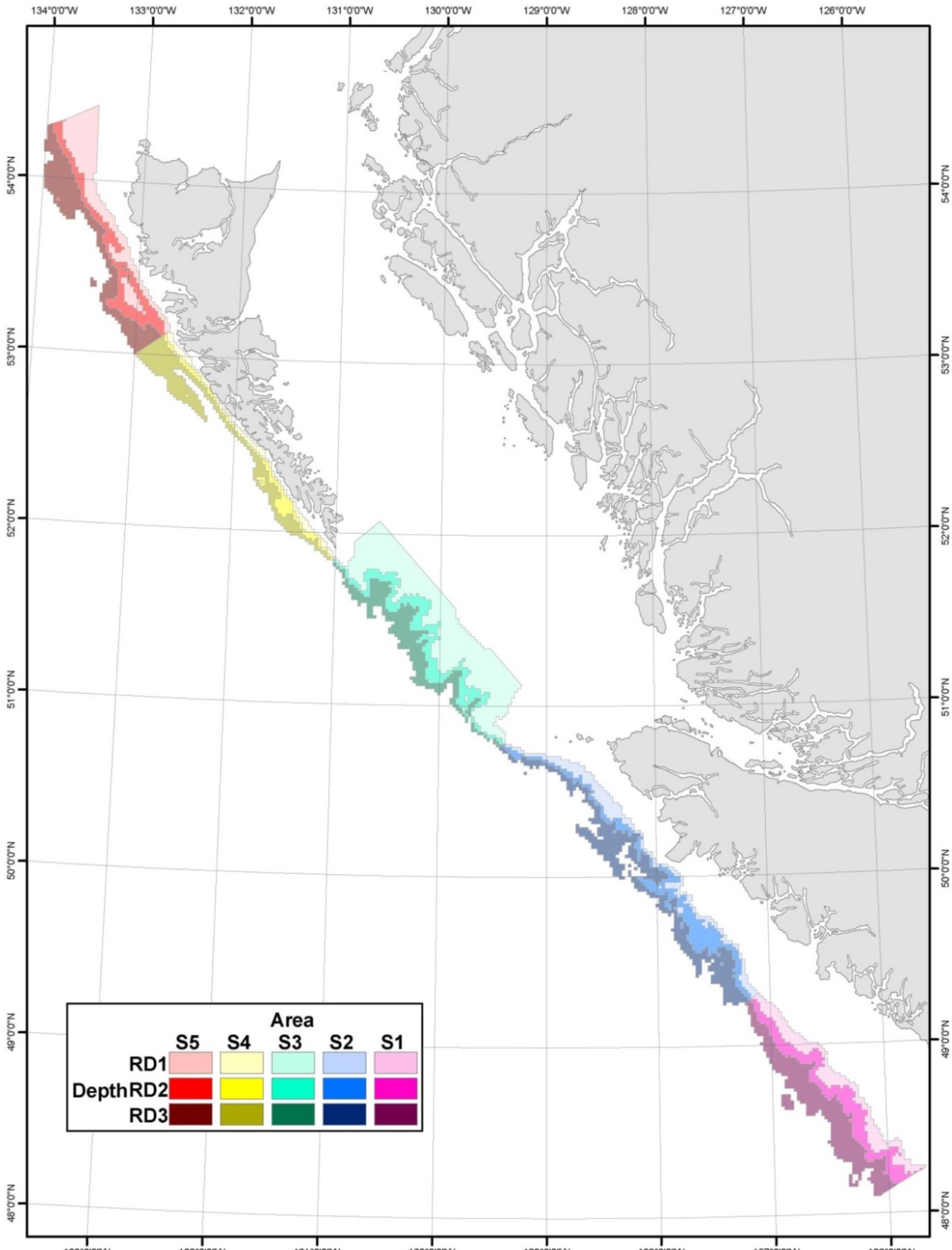

Figure 5. Sablefish Research and Assessment Survey randomized tagging program design showing the boundaries of each of the spatial and depth strata.

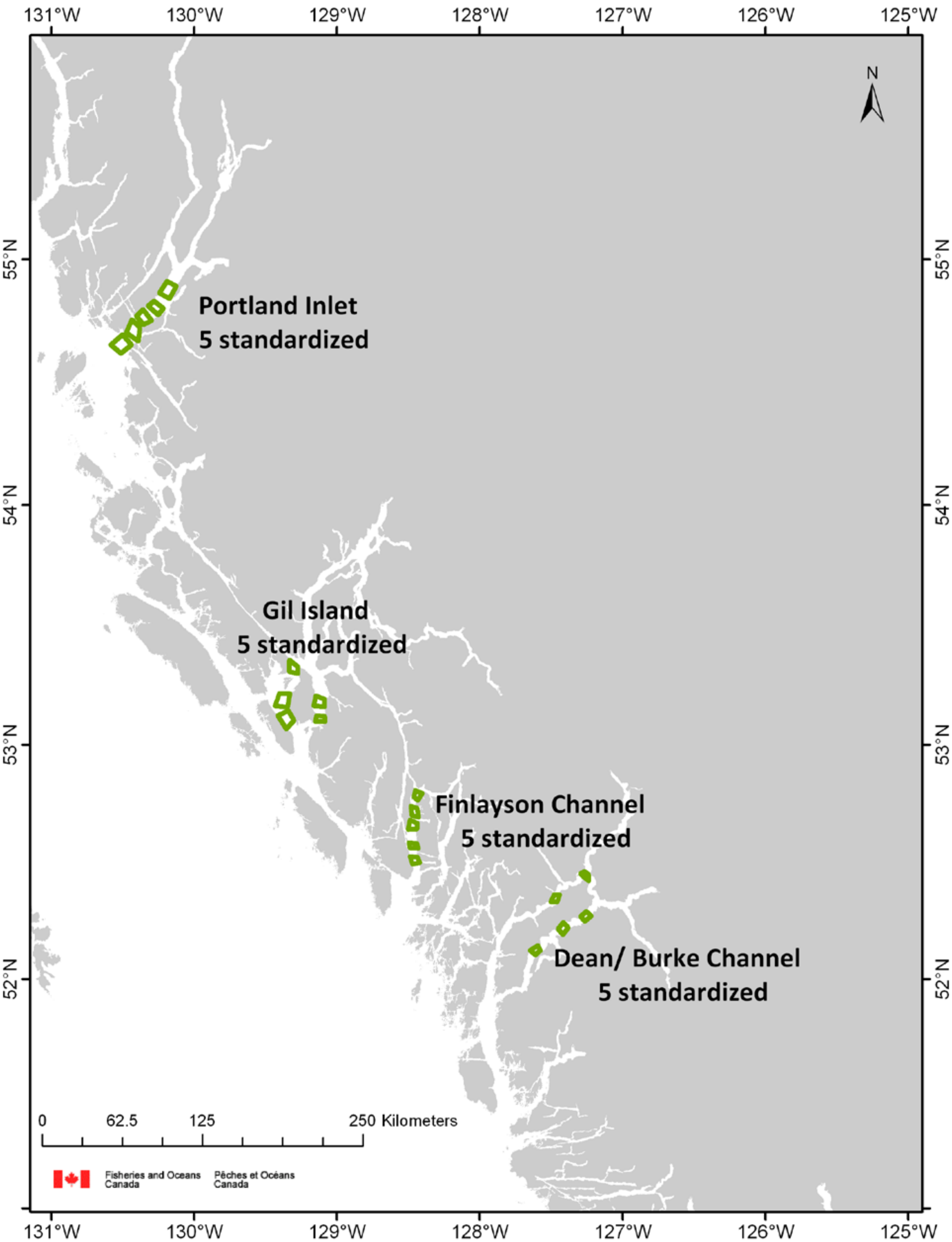

Figure 6. Sablefish Research and Assessment Survey Inlets program locations.

E. Multispecies 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 provide assistance in catch sorting and species identification and also collect biological samples from selected fish 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 2017, only the West Coast Vancouver Island area was surveyed.

F. International Pacific Halibut Commission Fishery-independent Setline Survey

The International Pacific Halibut Commission’s (IPHC) Fishery-independent Setline Survey (FISS) 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.

III. Reserves

The Government of Canada has the mandate to protect 10% of federal waters in marine protected areas (MPAs) by 2020 to fulfill its international commitment under the Aichi Biodiversity Convention (Target 11). Canada surpassed its interim milestone of 5% by 2017 by protecting 7.75% by the end of 2017 (http://www.dfo-mpo.gc.ca/oceans/conservation/2017-eng.html). In order to achieve the marine conservation targets, a number of initiatives are underway in British Columbia (Figure 7).

DFO along with the Province of British Columbia and 17 First Nations, has formed a Marine Protected Area Technical Team (MPATT) (http://mpanetwork.ca/bcnorthernshelf/) that is working to develop a network of MPAs for the Northern Shelf Bioregion. MPATT has compiled ecological, cultural and human use data to be used in an iterative planning process with ongoing stakeholder input to identify potential areas for the MPA network in NSB (https://www.seasketch.org/#projecthomepage/59767c74bac2eb558ded3d9c). The Hecate MPA that was designated under Canada's Oceans Act in February 2017 to protect glass sponge reefs in Hecate Strait will be part of that MPA network, as will the Gwaii Haanas National Marine Conservation Area Reserve (NMCA) and Haida Heritage Site. Parks Canada is working with its management board and stakeholders to zone the NMCA which will include some fully protected sites.

Another major initiative is the designation of the Offshore Pacific Seamounts and Vents Closure. The Area of Interest (AOI) was designated in 2017 and an offshore groundfish fishing closure was put into place to protect seamount and vent communities (Figure 7). The Endeavour Hydrothermal Vents MPA, designated under Canada's Ocean Act in 2003, is within the Offshore AOI. The Endeavour MPA was designated to ensure the protection of hydrothermal vents, and the unique ecosystems associated with them. The regulation to establish the MPA prohibits the removal, disturbance, damage or destruction of the venting structures or the marine organisms associated with them while allowing for scientific research that will contribute to the understanding of the hydrothermal vents ecosystem (http://www.dfo-mpo.gc.ca/oceans/mpa-zpm/endeavour-eng.html).

Following the closure of seamounts in the large offshore area, the Haida First Nation and Government of Canada increased protection within the SGaan Kinghlas-Bowie Seamount (SKB) MPA by closing it to all bottom-contact commercial fishing (January 2018, https://www.newswire.ca/news-releases/haida-nation-and-canada-increase-protection-at-the-sgaan-kinghlas---bowie-seamount-marine-protected-area-670142283.html). The SKB MPA, which was designated in 2008, protects communities living on Bowie Seamount which rises from depths to 3000 m to within 24 m of the surface, as well as two other seamounts and adjacent areas (http://www.dfo-mpo.gc.ca/oceans/mpa-zpm/bowie-eng.html).

The 164 Rockfish Conservation Areas (RCAs) designated as fishery closures between 2004-2007 (Yamanaka and Logan 2010), remain in place and are being evaluated as "other effective area-based conservation measure" to achieve the Aichi Target 11. Similarly, sponge reef fishery closures in the Strait of Georgia are also being considered as other effective measures. The Glass Sponge Reef Conservation Areas are closed to all commercial and recreational bottom contact fishing activities for prawn, shrimp, crab and groundfish (including halibut) in order to protect the Strait of Georgia and Howe Sound Glass Sponge Reefs (http://www.dfo-mpo.gc.ca/oceans/ceccsr-cerceef/closures-fermetures-eng.html). Some additional sponge reefs in Howe Sound have voluntary closures around them and will likely also be officially closed to bottom contact fishing soon (http://futureofhowesound.org/wp-content/uploads/2017/11/Stakeholder-Intro-Letter-Howe-Sound-Sponge-Reefs-Sep-2017-FINAL.pdf). Two other federal initiatives, the Scott Islands Marine National Wildlife Area (NWA), led by the Canadian Wildlife Service, and the Southern Gulf Islands NMCA, led by Parks Canada, are also in progress.

Literature Cited:

Yamanaka, K. and Logan, G. 2010. Developing British Columbia's Inshore Rockfish Conservation Strategy. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2: 28-46.

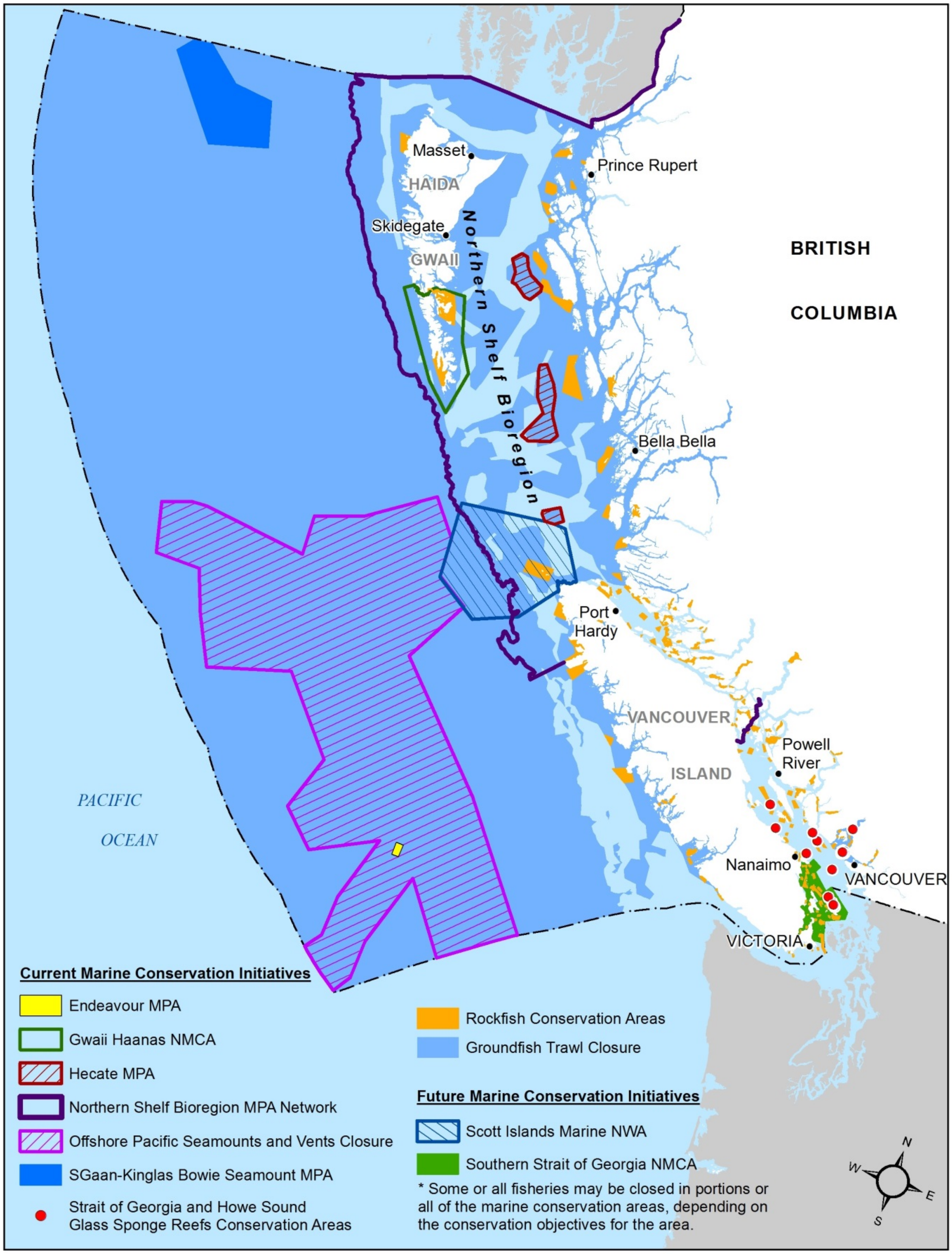

Figure 7. Map of Marine Conservation Target initiatives in British Columbia.

IV. Review of Agency Groundfish Research, Assessment and Management

A. Hagfish

1. Research

No new research in 2017.

2. Assessment

Nothing to report.

3. Management

There is currently no fishery for Hagfish in BC.

B. Dogfish and other sharks

1. Research

Ongoing data collection continued in 2017 through the Groundfish Synoptic Surveys, at-sea observer sampling, and recreational creel surveys. Anecdotal information continued to be collected through the Shark Sightings Network.

2. Assessment

Dogfish were last assessed in 2010, as two distinct stocks, an inshore stock residing within the waters of the Strait of Georgia and an offshore stock occupying all outer coast waters of British Columbia. No new assessment has been requested nor is one planned.

3. Management

Dogfish are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). There is currently very little targeted fishing for Dogfish as markets have essentially collapsed. Most fishery induced mortality is as bycatch in directed fisheries for other species with very little catch being retained or landed.

C. Skates

1. Research

Ongoing data collection continued in 2017 through surveys, at-sea observer sampling, and recreational creel surveys.

D. Pacific cod

1. Research

Ongoing data collection continued in 2017 through the 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 and 2017.

E. Walleye pollock

1. Research

Ongoing data collection continued in 2017 through the Groundfish Synoptic Surveys, at-sea observer sampling, and recreational creel surveys. There is a desire to resolve which ageing structures most accurately represent ages – otoliths using break-and-burn or fin rays. All areas along the BC coast need growth data to describe BC stocks, rather than relying on data from regions outside BC.

2. Assessment

A new stock assessment was presented for two BC stocks of Walleye Pollock – BC North encompassing the three most northerly Pacific Marine Fisheries Commission (PMFC) major areas (5C, 5D, 5E) and BC South including the remaining four outside PMFC major areas (3C, 3D, 5A, 5B plus minor areas 12 & 20). These stock definitions were selected on the basis of a difference in observed mean weights (BC North estimated near 1.0 kg/fish, BC South near 0.5 kg/fish). A delay-difference production model was used to assess each stock, using data from fishery-independent surveys, a CPUE series derived from commercial bottom trawl catch rates, and an annual mean weight series derived from unsorted commercial catch samples. Because there are no useable BC ageing data, we used survey age samples from the Gulf of Alaska (GoA) to specify growth for BC North and a published growth model from the Asian Sea of Okhotsk for BC South.

Each stock assessment explored a range of plausible natural mortality values as well as a range of ages for the knife-edge selectivity assumption because the biomass indices and the mean weight data used in the delay-difference model were not informative for these parameters. The stock assessment was conducted in a Bayesian framework, where the best fit to the data was used as the starting point for a search across the joint posterior parameter distributions using the Monte Carlo Markov Chain (MCMC) procedure. Based on the quality of MCMCs and plausible estimates of fishing mortality (F), posteriors for stock-specific composite scenarios were constructed by pooling 1000 MCMC samples from each of the selected runs to give a posterior of 3,000 samples for BC North and 6,000 samples for BC South. The composite reference scenarios were evaluated against historical reference points (HRPs) based on reconstructed spawning biomass trajectories, due to concerns about the stability of estimating B_0 and B_{2017}. The HRP B_{avg}, the average spawning biomass from 1967-2016, was used as a proxy for B_{MSY}, and B_{min}, the minimum spawning biomass from which it subsequently recovered to B_{avg}, was used in place of $0.4B_{MSY}$. Twice B_{min} was used in place of $0.8B_{MSY}$. The average exploitation rate over the period 1967-2016 (u_{avg}) was used in place of u_{msy}. The biomass at the beginning of 2017 for the model average BC North stock was evaluated as being primarily above the Upper Stock Reference (USR) while the 2017 beginning year biomass for the BC South stock was evaluated as being entirely above the USR (Figure 8).

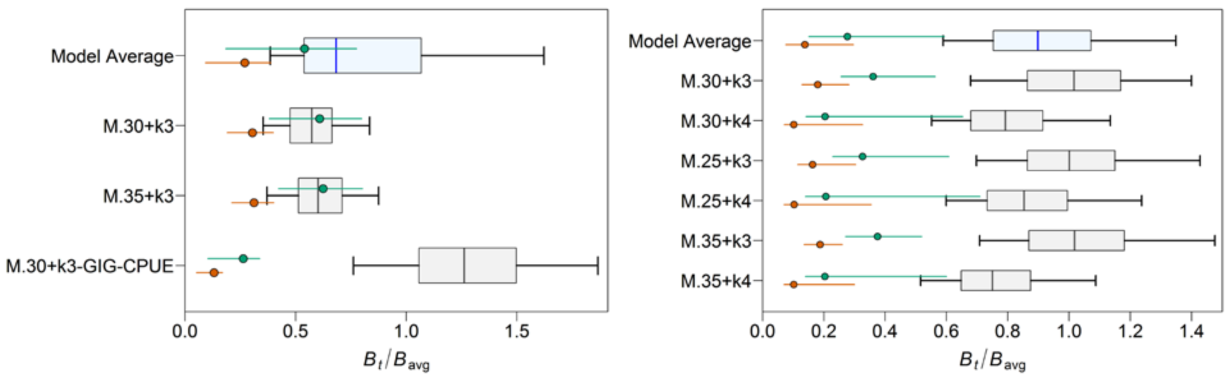

Figure 8.Status of the current stock B_{2017} relative to B_{avg} (L: BC North, R: BC South) with the circles showing median biomass reference points (B_{min}/B_{avg} [red], $2B_{min}/B_{avg}$ [green]), where B_{avg} is a proxy for B_{MSY}, B_{min} is the limit reference point (LRP), and $2B_{min}$ is the upper stock reference point (USR). The 90% credibility range is shown for the LRP and USR. Stock status is shown for the Model Average Composite scenario comprising pooled model runs. Box plots show the 5, 25, 50, 75 and 95 percentiles from the MCMC posteriors. M = instantaneous natural mortality(y^{-1}); k = age (y) at knife-edge recruitment.

3. Management

Walleye Pollock is an IVQ (individual vessel quota) species with a 2017 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 are usually 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 2017 Groundfish Trawl multi-species surveys planned, 5.2 t 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.

F. Pacific whiting (hake)

1. 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.

Triennial (until 2001), then biennial acoustic surveys, covering the known extent of the Pacific Hake stock have been run since 1995. An acoustic survey, ranging from California to northern British Columbia is currently run in odd years, to continue the biennial time series. There was a survey in 2017, which contributed to the time series used in the 2018 assessment model. The biomass estimate generated from the survey was 1.418 million t.

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. There was no 2018 survey due to the decommissioning of the W.E. Ricker, but there is a plan to continue the time series in 2019 with the new Offshore Fisheries Science Vessel

2. Assessment

As in previous years, and as required by the Agreement Between the Government of Canada and the Government of the United States of America on Pacific Hake/Whiting (the Pacific Whiting treaty), the 2018 harvest advice was prepared jointly by Canadian and U.S. scientists working together, collectively called the Joint Technical Committee (JTC) as stated in the treaty. The assessment model used was Stock Synthesis 3 (SS3). The 2018 model had almost the same model structure used in 2017, with updates to catch and age compositions. There was a re-parameterization of the time-varying selectivity parameters, a new age weighting method, and a new maturity ogive based on empirical maturities-at-age in the 2018 assessment. Those three changes had very little effect on the model output, as did other standard sensitivities requested by the Scientific Review Group.

The largest cohort caught in the fishery was age-3’s, followed by age 7’s. There was a larger proportion than usual of Age 1’s caught this year, with some even being found in Canadian waters in August.

There has not been an assessment of Pacific Hake in the Strait of Georgia, although the recent increases in catch may warrant one.

3. Management

Management of Pacific Hake has been under a treaty (The Agreement) between Canada and the United States since 2011. 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 2017 was 156,067 t including a carryover of 17,239 t. The shoreside/freezer trawler sector was allocated 141,067 t of this and caught 86,713 t (55.6% of total TAC). The Joint Venture (JV) fishery received a quota of 15,000 t in 2017, and caught 5,608 t. The majority of the Canadian Pacific Hake catch for the 2017 season was taken from the west coast of Vancouver Island.

The final decision on catch advice for the 2018 fishing season was made at the meeting of the International Pacific Hake JMC in Lynwood, Washington on Mar. 5 – Mar. 6, 2018. A coastwide TAC of 597,500 t for 2018 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.westcoast.fisheries.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html

Management of Strait of Georgia Pacific Hake has been implemented as ad-hoc quota allocation for the history of the fishery. Typical catch for the Strait has been approximately 10 - 40 metric tonnes for many years, but has seen an increase of several orders of magnitude in the last few years.

A. Grenadiers

1. Research

There is no directed work being conducted on Grenadiers but ongoing data collection continued in 2017 through surveys and at-sea observer sampling.

G. Rockfish

1. 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 2017 through the research surveys, at-sea observer programs (ASOP), recreational creel surveys, and an Internet Recreational Effort and Catch (iREC) Survey.

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.

a) Inshore Rockfish

Although DFO ship time was allocated for the longline survey in the Southern region of the Strait of Georgia in August 2017, the survey did not take place due to Coast Guard staffing issues and the lack of and available Captain with fishing experience. The Southern region that was supposed to be sampled in 2017 will be surveyed August 7-31, 2018.

The Offshore Hook and line survey conducted collaboratively with industry was completed in August and September of 2017, see the survey section (II) and Appendix 1 for further details.

b) Slope Rockfish

At the request of the PBS Ageing lab, advanced requests for ageing were submitted for Yellowmouth Rockfish (commercial: coastwide 2010-17; surveys: QCS synoptic 2009-17, WCHG synoptic 2012-16, WCVI synoptic 2012-14) and Pacific Ocean Perch (commercial : 3CD 2010-17, 5ABC 2015-17, 5DE 2011-17; surveys: HS synoptic 2005-17, QCS synoptic 2017, WCHG synoptic 2012-16; WCVI synoptic 2012-16).

Genetic work on separating the Rougheye/ Blackspotted Rockfish complex was initiated in 2010 and is planned to continue in 2018. Tissues samples are processed annually; aging of specimen sampled for DNA was initiated in 2017 in anticipation of completing an assessment by 2020.

2. Assessment

a) Inshore 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.. The full research document (Yamanaka et al., 2017) is now available at: http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2018/2018_001-eng.pdf.

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.

Literature Cited:

Yamanaka, K.L., McAllister, M.M., Etienne, M., Edwards, A.M., and Haigh, R. 2018. Stock Assessment for the Outside Population of Yelloweye Rockfish (*Sebastes ruberrimus*) for British Columbia, Canada in 2014. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/001. ix + 150 p..

b) Slope Rockfish

Pacific Ocean Perch, a commercially important species of rockfish that inhabits the marine canyons along the BC coast, was re-assessed in 2017 as a single stock harvested entirely in Pacific Marine Fisheries Commission (PMFC) major areas 5A, 5B, 5C, and in 5E south of 52°20′. This stock has supported a domestic trawl fishery for decades and was heavily fished by foreign fleets from the mid-1960s to mid-1970s.

An annual catch-at-age model (Awatea, variant of Coleraine) was tuned to two fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from two survey series (11 years of data) and the commercial fishery (34 years of data). The model started from an assumed equilibrium state in 1940, and the survey data covered the period 1967 to 2016. The two-sex model was implemented in a Bayesian framework (using the Markov Chain Monte Carlo search procedure) under a scenario that estimated both sex-specific natural mortality (M) and steepness of the stock-recruit function (h). Seven sensitivity analyses were performed to test the effect of data inputs to the model (Figure 9). A bridging analysis was performed using the 2010 data from the previous assessment to determine the effect of weighting the age frequencies with a new procedure that downweighted composition data instead of the 2010 procedure that used multinomial weighting.

The base model run suggested that strong recruitment in the early 1950s sustained the foreign fishery, and that a few strong year classes spawned in the late 1970s and 1980s sustained the domestic fishery into the 1990s. The spawning biomass (mature females only) at the beginning of 2017, B_{2017}, was estimated to be 0.27 (0.18, 0.42) of unfished biomass (median and 5th and 95th quantiles of the Bayesian posterior distribution). B_{2017} is estimated to be 1.03 (0.54, 1.96) of the spawning biomass at maximum sustainable yield, B_{MSY}.

Advice to managers was presented as decision tables that provided probabilities of exceeding limit and upper stock reference points over a five-year projection period across a range of constant catches. The DFO provisional 'Precautionary Approach compliant' reference points were used, which specify a 'limit reference point' of $0.4B_{MSY}$ and an 'upper stock reference point' of $0.8B_{MSY}$. The estimated spawning biomass at the beginning of 2017 had a 0.99 probability of being above the limit reference point, and a 0.74 probability of being above the upper stock reference point. Five-year projections using a constant catch of 2500 t/y (near a recent average five-year catch of 2400 t/y) indicated that, in 2022, the spawning biomass had probabilities of 0.97 of remaining above the limit reference point, and 0.71 of remaining above the upper stock reference point.

A Bayesian method was used to investigate potential ecosystem influences on recruitment and applied to the estimated recruitment from the 2010 stock assessment using a suite of climatic and environmental indicators. Results showed that none of the investigated indicators were able to reliably predict observed recruitment deviations, leading to the conclusion that using environmental information to improve model predictions for this stock could not be used at the time.

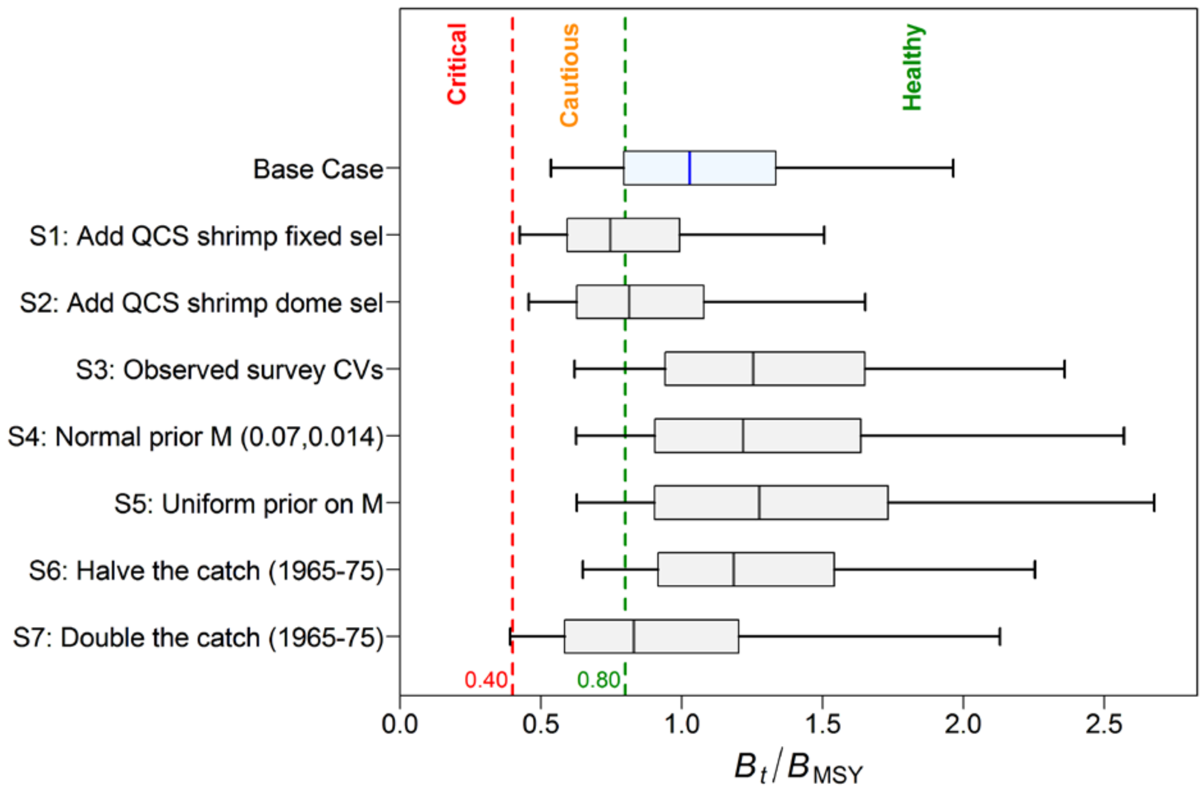

Figure 9.Status at beginning of 2017 of the 5ABC POP stock relative to the DFO PA provisional reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$ for the base-case stock assessment and seven sensitivity runs: S1 = add the QCS shrimp survey using a fixed selectivity curve; S2 = add the QCS shrimp survey using a fitted dome-shaped selectivity curve; S3 = use the observed survey CVs without adding process error; S4 = use a normal prior on M with a mean of 0.07 and a standard deviation of 0.014 (CV=20%); S5 = use a uniform prior on M; S6 = halve the catch in the years 1965-75 (during peak foreign fleet activity); S7 = double the catch in the yeas 1965-75. Boxplots show the 5, 25, 50, 75 and 95 quantiles from the MCMC posterior.

3. Management

a) 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 2019. A pre-COSEWIC document for inside and outside Yelloweye

Rockfish was completed in 2017 (Keppel and Olsen, 2017). This document collates all available biological and abundance information relating to Yelloweye Rockfish that DFO possesses. It was reviewed under CSAS November 8th, 2017, finalized and then presented to the COSEWIC author who will complete the Yelloweye Rockfish assessment report. Yelloweye Rockfish will likely be re-assessed by COSEWIC in the spring of 2019.

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 2017. Quillback Rockfish is up for reassessment by the COSEWIC by November 2019.

Literature cited:

Keppel, E. and N. Olsen. 2017. Pre-COSEWIC review of Yelloweye Rockfish (*Sebastes ruberrimus*) along the Pacific coast of Canada: biology, distribution and abundance trends. CSAP Working Paper 2016SAR11.

b) Slope Rockfish

Pacific Ocean Perch is an IVQ (individual vessel quota) species with a 2017 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 2017 Groundfish Trawl multi-species surveys, 17.9 t 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, 2017 to May 31, 2017 and from Oct 1, 2017 to Mar 31, 2018 to reduce harvesting pressure on Pacific Ocean Perch stocks during the spawning period.

H. Thornyheads

1. Research

Ongoing data collection continued in 2017 through surveys and at-sea observer sampling.

2. Assessment

No Thornyhead assessments were conducted in 2017. Longspine Thornyhead was designated "Special Concern" by COSEWIC in 2007. It is anticipated that an assessment may be requested in the near future.

3. Management

Longspine and Shortspine Thornyhead are both IVQ species with a 2017 coastwide TAC (total allowable catch) of 425 t and 769 t, respectively. Commercial TACs for these 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 2017 multi-species surveys, 1.9 t was accounted for before defining the Groundfish Trawl TACs for Shortspine Thornyhead, and 1.0 t was reserved for longline surveys. There were no adjustments for Longspine Thornyhead.

I. Sablefish

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.

1. Research

In addition to the annual Sablefish Research and Assessment Survey (see Appendix 1 for details) , research activities in 2017 included the continuation of a bottom contact research project during commercial trap gear fishing trips to SGaan Kinghlas-Bowie Seamount. Autonomous, trap-mounted deep-water cameras captured motion-activated and fixed-interval high definition videos of benthic substrate type, gear interaction with the substrate, and biological communities. In addition, trap-mounted tri- axial accelerometers recorded motion and orientation of the traps while standard oceanographic temperature-depth recorders measure in-situ depth and temperature

2. Assessment

Sablefish stock status is regularly evaluated via the MSE process. An operating model (i.e., representation of alternative hypotheses about 'true' Sablefish population dynamics) is used to simulate data for prospective testing of management procedure performance relative to stock and fishery objectives. The current 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 (DFO 2016). Specific modifications included: (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. These 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.

The status of the Sablefish stock is judged on the scale of the OM which was last updated in 2016. Based on the 2016 assessment Sablefish lie in the Cautious Zone under the DFO FPA Framework. However, as a result of recent above average recruitment attributed to the 2014 year class, the biomass of Sablefish in BC, as well as Alaska (Hanselman et al. 2017), appears to be increasing. Based on the most recent estimates of Sablefish catch and survey CPUE from the 2017 research and assessment survey, the current point estimate of legal-size Sablefish biomass in BC is 31,264 t

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).

The evaluation of the existing, and alternative, MPs in 2016/2017 led to the identification of a new preferred MP that is consistent with Canada’s Fisheries Decision Making Framework Incorporating the Precautionary Approach, and provides an acceptable balance of the trade-off between conservation and fishery objectives. This MP is based on a surplus production model fit to time-series observations of total landed catch, and the fishery independent survey CPUE, to forecast Sablefish biomass for the coming year. The surplus production model outputs are then inputs to a harvest control rule to calculate the recommended catch of legal Sablefish in a given year. This MP includes a 5-year phased-in period to a new maximum target harvest rate of 5.5%.

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 (Hanselmen et al. 2014) and little genetic evidence of population structure across these management regions (Jasonowicz et al. 2017) . 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. DFO has recently secured funding to work with an international team of Sablefish scientists to develop a coastwide Sablefish OM to understand the potential consequences of the mismatch between Sablefish stock structure and management by simulation testing current, and potential future, MPs to quantify their performance against a range of conservation and fishery objectives.

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.

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DFO. 2016. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

Hanselman, D.H., Heifetz, J., Echave, K.B. and Dressel, S.C., 2014. Move it or lose it: movement and mortality of sablefish tagged in Alaska. Canadian journal of fisheries and aquatic sciences, 72(2), pp.238-251.

Jasonowicz, A.J., Goetz, F.W., Goetz, G.W. and Nichols, K.M., 2016. Love the one you're with: genomic evidence of panmixia in the sablefish (*Anoplopoma fimbria*). Canadian Journal of Fisheries and Aquatic Sciences, 74(3), pp.377-387.

3. Management

In 2013, fishing industry stakeholders proposed a TAC floor of 1,992 t, because lower quotas may increase economic risks. The Sablefish MP first applied in 2010 was therefore 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. As a result of lower productivity estimates derived from the revised OM, and subsequent MP simulation testing 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 therefore revised so as to not include a TAC floor in addition to phasing in a reduction in the annual harvest ratefrom 9.5% to 5.5% over five years. The resulting proposed TAC for the 2018/19 fishing year is 2,720 t, a ~20% over the 2017/18 TAC. However, fishing industry stakeholders proposed a smaller increase in TAC of 250 t to enhance rebuilding of the stock and so the final proposed TAC for 2018/19 is 2526 t.

An update of the MSE simulation work is planned for 2019/20.

J. Lingcod

1. Research

Ongoing data collection continued in 2017 through research surveys, recreational creel surveys, and an Internet Recreational Effort and Catch (iREC) Survey.

2. Assessment

Outside Lingcod are to be assessed in the spring of 2019 so data are being gathered for analysis.

K. Atka mackerel

The distribution of Atka mackerel does not extend into the Canadian zone.

L. Flatfish

1. Research

Ongoing data collection in support of the flatfish research program continued in 2017 through research surveys and at-sea observer sampling.

2. Assessment

In 2017, an assessment for Arrowtooth Flounder was finalized and published through the Canadian Science Advice Secretariat (CSAS).

In 2017 work was initiated by a graduate student (PhD candidate – Samuel Johnson) at Simon Fraser University under a Mitacs accelerate grant on a project to simultaneously assess the five species of commercially harvested flatfish in British Columbia, Arrowtooth Flounder, Sothern Rock Sole, English Sole, Dover sole and Petrale sole. DFO's primary role in this project is as a provider of data, and secondarily as a potential client. If successful, the methods and results of this work will be peer reviewed through the Canadian Science Advisory Secretariat process and if accepted, used as harvest advice actionable by DFO Groundfish fisheries managers.

3. Management

Arrowtooth Flounder, Sothern Rock Sole, English Sole, Dover 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.

M. 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.

N. Other groundfish species

No research, assessment or management to report for other groundfish species.

V. Ecosystem Studies

A. Development of a management procedure framework and data-synopsis report for 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. Ultimately, the meeting participants identified a preference for applying a modified approach for BC groundfish fisheries. Instead of a traditional tiered approach, the workshop proceedings suggest considering data-richness on a continuous scale and focusing on simulation testing multiple management procedures on a stock-by-stock basis to choose an approach that best meets fisheries risk objectives.

The goal of the project is to develop a framework for applying a management-procedure approach to data-limited groundfish stocks in British Columbia. The framework will formalize the process of testing and selecting management procedures for data-limited groundfish fisheries, which will support the provision of scientific advice to fisheries managers in the context of conservation (sustainable total allowable catches, COSEWIC) and eco-certification (Marine Stewardship Counsel). Although this project may use data tiers for communication purposes, it will focus on developing a procedural framework for building appropriate operating models, testing suites of management procedures, and determining management procedures that best meet the objectives of fisheries management and stakeholders for given stocks. In addition to this procedural framework, this project aims to produce generic operating models that can be modified on a stock-by-stock basis and generate a reproducible data synopsis of the available data and general index trends for candidate groundfish fish stocks.

There are numerous expected benefits of this project. Compared to a traditional tiered approach, this management-procedure approach is focused on achieving long-term performance objectives instead of biological estimation; incorporates feedback between management procedures and the underlying system; and will allow us to take advantage of available data for specific stocks rather than prescribing one estimation model per data tier. Compared to the status quo, this framework will allow DFO to provide scientific advice on more stocks; will develop a standardized and transparent assessment approach across stocks; will require less effort to update advice between full re-assessments and thereby reduce the turnaround time between science advice request and provision of such advice; and will build an understanding of the most important data needs and research priorities for reducing uncertainty in stock advice.

A science steering committee has been meeting to plan the current 'management procedure' phase of the project since the fall of 2017 and will convene the first technical working group on April 27 2018. The intended outcome of the technical working group meetings and eventual original peer review process will be a research document with visualizations of nearly all available groundfish data, with the expectation of updating this on an annual basis, and a research document and science advisory report outlining an agreed upon management procedure approach for British Columbia groundfish.

VI. Other related studies

A. 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. Participants contributed to an annotated bibliography of 44 Canadian examples that have already considered ecosystem effects in stock assessments, advice to managers or research. Most of the talks and R code from the break-out groups are publically available at https://drive.google.com/drive/folders/0B5RDkOmwzCjnOXpNbVZtMHNWaTg and https://github.com/andrew-edwards/empirical-dyn-mod.

The Proceedings from the workshop were published as

Edwards, A.M., Haigh, R., Tallman, R., Swain, D.P., Carruthers, T.R., Cleary, J.S., Stenson, G. and Doniol-Valcroze, T. (2017). Proceedings of the Technical Expertise in Stock Assessment (TESA) National Workshop on 'Incorporating an ecosystem approach into single-species stock assessments' 21-25 November 2016, Nanaimo, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 3213: vi + 53 p. Available at http://publications.gc.ca/collections/collection_2017/mpo-dfo/Fs97-6-3213-eng.pdf.

B. Size Spectrum Analysis

The size spectrum of an ecological community characterizes how a property, such as abundance or biomass, varies with body size. Size spectra are often used as ecosystem indicators of marine systems. They have been fitted to data from various sources, including groundfish trawl surveys. Over the past decades several methods have been used to fit size spectra to data. Edwards et al. (2017) documented eight such methods, demonstrating their commonalities and differences. They found that four of the eight tested methods can sometimes give reasonably accurate estimates of the exponent of the individual size distribution (which is related to the slope of the size spectrum). However, sensitivity analyses found that maximum likelihood estimation is the only method that is consistently accurate, and the only one that yields reliable confidence intervals for the exponent – it was therefore the recommended method. The paper provides documented R code for fitting and plotting results (continually updated at https://github.com/andrew-edwards/fitting-size-spectra), to provide consistency in future studies and improve the quality of any resulting advice to ecosystem managers. In particular, the calculation of reliable confidence intervals will allow proper consideration of uncertainty when making management decisions.

Edwards A.M., Robinson, J.P.W. , Plank, M.J., Baum, J.K. and Blanchard, J.L.. 2017. Testing and recommending methods for fitting size spectra to data. Methods in Ecology and Evolution, 8:57-67. Plus 44 pages Supplementary Information and documented R code for reproducibility and others to apply to their own data. Available at https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12641.

C. Groundfish Data Unit

Principal Groundfish Data Unit activities in 2017 included the ongoing population of the groundfish biological samples database (GFBio), scanning and archiving “rescued” data, answering internal and external requests for groundfish data, and working with Groundfish field program staff on various data management issues.

The GFBio database now includes 28,222 trips and approximately 11,256,774 specimens. Data entry activities concentrated on input of recent and historic groundfish research cruises and current-year commercial biological data from at-sea and dockside observers, as well as some non-groundfish survey data from surveys utilizing the GFBioField system.

The Government of Canada is continuing to develop and promote an “Open Data” portal where scientific data will be freely available for download by members of the general public (https://open.canada.ca/en/open-data). In 2017, the data unit prepared the groundfish synoptic trawl surveys datasets for eventual release on the Open Data portal; the datasets and metadata are currently in review.

VII. Publications

A. Primary Publications

Haggarty, D. R., K. E. Lotterhos and J. B. Shurin. 2017. Young-of-the-year recruitment does not predict the abundance of older age classes in black rockfish in Barkley Sound, British Columbia, Canada." Marine Ecology Progress Series 574: 113-126.

King, J.R. and Surry, A.M. 2017. Seasonal and daily movements of the Bluntnose Sixgill Shark (*Hexanchus griseus*) in the Strait of Georgia from satellite tag data. Env. Biol. of Fishes. 100: 1543-1559.

King, J.R., McFarlane, G.A., Gertseva, V., Gasper, J., Matson, S., and Tribuzio, C.A. 2017. Shark Interactions with Directed and Incidental Fisheries in the Northeast Pacific Ocean: historic and current encounters, and challenges for shark conservation. In: Shawn E. Larson and Dayv Lowry, editors, Advances in Marine Biology, Vol. 78, Oxford: Academic Press, 2017, pp. 9-44.

King, J.R., Helser, T., Gburski, C., Ebert, D.A., Cailliet, G., and Kastelle, C.R. 2017. Bomb radiocarbon analyses validate and inform age determination of longnose skate (*Raja rhina*) and big skate (*Beringraja binoculata*) in the north Pacific Ocean. Fisheries Research 193(2017): 195-206.

B. Other Publications

Edwards A.M., Robinson, J.P.W. , Plank, M.J., Baum, J.K. and Blanchard, J.L.. 2017. Testing and recommending methods for fitting size spectra to data. Methods in Ecology and Evolution, 8:57-67. Plus 44 pages

Edwards, A.M., Haigh, R., and Starr, P.J. 2017. Redbanded Rockfish (*Sebastes babcocki*) stock assessment for the Pacific coast of Canada in 2014. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/058. v + 182 p

Edwards, A.M., Haigh, R., Tallman, R., Swain, D.P., Carruthers, T.R., Cleary, J.S., Stenson, G. and Doniol-Valcroze, T. 2017. Proceedings of the Technical Expertise in Stock Assessment (TESA) National Workshop on ‘Incorporating an ecosystem approach into single-species stock assessments’ 21-25 November 2016, Nanaimo, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 3213: vi + 53 p. Available at http://publications.gc.ca/collections/collection_2017/mpo-dfo/Fs97-6-3213-eng.pdf.

Edwards, A.M., Taylor, I.G., Grandin, C.J., and Berger, A.M.. 2018. Status of the Pacific Hake(whiting) stock in U.S. and Canadian waters in 2018. Prepared by the Joint Technical Committee of the U.S. and Canada Pacific Hake/Whiting Agreement, National Marine Fisheries Service and Fisheries and Oceans Canada. 220.

Grandin, C. and Forrest, R. 2017. Arrowtooth Flounder (*Atheresthes stomias*) Stock Assessment for the West Coast of British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/025. v + 87 p

King, J.R. 2017. Shortfin mako (*Isurus paucus*) incidental catch statistics in Canadian fisheries. ISC/17/SHARKWG-3/01.

Nottingham, M.K., Williams, D.C., Wyeth, M.R. and Olsen, N. 2018. Summary of the Queen Charlotte Sound synoptic bottom trawl survey, July 2-28, 2013. Can. Manuscr. Rep. Fish. Aquat. Sci. 3135: viii + 71 p.

Nottingham, M.K., Williams, D.C., Wyeth, M.R., and Olsen, N. 2018. Summary of the Hecate Strait synoptic bottom trawl survey, May 26 – June 22, 2015. Can. Manuscr. Rep. Fish. Aquat. Sci. 3126: viii + 55 p.

Nottingham, M.K., Williams, D.C., Wyeth, M.R., and Olsen, N. 2018. Summary of the West Coast Haida Gwaii synoptic bottom trawl survey, August 24 - September 19, 2012. Can. Manuscr. Rep. Fish. Aquat. Sci. 3133: viii + 55 p.

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Starr, P.J. and Haigh, R. 2017. Stock assessment of the coastwide population of Shortspine Thornyhead (*Sebastolobus alascanus*) in 2015 off the British Columbia coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/015. ix + 174 p.

Williams, D.C., Nottingham, M.K., Olsen, N. and Wyeth, M.R. 2018. Summary of the Queen Charlotte Sound synoptic bottom trawl survey, July 4 to 31, 2011. Can. Manuscr. Rep. Fish. Aquat. Sci. 3127: viii + 69 p

Williams, D.C., Nottingham, M.K., Olsen, N. and Wyeth, M.R. 2017. Summary of the Hecate Strait synoptic bottom trawl survey, May 28 – June 23, 2013. Can. Manuscr. Rep. Fish. Aquat. Sci. 3142: viii + 60 p.

Williams, D.C., Nottingham, M.K., Olsen, N. and Wyeth, M.R. 2017. Summary of the West Coast Vancouver Island synoptic bottom trawl survey, May 22 - June 16, 2012. Can. Manuscr. Rep. Fish. Aquat. Sci. 3139: viii + 57 p.

Yamanaka, K.L., McAllister, M.M., Etienne, M., Edwards, A.M., and Haigh, R. 2018. Stock Assessment for the Outside Population of Yelloweye Rockfish (Sebastes ruberrimus) for British Columbia, Canada in 2014. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/001. ix + 150 p..

Appendix 1: Details of Fisheries and Oceans, Canada Pacific Region Groundfish Surveys in 2017

A. Multispecies Synoptic Bottom Trawl Surveys

1. Hecate Strait Multispecies Synoptic Bottom Trawl Survey

The Hecate Strait Multispecies Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between May 19 and June 15. We assessed a total of 192 blocks (**Table 1**, **Figure 10**). Of the 152 total tows conducted, 138 were successful and 13 were failures due to hang ups or insufficient bottom time. One additional block was successfully fished but, due to a large catch of coral, the block has been removed from the survey frame and the tow is considered unusable. Note that some blocks are only successfully fished following more than one attempt.

The total catch weight of all species was 81,391 kg. The mean catch per tow was 550 kg, averaging 23 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (*Atheresthes stomias*), Spotted Ratfish (*Hydrolagus colliei*), English Sole (*Parophrys vetulus*), Dover Sole (*Microstomus pacificus*), 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 2**. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 19,907 individual fish of 43 different species (**Table 3**).

Table 1. 2017 Hecate Strait Multispecies 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
10 to 70 m	3	27	0	47	0	81
70 to 130 m	1	5	0	44	0	51
130 to 220 m	0	5	0	38	0	44
220 to 500 m	0	5	1	9	0	16
Total	**4**	**42**	**1**	**138**	**0**	**192**

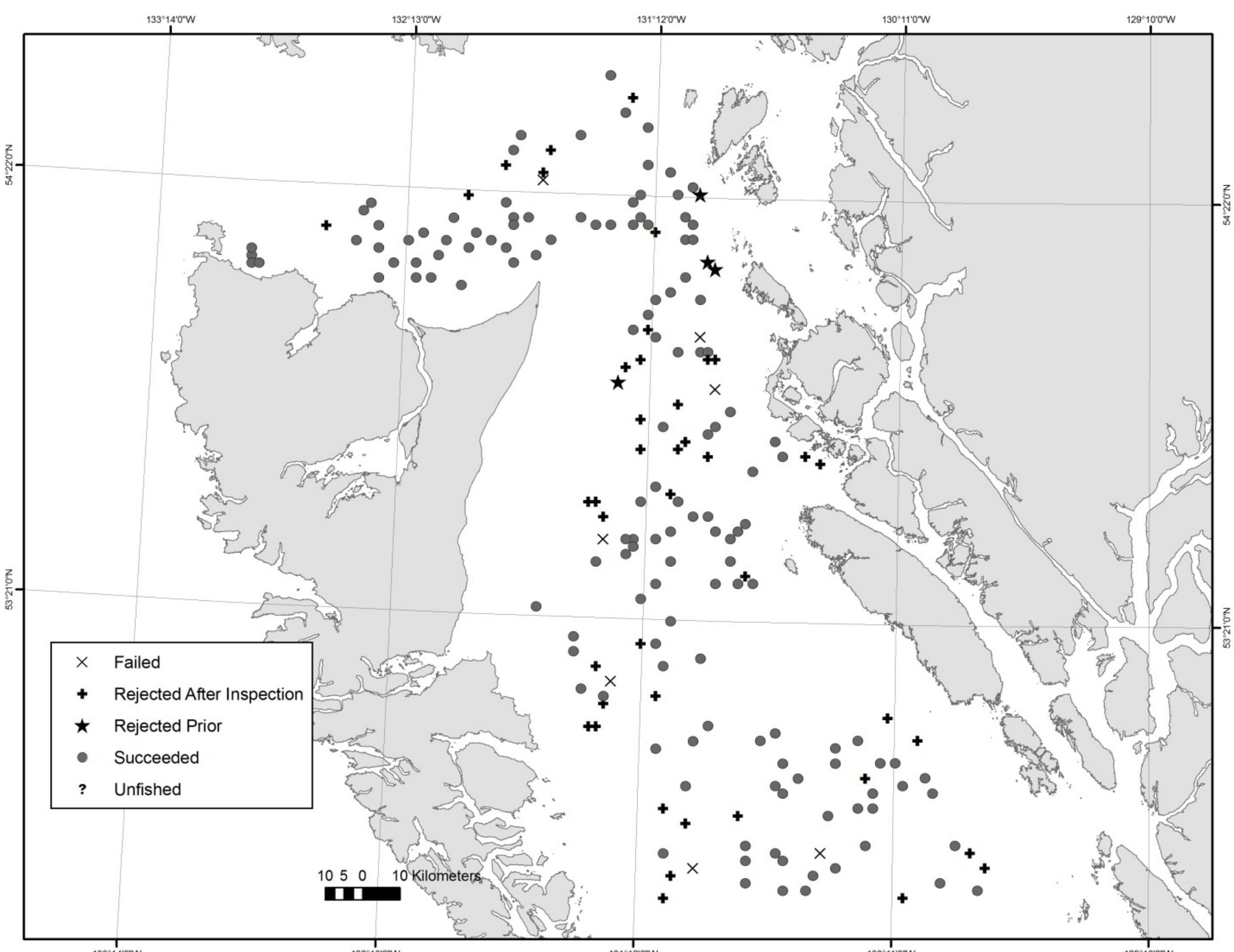

Figure 10. Final status of the allocated blocks for the 2017 Hecate Strait Multispecies Synoptic Bottom Trawl Survey.

Table 2. 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 2017 Hecate Strait Multispecies Synoptic Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Spotted Ratfish	*Hydrolagus colliei*	134	16453	10949	0.21
Arrowtooth Flounder	*Atheresthes stomias*	103	15321	11073	0.27
English Sole	*Parophrys vetulus*	97	12162	11533	0.54
Dover Sole	*Microstomus pacificus*	90	5022	3330	0.21
Sablefish	*Anoplopoma fimbria*	77	4018	2413	0.3
Rex Sole	*Glyptocephalus zachirus*	105	3214	2501	0.52
Pacific Cod	*Gadus macrocephalus*	107	2516	1555	0.35
Pacific Halibut	*Hippoglossus stenolepis*	84	2462	1898	0.21
Walleye Pollock	*Gadus chalcogrammus*	82	2272	1219	0.34
Southern Rock Sole	*Lepidopsetta bilineata*	72	1532	1540	0.15
Big Skate	*Beringraja binoculata*	51	1406	1213	0.35
Pacific Ocean Perch	*Sebastes alutus*	47	1321	613	0.61
Yellowtail Rockfish	*Sebastes flavidus*	23	1036	546	0.72
North Pacific Spiny Dogfish	*Squalus suckleyi*	102	986	664	0.11
Flathead Sole	*Hippoglossoides elassodon*	57	960	557	0.32
Longnose Skate	*Raja rhina*	31	504	334	0.3
Pacific Hake	*Merluccius productus*	25	476	368	0.23
Redbanded Rockfish	*Sebastes babcocki*	36	471	329	0.18
Starry Flounder	*Platichthys stellatus*	15	391	409	0.35
Petrale Sole	*Eopsetta jordani*	67	362	239	0.18
Sand Sole	*Psettichthys melanostictus*	33	344	370	0.26
Quillback Rockfish	*Sebastes maliger*	44	312	226	0.27
Butter Sole	*Isopsetta isolepis*	31	273	255	0.33
Shortspine Thornyhead	*Sebastolobus alascanus*	36	261	203	0.24
Silvergray Rockfish	*Sebastes brevispinis*	40	249	136	0.19

Table 3. Number of fish sampled for biological data during the 2017 Hecate Strait Multispecies 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
North Pacific Spiny Dogfish	*Squalus suckleyi*	383	275
Big Skate	*Beringraja binoculata*	211	0
Sandpaper Skate	*Bathyraja interrupta*	26	0
Longnose Skate	*Raja rhina*	90	0
Spotted Ratfish	*Hydrolagus colliei*	2092	0
Eulachon	*Thaleichthys pacificus*	984	0
Pacific Cod	*Gadus macrocephalus*	821	602
Pacific Hake	*Merluccius productus*	267	83
Pacific Tomcod	*Microgadus proximus*	332	0
Walleye Pollock	*Gadus chalcogrammus*	899	172
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	49	49
Pacific Ocean Perch	*Sebastes alutus*	435	224
Redbanded Rockfish	*Sebastes babcocki*	206	205
Silvergray Rockfish	*Sebastes brevispinis*	115	0
Copper Rockfish	*Sebastes caurinus*	62	54
Greenstriped Rockfish	*Sebastes elongatus*	38	0
Yellowtail Rockfish	*Sebastes flavidus*	124	51
Quillback Rockfish	*Sebastes maliger*	339	250
Bocaccio	*Sebastes paucispinis*	48	48
Canary Rockfish	*Sebastes pinniger*	70	50
Redstripe Rockfish	*Sebastes proriger*	95	59
Yellowmouth Rockfish	*Sebastes reedi*	35	0
Yelloweye Rockfish	*Sebastes ruberrimus*	12	12
Pygmy Rockfish	*Sebastes wilsoni*	25	0
Sharpchin Rockfish	*Sebastes zacentrus*	57	0
Shortspine Thornyhead	*Sebastolobus alascanus*	390	130
Sablefish	*Anoplopoma fimbria*	821	377
Kelp Greenling	*Hexagrammos decagrammus*	60	0
Lingcod	*Ophiodon elongatus*	310	222
Pacific Sanddab	*Citharichthys sordidus*	585	0
Arrowtooth Flounder	*Atheresthes stomias*	1847	514
Petrale Sole	*Eopsetta jordani*	305	212
Rex Sole	*Glyptocephalus zachirus*	1556	402
Flathead Sole	*Hippoglossoides elassodon*	367	0
Pacific Halibut	*Hippoglossus stenolepis*	516	0
Butter Sole	*Isopsetta isolepis*	316	0
Southern Rock Sole	*Lepidopsetta bilineata*	1170	838
Slender Sole	*Lyopsetta exilis*	115	0
Dover Sole	*Microstomus pacificus*	1210	665
English Sole	*Parophrys vetulus*	1876	905
Starry Flounder	*Platichthys stellatus*	118	0
Curlfin Sole	*Pleuronichthys decurrens*	158	0
Sand Sole	*Psettichthys melanostictus*	372	295

2. Queen Charlotte Sound Multispecies Synoptic Bottom Trawl Survey

The Queen Charlotte Sound Multispecies Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between July 7 and August 1, 2017. We assessed a total of 291 blocks (**Table 4**, **Figure 11**). Of the 268 total tows conducted, 240 were successful and 28 were failures due to hang ups or insufficient bottom time. Note that some blocks are only successfully fished following more than one attempt.

The total catch weight of all species was 119,374 kg. The mean catch per tow was 452 kg, averaging 24 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (*Sebastes alutus*), Arrowtooth Flounder (*Atheresthes stomias*), Yellowmouth Rockfish (*Sebastes reedi*), Silvergray Rockfish (*Sebastes brevispinis*), 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 33,198 individual fish of 48 different species (**Table 6**). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 4. 2017 Queen Charlotte Sound Multispecies 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
South 50 to 125 m	0	2	2	36	0	40
South 125 to 200 m	0	10	5	57	0	72
South 200 to 330 m	0	2	3	29	0	34
South 330 to 500 m	0	2	0	8	0	10
North 50 to 125 m	0	7	1	12	0	20
North 125 to 200 m	1	3	5	51	0	60
North 200 to 330 m	0	5	2	40	0	47
North 330 to 500 m	0	1	0	7	0	8
Total	**1**	**32**	**18**	**240**	**0**	**291**

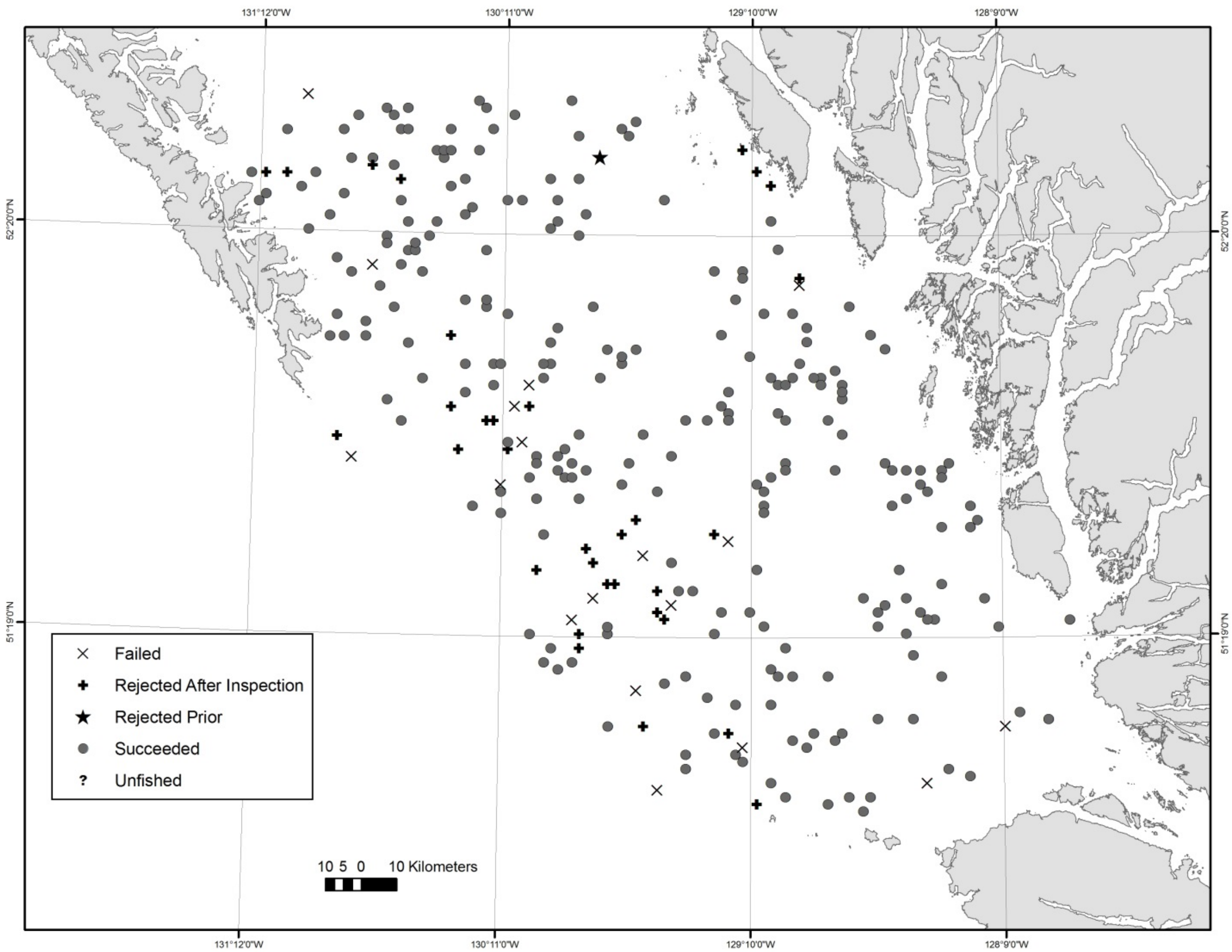

Figure 11. Final status of the allocated blocks for the 2017 Queen Charlotte Sound Multispecies Synoptic Bottom Trawl Survey.

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 2017 Queen Charlotte Sound Multispecies Synoptic Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Pacific Ocean Perch	*Sebastes alutus*	143	24917	17132	0.16
Arrowtooth Flounder	*Atheresthes stomias*	199	16769	12314	0.19
Silvergray Rockfish	*Sebastes brevispinis*	141	9921	6541	0.4
Yellowmouth Rockfish	*Sebastes reedi*	66	9191	6336	0.44
Sablefish	*Anoplopoma fimbria*	169	7168	5342	0.25
Splitnose Rockfish	*Sebastes diploproa*	36	6142	4500	0.38
Pacific Hake	*Merluccius productus*	129	4861	3549	0.17
Rex Sole	*Glyptocephalus zachirus*	190	3053	2260	0.1
Dover Sole	*Microstomus pacificus*	172	2774	2101	0.12
Spotted Ratfish	*Hydrolagus colliei*	220	2688	2700	0.22
Walleye Pollock	*Gadus chalcogrammus*	160	2294	1745	0.29
Sharpchin Rockfish	*Sebastes zacentrus*	77	1993	1455	0.6
North Pacific Spiny Dogfish	*Squalus suckleyi*	131	1856	1398	0.27
Shortspine Thornyhead	*Sebastolobus alascanus*	100	1839	1424	0.12
Flathead Sole	*Hippoglossoides elassodon*	111	1805	1381	0.16
Redbanded Rockfish	*Sebastes babcocki*	111	1562	1106	0.21
Yellowtail Rockfish	*Sebastes flavidus*	58	1529	1084	0.46
Redstripe Rockfish	*Sebastes proriger*	85	1422	1074	0.26
English Sole	*Parophrys vetulus*	112	1260	1041	0.21
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	69	910	612	0.29
Canary Rockfish	*Sebastes pinniger*	66	774	557	0.24
Lingcod	*Ophiodon elongatus*	72	769	586	0.45
Pacific Halibut	*Hippoglossus stenolepis*	73	760	647	0.15
Pacific Cod	*Gadus macrocephalus*	90	751	526	0.17
Petrale Sole	*Eopsetta jordani*	115	674	535	0.22

Table 6. Number of fish sampled for biological data during the 2017 Queen Charlotte Sound Multispecies 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*	3	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	428	207
Aleutian Skate	*Bathyraja aleutica*	1	0
Big Skate	*Beringraja binoculata*	13	0
Sandpaper Skate	*Bathyraja interrupta*	40	0
Longnose Skate	*Raja rhina*	135	0
Spotted Ratfish	*Hydrolagus colliei*	858	0
Eulachon	*Thaleichthys pacificus*	509	0
Pacific Cod	*Gadus macrocephalus*	567	432
Pacific Hake	*Merluccius productus*	1485	506
Walleye Pollock	*Gadus chalcogrammus*	2131	221
Rougheye/Blackspotted Rockfish	*Sebastes aleutianus/melanostictus*	524	524
Pacific Ocean Perch	*Sebastes alutus*	2570	1867
Redbanded Rockfish	*Sebastes babcocki*	821	605
Shortraker Rockfish	*Sebastes borealis*	10	10
Silvergray Rockfish	*Sebastes brevispinis*	1323	776
Darkblotched Rockfish	*Sebastes crameri*	119	0
Splitnose Rockfish	*Sebastes diploproa*	425	300
Greenstriped Rockfish	*Sebastes elongatus*	318	0
Puget Sound Rockfish	*Sebastes emphaeus*	40	36
Widow Rockfish	*Sebastes entomelas*	116	27
Yellowtail Rockfish	*Sebastes flavidus*	380	168
Rosethorn Rockfish	*Sebastes helvomaculatus*	251	0
Shortbelly Rockfish	*Sebastes jordani*	404	0
Quillback Rockfish	*Sebastes maliger*	176	125
Bocaccio	*Sebastes paucispinis*	163	163
Canary Rockfish	*Sebastes pinniger*	338	222
Redstripe Rockfish	*Sebastes proriger*	947	396
Yellowmouth Rockfish	*Sebastes reedi*	574	433
Yelloweye Rockfish	*Sebastes ruberrimus*	54	54
Harlequin Rockfish	*Sebastes variegatus*	54	0
Pygmy Rockfish	*Sebastes wilsoni*	115	0
Sharpchin Rockfish	*Sebastes zacentrus*	747	21
Shortspine Thornyhead	*Sebastolobus alascanus*	1726	249
Longspine Thornyhead	*Sebastolobus altivelis*	52	52
Sablefish	*Anoplopoma fimbria*	2120	954
Lingcod	*Ophiodon elongatus*	248	184
Pacific Sanddab	*Citharichthys sordidus*	814	0
Arrowtooth Flounder	*Atheresthes stomias*	3029	907
Petrale Sole	*Eopsetta jordani*	371	258
Rex Sole	*Glyptocephalus zachirus*	2930	394
Flathead Sole	*Hippoglossoides elassodon*	1433	0
Pacific Halibut	*Hippoglossus stenolepis*	124	0
Southern Rock Sole	*Lepidopsetta bilineata*	490	330
Slender Sole	*Lyopsetta exilis*	892	0
Dover Sole	*Microstomus pacificus*	1331	520
English Sole	*Parophrys vetulus*	926	590
Curlfin Sole	*Pleuronichthys decurrens*	73	0

B. Hard Bottom Longline Hook Surveys

1. Outside (Pacific Halibut Management Association) Longline Survey

The Outside Longline Survey was conducted in the northern region of the outside area. Three commercial hook and line vessels where chartered in August and together completed a total of 197 blocks (**Figure 12**).

The F/V Western Sunset surveyed the southern part of the mainland coast and completed a total of 66 sets from August 9 to 28, 2017. The F/V Borealis 1 surveyed the northern part of the mainland coast and Dixon Entrance and completed a total of 66 sets from August 2 to 20, 2017. The F/V Banker II surveyed the area around Haida Gwaii and completed a total of 65 sets from August 13 to September 4, 2017.

The most common species captured during the 2017 Outside Longline Survey was Pacific Halibut (*Hippoglossus stenolepis*), followed by Quillback Rockfish (*Sebastes maliger*), Yelloweye Rockfish (*Sebastes ruberrimus*), and North Pacific Spiny Dogfish (*Squalus suckleyi*) (**Table 7**). **Table 8** provides an annual summary of the total catch of in the northern region.

During the Outside 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 9** provides an annual summary by species of the number of fish that were sampled for biological data during the Outside Longline Survey in the northern region. A total of 4692 individual fish were sampled for biological data in 2017.

A temperature depth recorder was attached to most of the sets during the 2017 Outside Longline Survey.

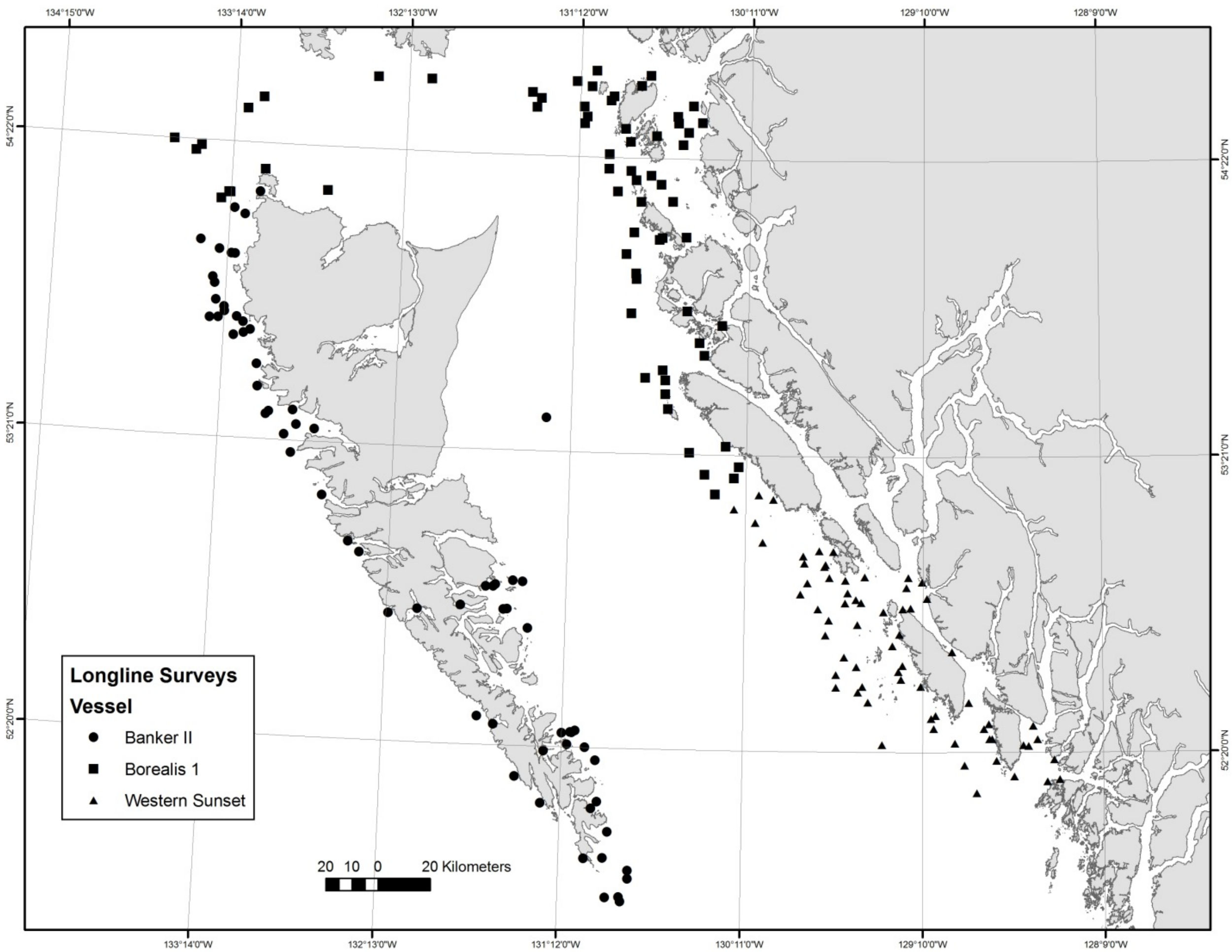

Figure 12. Longline set locations of the 2107 Outside Hard Bottom Longline Hook Survey.

Table 7. 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 2017 Outside Hard Bottom Longline Hook Survey.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)
Pacific Halibut	*Hippoglossus stenolepis*	190	3750	17.30
Quillback Rockfish	*Sebastes maliger*	121	3143	14.50
Yelloweye Rockfish	*Sebastes ruberrimus*	136	2917	13.46
North Pacific Spiny Dogfish	*Squalus suckleyi*	132	2697	12.44
Spotted Ratfish	*Hydrolagus colliei*	151	1794	8.28
Sablefish	*Anoplopoma fimbria*	84	1317	6.08
Pacific Cod	*Gadus macrocephalus*	82	961	4.43
Arrowtooth Flounder	*Atheresthes stomias*	67	816	3.76
Silvergray Rockfish	*Sebastes brevispinis*	89	747	3.45
Longnose Skate	*Raja rhina*	127	605	2.79
Redbanded Rockfish	*Sebastes babcocki*	39	526	2.43
Canary Rockfish	*Sebastes pinniger*	67	519	2.39
Lingcod	*Ophiodon elongatus*	115	501	2.31
Copper Rockfish	*Sebastes caurinus*	29	218	1.01
China Rockfish	*Sebastes nebulosus*	26	198	0.91
Big Skate	*Beringraja binoculata*	52	127	0.59
Rosethorn Rockfish	*Sebastes helvomaculatus*	44	115	0.53
Walleye Pollock	*Gadus chalcogrammus*	31	113	0.52
Petrale Sole	*Eopsetta jordani*	26	67	0.31
Southern Rock Sole	*Lepidopsetta bilineata*	27	67	0.31
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	12	66	0.30
Tiger Rockfish	*Sebastes nigrocinctus*	24	52	0.24
Yellowtail Rockfish	*Sebastes flavidus*	21	51	0.24
Sandpaper Skate	*Bathyraja interrupta*	21	49	0.23
Shortspine Thornyhead	*Sebastolobus alascanus*	10	39	0.18

Table 8. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the Outside Hard Bottom Longline Hook Survey northern region.

Species	2006	2008	2010	2012	2015	2017
Pacific Halibut	5370	3922	3095	4367	4430	3750
Yelloweye Rockfish	3706	3957	3676	4217	4834	2917
North Pacific Spiny Dogfish	8114	2340	3414	2686	1071	2697
Quillback Rockfish	2106	2324	2532	3032	3064	3143
Spotted Ratfish	1134	1379	1154	1665	1577	1794
Pacific Cod	1346	1241	1237	1309	1648	961
Arrowtooth Flounder	1343	1665	1085	1101	893	816
Silvergray Rockfish	1159	1073	750	1141	635	747
Sablefish	1290	540	700	639	547	1317
Redbanded Rockfish	1018	726	534	1034	563	526
Lingcod	1010	1056	549	711	483	501
Longnose Skate	781	798	603	710	649	605
Canary Rockfish	750	712	554	945	566	519
Copper Rockfish	193	166	170	191	151	218
China Rockfish	70	191	204	211	168	198
Rosethorn Rockfish	120	169	143	270	135	115
Big Skate	184	85	90	149	160	127
Shortspine Thornyhead	135	188	62	54	55	39
Walleye Pollock	79	69	12	38	63	113
Tiger Rockfish	31	53	64	94	60	52
Rougheye/Blackspotted Rockfish Complex	55	45	27	61	19	66
Greenstriped Rockfish	38	55	47	68	33	25
Yellowtail Rockfish	43	28	18	95	27	51
Sandpaper Skate	82	50	7	27	46	49
Southern Rock Sole	23	16	8	20	75	67

Table 9. Annual summary of the number of fish sampled for biological data during the Outside Hard Bottom Longline Hook Survey in the northern region.

Species	2006	2008	2010	2012	2015	2017
Yelloweye Rockfish	2857	2746	2472	2597	2129	2129
Quillback Rockfish	1738	2013	2112	2474	1922	1687
Redbanded Rockfish	374	364	417	764	344	363
Canary Rockfish	135	178	176	569	288	0
Silvergray Rockfish	144	182	151	624	155	0
Copper Rockfish	135	139	148	188	142	210
China Rockfish	39	153	97	167	140	187
Rosethorn Rockfish	27	47	73	108	76	0
Tiger Rockfish	28	52	44	67	58	40
Shortspine Thornyhead	108	44	55	26	8	0
Rougheye/Blackspotted Rockfish Complex	44	28	22	58	20	51
Yellowtail Rockfish	13	8	8	62	13	0
Greenstriped Rockfish	5	7	18	50	18	0
Vermilion Rockfish	2	7	16	15	19	9
Pacific Cod	57	0	0	0	0	0
North Pacific Spiny Dogfish	0	0	0	52	0	0
Black Rockfish	2	5	11	1	16	16
Bocaccio	9	1	0	16	9	0
Blackspotted Rockfish	0	24	0	0	0	0
Yellowmouth Rockfish	0	3	0	19	0	0
Blue Shark	0	0	0	0	18	0
Dusky Rockfish	0	0	0	18	0	0
Darkblotched Rockfish	0	0	0	0	5	0
Pacific Ocean Perch	0	0	1	3	0	0
Redstripe Rockfish	0	0	0	2	0	0
Shortraker Rockfish	2	0	0	0	0	0
Sharpchin Rockfish	0	1	0	0	0	0
Kelp Greenling	1	0	0	0	0	0
Deacon Rockfish	0	0	0	1	0	0

2. Inside (DFO) Hard Bottom Longline Hook

The Inside Hard Bottom Longline Hook Survey was not completed in 2017 due to crewing limitations.

3. Sablefish Research and Assessment Survey

The 2017 Sablefish Research and Assessment Survey was conducted on the Pacific Viking from October 6 to November 21, 2017. A total of 109 sets were completed (**Figure 13**) including 89 Randomized Tagging Program sets (**Table 10**) and 20 Inlets Program sets (**Table 11**).

The total catch of the survey was 100,415 kg (**Table 12**) and the average catch per set was 921 kg. The most abundant fish species encountered by weight were Sablefish (*Anoplopoma fimbria*), followed by Pacific Halibut (*Hippoglossus stenolepis*), Arrowtooth Flounder (*Atheresthes stomias*), and Lingcod (*Ophiodon elongatus*). An annual summary of catch for common species are shown for the Randomized Tagging Program in **Table 13** and in **Table 14** for the Inlet Program. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 21,042 individual fish of 6 different species (**Table 15**).

Table 10. Summary of sets made during the 2017 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	3	15
S5 (North West Coast Haida Gwaii or NWCHG)	6	7	5	18
Total	**32**	**34**	**23**	**89**

Table 11. Summary of sets made during the 2017 Sablefish Inlets Program.

Location	**Number of sets**
Dean/Burke Channel	5
Finlayson Channel	5
Gil Island	5
Portland Inlet	5

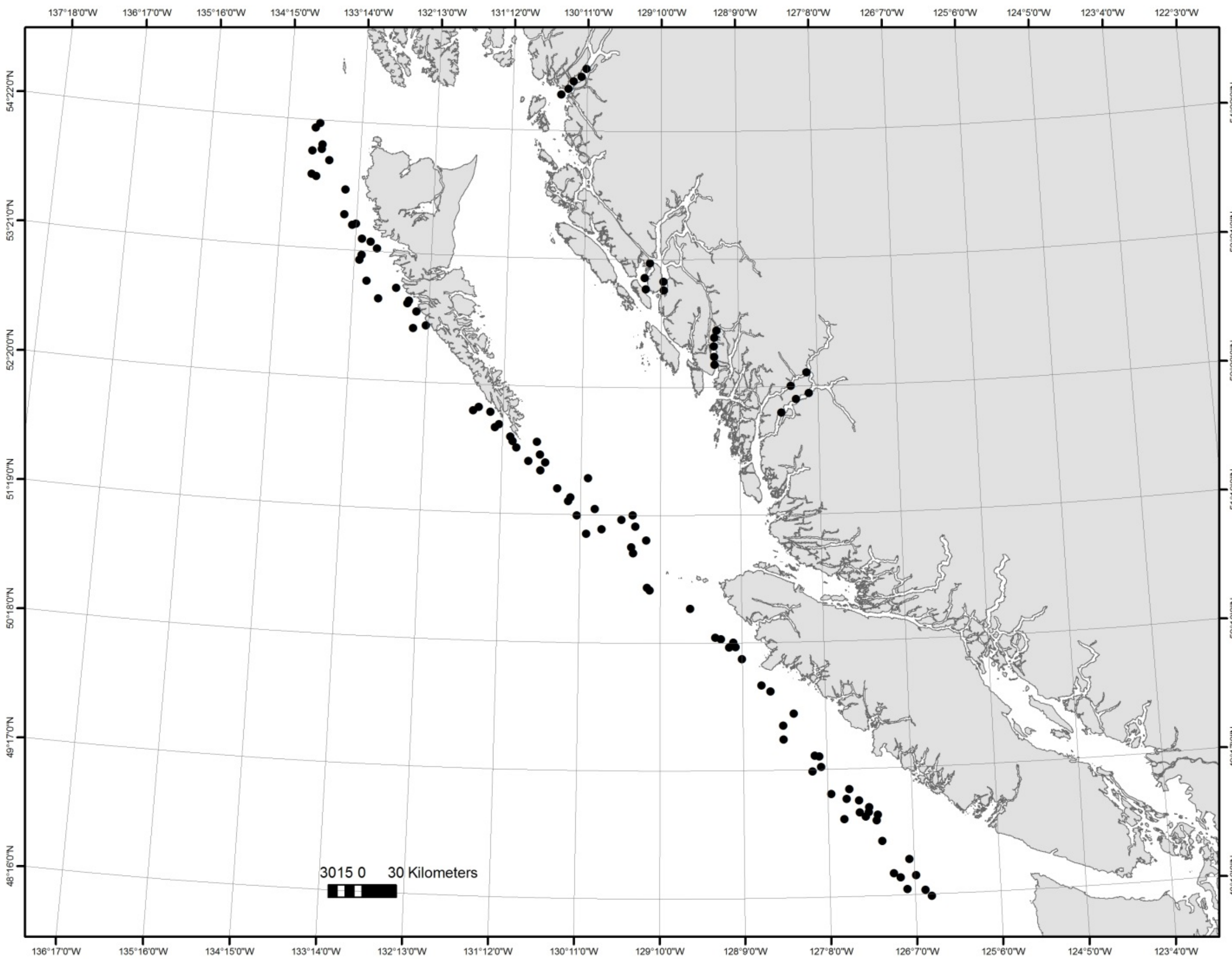

Figure 13. Set locations of the 2017 Sablefish Research and Assessment Survey.

Table 12. Total catch for the top 35 species (by weight) captured during the 2017 Sablefish Research and Assessment Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Sablefish	*Anoplopoma fimbria*	44714	93549
Pacific Halibut	*Hippoglossus stenolepis*	255	2006
Arrowtooth Flounder	*Atheresthes stomias*	700	1402
Lingcod	*Ophiodon elongatus*	107	1054
North Pacific Spiny Dogfish	*Squalus suckleyi*	159	499
Redbanded Rockfish	*Sebastes babcocki*	287	478
Rougheye/ Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	258	446
Pacific Grenadier	*Coryphaenoides acrolepis*	276	284
Giant Grenadier	*Albatrossia pectoralis*	67	267
Shortraker Rockfish	*Sebastes borealis*	26	98
Grooved Tanner Crab	*Chionoecetes tanneri*	243	93
Shortspine Thornyhead	*Sebastolobus alascanus*	58	80
Yelloweye Rockfish	*Sebastes ruberrimus*	22	67
Dover Sole	*Microstomus pacificus*	12	14
Fragile Urchin	*Allocentrotus fragilis*	15	9
	Lithodes couesi	16	7
Pacific Flatnose	*Antimora microlepis*	12	7
Yellowmouth Rockfish	*Sebastes reedi*	5	6
Pacific Cod	*Gadus macrocephalus*	2	6
	Primnoidae	1	5
Pink Snailfish	*Paraliparis rosaceus*	7	4
Rosethorn Rockfish	*Sebastes helvomaculatus*	7	3
Brown Box Crab	*Lopholithodes foraminatus*	3	2
Petrale Sole	*Eopsetta jordani*	1	2
	Octopodidae	1	2
Rockfishes	*Sebastes*	1	1
Longspine Thornyhead	*Sebastolobus altivelis*	7	1
Canary Rockfish	*Sebastes pinniger*	1	1
	Paralomis multispina	2	1
Walleye Pollock	*Gadus chalcogrammus*	1	0
	Rathbunaster californicus	2	0
East Pacific Red Octopus	*Octopus rubescens*	1	0
Spotted Ratfish	*Hydrolagus colliei*	1	0
	Paragorgia	1	0
	Neptuneidae	16	0

Table 13. 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	2017
Sablefish	22055	16348	17730	24105	18833	20326	15529	17375	22568	16845	18095	14266	25428	18073	36604
Arrowtooth Flounder	352	665	598	763	1655	1163	1787	553	1037	921	414	864	610	427	686
Pacific Grenadier	338	644	399	313	880	608	829	676	742	715	254	534	686	627	276
North Pacific Spiny Dogfish	800	532	465	317	437	162	565	414	868	966	386	287	365	699	158
Rougheye/Blackspotted Rockfish Complex	187	398	166	355	558	513	418	406	266	941	223	488	320	386	257
Pacific Halibut	76	71	114	163	185	125	224	172	256	342	99	447	444	283	165
Redbanded Rockfish	111	101	113	93	154	257	150	131	244	208	127	241	295	217	287
Giant Grenadier	29	132	97	67	162	146	179	118	105	195	80	87	206	72	67
Lingcod	89	76	128	108	201	109	93	97	165	71	88	92	121	154	106
Yelloweye Rockfish	18	41	33	22	71	58	60	21	106	34	13	17	81	97	22

Table 14. 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	2017
Sablefish	9964	9933	7066	5062	3453	2498	4339	7507	11034	6213	3271	3341	2708	5050	8110
Pacific Halibut	39	63	72	104	111	99	78	109	108	113	88	265	333	243	90
Arrowtooth Flounder	10	14	23	46	101	108	49	25	11	20	11	49	30	24	14
North Pacific Spiny Dogfish	0	6	6	6	8	1	2	15	18	12	4	5	44	14	1
Dover Sole	1	0	4	4	4	23	1	0	0	1	2	5	1	1	2
Walleye Pollock	2	0	7	1	6	3	3	3	3	4	1	4	2	2	1
Pacific Sleeper Shark	1	6	1	5	5	4	2	0	1	0	0	2	0	2	0
Shortraker Rockfish	0	0	0	4	4	5	4	1	3	2	0	0	3	0	0
Pacific Cod	0	0	0	0	0	8	1	5	0	1	1	2	1	0	1
Rougheye/Blackspotted Rockfish Complex	0	2	0	1	2	1	1	1	0	2	0	2	0	1	1

Table 15. Number of fish sampled for biological data during the 2017 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
Pacific Halibut	*Hippoglossus stenolepis*	0	248	0
Redbanded Rockfish	*Sebastes babcocki*	0	29	0
Rougheye/ Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	0	184	184
Sablefish	*Anoplopoma fimbria*	15631	20563	4693
Shortraker Rockfish	*Sebastes borealis*	0	26	26
Yelloweye Rockfish	*Sebastes ruberrimus*	0	21	21

C. Multispecies Small-mesh Bottom Trawl Survey

The 2017 survey was conducted onboard the F/V Nordic Pearl and ran from May 3 to May 18. A total of 125 tows were completed, of which 119 were usable (**Figure 14**). Tows were determined to be unusable if there was insufficient bottom contact time or if the gear was damaged. The total catch weight of all species was 50,328 kg. The mean catch per tow was 419 kg, averaging 34 different species of fish and invertebrates in each. Over all tows over the entire survey, the most abundant fish species encountered were Sablefish (*Anoplopoma fimbria*), Rex Sole (*Glyptocephalus zachirus*), Flathead Sole (*Hippoglossoides elassodon*), Pacific Hake (*Merluccius productus*), and Dover Sole (*Microstomus pacificus*). The number of tows where the species was captured, total catch weight from successful tows, estimated biomass, and relative survey error for the top 25 fish species by weight are shown in **Table 16** for the West Coast Vancouver Island 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 11,782 individual fish from 20 different groundfish species (**Table 17**). 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*).

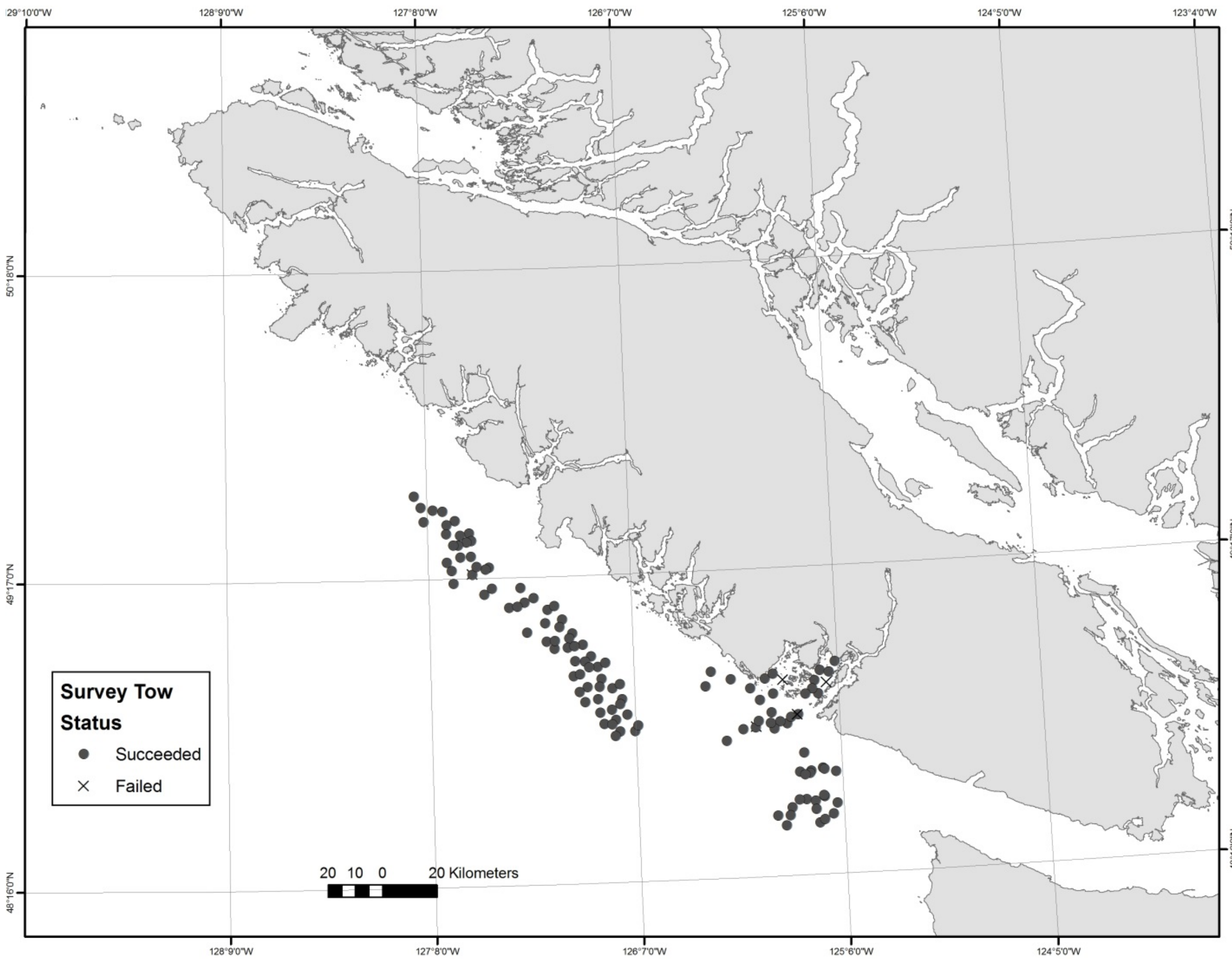

Figure 14. Tow locations of the 2017 Multispecies Small Mesh Bottom Trawl Survey.

Table 16. Number of tows, catch weight from successful tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the West Coast Vancouver Island tow locations of the 2017 Multispecies Small Mesh Bottom Trawl Survey.

Species	Scientific name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Sablefish	*Anoplopoma fimbria*	72	6427	5581	0.65
Rex Sole	*Glyptocephalus zachirus*	71	4193	4349	0.05
Dover Sole	*Microstomus pacificus*	71	3068	3154	0.09
Pacific Hake	*Merluccius productus*	66	2899	3295	0.26
North Pacific Spiny Dogfish	*Squalus suckleyi*	57	2700	3226	0.46
Flathead Sole	*Hippoglossoides elassodon*	70	2569	2758	0.14
Slender Sole	*Lyopsetta exilis*	71	1436	1493	0.06
Pacific Sanddab	*Citharichthys sordidus*	43	956	921	0.17
Arrowtooth Flounder	*Atheresthes stomias*	65	900	926	0.13
Spotted Ratfish	*Hydrolagus colliei*	67	502	514	0.13
Blackbelly Eelpout	*Lycodes pacificus*	65	419	427	0.17
Yellowtail Rockfish	*Sebastes flavidus*	40	412	488	0.3
Pacific Cod	*Gadus macrocephalus*	24	403	461	0.31
Walleye Pollock	*Gadus chalcogrammus*	68	333	344	0.16
English Sole	*Parophrys vetulus*	61	309	319	0.18
Longnose Skate	*Raja rhina*	61	248	254	0.12
Eulachon	*Thaleichthys pacificus*	56	236	221	0.22
Canary Rockfish	*Sebastes pinniger*	11	159	194	0.57
Darkblotched Rockfish	*Sebastes crameri*	49	155	173	0.5
Pacific Halibut	*Hippoglossus stenolepis*	27	151	161	0.19
Greenstriped Rockfish	*Sebastes elongatus*	40	147	204	0.75
Petrale Sole	*Eopsetta jordani*	44	140	160	0.21
Lingcod	*Ophiodon elongatus*	33	83	83	0.27
Redstripe Rockfish	*Sebastes proriger*	11	64	88	0.86
Pacific Herring	*Clupea pallasii*	51	61	67	0.23

Table 17. Number of fish sampled for biological data during the 2017 Multispecies Small Mesh Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
North Pacific Spiny Dogfish	*Squalus suckleyi*	227	0
Big Skate	*Beringraja binoculata*	26	0
Sandpaper Skate	*Bathyraja interrupta*	52	0
Longnose Skate	*Raja rhina*	427	0
American Shad	*Alosa sapidissima*	83	0
Eulachon	*Thaleichthys pacificus*	4610	0
Pacific Cod	*Gadus macrocephalus*	64	0
Walleye Pollock	*Gadus chalcogrammus*	1308	0
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	46	46
Darkblotched Rockfish	*Sebastes crameri*	5	0
Bocaccio	*Sebastes paucispinis*	96	94
Yelloweye Rockfish	*Sebastes ruberrimus*	1	1
Sablefish	*Anoplopoma fimbria*	1602	0
Lingcod	*Ophiodon elongatus*	49	10
Arrowtooth Flounder	*Atheresthes stomias*	174	0
Petrale Sole	*Eopsetta jordani*	202	0
Rex Sole	*Glyptocephalus zachirus*	1353	0
Pacific Halibut	*Hippoglossus stenolepis*	45	0
Dover Sole	*Microstomus pacificus*	1000	0
English Sole	*Parophrys vetulus*	412	0

D. IPHC Fishery-independent Setline Survey

The 2017 IPHC Survey was conducted by two chartered commercial hook and line vessels and together completed a total of 166 sets (**Figure 15**). The Pender Isle completed a total of 43 sets at the IPHC Charlotte stations from July 5 to 20, 2017. The Vanisle completed a total of 123 sets in the IPHC Goose Island, James, and Vancouver stations from May 30 to July 28, 2017.

The most common species captured during the 2017 IPHC survey was North Pacific Spiny Dogfish (*Squalus suckleyi*) followed by Pacific Halibut (*Hippoglossus stenolepis*), Sablefish (*Anoplopoma fimbria*), and Yelloweye Rockfish (*Sebastes ruberrimus*) (Table 18). Table 19 provides an annual summary of the total catch of 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 20 provides an annual summary by species of the number of fish that were sampled for biological data during the IPHC Survey. A total of 1578 individual fish were sampled for biological data in 2017.

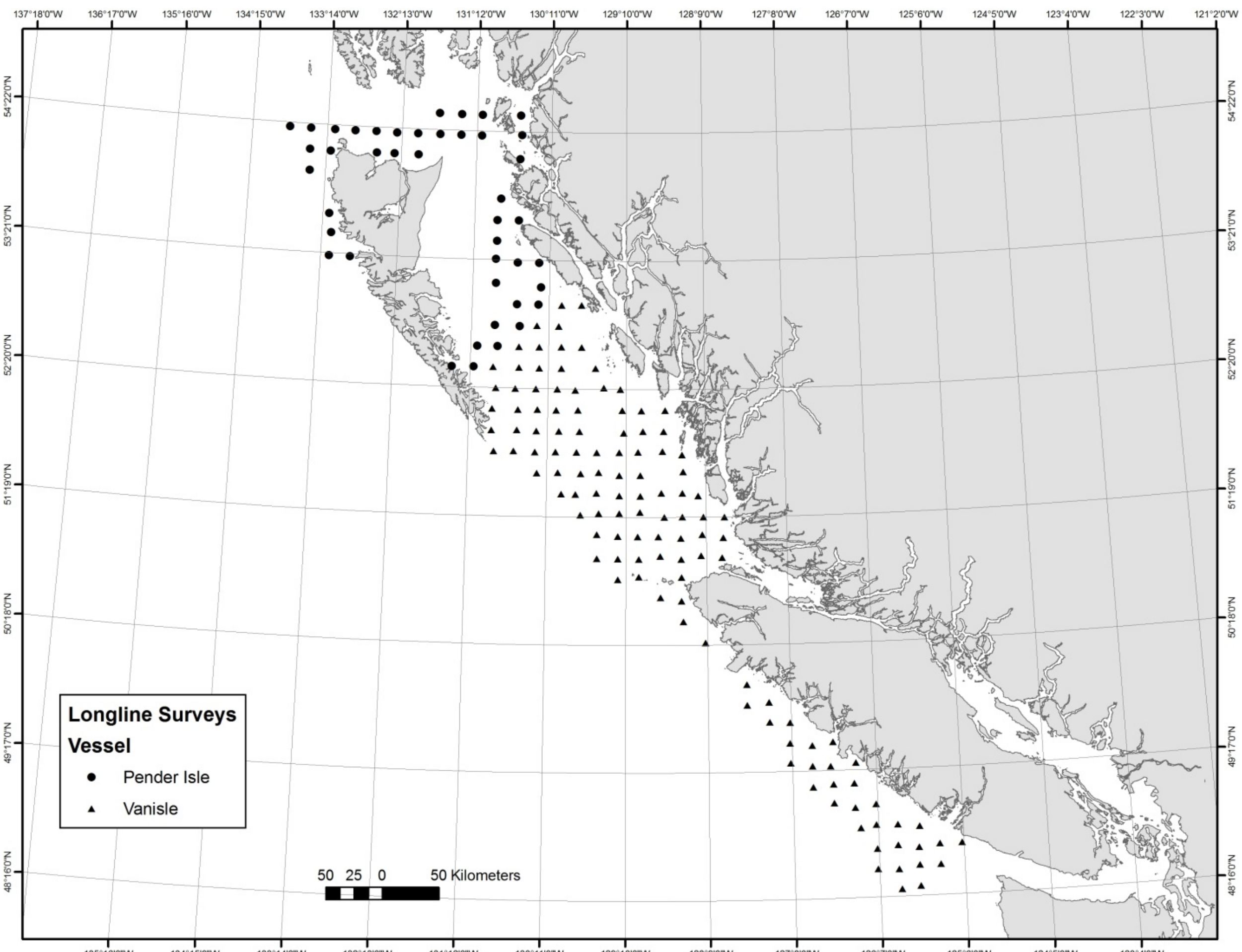

Figure 15. Longline set locations of the 2017 IPHC longline survey.

Table 18. 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 2017 IPHC survey.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)
North Pacific Spiny Dogfish	*Squalus suckleyi*	157	7234	43.29
Pacific Halibut	*Hippoglossus stenolepis*	160	4901	29.33
Sablefish	*Anoplopoma fimbria*	96	1631	9.76
Yelloweye Rockfish	*Sebastes ruberrimus*	52	750	4.49
Redbanded Rockfish	*Sebastes babcocki*	52	497	2.97
Longnose Skate	*Raja rhina*	91	345	2.06
Arrowtooth Flounder	*Atheresthes stomias*	70	316	1.89
Big Skate	*Beringraja binoculata*	65	246	1.47
Quillback Rockfish	*Sebastes maliger*	27	139	0.83
Lingcod	*Ophiodon elongatus*	42	136	0.81
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus complex*	13	81	0.48
Thornyheads	*Sebastolobinae*	11	76	0.45
Shortspine Thornyhead	*Sebastolobus alascanus*	14	64	0.38
Pacific Cod	*Gadus macrocephalus*	28	61	0.37
Tope Shark	*Galeorhinus galeus*	19	42	0.25
Canary Rockfish	*Sebastes pinniger*	16	27	0.16
Silvergray Rockfish	*Sebastes brevispinis*	11	23	0.14
Spotted Ratfish	*Hydrolagus colliei*	19	23	0.14
Shortraker Rockfish	*Sebastes borealis*	2	22	0.13
Blue Shark	*Prionace glauca*	17	21	0.13
Aleutian Skate	*Bathyraja aleutica*	9	18	0.11
Petrale Sole	*Eopsetta jordani*	9	16	0.10
Sandpaper Skate	*Bathyraja interrupta*	4	7	0.04
Pacific Sanddab	*Citharichthys sordidus*	4	4	0.02
Flatfishes	*Pleuronectiformes*	2	3	0.02

Table 19. 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	2017
North Pacific Spiny Dogfish	14166	11814	15114	13984	12952	8854	19112	17562	12847	7985	8938	6617	5563	7234
Pacific Halibut	7101	8570	7075	5567	4912	6901	9308	10784	6487	8480	9642	10268	8135	4901
Sablefish	4169	5610	5033	3000	2020	2360	3342	4077	2648	1933	1716	2444	2404	1631
Arrowtooth Flounder	1381	2135	1671	1060	724	1109	1910	2014	1238	981	910	896	830	316
Redbanded Rockfish	1309	2013	1597	1285	739	1157	1946	1625	973	848	939	597	871	497
Yelloweye Rockfish	1225	1545	1174	1005	693	840	1371	1744	955	877	716	708	926	750
Longnose Skate	926	1147	1011	795	645	781	1243	1385	922	1008	1161	1086	740	345
Lingcod	263	308	201	375	335	411	504	324	237	311	321	324	243	136
Rougheye/Blackspotted Rockfish Complex	287	474	541	216	121	279	346	159	229	156	190	139	178	81
Big Skate	222	256	236	159	102	95	116	221	202	150	201	109	141	246
Quillback Rockfish	156	144	300	198	122	88	182	251	182	114	155	188	139	139
Pacific Cod	80	333	253	162	62	52	98	149	269	117	248	260	113	61
Shortspine Thornyhead	202	190	216	152	59	92	157	171	13	61	52	14	130	64
Silvergray Rockfish	62	68	109	155	65	140	78	87	118	63	70	35	60	23
Spotted Ratfish	58	47	98	100	32	46	36	34	77	52	71	57	43	23
Canary Rockfish	19	25	69	63	21	43	70	35	34	19	36	34	24	27
Shortraker Rockfish	33	27	30	17	44	18	152	17	16	12	42	19	31	22
Unknown Fish	2	0	0	420	0	0	0	1	2	0	0	0	0	0
Thornyheads	0	0	0	0	15	17	0	1	108	30	60	91	3	76
Blue Shark	19	125	12	0	3	1	8	15	0	14	24	57	66	21
Tope Shark	5	30	17	2	2	11	16	25	9	3	18	87	67	42
Petrale Sole	10	27	18	16	14	14	16	19	35	19	25	29	39	16
Bocaccio	19	32	16	37	15	32	24	15	23	14	13	10	8	2
Aleutian Skate	0	0	0	12	16	19	8	19	14	20	34	22	36	18
Pacific Sleeper Shark	8	21	5	7	9	5	9	5	3	2	3	3	5	3

Table 20. 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	2017
Redbanded Rockfish	866	1312	1379	1201	712	1130	1889	1598	971	843	927	582	823	479
Yelloweye Rockfish	838	1240	1065	958	682	832	1349	1727	950	878	711	699	926	729
Sablefish	2216	2917	0	0	0	0	0	0	0	0	0	0	0	0
Rougheye/Blackspotted Rockfish Complex	102	292	525	210	112	277	368	149	230	154	179	131	164	79
Quillback Rockfish	115	133	234	186	119	86	177	246	179	112	150	177	128	136
Silvergray Rockfish	21	24	47	141	60	136	77	87	114	57	67	32	56	22
North Pacific Spiny Dogfish	0	0	0	0	0	0	0	0	485	0	0	0	0	0
Shortspine Thornyhead	0	120	151	136	0	0	0	75	0	0	0	0	0	0
Canary Rockfish	5	19	39	60	15	43	65	33	32	17	35	32	22	26
Shortraker Rockfish	15	10	29	16	44	16	116	19	15	12	40	18	30	18
Bocaccio	4	14	7	33	13	31	24	14	23	14	11	10	8	1
Yellowmouth Rockfish	0	2	2	3	9	6	12	4	5	3	4	5	9	2
China Rockfish	1	5	6	0	8	9	6	1	5	2	2	3	7	2
Tope Shark	0	0	0	0	0	0	0	0	0	0	0	0	0	54
Copper Rockfish	0	5	2	0	0	6	2	4	4	12	0	1	4	2
Greenstriped Rockfish	0	8	2	2	2	2	2	2	5	2	2	1	1	1
Blue Shark	0	0	0	0	0	0	0	0	0	0	0	0	2	24
Blackspotted Rockfish	0	0	0	0	0	0	24	0	0	0	0	0	0	0
Yellowtail Rockfish	0	5	4	4	1	0	0	1	2	0	1	2	0	1
Rosethorn Rockfish	0	0	0	0	1	3	1	1	2	3	4	2	0	1
Vermilion Rockfish	0	0	0	2	0	0	0	0	0	0	1	2	1	0
Tiger Rockfish	0	0	0	1	1	0	0	0	1	0	0	0	1	0
Black Rockfish	0	0	0	2	0	0	0	0	0	0	2	0	0	0
Darkblotched Rockfish	0	0	0	0	2	0	0	0	1	0	0	0	0	0
Sleeper Sharks	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Bluntnose Sixgill Shark	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Redstripe Rockfish	0	1	0	0	0	0	0	0	0	0	0	0	0	0

TSC Agency Reports – IPHC 2018

Contents

I. 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 2017 and early 2018:

Name	Position	Start Date	End Date
Kelly McElligott	Data Transcriber	January 2017	December 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	
Collin Winkowski	Survey Coordinator Human Resources	January 2018	
Anna Simeon	Biological Science Laboratory Technician	March 2018	

* Note that the numbering in the subsequent lines reflects the sequence of position changes starting with this opening. Only the last person is new to IPHC.

II. Surveys

Background

The International Pacific Halibut Commission's (IPHC's) fishery-independent setline survey (FISS or setline survey) provides catch information and biological data on Pacific halibut (*Hippoglossus stenolepis)* that are collected independently of the commercial fishery. These data, which are collected using standardized methods, bait, and gear during the summer of each calendar year, provide an important comparison with data collected from the commercial fishery. The commercial fishery is variable in its gear composition and distribution of fishing effort over time, and presents a broad spatial and temporal sampling of the stock. Pacific halibut biological data collected on the setline survey (e.g. the size, age, and sex composition) 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 setline 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 IPHC has conducted fishery-independent setline surveys in selected areas during most years since 1963 (with a break from 1987 to 1992). Historical information regarding previous setline survey operations has been presented in IPHC Annual Reports and Survey Manuals; IPHC Report of Assessment and Research Activities documents 1993-2017; and IPHC Technical Reports 18 and 58. The majority of the current FISS station design and sampling protocols have been standardized since 1998.

Fishery-independent Setline Survey (FISS) design and procedures

In summary, the 2017 FISS chartered twelve commercial longline vessels (five Canadian and six U.S.) during a combined 74 trips and 780 charter days. All 1,499 setline survey stations planned for the 2017 setline survey season were either scouted or completed. Of these stations, 1,493 (99.6%) were considered successful for stock assessment analysis. A total of 13 special projects were facilitated and completed, and 12,922 otoliths were collected coastwide. Approximately 569,576 pounds (258 t) of Pacific halibut, 51,338 pounds (23 t) of Pacific cod, and 31,674 pounds (14 t) of rockfish were landed from the setline survey stations. Compared to the 2016 setline survey, weight-per-unit-effort increased in IPHC Regulatory Areas 2C, 4A, 4C, and 4D, with decreases in IPHC Regulatory Areas 2A, 2B, 3A, 3B, and 4B. Descriptions of the FISS design and procedures follow.

Design

The IPHC's FISS design encompasses nearshore and offshore waters of the IPHC Convention Area (Figure 1a). The current setline survey station layout has been in place since 1998 (with some additions in 2006 (Bering Sea), and in 2011 (IPHC Regulatory Area 2A)).

The IPHC Regulatory Areas are divided into 32 regions, each requiring between 10 and 46 charter days to survey (Table 1). Setline survey 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 IPHC Regulatory Areas). Figure 1b depicts the FISS station positions, charter region divisions, and IPHC Regulatory Areas surveyed.

The current standard grid (SG) station layout has been in place since 1998, with the addition of stations around the Pribilof Islands and St. Matthew Island beginning in 2006 and twelve stations in the Washington/Oregon charter regions beginning in 2011. Thirteen extra stations (ES) in southeast Alaska and eight rockfish (*Sebastes spp*.) index (RI) stations in the Washington charter region are fished on a different layout than the FISS and are not included in the IPHC stock assessment dataset.

Six skates were set in IPHC Regulatory Area 2A and seven skates in IPHC Regulatory Area 4CDE. IPHC Regulatory Areas 2B, 2C, 4A and 4B had five skates of baited gear set at each setline survey station in all charter regions. Setline survey specifications for gear, setting schedule, and soak time have been consistent since 1998. Setline survey gear consists of fixed-hook, 1,800-foot (549 m) skates with 100 16/0 circle hooks baited with 0.25 to 0.33 pounds (0.11 to 0.15 kg) of chum salmon (*Oncorhynchus keta*) and spaced 18 feet (5.5 m) apart. Gangion length ranges from 24 to 48 inches (61 cm to 122 cm). Each vessel sets one to four stations daily beginning at or after 0500 AM, and soaks the gear at least five hours before hauling. Vessels avoided soaking the gear at night, when possible. Data from gear soaked longer than 24 hours were not used for stock assessment purposes.

Sets were considered ineffective for stock assessment if predetermined limits for lost gear, snarls, depredation, or displacement from station coordinates were exceeded. The fork lengths of all Pacific halibut captured at FISS stations were recorded to the nearest centimeter and all lengths stated hereafter will be fork lengths. Each length was converted to an estimated weight using a standard formula, and these weights were then used to generate the weight per unit effort (WPUE) data. Average WPUE, expressed as net pounds per skate, was calculated by dividing the estimated catch in pounds (net weight) of Pacific halibut equal to or over 32 inches (81.3 cm; O32 Pacific halibut) in length by the number of skates hauled for each station, and averaging these values by area (statistical, charter, or regulatory).

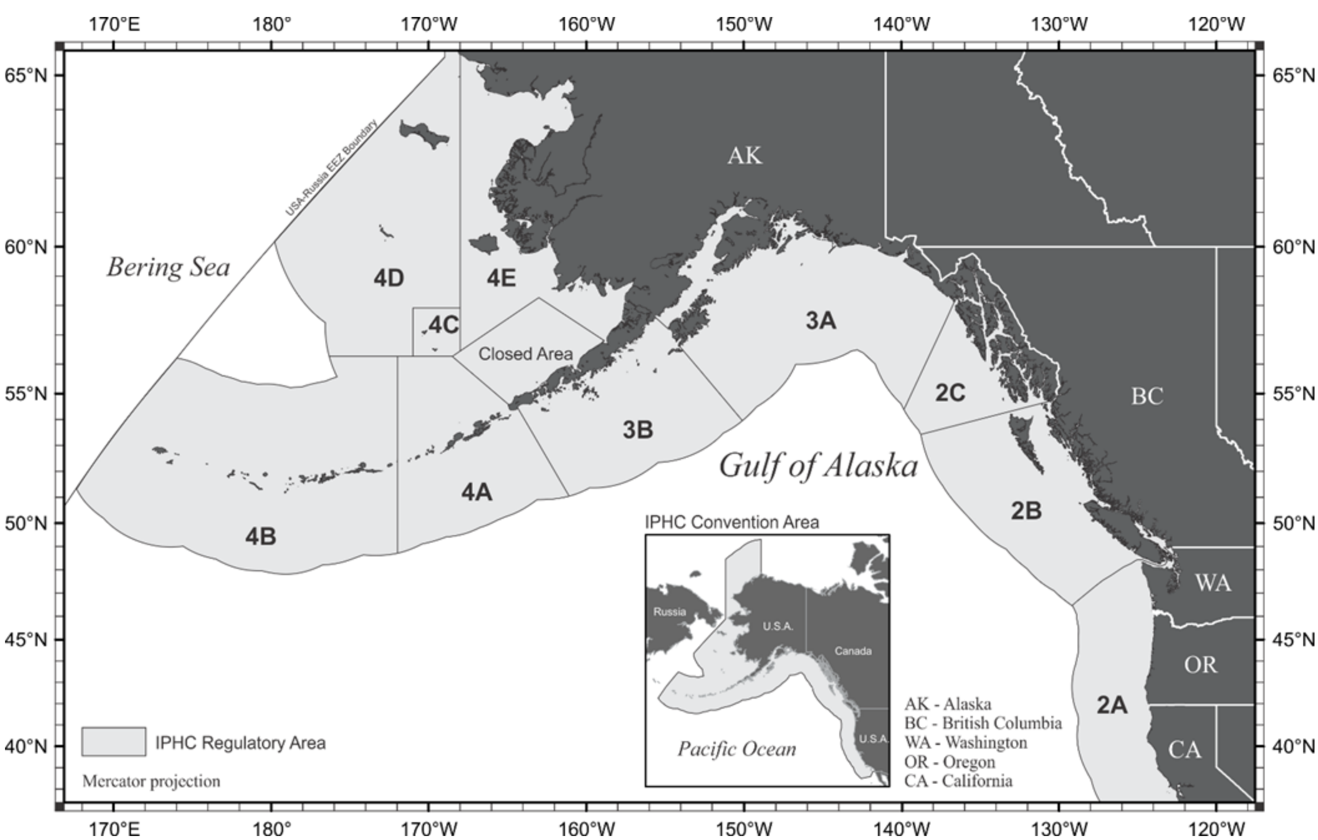

Figure 1a. Map of the IPHC Convention Area and IPHC Regulatory Areas.

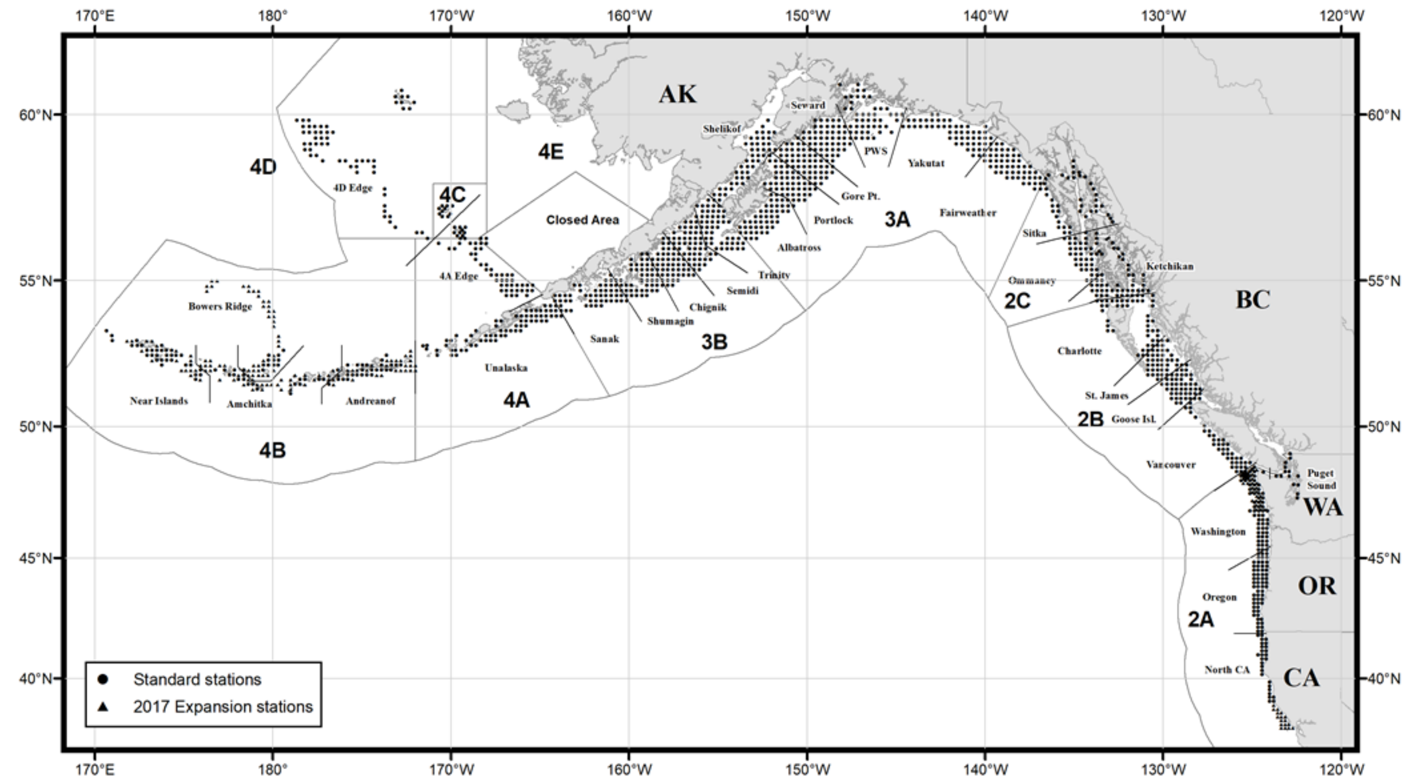

Figure 1b. 2017 IPHC fishery-independent setline survey station positions, charter region divisions, and IPHC Regulatory Areas.

Vessel Operations

Fishing vessels are chosen through a competitive bid process each year where up to 3 regions per vessel are awarded and 10-15 vessels are chosen. In 2017, twelve commercial longline vessels (five Canadian and six U.S.), were chartered by the IPHC for our fishery-independent setline survey operations. During a combined 74 trips and 780 charter days, these vessels fished 32 charter regions, covering habitat from northern California on to the island of Attu in the Aleutian Islands, and north along and including the Bering Sea continental shelf (Table 1).

Fishery-Independent Setline Survey (FISS) Expansion Stations

Since 2014, the IPHC has been sampling expansion setline survey stations in one or two IPHC Regulatory Areas each year (Figure 2). Commercial fishery data and other sources have shown the presence of Pacific halibut down to depths of 732 m (400 fm) and in waters shallower than 37 m (20 fm). Further, most IPHC Regulatory Areas have substantial gaps in station coverage within the standard 37-503 m depth range. The incomplete coverage of Pacific halibut habitat by the setline survey could potentially lead to biased estimates of the weight per unit effort (WPUE) and numbers per unit effort (NPUE) when used in the density indices for stock assessment modelling and for stock distribution estimation. For this reason, the IPHC has been undertaking a sequence of expansions since 2014 (following a 2011 pilot), with setline survey stations added to the standard grid to cover habitat not previously sampled.

In 2017, 145 stations were added to IPHC Regulatory Area 4B, which included depths as shallow as 50 fathoms (91 m) and as deep as 400 fathoms (732 m). IPHC Regulatory Area 2A was fished with the same expansion as in 2014 including an additional 17 stations in the Northern California charter region, an additional densified grid of 26 stations in the Washington charter region, and repeating the 14 stations into Puget Sound (National Marine

Sanctuaries Permits OCNMS-2017-006 and MULTI-2017-011). All 1,499 setline survey stations planned for the 2017 setline survey season were either scouted or completed. Of these stations, 1,493 (99.6%) were considered successful for stock assessment analysis.

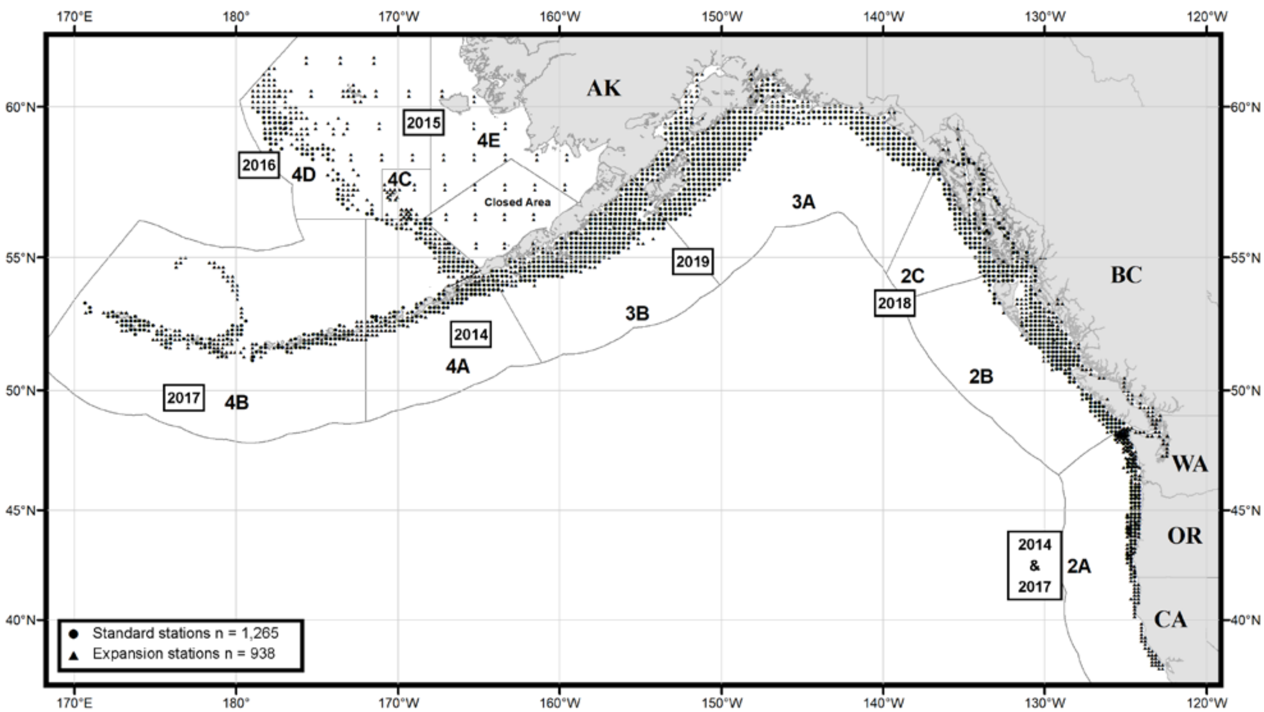

Figure 2. IPHC fishery-independent setline survey (FISS) and expansion stations planned (2014-19).

2017 FISS Expansion in IPHC Regulatory Area 2A

This was the third year of expansion in IPHC Regulatory Area 2A which already had an expansion of the grid in Oregon down to 42° N latitude in 2011 and 2014, including Puget Sound in Washington. Northern California stations were first surveyed in 2013 down to 40° N latitude to investigate anecdotal reports of increasing Pacific halibut catches in the southern range. Northern California stations were again surveyed in the expansion in 2014, fishing as far south as 39° N latitude. In 2017, the expansion went further south to 37°45' N latitude (near San Francisco) and included Puget Sound. In addition, an ad-hoc densified expansion grid off the north Washington coast was surveyed for the first time in 2017 (per the ad-hoc Annual Meeting recommendation, AM093–Rec.03, and detailed in papers IPHC-2017-AM093-06_ADD_1 and 2). A total of 212 stations were surveyed in IPHC Regulatory Area 2A in 2017, of which 108 were expansion stations, including 26 ad-hoc densified grid stations off the north Washington coast (Figure 3 & Table 2). The FISS was conducted under applicable permits, including but not limited to National Marine Sanctuaries Permits OCNMS-2017-006 and MULTI-2017-011.

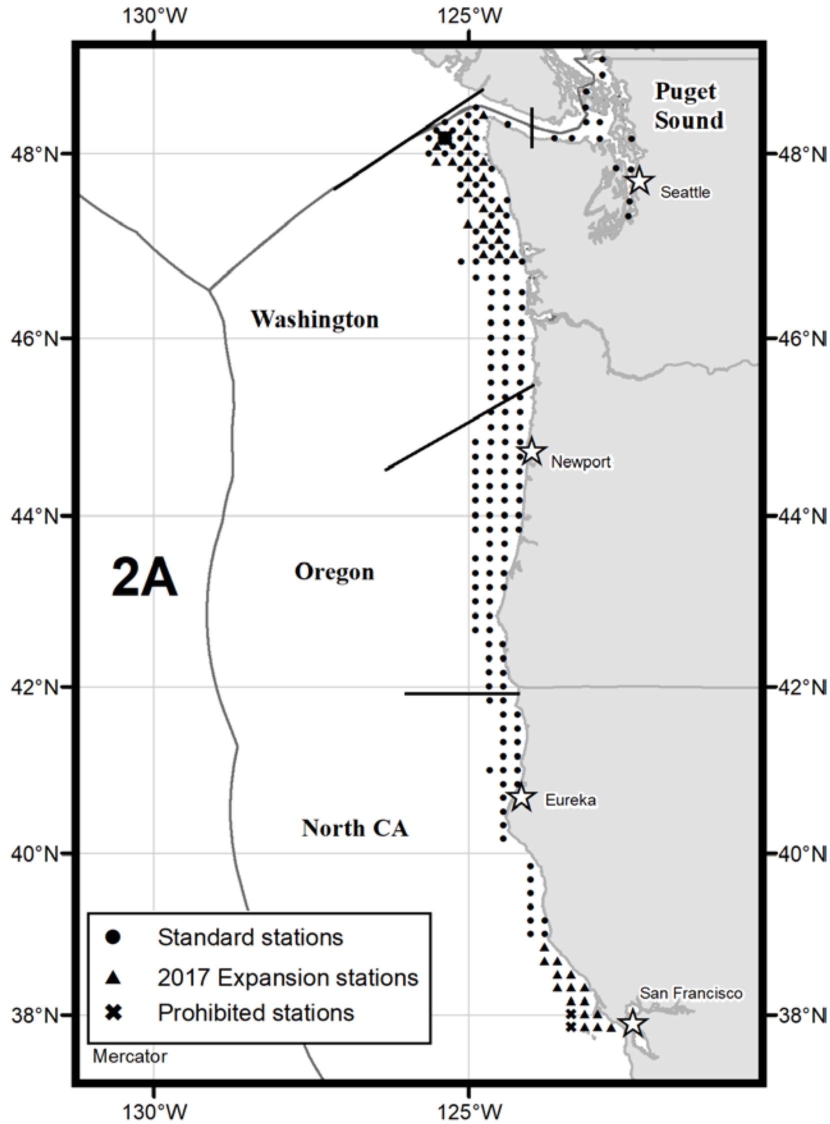

Figure 3. 2017 IPHC fishery-independent setline survey stations in IPHC Regulatory Area 2A with charter regions.

Table 2. IPHC Regulatory Area 2A setline survey charter regions and count by station type.

California	Station count
Expansion -Previously fished	27
New expansion	15*
Oregon	
Expansion	13
Standard grid	47
Washington	
Expansion	13
Densified grid	26
Standard grid	49
Rockfish Index	8

*2 stations were not permitted because of habitat closures

2017 FISS Expansion in International Pacific Halibut Commission Regulatory Area 4B

As a continued part of a multi-year coastwide effort to expand our setline survey coverage and depth profile, an additional 145 stations were added to IPHC Regulatory Area 4B including stations as shallow as 50 fathoms (91 m) and as deep as 400 fathoms (732 m) (Figure 1, Figure 4). To help manage this expansion, the historical Adak and Attu charter regions were divided into four new regions named Amchitka, Andreanof, north and south Bowers Ridge, and Near Islands (Figure 4 & Table 3).

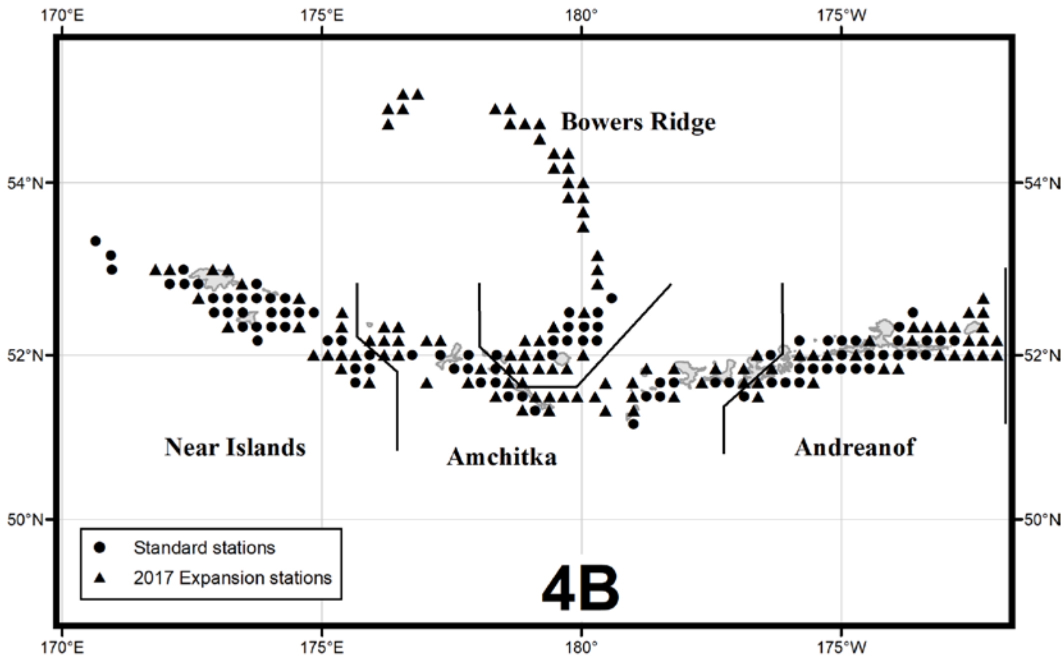

Figure 4. 2017 IPHC fishery-independent setline survey stations in IPHC Regulatory Area 4B with charter regions.

Table 3. IPHC Regulatory Area 4B setline survey charter regions and count by station type.

Andreanof	Station count
Expansion	28
Standard grid	26
Amchitka	
Expansion	31
Standard grid	18
Bowers South	
Expansion	13
Standard grid	12
Bowers North	
Expansion	24
Standard grid	1
Near Islands	
Expansion	17
Standard grid	32

Weight Per Unit Effort

The FISS covers commercial as well as non-commercial fishing grounds, so the average WPUE for all IPHC Regulatory Areas surveyed was below that of the commercial fleet.

Compared to 2017 results, setline survey WPUE increased in IPHC Regulatory Areas 2C (+23%), 4A (+2%), 4C (+28%), and 4D (+95%). WPUE decreased in IPHC Regulatory Areas 2A (-53%), 2B (-10%), 3A (-10%), 3B (-20%) and 4B (-7%) (Figure 5). Since 2011, IPHC Regulatory Area 2C's WPUE has exceeded IPHC Regulatory Area 3A's, and has been the highest WPUE of all the regions.

Setline survey WPUE increased by 17% in the Oregon charter region, but decreased by 70% in the Washington region. WPUE increased in two out of the four regions of IPHC Regulatory Area 2B, with Charlotte and St. James increasing by 4% and 7%, respectively. In the Vancouver (-39%) and Goose Island (-34%) charter regions, WPUE decreased. WPUE in IPHC Regulatory Area 2C increased in the Sitka (+18%), Ommaney (+12%), and Ketchikan (+44%) charter regions.

In IPHC Regulatory Area 3A, WPUE increased in the PWS (+2%), Shelikof (+74%), and Portlock (+21%) charter regions, while decreases were observed in Fairweather (-27%), Yakutat (-16%), Seward (-14%), Gore Point (-43%), and Albatross (-16%). IPHC Regulatory Area 3B WPUE decreased in Chignik (-19%), Sanak (-36%), Semidi (-23), Shumagin (-2%), and Trinity (-16%) regions when compared to last year. All four charter regions along the Aleutian chain increased in 2017 as compared to last year, with Attu region's WPUE increasing by 13%, and Adak and Unalaska up 3%. On the Bering Sea continental shelf, WPUE for St. Paul Island decreased by 2% and stations around St. George increased by 30%. The IPHC Regulatory Area 4A Edge and 4D Edge region's WPUE increased by 8% and 98%, respectively.

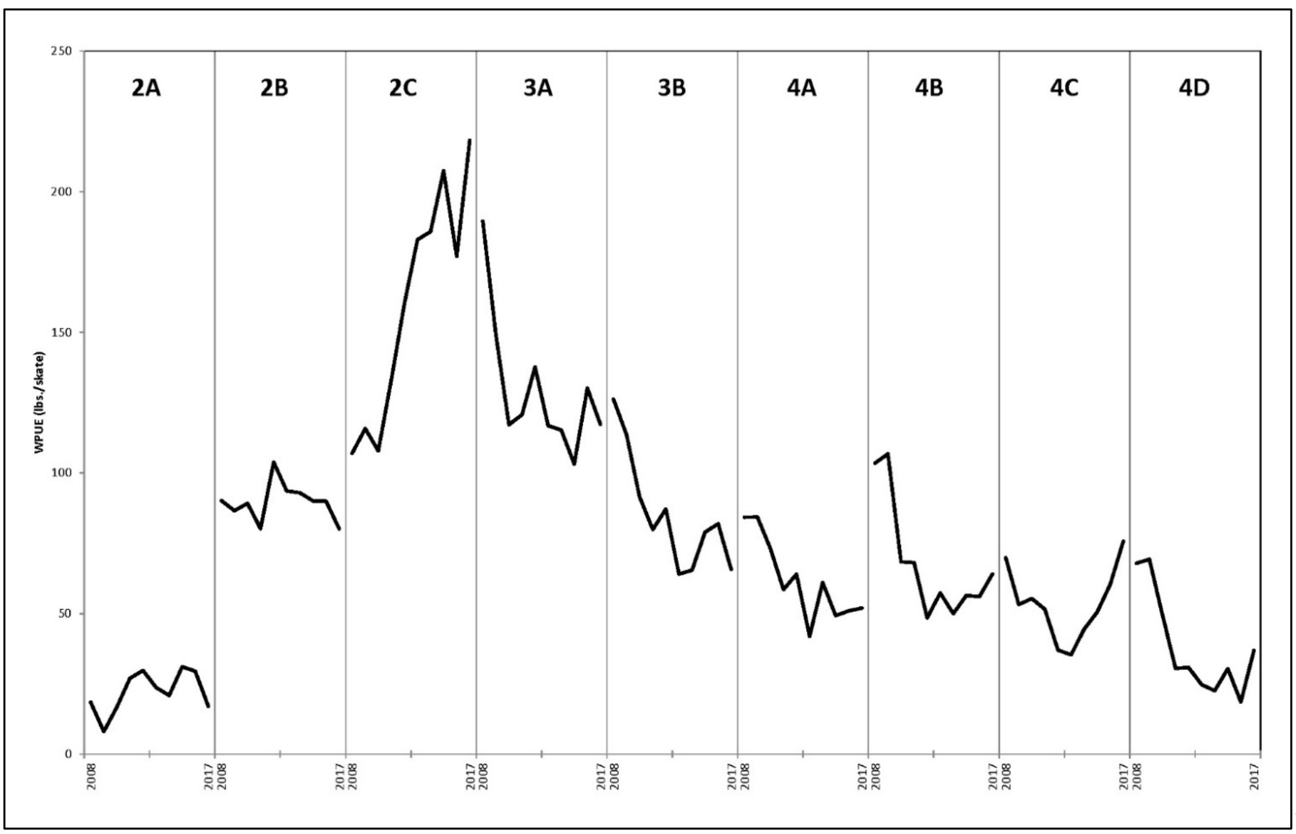

Figure 5. Average O32 WPUE (lbs/skate) of Pacific halibut by IPHC Regulatory Area from all effective standard grid and expansion stations occupied on 2008-2017 setline surveys.

Numbers per unit effort

Trends in the coastwide numbers per unit effort (NPUE) since 2008 are shown in Figure 6 for both O32 and U32 Pacific halibut. There was a 31% decrease in the relative numbers of U32 caught and a 6% decrease in catch rates of O32 length Pacific halibut when compared to 2016 (Figure. 6). In 2017, there were 16% more U32 Pacific halibut captured than O32 Pacific halibut, which is a 9% decrease in difference from 2016.

Some interesting trends can be noted when NPUE is observed by IPHC Regulatory Area (Figure 7). A larger NPUE of O32 as compared to U32 Pacific halibut was seen in all IPHC Regulatory Areas except for 3B and 4A. In 2017, IPHC Regulatory Area 2C showed an increase in O32 Pacific halibut with a decrease in U32 Pacific halibut average NPUE. IPHC Regulatory Area 2B had slight decreases in both O32 and U32 average NPUE. IPHC Regulatory Area 4A had a slight increase in both O32 and U32 Pacific halibut rate of capture. IPHC Regulatory Area 3B continues to have the largest gap between O32 and U32 Pacific halibut, with a difference of 51% between the two groups.

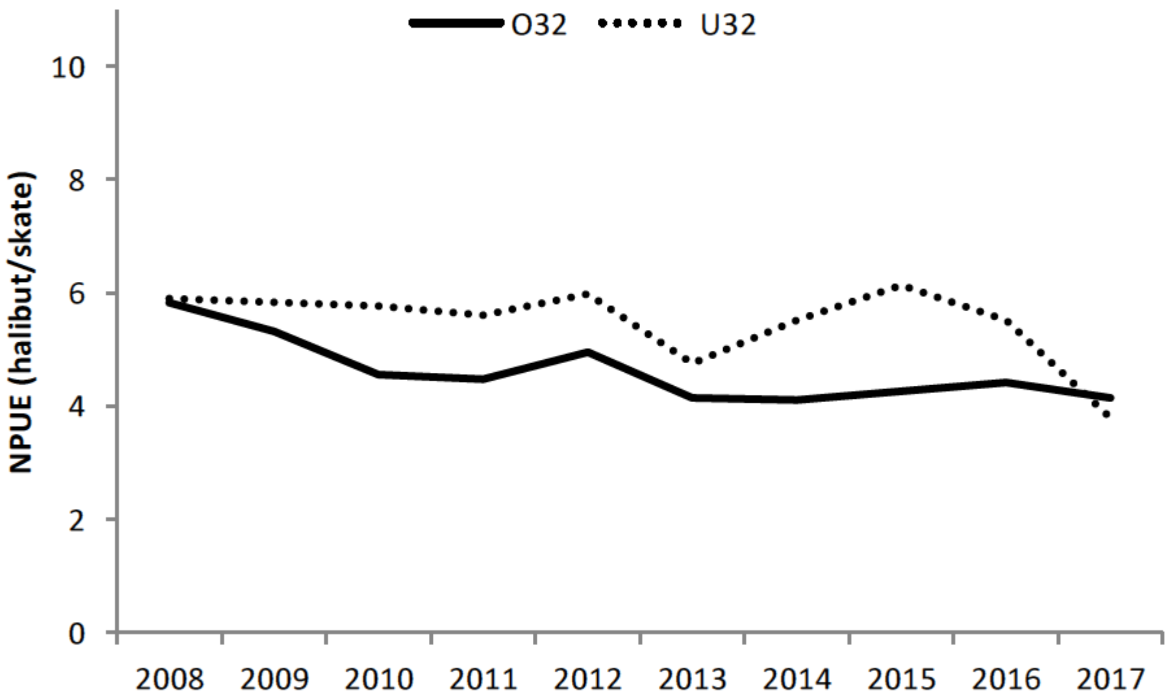

Figure 6. Setline survey NPUE (Pacific halibut/skate) coastwide from 2008-2017. Includes data from SG and ES effective stations.

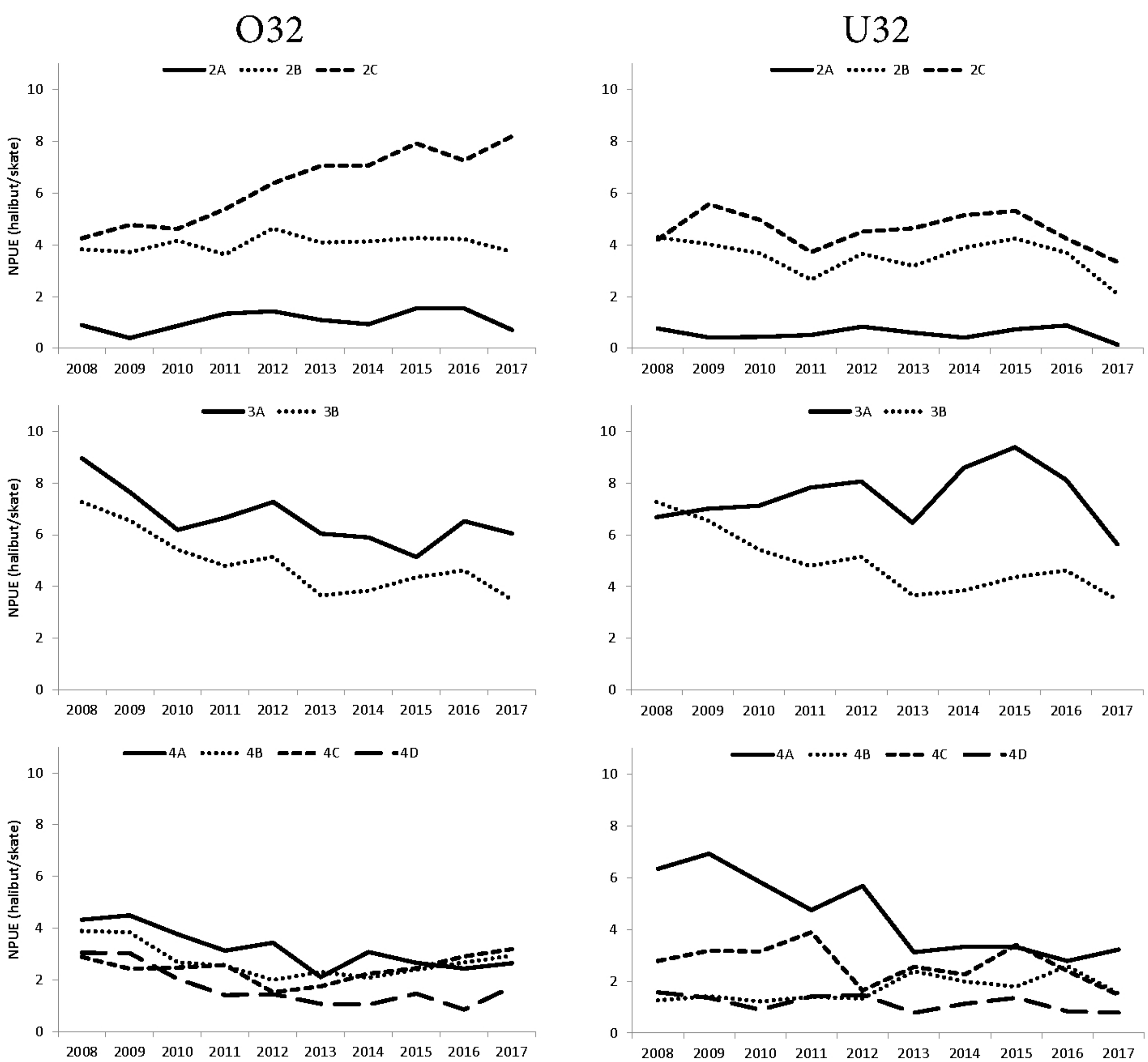

Figure 7. Setline survey NPUE (Pacific halibut/skate) by IPHC Regulatory Area from 2008 to 2017. Individual charter regions are plotted within each IPHC Regulatory Area panel, as indicated. O32 Pacific halibut is on the left, U32 on the right. Includes data from effective standard grid and expansion stations.

Length distribution

Slightly less than 47% of Pacific halibut caught on the setline survey were smaller than the current commercial legal size limit (U32 Pacific halibut), with a median length of 79 cm coastwide (Figure 8). In 2017, the median lengths of Pacific halibut captured increased in all International Pacific Halibut Commission Regulatory (IPHC) Areas except 4A (Figure 8). IPHC Regulatory Areas 3A, 3B, and 4A had median lengths below the legal-size limit. In 2017, the largest median length was in IPHC Regulatory Area 2A (97 cm). The length frequency distribution of Pacific halibut from catches in the 2017 FISS, by IPHC Regulatory Area (Figure 9).

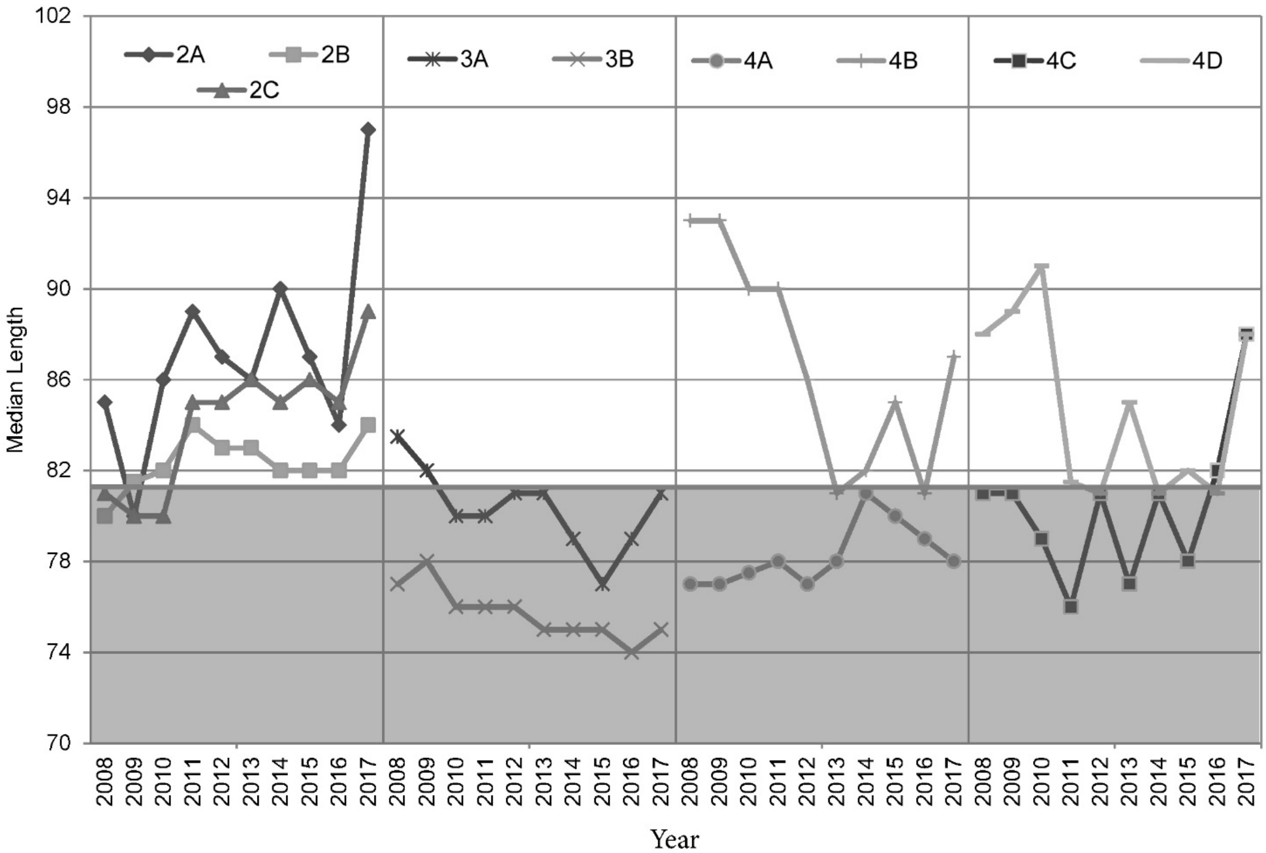

Figure 8. Median length of Pacific halibut caught on setline survey, by IPHC Regulatory Area, from 2008 to 2017.The shaded area shows length below the current commercially-legal size limit. Includes data from effective standard grid and expansion stations.

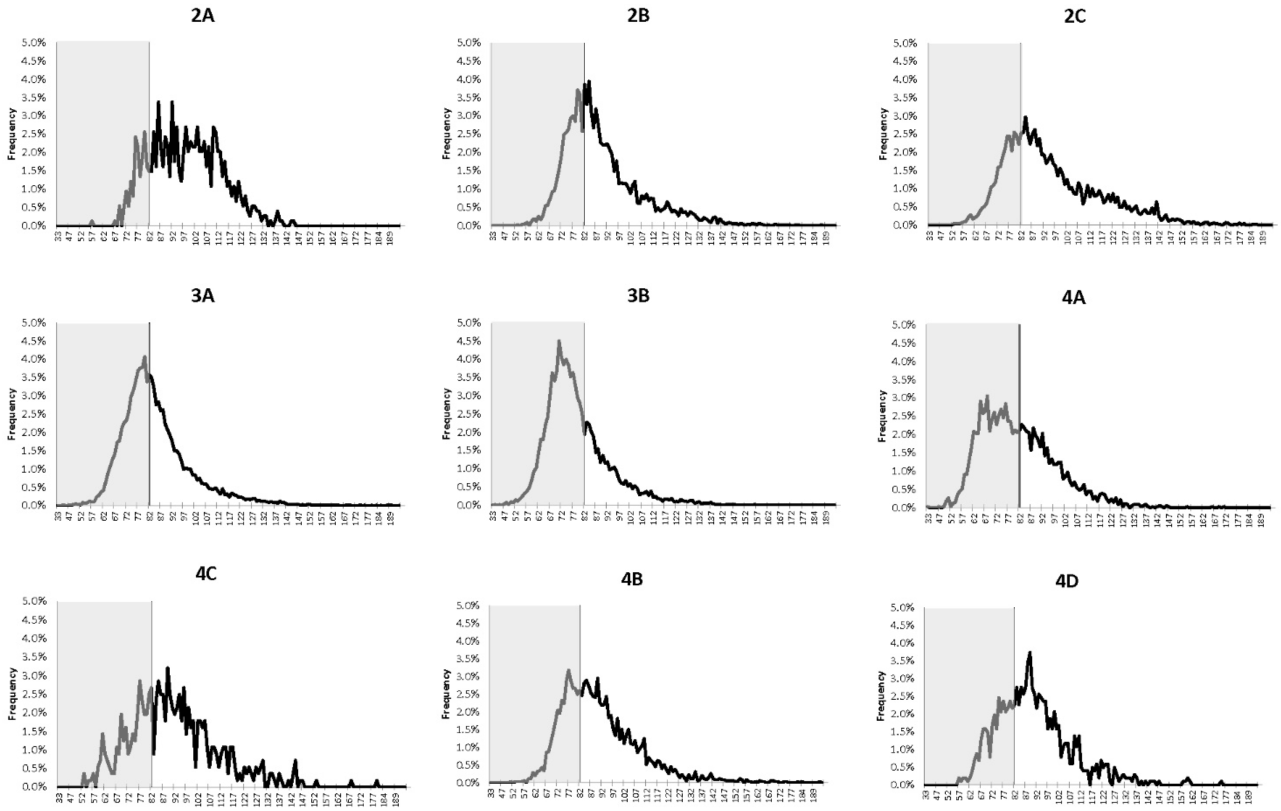

Figure 9. The length (cm) frequency distribution of Pacific halibut, by Regulatory Area, from catches in the 2017 setline survey. Shaded areas denote smaller than current legal commercial size limit. Catch from rockfish index stations not included.

Sex composition

The sex composition for Pacific halibut captured and sampled for otolith collection has shown considerable variation among areas, ranging from 41% to 87% females (Figure 10). IPHC Regulatory Area 4B had the lowest percentage of females in the catch, and has been consistently below 50% since 1998. IPHC Regulatory Area 4C currently has the highest percentage of females, observing the first decrease in the past couple of years. Most female Pacific halibut caught during the setline survey period (i.e., summer months) were in the ripening stage and expected to spawn in the upcoming season.

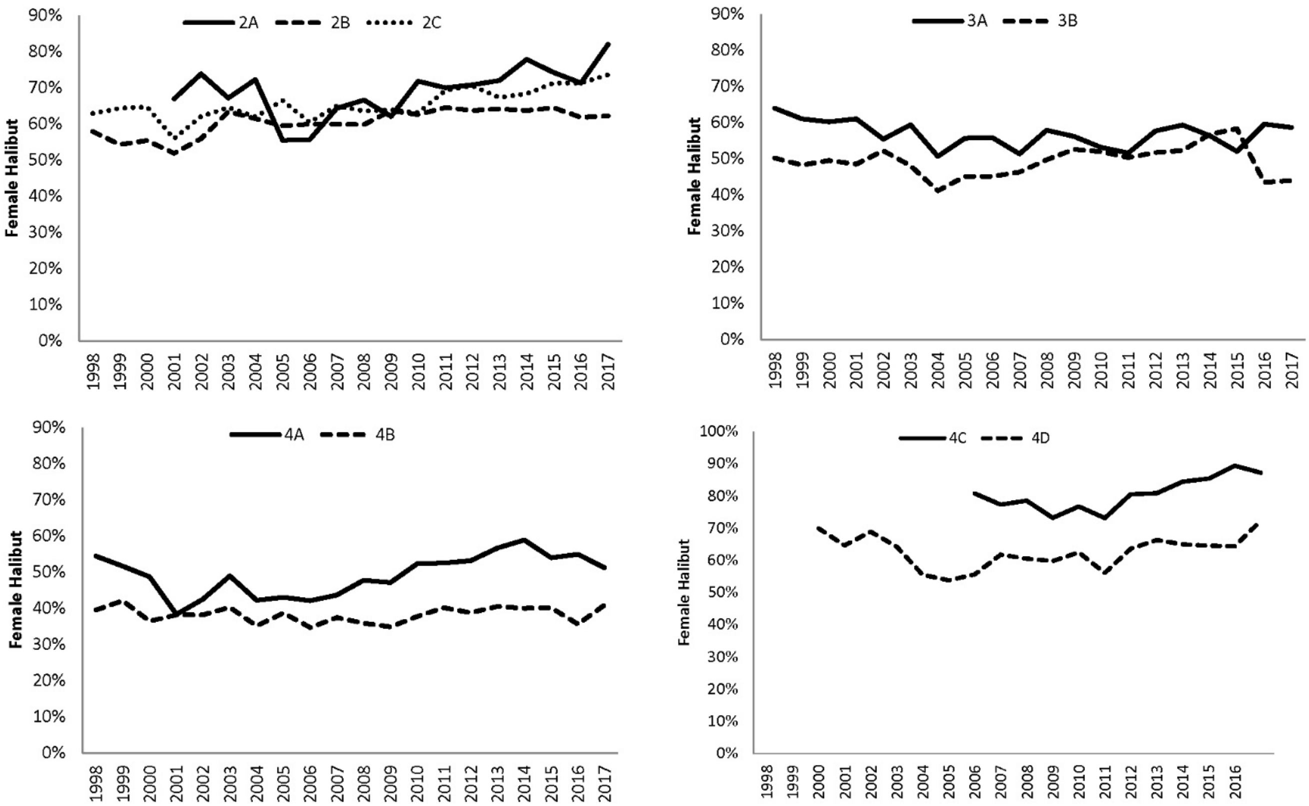

Figure 13. Percentage of Pacific halibut captured and sampled for otolith collection that was composed of females, by IPHC Regulatory Area, from 1998 to 2017.

Otolith collection and Pacific halibut age results

The otolith collection goal for the 2017 setline survey was 2,000 otoliths per IPHC Regulatory Area, with a minimum target of 1,500 per IPHC Regulatory Area. Fewer than 1,500 otoliths were collected in IPHC Regulatory Areas 2A, 4C, and 4D as the catch rates were low and there are fewer stations in these IPHC Regulatory Areas.

The age distribution of Pacific halibut sampled from the 2017 IPHC setline survey is summarized in Tables 4-6. The 2005 year class (12-year-olds) accounted for the largest proportion (in numbers) of sampled Pacific halibut for all IPHC Regulatory Areas and sexes combined. The next most abundant year classes were 2004 and 2006 (13- and 11-year-olds, respectively).

Twelve-year-olds were the most abundant age class for female Pacific halibut sampled from all IPHC Regulatory Areas combined, as well as for females in all IPHC Regulatory Areas except for IPHC Regulatory Area 4A (Table 5).

The second and third most abundant age classes for sampled females across all IPHC Regulatory Areas were 13- and 11-year-olds, respectively.

The 2005 year class (12-year-olds) was the largest for male Pacific halibut from all IPHC Regulatory Areas combined, as well as from IPHC Regulatory Areas 2, 3B, 4A, and 4B (Table 6). The second and third most abundant age classes for sampled males across all IPHC Regulatory Areas were 13- and 11-year-olds, respectively.

Mean age and fork length (FL) by IPHC Regulatory Area of sampled setline survey Pacific halibut for the years 2008-2017 are presented in Table 7. Average length was calculated only from fish that were aged. Average age was higher and average fork length was lower for males than females in all IPHC Regulatory Areas for all years with the exception of IPHC Regulatory Area 4C in 2008, where the average age was slightly lower for males than females.

The youngest and oldest Pacific halibut in the 2017 setline survey samples were determined to be four and 46 years old (Table 8). There were four fish determined to be four years old: a female from IPHC Regulatory Area 3A measuring 53 cm FL; two females from IPHC Regulatory Area 3B measuring 53 and 55 cm FL); and one male from IPHC Regulatory Area 3B measuring 71 cm FL. The 46-year-old was a male captured in IPHC Regulatory Area 4B with a fork length of 119 cm. The maximum fork length recorded for setline survey-caught Pacific halibut in 2017 was 190 cm: a female from IPHC Regulatory Area 3A aged at 22 years. The smallest Pacific halibut sampled in the 2017 setline survey measured 33 cm FL: a male from IPHC Regulatory Area 4A aged at five years.

Table 4. Age distribution (number of individuals sampled) of all Pacific halibut (male, female, and unknown sex combined) collected in the 2017 fishery-independent setline survey. "Sample rate" indicates the percentage of those Pacific halibut captured in each IPHC Regulatory Area whose otoliths were removed for subsequent aging.

	IPHC Regulatory Area									
	2A	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**4C**	**4D**	
	Sample rate (%)									
	100	35	33	9	13	78	45	100	100	
Age (years)										**Total**
4				1	3					**4**
5	1	7	9	5	10	9	4	7	2	**54**
6	4	18	26	13	25	34	14	12	7	**153**
7	12	23	21	13	38	40	43	9	10	**209**
8	18	31	43	18	37	86	26	23	29	**311**
9	86	129	117	82	110	222	76	71	92	**985**
10	104	123	145	107	115	172	72	57	130	**1,025**
11	125	204	240	174	183	220	109	69	131	**1,455**
12	193	345	371	287	289	335	228	87	133	**2,268**
13	141	240	349	233	208	331	191	77	106	**1,877**
14	64	105	184	145	144	249	175	50	96	**1,212**
15	47	88	186	140	113	163	113	38	55	**943**
16	20	45	113	94	41	82	62	8	30	**495**
17	14	43	82	97	34	65	55	7	16	**413**
18	10	32	81	95	29	56	41	4	11	**359**
19	11	11	49	47	21	28	38		9	**214**
20	4	13	35	29	6	25	31		11	**154**
21	4	4	13	20	2	12	19		6	**80**
22	1	3	12	17	2	10	11		6	**62**
23	3	3	10	7	1	9	18		6	**57**
24	1		4	2	2	4	13		6	**32**
25	1	2	5	5	2	4	9	1	2	**31**
≥26	1	2	9	3	6	31	60	2	59	**173**
Total	**865**	**1,471**	**2,104**	**1,634**	**1,421**	**2,187**	**1,408**	**522**	**953**	**12,565**

Table 5. Age distribution (number of individuals sampled) of female Pacific halibut collected in the 2017 fishery-independent setline survey. Note that Pacific halibut are not sampled at the same rate in all IPHC Regulatory Areas (see rates in Table 1), and that there are not separate sampling rates by sex within an IPHC Regulatory Area.

	IPHC Regulatory Area									
Age	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**4C**	**4D**	**Total**
4				1	2					**3**
5	1	6	7	4	8	5	3	7	2	**43**
6	3	9	16	7	22	28	7	10	4	**106**
7	11	15	14	10	26	28	30	6	9	**149**
8	15	19	29	11	18	54	15	19	17	**197**
9	65	83	80	51	60	101	37	66	66	**609**
10	84	91	97	72	47	95	37	46	97	**666**
11	101	125	179	122	77	93	57	64	97	**915**
12	158	230	285	202	126	164	116	79	106	**1,466**
13	118	159	279	152	100	172	103	65	84	**1,232**
14	52	65	131	89	59	139	71	47	73	**726**
15	38	44	142	77	36	83	44	31	40	**535**
16	11	22	87	43	9	42	14	7	23	**258**
17	12	19	57	39	9	26	20	4	10	**196**
18	6	9	53	31	11	28	14	3	6	**161**
19	10	3	29	12	4	11	3		5	**77**
20	1	2	23	7		14	6		7	**60**
21	3	1	8	5		3	4		1	**25**
22	1	2	8	2		5	3		4	**25**
23	3		6	2		4	2		3	**20**
24	1		2			2	3		4	**12**
25		1	5			1	2	1	1	**11**
≥26		2	4	2		9	9		23	**49**
Total	**694**	**907**	**1,541**	**941**	**614**	**1,107**	**600**	**455**	**682**	**7,541**

Table 6. Age distribution (number of individuals sampled) of male Pacific halibut collected in the 2017 fishery-independent setline survey. Note that Pacific halibut are not sampled at the same rate in all IPHC Regulatory Areas (see rates in Table 4), and that there are not separate sampling rates by sex within an IPHC Regulatory Area.

	IPHC Regulatory Area									
Age	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**4C**	**4D**	**Total**
4					1					**1**
5		1	1	1	2	4	1			**10**
6	1	9	9	6	3	5	7	2	3	**45**
7	1	8	5	2	12	12	12	3	1	**56**
8	3	12	14	6	18	31	11	4	12	**111**
9	21	45	35	30	49	119	38	5	26	**368**
10	19	32	45	34	65	77	33	11	33	**349**
11	22	78	58	46	106	125	50	5	33	**523**
12	34	113	85	82	159	169	109	8	26	**785**
13	21	77	69	80	103	156	84	11	21	**623**
14	11	40	53	52	82	108	104	3	23	**476**
15	9	43	44	63	76	79	67	7	15	**403**
16	9	23	26	50	32	39	47	1	7	**234**
17	2	23	24	58	25	38	33	3	6	**212**
18	4	23	28	63	18	27	27	1	5	**196**
19	1	8	20	35	17	16	34		4	**135**
20	3	11	12	22	6	11	24		4	**93**
21	1	3	5	15	1	9	15		5	**54**
22		1	4	15	2	5	7		2	**36**
23		3	4	5	1	5	16		3	**37**
24			2	1	2	2	10		2	**19**
25	1	1		4	1	3	7		1	**18**
≥26	1		5	1	5	21	51	2	36	**122**
Total	**164**	**554**	**548**	**671**	**786**	**1,061**	**787**	**66**	**268**	**4,905**

Table 7 . Mean age (in years) and mean fork length (in centimeters) of sampled Pacific halibut caught on standard survey skates by sex and IPHC Regulatory Area (CLS = Bering Sea closed area), 2008-2017 (F = female, M = male).

IPHC Regulatory Area		2008		2009		2010		2011		2012[1]		2013		2014		2015		2016		2017	
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
2A	Age	11.3	11.4	10.3	11.0	11.0	11.1	11.4	12.0	11.8	12.0	11.2	11.6	10.5	11.4	10.6	11.1	10.8	11.8	12.0	12.4
	Length	90.3	78.8	89.5	79.4	93.1	79.1	95.6	81.5	95.1	80.1	94.7	80.4	95.8	81.3	93.0	80.5	92.1	78.5	100.7	81.1
2B	Age	10.6	11.1	11.2	11.8	10.9	11.4	11.1	11.6	11.4	12.3	11.4	12.3	11.2	12.6	11.3	12.4	11.5	12.3	12.0	12.8
	Length	91.0	77.2	93.5	77.4	93.8	78.2	94.6	78.5	95.2	79.8	94.4	79.1	92.1	78.8	91.8	78.7	93.4	78.1	95.6	80.0
2C	Age	11.4	11.5	10.9	11.7	11.0	11.5	11.9	12.0	11.2	11.6	11.9	12.4	11.7	12.3	11.9	12.3	12.7	13.2	13.1	13.4
	Length	93.4	78.8	90.6	78.2	91.0	77.0	96.9	79.8	95.8	80.1	96.4	79.4	97.0	80.0	97.7	80.4	96.7	81.0	100.7	82.9
3A	Age	12.9	16.0	11.7	14.6	12.1	15.0	12.2	14.9	12.2	14.6	12.7	14.3	11.8	13.8	11.8	13.7	12.8	14.6	12.8	14.7
	Length	93.7	81.8	89.5	79.6	89.4	78.7	87.6	78.3	90.1	78.6	89.4	76.4	87.7	75.5	88.5	75.3	90.4	76.0	92.0	77.2
3B	Age	11.1	14.4	10.6	13.5	10.7	13.0	10.8	12.9	10.7	12.5	11.3	13.3	10.9	12.7	11.3	12.8	11.5	12.4	11.6	12.8
	Length	83.0	78.1	82.3	77.6	81.8	75.9	81.5	74.2	81.7	74.9	80.3	73.3	80.5	73.4	82.3	72.2	83.9	71.2	87.8	73.2
4A	Age	10.7	13.5	10.5	12.6	10.6	12.7	10.8	13.2	11.1	13.2	11.3	13.4	12.3	14.7	11.5	13.9	12.3	13.0	12.5	13.0
	Length	82.4	78.6	84.1	77.6	82.6	76.6	83.4	76.5	82.8	76.6	85.8	78.3	88.2	79.7	84.7	77.0	89.1	74.1	88.0	74.1
4B	Age	12.6	15.8	13.1	15.9	12.2	14.9	12.2	15.2	11.8	13.9	11.0	13.6	11.2	13.7	11.0	13.6	11.4	13.6	12.8	15.3
	Length	103.4	92.1	103.8	92.7	100.3	90.3	98.4	89.7	96.6	86.5	89.4	84.1	92.0	84.1	94.6	86.2	91.1	82.1	96.7	85.3
4C	Age	10.5	10.4	9.6	10.8	10.2	10.8	10.4	11.2	11.3	13.2	10.6	11.2	11.3	11.4	10.7	11.4	11.7	12.1	11.5	12.3
	Length	88.0	72.7	84.1	75.1	84.3	73.8	82.0	72.8	86.3	78.8	80.7	74.2	84.7	72.9	83.1	72.2	87.0	74.9	93.9	74.3
4D	Age	13.4	16.1	13.8	16.6	14.4	17.4	13.2	14.9	12.0	13.7	13.8	15.2	12.3	13.1	12.5	13.3	13.3	14.2	12.8	15.1
	Length	93.8	85.3	94.4	86.7	96.6	87.3	88.4	80.9	86.6	78.5	91.9	81.5	88.2	77.6	88.2	77.6	88.1	77.7	93.7	80.6
4E	Age	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10.1	12.5	----	----	----	----
	Length	----	----	----	----	----	----	----	----	----	----	----	----	----	----	89.0	79.9	----	----	----	----
CLS	Age	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10.4	11.2	----	----	----	----
	Length	----	----	----	----	----	----	----	----	----	----	----	----	----	----	86.9	73.4	----	----	----	----

[1]Does not include otoltihs from fish sampled on experimental bait skates that were fished concurrently with standard survey skates during 2012 bait study (Webster et al. 2013).

Table 8. Maximum and minimum age (in years) and fork length (in centimeters) of Pacific halibut for which sex was determined, collected in the 2017 fishery-independent setline survey, by IPHC Regulatory Area and sex.

IPHC Regulatory Area	Sex	Max. age	Min. age	Max. length	Min. length
2A	Female	24	5	145	60
2A	Male	33	6	113	57
2B	Female	30	5	174	55
2B	Male	25	5	127	56
2C	Female	31	5	186	57
2C	Male	32	5	139	54
3A	Female	28	4	190	48
3A	Male	27	5	147	51
3B	Female	19	4	161	50
3B	Male	31	4	127	48
4A	Female	34	5	155	50
4A	Male	37	5	121	33
4B	Female	36	5	174	53
4B	Male	46	5	134	57
4C	Female	25	5	180	56
4C	Male	36	6	106	53
4D	Female	32	5	175	57
4D	Male	42	6	134	34

III. Reserves – N/A

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

A. Pacific halibut and IPHC activities

1. Research

Abstract

Since its inception, the IPHC has had a long history of research activities devoted to describing and understanding the biology of the Pacific halibut (*Hippoglossus stenolepis*). At the present time, the main objectives of the Research Program put forward by the Biological and Ecosystem Science Branch at IPHC are to:

1) identify and assess critical knowledge gaps in the biology of the Pacific halibut;
2) understand the influence of environmental conditions; and
3) apply the resulting knowledge to reduce uncertainty in current stock assessment models.

Traditionally, IPHC staff propose new projects annually that are designed to address key biological issues as well as the continuation of certain projects initiated in previous years. Proposals are based on their own input as well as input from the Commissioners, stakeholders, and specific subsidiary bodies to the IPHC such as the Research Advisory Board (RAB) and the Scientific Review Board (SRB). Proposed research projects are presented to the Commissioners for feed-back and subsequent approval. Importantly, biological research activities at IPHC are guided by a Five-Year Research Plan that is put forward by the Branch Manager identifying key research areas that follow Commission objectives. According to the Five-Year Research Plan for the period 2018-2023, the primary biological research activities at IPHC can be summarized in five main areas:

1) Reproduction
2) Growth and Physiological Condition
3) Discard Mortality and Survival
4) Distribution and Migration
5) Genetics and Genomics

These research areas have been selected for their important management implications. The studies conducted on Reproduction are aimed at providing information on the sex ratio of the commercial catch and to improve current estimates of maturity. The studies conducted on Growth are aimed at describing the role of some of the factors responsible for the observed changes in size-at-age and to provide tools for measuring growth and physiological condition in Pacific halibut. The proposed work on Discard Mortality and Survival is aimed at providing updated estimates of discard mortality rates in both the longline and the trawl fisheries. The studies conducted on Distribution and Migration are aimed at further understanding larval and juvenile dispersal, distribution of all life stages in relation to the environment, and reproductive and seasonal migration and identification of spawning times and locations. The studies conducted on Genetics and Genomics are aimed at describing the genetic structure of the Pacific halibut population and at providing the means to investigate rapid adaptive changes in response to fishery-dependent and fishery-independent influences. 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 2018

The following projects are being conducted at IPHC in 2018:

Project 621.16 ("*Development of genetic sexing techniques*") is the continuation of a project dealing with genetic sex identification of the commercial catch that will entail the testing and application of the recently developed genetic assays for sex identification.

Projects 642.00 ("*Assessment of mercury and other contaminants*") and **661.11** ("*Ichthyophonus incidence monitoring*") represent the continuation of projects monitoring the prevalence of heavy metal contamination and *Ichthyophonus* infection in the Pacific halibut population, respectively.

A total of four projects are continuing migration-related studies. Three of these projects involve tagging and include: **Project 650.18:** "*Archival tags: tag attachment protocols*", **Project 650.21:** "*Investigation of Pacific halibut dispersal in IPHC Regulatory Area 4B*"; and **Project 670.11:** "*Wire tagging of Pacific halibut on NMFS trawl and setline surveys*". A fourth migration-related project, **Project 675.11** ("Tail pattern recognition"), is investigating the identification of individual tail markings in U32 fish through the collection of tail images from IPHC's fishery-independent setline survey.

Project 669.11 ("*At-sea collection of Pacific halibut weight to reevaluate conversion factors*") is continuing to collect weights at sea to improve estimation of the weight-length relationship in adult Pacific halibut.

Project 672.12 ("*Condition Factors for Tagged U32 Fish*") is continuing to study the relationship between the physiological condition of fish and migratory performance and growth as assessed by tagging in U32 fish in order to better understand the potential use of quantitative physiological indicators in predicting migratory performance and growth.
Project 673.13 ("*Sequencing the Pacific halibut genome*") is continuing the first characterization of the genome of the Pacific halibut that will be instrumental to provide genomic resolution to genetic markers for sex, reproduction, and growth that are currently being investigated.

Project 673.14 (*"Identification and validation of markers for growth in Pacific halibut"*) is continuing to identify and validate molecular and biochemical profiles that are characteristic of specific growth patterns and that will be used to identify different growth trajectories in the Pacific halibut population and evaluate potential effects of environmental influences on growth patterns. This project has also received funding from the North Pacific Research Board under project number 1704.

Project 672.13 ("*Discard mortality rates and injury classification profile by release method*") is continuing to study the relationship between hook release methods in the longline fishery and associated injuries with the physiological condition of fish and with post-release survival in order to update current estimates of discard mortality rates in the directed longline Pacific halibut fishery. This project has also received funding from the Saltonstall-Kennedy NOAA grant program under project number NA17NMF4270240.

Project 674.11 ("*Full characterization of the annual reproductive cycle*") is continuing to characterize the annual reproductive cycle of male and female Pacific halibut in order to improve our understanding of sexual maturation in this species and to improve maturity assessments and maturity-at-age estimates.

Two new projects at IPHC are starting in 2018. **Project 2018-01** ("*Influence of thermal history on growth*") will study the thermal profile experienced by fish at sea as assessed by archival tagging and otolith microchemistry in order to investigate the relationship between growth patterns (or productivity) and both spatial and temporal variability in environmental conditions for growth. **Project 2018-04** ("*Larval connectivity*") will study the movement and connectivity of Pacific halibut larvae both within and between the Gulf of Alaska and the Bering Sea

In addition to these continuing and new projects at IPHC, we note the participation of IPHC in an externally-funded and coordinated project entitled "*Survival of Pacific halibut released from Bering Sea flatfish trawl catches through expedited sorting*". This project is continuing to study the efficacy of expedited release as a method for reducing Pacific halibut discard mortality following trawl capture and the development of methods for the estimation of discard mortality rates without the need for fish-by-fish vitality estimation. This project is funded by the Saltonstall-Kennedy program under project number 15AKR013 and by the North Pacific Research Board under project number NPRB 1510.

Figure 2 presents a schematic diagram of the IPHC research projects, their interactions, and their relationship to the major research areas identified in the IPHC Five-Year Research Plan.

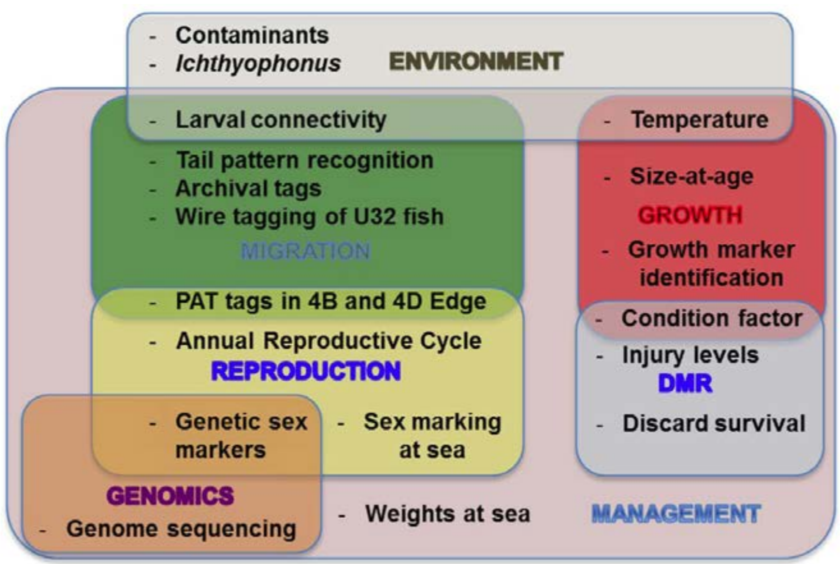

Figure 2. Schematic diagram of IPHC research projects and their interactions

Other ongoing data collection projects

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 2018 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 sampling program

IPHC Port Team – Lara Erikson, commercial fisheries 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, tissue samples, fork lengths, weights, 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 and the tissue samples provide sex composition. Lengths and weight data, in combination with age data and sex data, provide size-at-age analyses by sex. 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.

2. Assessment

The 2017 Stock Assessment and 2018 Harvest Advice

Sources of mortality: In 2017, total removals were below the 100-year average, and have been stable near 42 million pounds (19,050 t) from 2014 to 2017. In 2017, 83% of the total removals from the stock were retained, compared to 80% in 2016.

Fishing intensity: The 2017 mortality from all sources corresponds to a point estimate of Spawning Potential Ratio (SPR) = 40% (there is a 75% chance that fishing intensity exceeded the IPHC's reference level of 46%). In order to reach the interim reference level, catch limits would need to be reduced for 2018. The Commission does not currently have a coastwide limit fishing intensity reference point.

Stock status (spawning biomass): Current female spawning biomass is estimated to be just above 200 million pounds (90,700 t), which corresponds to only a 6% chance of being below the IPHC threshold (trigger) reference point of $SB_{30\%}$, and less than a 1% chance of being below the IPHC limit reference point of $SB_{20\%}$. Therefore, no adjustment to the target fishing intensity is required, and the stock is not considered to be 'overfished.' Projections indicate that the target fishing intensity is likely to result in similar but declining biomass levels in the near future.

Stock distribution: Regional stock distribution has been stable within estimated credibility intervals over the last five years. Region 2 (IPHC Regulatory Areas 2A, 2B, and 2C) currently represents a greater proportion, and Region 3 (IPHC Regulatory Areas 3A and 3B) a lesser proportion, of the coastwide stock than observed in previous decades.

The complete reports of the 2017 stock assessment and 2018 harvest advice are available on the IPHC website at https://iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094 (please see papers IPHC-2018-AM094-08 through -11).

3. Management

The International Pacific Halibut Commission (IPHC) completed its 94th Annual Meeting (AM094) in Portland, Oregon, U.S.A., on 26 January 2018, with Dr. James Balsiger of the U.S.A. presiding as Chairperson. More than 200 Pacific halibut industry stakeholders attended the meeting, with over 100 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. Documents and presentations from the Annual Meeting are available on the Annual Meeting page on the IPHC website: https://iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094.

Catch Limits

The IPHC did not agree on new Pacific halibut catch limits for 2018, and therefore the catch limits adopted by the IPHC in 2017 remain in place. Both Contracting Parties, Canada and the United States of America, indicated their intention to pursue more restrictive catch limits for 2018 via domestic regulatory processes, as allowed by the *Convention between Canada and the United States of America for the preservation of the* [Pacific] *halibut fishery of the Northern Pacific ocean and Bering sea*. Since then, both countries have implemented more restrictive catch limits for 2018.

Note that these catch limits are more restrictive than the catch limits published by the IPHC in the *Pacific Halibut Fishery Regulations (2018)* (https://iphc.int/uploads/pdf/regs/iphc-2018-regs.pdf).

On 23 March 2018, the United States of America, via NOAA-Fisheries, announced the adoption and implementation of the following 2018 catch limits for the commercial Pacific halibut fisheries in IPHC Regulatory Area 2A:

	Catch limit (pounds)	Catch limit (metric tons)
IPHC Regulatory Area 2A	**1,190,000**	**539.78**
Treaty Indian commercial	389,500	176.68
Non-treaty directed commercial (south of Pt. Chehalis)	201,845	91.56
Non-treaty incidental catch in salmon troll fishery	35,620	16.16
Non-treaty incidental catch in sablefish fishery (north of Pt. Chehalis)	50,000	22.68

More restrictive 2018 catch limits for non-commerical fisheries in IPHC Regulatory Area 2A – the Treaty Indian ceremonial and subsistence and recreational (sport) fisheries in Wasington, Oregon, and California – are specified in the final promulgation of the Pacific Fishery Management Council's Catch Sharing Plan for 2018.

On 13 February 2018, Canada, via Fisheries and Oceans Canada (DFO), announced the adoption and implementation of the following 2018 catch limits for Pacific halibut fisheries in IPHC Regulatory Area 2B:

	Catch limit (pounds)	Catch limit (metric tons)
IPHC Regulatory Area 2B	**6,223,985**	**2,823.18**
Commercial Total Allowable Catch	5,295,995	2402.25
Recreational Total Allowable Catch	927,990	420.93

On 19 March 2018, NOAA-Fisheries announced the adoption and implementation of the following 2018 catch limits for the Pacific halibut fisheries in IPHC Regulatory Areas 2C, 3A, 3B, 4A, 4B and 4CDE:

	Catch limit (pounds)	Catch limit (metric tons)
IPHC Regulatory Area 2C	**4,450,000**[1]	**2,018.51**[1]
Commercial (IFQ)	3,570,000	1,619.32
Charter sport	810,000	367.41
IPHC Regulatory Area 3A	**9,450,000**[1]	**4,286.49**[1]
Commercial (IFQ)	7,350,000	3,333.91
Charter sport	1,790,000	811.94
IPHC Regulatory Area 3B	**2,620,000**	**1,188.41**
IPHC Regulatory Area 4A	**1,370,000**	**621.42**
IPHC Regulatory Area 4B	**1,050,000**	**476.27**
IPHC Regulatory Area 4CDE	**1,580,000**	**716.68**
IPHC Regulatory Area 4C	733,500	332.71
IPHC Regulatory Area 4D	733,500	332.71
IPHC Regulatory Area 4E	113,000	51.26

[1] In accordance with the catch sharing plan in place for this IPHC Regulatory Area, this overall total includes estimates for discard mortality.

NOAA-Fisheries also announced the following 2018 management measures for the charter recreational fisheries in IPHC Regulatory Areas 2C and 3A, based on the revised 2018 catch limits:

- In IPHC Regulatory Area 2C: a one-fish daily bag limit, with a reverse slot limit that allows retention of Pacific halibut less than 38 inches or greater than 80 inches, and no annual limit.

- In IPHC Regulatory Area 3A: a two-fish daily bag limit, a maximum size limit of less than or equal to 28 inches on one of those Pacific halibut, and a four-fish annual limit. In addition, Wednesdays will be closed to charter fishing in IPHC Regulatory Area 3A all season, along with six Tuesday (July 10, July 17, July 24, July 31, August 7, and August 14) closures in the summer. Vessels and charter permit holders will continue to be limited to one trip per day.

Fishing Periods (Season dates)

The Commission approved a season of 24 March to 7 November 2018, for the U.S. and Canadian quota fisheries. Seasons will commence at noon local time on 24 March and terminate at noon local time on 7 November 2018 for the following fisheries and IPHC Regulatory Areas: the Canadian Individual Vessel Quota (IVQ) fishery in IPHC Regulatory Area 2B, and the United States IFQ and CDQ fisheries in IPHC Regulatory Areas 2C, 3A, 3B, 4A, 4B, 4C, 4D, and 4E. All IPHC Regulatory Area 2A commercial fishing, including the treaty Indian commercial fishery, will take place between 24 March and 7 November 2018. The Saturday opening date was chosen to facilitate marketing.

In IPHC Regulatory Area 2A, seven 10-hour fishing periods for the non-treaty directed commercial fishery south of Point Chehalis, Washington, are recommended: 27 June, 11 July, 25 July, 8 August, 22 August, 5 September, and 19 September 2018. 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.

IPHC Regulatory 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 IPHC Regulatory 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 IPHC Regulatory Area 2A IPHC licensing procedures did not change.

Regulatory Changes

The IPHC adopted a number of regulatory changes to update and clarify existing regulations, including:

- A change to allow the use of leased IFQ by CDQ organizations in IPHC Regulatory Areas 4B, 4C, 4D and 4E
- A change to allow the use of pot gear for directed Pacific halibut fishing in areas where such gear is allowed by Contracting Party domestic regulations.
- Clarifications to the regulations for landing catch with the head on, reflecting the experience gained since this regulation was first adopted in 2017.

A complete summary of the regulatory actions taken by the IPHC for 2018 can be found in the report of the 94th Annual Meeting, posted on the IPHC website.

Other Actions

Harvest Policy Analysis

The IPHC provided direction to the Management Strategy Advisory Board (MSAB) for further work on harvest strategy policy development, including consideration of both scale – the level of removals from the stock – and distribution – how the catch is distributed across the range of the stock.

Expanded Survey

The IPHC 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 IPHC Regulatory Areas and to encompass all depths over which the stock is distributed. In 2018, the setline survey in IPHC Regulatory Areas 2A, 2B, and 2C will be expanded beyond the standard grid of setline survey stations fished each year.

Meeting Report

The Report of the 94th Session of the IPHC Annual Meeting (AM094) has been published and posted at the Annual Meeting page of the IPHC website: https://iphc.int/uploads/pdf/am/2018am/iphc-2018-am094-r.pdf . The Report includes details on all the decisions, recommendations, and requests made by the Commission during the Annual Meeting.

V. 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.]

VI. Publications

International Pacific Halibut Commission. 2017. Report of Assessment and Research Activities 2017. https://www.iphc.int/uploads/pdf/am/2018am/iphc-2017-rara27-r.pdf

Northwest Fisheries Science Center

National Marine Fisheries Service

NOAA Fisheries

Agency Report to the Technical Subcommittee

of the Canada-U.S. Groundfish Committee

April 2018

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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 2017, 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 Kevin.Werner@noaa.gov, (206) 860 – 6795.

II. Surveys

A. U.S. West Coast Groundfish Bottom Trawl Survey

The NWFSC conducted its twentyith annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2017 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 2017, we continued to utilized an updated backdeck data collection system with improved software applications, and wireless networking. Programming used to gather data for the groundfish survey was rewritten so that the various components were fully integrated, updated to include multiple sensor streams, and enhanced to increase flexibility for data input from special projects and future undefined data sources. The changes in the back-deck programming, wheel house programming and data QA/QC process resulted in overall improvements to data collection efficiency and anticipated future decreases in time requirements for data to be made available to the Data Warehouse. 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) Collection of voucher specimens for multiple fish species – Northwest Fisheries Science Center and University of Washington;
2) Lingcod aging study – collect otolith and fin ray from one lingcod in any tow where they are collected – NWFSC Aging Laboratory;
3) 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;
4) Collect gill filaments from all lingcod with age samples for enhanced DNA analysis – Jameal Samhouri, Conservation Biology Division, NWFSC;
5) Collect fin clips from all Pacific sleeper sharks (*Somniosus pacificus*) to examine genetics – NOAA, NWFSC – Cindy Tribuzio
6) Collect all specimens of sharpnose sculpin (*Clinocottus acuticeps*) for species confirmation – Dan Kamikawa
7) Request for photographs of lamprey scars and specimens for Pacific lamprey (*Lampetra tridentata*) and river lamprey (*Lampetra ayresii* – NWFSC, Conservation Division, Newport;
8) Collect the first 6-8 caudal thorns from big skate – Tyler Johnson, Aging Laboratory, NWFSC
9) Collect and freeze all brown and filetail catsharks captured between San Francisco and Monterey Bay – Matt Jew, Moss Landing Marine Laboratories;
10) Collection of all biological data and specimens of deepsea skate (*Bathyraja abyssicola)* and broad skate ((*Amblyraja badia*) - Moss Landing Marine Laboratories;
11) Collect biological information on 20 – 30 brown, longnose and filetail catcharks from all hauls where they occur – Amber Reichert, Moss Landing Marine Laboratories;
12) Collection of all specimens of Pacific black dogfish (*Centroscyllium nigrum*), velvet dog shark *(Zameus squamulosus) and* Cookiecutter Shark *(Isistius brasiliensis).* – Moss Landing Marine Laboratories;
13) 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;
14) Collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* and velvet dog shark (*Zameus squamulosus*) – Moss Landing Marine Laboratories;
15) 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;
19) Coral population genetics - Collect whole specimens of *Desmophyllum dianthus* - in 95% ETOH – Cheryl Morrison;
20) Collect sex, total length and photograph dorsal side (including close up of dorsal side of snout) for all big skate (*Beringraja binoculata*), California skate (*Raja inornata*) and starry skate (*Raja stellulata*) captured at depths greater than 300 m – Joe Bizzarro;
21) Growth of Pacific octopods – collect all vampire squid and incirrate octopods (*Japetelle*/*Bolitaena* complex – Henk-Jan Hoving and Richard Schwarz;
22) Rosy rockfish maturity – collect whole ovary and otoliths from any rosy rockfish – Sue Sogard
23) Pacific flatnose – Collect up to 30 fin clips per leg for DNA analysis, 25 random scale samples and 25 random fish – Alexei M. Orlov.

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, canary rockfish, 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 2017 West Coast Groundfish Trawl Survey; and 8) Collection of ovaries and finclips from copper rockfish, cowcod, 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, Pacific sanddab, petrale sole, sablefish, and lingcod; 11) Collection of voucher specimens for teaching purpose; 12) Photograph, tag, bag and freeze deep water species such as arbiter snailfish (*Careproctus kamikawi*) and other rare or unidentified deep water species; 13) collection of ovaries from Dover sole, longspine thornyhead, lingcod, petrale sole, widow rockfish and arrowtooth flounder; 14) macroscopic analysis of maturity of spiny dogfish.

For more information please contact Aimee Keller at Aimee.Keller@noaa.gov

B. Southern California shelf rockfish hook-and-line survey

In early Fall 2017, FRAM personnel conducted the 14th 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 13 biologists participating during the course of the survey. The three vessels sampled a total of 198 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 2017 survey, but given the increase in number of sites sampled, should be slightly more productive relative to the 2016 survey where approximately 5,942 sexed lengths and weights, 4,872 fin clips, and 4,738 otolith pairs were taken during the course of the entire survey representing approximately 40 different species of fish. Several ancillary projects were also conducted during the course of the survey. Approximately 486 ovaries were collected from 9 different species to support the development of maturity curves and fecundity analysis. 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. For the second consecutive year, the survey caught a whitespeckled rockfish (*S. moseri*) - a species rarely captured with fishing gear. There are fewer than 10 documented captures of *S. moseri*, and the two individuals caught on the hook and line survey were submitted to the University of Washington's Burke Museum. Researchers also deployed an underwater video sled to capture visual observations for habitat analysis, species composition, and fish behavior studies. The survey continued to descend or release and tag all individuals captured at 6 sites located inside federal marine reserves. To date, approximately 350 individuals have been tagged. During the 2017 stock assessment cycle, data and specimens were incorporated into the assessments for bocaccio, blue rockfish, yelloweye rockfish, yellowtail rockfish, and lingcod.

For more information, please contact John Harms at John.Harms@noaa.gov

C. 2017 joint U.S.-Canada integrated ecosystem and Pacific hake acoustic-trawl summer survey

The joint U.S.–Canada integrated ecosystem and Pacific hake acoustic-trawl summer survey was conducted in U.S. and Canadian waters by a U.S. team (NWFSC/FRAM) on the NOAA Ship *Bell M. Shimada* from 22 June 2017 to 13 September 2017, and by a Canadian team (DFO/Pacific region) on the Canadian chartered F/V *Nordic Pearl* from 16 August 2017 to 6 September 2017. Data collected during the survey were processed to provide an estimate of the abundance and spatial distribution of the coastal Pacific hake stock shared by both countries. The survey covered the slope and shelf of the U.S. and Canada West Coast with acoustic transects from roughly 34.5°N (Point Conception, California) to 54.8°N (Southeast Alaska and Dixon Entrance). Transects were oriented east-west (except for transects in Dixon Entrance that were oriented north-south) and were spaced 10 nm apart. Acoustic data were collected on the *Shimada* with a Simrad EK60 scientific echosounder system operating at frequencies of 18, 38, and 120 kHz, as well as with a Simrad EK80 broadband scientific echosounder operating at frequencies of 70 and 200 kHz. On the *Nordic Pearl*, acoustic data were collected with a Simrad EK60 echosounder operating at frequencies of 38 and 120 kHz. The *Shimada* collected acoustic data from 102 transects and the *Nordic Pearl* from 35, resulting in a total survey-wide linear distance of 5,246 nautical miles of acoustical transect that were used for the hake biomass estimate. Aggregations of adult (age 2+) Pacific hake were detected on 91 transects from just north of Morro Bay (35.5°N), along the U.S. West Coast and west side of Vancouver Island, in Queen Charlotte Sound and Hecate Strait (up to 53.3°N), and along the southwest portion of Haida Gwaii. Highest concentrations of Pacific hake were observed from San Francisco to Newport, near the entrance to the Strait of Juan de Fuca, along the northwest side of Vancouver Island, and in Hecate Strait. Hake sign was relatively light off southern California and in Queen Charlotte Sound. Hake were absent in Dixon Entrance, southeast Alaska, and along most of the West Coast of Haida Gwaii. Midwater trawls equipped with a camera system were conducted to verify species composition of observed backscatter layers and to obtain biological information (e.g., size and sex distribution, age composition, sexual maturity). A total of 68 successful midwater trawls (51 by the *Shimada* and 17 by the *Northern Pearl*) resulted in a combined total hake catch of 31,904 kg (14,008 kg from the *Shimada* and 17,896 kg from the *Northern Pearl*). Hake accounted for 75% of the catch in U.S. waters and 89% of the catch in Canadian waters. The estimated total biomass of adult Pacific hake in 2017 was 1.418 million metric tons. Although the 2017 estimate represented a decrease of 34% from the 2015 biomass estimate (1.418 vs. 2.156), it was very close to an historical average as observed since 1995. Approximately 73% of the 2017 estimate was from U.S. waters. Age-3 hake (2014 year class) were dominant in 2017, accounting for over 60% of the total survey-wide observed adult biomass.

For more information, please contact Sandy Parker-Stetter at sandy.parker-stetter@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 Sandy Parker-Stetter at sandy.parker-stetter@noaa.gov.

III. Reserves

A. Cowcod Conservation Area Research

1. Potential reserve effects of Cowcod Conservation Areas on shelf rockfish in the Southern California Bight

Investigators: C. Jones, J.H. Harms, J. Benante, A. Chappell, J.R. Wallace and A.A. Keller

The Northwest Fisheries Science Center (NWFSC) annually conducts a fishery-independent hook and line survey to monitor groundfish associated with hard bottom habitats within the Southern California Bight (SCB). The survey was developed in 2003 and is a collaborative effort among Pacific States Marine Fisheries Commission, NWFSC, and southern California's sportfishing industry. The survey's historical sampling frame (2003-2013) consisted of 121 fixed sites and excluded two large Cowcod Conservation Areas (CCAs). The CCAs were implemented in 2001 to protect shelf habitat and fishery resources in areas where cowcod (Sebastes levis) are most abundant by prohibiting bottom fishing in depths greater than 37 meters. In 2014, at the request of the Pacific Fishery Management Council, the hook and line survey initiated sampling inside the CCAs, and currently monitors approximately 80 sites inside the two closures. Survey data results from 2014-2016, show a significantly higher total catch inside the CCAs versus outside. In addition, the mean number of species observed per site visit is greater inside the CCAs. With only four years of data inside the CCAs, the hook and line survey will continue to monitor these sites into the future and document other potential effects on shelf rockfish related to the CCAs. Sampling inside the CCAs will also allow for a more robust estimation of relative abundance for several important rockfish species in the SCB.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

2. Variation in size and catch of demersal fish species within the Southern California Bight in relation to the Cowcod Conservation Areas (2014 - 2016)

Investigators: A.A. Keller, J.H. Harms, J.R. Wallace, J. Benante, C. Jones and A. Chappell

Since 2001, fishing was prohibited at depths greater than 36 m in two large (10878 km^2 and 260 km^2) Southern California Bight marine reserves known as the Cowcod Conservation Areas (CCAs). The Pacific Fishery Management Council established the CCAs in response to declining abundance of west coast rockfishes, particularly overfished cowcod. We investigated variations in catch rate, size, length frequency and percent of positive sites for 12 abundant groundfish (bank, bocaccio, chilipepper, copper, cowcod, greenspotted, lingcod, olive, speckled, squarespot, starry and the vermilion-sunset complex) inside and outside the CCAs using data from the Southern California Hook and Line Survey, an annual fishery independent survey. From 2014 to 2016, the Hook and Line Survey sampled up to 75 fixed sites within the CCAs and 121 sites outside the restricted areas using rod and reel gear. Generalized Linear Models (GLMs) that included area, year, depth and distance from port revealed significantly greater catch rates for 8 of 12 species and total catch of all species within the CCAs related to the area main effect ($P< 0.03$)). Significantly elevated catch occurred for cowcod within the CCAs ($P < 0.0001$) but related to depth not area. Significantly lower catch occurred for copper, lingcod, and the vermilion complex inside the CCAs. We also observed significant differences ($P<0.05$) in length frequency distribution and mean size for nine species and the vermilion-sunset complex with larger fish present inside the CCAs. Length frequency and mean size of bank and starry rockfishes were not significantly different by area. The proportion of sites positive for individual species tended to be greater inside the CCAs for nine species, although significant differences occurred only for bank, bocaccio and starry rockfishes.

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

A. Hagfish: No research or assessments in 2017

B. Dogfish and other sharks: No assessments in 2017

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.

Citation: Tribuzio, C.A. and K.S. Andrews. 2016. If the tag fits.....finding the glass slipper of tags for spiny dogfish (*Squalus suckleyi*). Western Groundfish Conference, Newport, OR. February 2016.

For more information please contact 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 Kelly Andrews at Kelly.Andrews@noaa.gov.

c) Shark Interactions with Directed and Incidental Fisheries in the Northeast Pacific Ocean: Historic and Current Encounters, and Challenges for Shark Conservation.

Investigators: J. King, G. McFarlane, V. Gertseva, J. Gasper, S.Matson and C. Tribuzio

For over 100 years, sharks have been encountered, as either directed catch or incidental catch, in commercial fisheries throughout the Northeast Pacific Ocean. A long-standing directed fishery for North Pacific Spiny Dogfish (*Squalus suckleyi*) has occurred and dominated shark landings and discards. Other fisheries, mainly for shark livers, have historically targeted species including

Bluntnose Sixgill Shark (*Hexanchus griseus*) and Tope Shark (*Galeorhinus galeus*). While incidental catches of numerous species have occurred historically, only recently have these encounters been reliably enumerated in commercial and recreational fisheries. In this chapter we present shark catch statistics (directed and incidental) for commercial and recreational fisheries from Canadian waters (off British Columbia), southern US waters (off California, Oregon, and Washington), and northern US waters (off Alaska). In total, 17 species of sharks have collectively been encountered in these waters. Fishery encounters present conservation challenges for shark management, namely, the need for accurate catch statistics, stock delineation, life history parameter estimates, and improved assessments methods for population status and trends. Improvements in management and conservation of shark populations will only come with the further development of sound science-based fishery management practices for both targeted and incidental shark fisheries.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

C. Skates: No assessments in 2017

1. Research

a) Standardizing the age reading protocol for longnose skate (*Raja rhina*).

Investigators: M. Arrington, T. Essington, T. Helser, B. Matta, C. Gburski, V. Gertseva, O.Ormseth and J.King

Longnose skate (*Raja rhina*) occur along most of the North American Pacific coast. While there is not currently a directed fishery for skates, they are commonly caught and retained as bycatch in the groundfish fishery. The ability to accurately estimate their abundance is important because their long life span and low fecundity make skates more vulnerable to overfishing. Despite this species' continuous range, it is managed in three separate regions: U.S. West Coast, British Columbia, and Gulf of Alaska. Each region currently has different age determination protocols which may lead to biases in age estimates. With collaboration between these three federal agencies, this study aims to standardize aging protocols based on validated age reading criteria. In doing so, spatial and temporal variability in growth may be also be explored. The results from this study will increase available age data and improve the understanding of longnose skate life history parameters as well as potentially improve the precision of abundance estimates.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

D. Pacific cod: No research or assessments in 2017

E. Walleye Pollock: No assessments in 2017

1. Research

a) The relative influence of temperature and size-structure on fish distribution shifts: A case-study on Walleye pollock in the Bering Sea

Investigators: J. Thorson, S. Kotwicki and J. Ianelli

Research has estimated associations between water temperature and the spatial distribution of marine fishes based upon correlations between temperature and the centroid of fish distribution (centre of gravity, COG). Analysts have then projected future water temperatures to forecast shifts in COG, but often neglected to demonstrate that temperature explains a substantial portion of historical distribution shifts. We argue that estimating the proportion of observed distributional shifts that can be attributed to temperature vs. other factors is a critical first step in forecasting future changes. We illustrate this approach using Gadus chalcogrammus (Walleye pollock) in the Eastern Bering Sea, and use a vector-autoregressive spatiotemporal model to attribute variation in COG from 1982 to 2015 to three factors: local or regional changes in surface and bottom temperature ("temperature effects"), fluctuations in size-structure that cause COG to be skewed towards juvenile or adult habitats ("size-structured effects") or otherwise unexplained spatiotemporal variation in distribution ("unexplained effects"). We find that the majority of variation in COG (including the north-west trend since 1982) is largely unexplained by temperature or size-structured effects. Temperature alone generates a small portion of primarily north–south variation in COG, while size-structured effects generate a small portion of east–west variation. We therefore conclude that projections of future distribution based on temperature alone are likely to miss a substantial portion of both the interannual variation and interdecadal trends in COG for this species. More generally, we suggest that decomposing variation in COG into multiple causal factors is a vital first step for projecting likely impacts of temperature change.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov.

F. Pacific whiting (hake)

1. Research

a) Spatio-temporal reproductive patterns in Pacific Hake, *Merluccius productus,* using a flexible model to estimate functional maturity

Investigators: M.A. Head, I.G. Taylor and J.M. Cope

Over the last decade, fisheries managers increasingly identified a need for up-to-date, coast wide reproductive information on groundfishes along the west coast. Many management models used out of date maturity studies that were localized and often from unreliable macroscopic maturity estimates. In response to this, the NWFSC FRAM's division instituted a reproductive biology program in 2009 using two sampling platforms. We sampled Pacific hake ovaries from the West Coast Groundfish Trawl Survey in 2009 and 2012 - 2017. In 2012, we expanded the sampling platform to capture better spatio-temporal patterns. This included sampling from the Fisheries Engineering Acoustics and Technology (FEAT) summer survey, the at-sea hake observer program in the spring and fall months, and finally the FEAT winter survey in 2016 – 2017. From 2009 – 2016, we histologically assessed 2544 hake maturity samples. These coast wide collections allowed us to explore biogeographic relationships North and South of Pt. Conception, CA

(34.44°N) within varying temporal patterns. Overall length and age at 50% (L_{50}, A_{50}) maturity were estimated at 33.4 cm and 2.3 years. However, L_{50} results north and south of Pt. Conception varied substantially, with corresponding L_{50} estimates of 35.0 and 26.2 cm. In addition, to the varying spatial relationships, we found temporal trends in their reproductive cycle; including time of spawning, shift in spawning locality, and interannual variability in the rate of skipped spawning. To account for skip spawning we estimated length at maturity using a spline model that incorporates the fraction of adult sexually mature skip spawners into a flexible asymptote.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

2. Assessment

a) Status of the Pacific (whiting) stock in U.S. and Canadian waters in 2018

Investigators: A. Edwards, I. Taylor, C. Grandin and A. Berger

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 2018. Coast-wide fishery landings of Pacific hake averaged 230 thousand mt from 1966 to 2017, with a low of 90 thousand mt in 1980 and a peak of 441 thousand mt in 2017. Prior to 1966 the total removals were negligible relative to the modern fishery. Recent coast-wide landings from 2008–2017 have been above the long term average, at 276 thousand mt. Landings between 2013 and 2015 were predominantly comprised of fish from the very large 2010-year class, comprising around 70% of the total removals. Landings in 2016 and 2017 had high proportions for the 2010 and 2014-year classes. In 2017, U.S. fisheries caught mostly 3- and 7-year old fish from the 2010 and 2014 year classes, while the Canadian fisheries encountered mostly 7-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 2018 assessment with the addition of fishery catch and age compositions from 2017, the acoustic survey biomass estimate and age composition for 2017, 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, the potentially above average 2016 year-class, uncertain selectivity, and uncertainty about historical weight-at-age of fish (i.e., that associated with equilibrium conditions prior to or in the absence of fishing). However, with recruitment being a main source of uncertainty in the projections, 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 0.568 million mt in 2010 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 2018 female spawning biomass is estimated to be 66.7% of the unfished equilibrium level (B_0) with a 95% posterior credibility interval ranging from 33% to 136%. The median estimated 2018 female spawning biomass is 1.36 million mt.

Estimates of historical Pacific hake recruitment indicate very large year classes in 1980, 1984, 1999, and 2010. The U.S. fishery and the coastwide acoustic survey show that the 2014 year-class comprised a very large proportion of the observations in 2017. Uncertainty in estimated recruitments is substantial, especially for 2014 and 2016, as indicated by broad posterior intervals. The fishing intensity on the Pacific Hake stock is estimated to have been below the $F_{40\%}$ target in all years, with the median estimate for 1999 being only slightly below (99.4% of the target). Fishing intensity has been substantially below the $F_{40\%}$ target since 2012, but has been rising since 2015. The official coastwide total catch target adopted by the U.S. and Canada has not been exceeded since 2002. Fishing intensity is estimated to have not exceeded the target rate. Recent catch and levels of depletion are presented in Figure 1.

Management strategy evaluation tools are being 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 being developed, and 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.

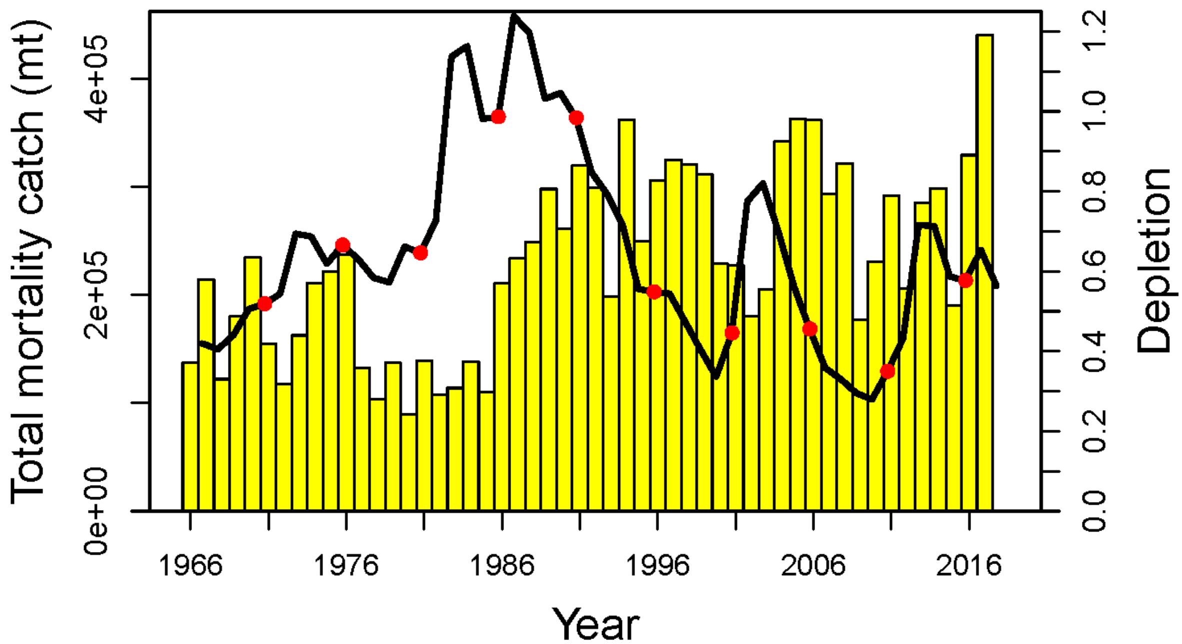

Figure 1. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2017.

For more information, please contact Ian Taylor at Ian.Taylor@noaa.gov or Aaron Berger at Aaron.Berger@noaa.gov.

G. Grenadiers: No research or assessments in 2017

H. Rockfish

1. Research

a) Canary rockfishes (*Sebastes pinniger*) return from the brink: catch, distribution and life history along the U.S. west coast (Washington to California)

Investigators: A.A. Keller, P.H. Frey, J.R. Wallace, M.A. Head, C.R. Wetzel, J.M. Cope and J.H. Harms

We examined catch, distribution, and life history parameters for canary rockfishes *Sebastes pinniger*, an important groundfish that severely limited other U.S. west coast fisheries from 2000 to 2015 due to their overfished status. Average catch varied among years but catch-per-unit-effort, tows with positive catch, and biomass significantly increased since 2007. Weight-length and size-at-age relationships varied by regions separated at key biogeographic breakpoints. Weight increased more rapidly as a function of length north of Pt. Conception, CA, regardless of gender. Growth rates of females and maximum size of males increased with latitude with the greatest increases north of Pt. Conception. Mature females most commonly occurred north of Cape Mendocino, CA and at depths >115 m. Observed variations in spatial patterns (catch and distribution) and life history characteristics combined with reduced occurrence of large/old canary south of Cape Mendocino suggest coast-wide differences that indirectly imply existence of distinct biological stocks. However, since growth and condition appear related to basin-wide (Pacific Decadal Oscillation) and regional (based on *in situ* data) climatic effects, environmental variation may also contribute to the differences observed here.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

b) 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, N. Tolimieri, C.J. Harvey, 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 Kelly Andrews at Kelly.Andrews@noaa.gov.

c) Integrating formal and citizen-science surveys to develop a young-of-year rockfish monitoring plan for the Puget Sound

Investigators: K.S. Andrews, N. Tolimieri, D. Tonnes, R. Pacunski and S. Larson.

The Rockfish Recovery Plan for two species of rockfish in the Puget Sound/Georgia Basin distinct population segment identifies the development of a young-of-year (YOY) abundance index as one its research priorities. We are working with several stakeholders in the region to develop a plan to monitor these individuals across the Puget Sound region. This will include formal site selection of habitats and locations to monitor, a network of individuals and organizations that would be capable of getting out and surveying for YOY at appropriate times during the year. We are also developing analytical tools that will allow for the integration of data collected by both formal scientific surveys and citizen-science surveys. This analysis will determine if agencies and citizen science surveys can able produce an index of YOY abundance using a variety of survey methods or whether a more formal standardization of survey methods needs to be implemented in order to successfully monitor these individuals. This data will be used by the Western Regional Office as one piece of information to help manage and assess the recovery of yelloweye rockfish and bocaccio in the Puget Sound/Georgia Basin region.

For more information please contact Kelly Andrews at Kelly.andrews@noaa.gov.

d) 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 Kelly Andrews at Kelly.Andrews@noaa.gov.

e) 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 NOAA’s Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov.

2. Assessments

a) The Combined Status of Blue and Deacon Rockfishes in U.S. Waters off California and Oregon in 2017

Investigators: E.J. Dick, A. Berger, J. Bizzarro, K.M. Bosley, J. Cope, J. Field, L. Gilbert-Horvath, N. Grunloh, M. Ivens-Duran, R. Miller, K. Privitera-Johnson and B.T. Rodomsky

This assessment reports the status of the Blue Rockfish (*Sebastes mystinus*) and the recently described Deacon Rockfish (*Sebastes diaconus*) as a stock complex in U.S. waters off the coast of California and Oregon. The complex is modeled with two independent stock assessments to approximate spatial variation in species composition, exploitation history, and other factors affecting stock dynamics. The California model represents the stock complex in U.S. waters from Point Conception (34° 27′ North latitude) to the California-Oregon border (42° N. lat.), and the

Oregon model includes all U.S. waters off the coast of Oregon. Recent genetic analyses suggest that Blue Rockfish may be the dominant species south of Monterey Bay, CA, with an increasing fraction of Deacon Rockfish north of Monterey and into Oregon. Historical data streams did not separate the two species or estimate removals at a spatial scale small enough to evaluate assessment boundaries near Monterey Bay.

Harvest of Blue and Deacon Rockfishes (BDR) is primarily from recreational fisheries, with a smaller commercial component coming from longline and hook and line gear types. Total removals in California north of Point Conception increased steadily following World War II, peaking in the late 1970s and early 1980s with annual removals exceeding 600 mt per year (Figure 1). This was followed by a decline in catch until about 2010. Recent years have seen a steady increase in landings, but total removals remain low relative to historical levels. Total landings in Oregon have generally increased through time up until the late-1990s when landings returned to levels in the 2000s that more consistent with those observed in the 1980s (Figure 2). Since the implementation of management limits on the Oregon commercial fishery in 2004 (fleet size limit, annual landing caps, and daily and period landing limits) and on the recreational fishery since 2001 (bag limit reductions), landings have reduced and have been generally stable.

California

The California assessment is structured as a single, sex-disaggregated, unit population, spanning U.S. waters from Point Conception to the California-Oregon border, and operates on an annual time step covering the period 1900 to 2017. The model is conditioned on catch from two sectors (commercial and recreational) divided among eight fleets, and is informed by five abundance indices. Size composition data include lengths from multiple fleets, and a limited number of age structures from the recreational fishery and two research programs.

Spawning output of BDR in California was estimated to be 812 million eggs in 2017 (~95% asymptotic intervals: 0-1,661 million eggs), or 37% of unfished spawning output ("depletion," ~95% asymptotic intervals: 0-78.5%; Figure 1). In California, spawning output declined rapidly in the 1970s and early 1980s, falling below the minimum stock size threshold in the early 1980s, followed by a steady recovery since the late 2000s. The trend in spawning output in 2017 is approaching the management target (40% of unfished spawning output), but the precision of that estimate is low relative to other management reference points (e.g. the $SPR_{50\%}$ proxies for target spawning output and maximum yield). A recent, strong recruitment in 2013 has contributed to the recent increase in BDR biomass in California. Above-average recruitments in 2008 and 2009 are largely driven by recent age data covering the years 2010-2011, but the 2007 recruitment appears to be supported by multiple data sources, as well. Overall, variability in recruitment is average (to low) relative to other rockfish species. The annual (equilibrium) SPR harvest rate for BDR in California has been below target since 2008. Prior to 2008, the harvest rate exceeded the target for over 30 years, regularly reaching levels 50% above target in the 1980s and 1990s. As with current estimates of spawning output, recent estimates of exploitation status are highly uncertain, ranging from 13% to 120% of target in 2016.

The 2017 BDR assessment for California is generally consistent with the results of the 2007 assessment. However, estimates of recent stock size based on the 2017 assessment are imprecise, which results in imprecise forecasts of yield. Uncertainty associated with natural mortality, steepness of the stock-recruitment relationship, the lack of available age data, and gender-specific population dynamics were the main drivers of model imprecision.

Oregon

The Oregon assessment is structured as a single, sex-disaggregated, unit population, spanning Oregon coastal waters, and operates on an annual time step covering the period 1892 to 2017. The model is conditioned on catch from two sectors (commercial and recreational) divided among 5 fleets, and is informed by four abundance indices, length compositions for each fleet, and age compositions from the recreational fishery, the commercial fishery, and from research surveys.

BDR spawning output in Oregon was estimated to be 296 million eggs in 2017 (~95% asymptotic intervals: 64-527 million eggs), which when compared to unfished spawning output equates to a depletion level of 69% (~95% asymptotic intervals: 0.52-0.85; Figure 2) in 2017. In general, spawning output has been trending slightly downwards, with the exception of an increase in the 1990s due to several high recruitment years. Stock size is estimated to be at the lowest level throughout the historic time series in 2017, but the stock is estimated to be well above the management target of $B_{40\%}$. Recruitment variability was dynamic for BDR in Oregon and indicated well above average recruitment in 2013. Other years with relatively high estimates of recruitment were 1993, 1994, and 1995. The BDR stock in Oregon has not been depleted to levels that would provide information on how recruitment changes with spawning output at low spawning output levels. Harvest rates in Oregon have generally increased through time until the mid-1990s when harvest was reduced to a relatively stable level beginning in the 2000s. The maximum relative harvest rate was 0.92 in 1993 (or 92% of the target level) before declining again to around 0.40 in recent years. In 2016, Oregon BDR biomass is estimated to have been 1.73 times higher than the target biomass level, and fishing intensity remains lower than the SPR fishing intensity target.

Major sources of uncertainty associated with the 2017 BDR assessment for Oregon were the size of population scale, natural mortality, gender-specific population dynamics (selectivity), and catch history for certain time periods. Significant uncertainty about recruitment in recent years leads to uncertainty in short term forecasts of yield.

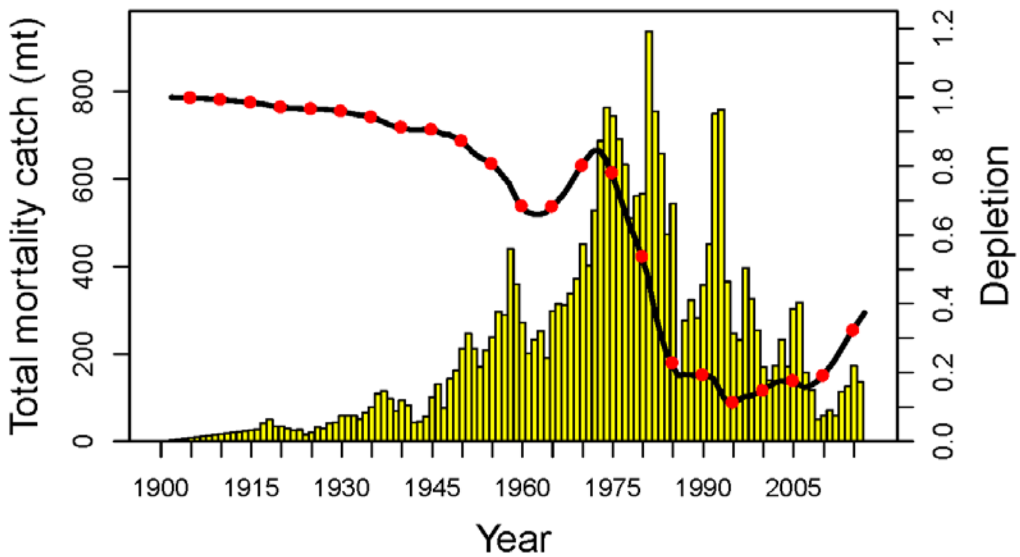

Figure 2. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Blue and Deacon Rockfishes in California, 1900-2016.

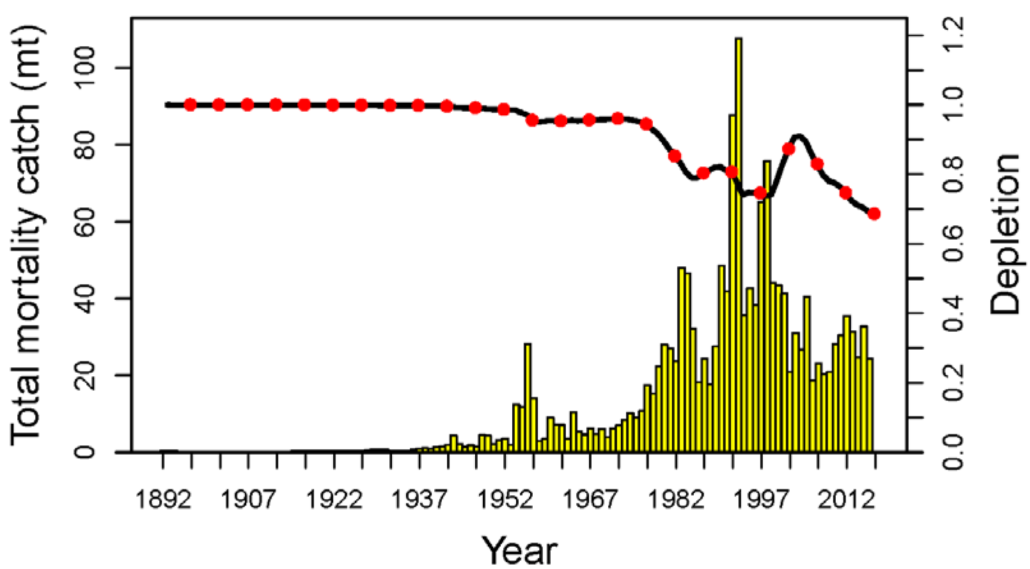

Figure 3. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Blue and Deacon Rockfishes in Oregon, 1892-2016.

For more information, please contact E.J. Dick at Edward.Dick@noaa.gov (California assessment) or Aaron Berger at Aaron.Berger@noaa.gov (Oregon assessment).

b) Darkblotched rockfish

Investigators: J.R. Wallace and V. Gertseva

Darkblotched rockfish (*Sebastes crameri*) in the Northeast Pacific Ocean occur from the southeastern Bering Sea and Aleutian Islands to near Santa Catalina Island in southern California. This species is most abundant from off British Columbia to Central California. Commercially important concentrations are found from the Canadian border through Northern California. This assessment focuses on the portion of the population that occurs in coastal waters of the western United States, off Washington, Oregon and California, the area bounded by the U.S.-Canada border on the north and U.S.-Mexico border on the south. The population within this area is treated as a single coastwide stock, due to the lack of biological and genetic data supporting the presence of multiple stocks.

Darkblotched rockfish has always been caught primarily with commercial trawl gear, as part of a complex of slope rockfish, which includes Pacific ocean perch (*Sebastes alutus*), splitnose rockfish (*Sebastes diploproa*), yellowmouth rockfish (*Sebastes reedi*), and sharpchin rockfish (*Sebastes zacentrus*). Catches taken with non-trawl gear over the years comprised less than 2% of the total coastwide domestic catch. This species has not been taken recreationally.

Catch of darkblotched rockfish first became significant in the mid-1940s when balloon trawl nets (efficient in taking rockfish) were introduced, and due to increased demand during World War II. The largest removals of the species occurred in the 1960s, when foreign trawl fleets from the former Soviet Union, Japan, Poland, Bulgaria and East Germany came to the Northeast Pacific Ocean to target large aggregations of Pacific ocean perch, a species that co-occurs with darkblotched rockfish. In 1966 the removals of darkblotched rockfish reached 4,220 metric tons. By the late-1960s, the foreign fleet had more or less abandoned the fishery. Shoreside landings of darkblotched rockfish rose again between the late-1970s and the late-1980s, peaking in 1987 with landings of 2,415 metric tons. In 2000, the species was declared overfished, and landings substantially decreased due to management regulations. During the last decade the average landings of darkblotched rockfish made by the shoreside fishery was around 120 metric tons. Since the mid-1970s, a small amount of darkblotched rockfish has been also taken as bycatch in the at-sea Pacific hake fishery, with a maximum annual removal of 49 metric tons that occurred in 1995. In 2000, the species was declared overfished, and landings substantially decreased due to management regulations. During the last decade the average landings of darkblotched rockfish made by the domestic trawl fishery was around 120 metric tons.

The first stock assessment of darkblotched rockfish was done in 1993 and stock assessments have been conducted frequently since then. This current update assessment, conducted in 2017, shows that the stock of darkblotched rockfish off the continental U.S. Pacific Coast is currently at 40.03% of its unexploited level. This is just above the management target of 40% of unfished spawning output ($SB_{40\%}$). The time series of total mortality catch (landings plus discards) and estimated depletion for darkblotched rockfish are presented in Figure 1.

The spawning output of darkblotched rockfish started to decline in the 1940s, during World War II, but exhibited a sharp decline in the 1960s during the time of the intense foreign fishery targeting

Pacific ocean perch. Between 1965 and 1976, spawning output dropped from 90% to 64% of its unfished level. Spawning output continued to decline throughout the 1980s and 1990s and in 2000 reached its lowest estimated level of 17% of its unfished state. Since 2000, the spawning output has been slowly increasing, which corresponds to decreased removals due to management regulations.

The assessment model captures some uncertainty in estimated size and status of the stock through asymptotic confidence intervals estimated within the model. To further explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in key model assumptions, a variety of sensitivity runs were performed. A major source of uncertainty in the assessment is related to natural mortality, which was found to have a relatively large influence on the perception of current stock size. Female natural mortality in the assessment is fixed at the value estimated outside the model, based on other life history characteristics of the species, while male natural mortality is estimated within the model. Uncertainty from natural mortality is reported via alternate states of nature in the decision table, bracketing the base model results.

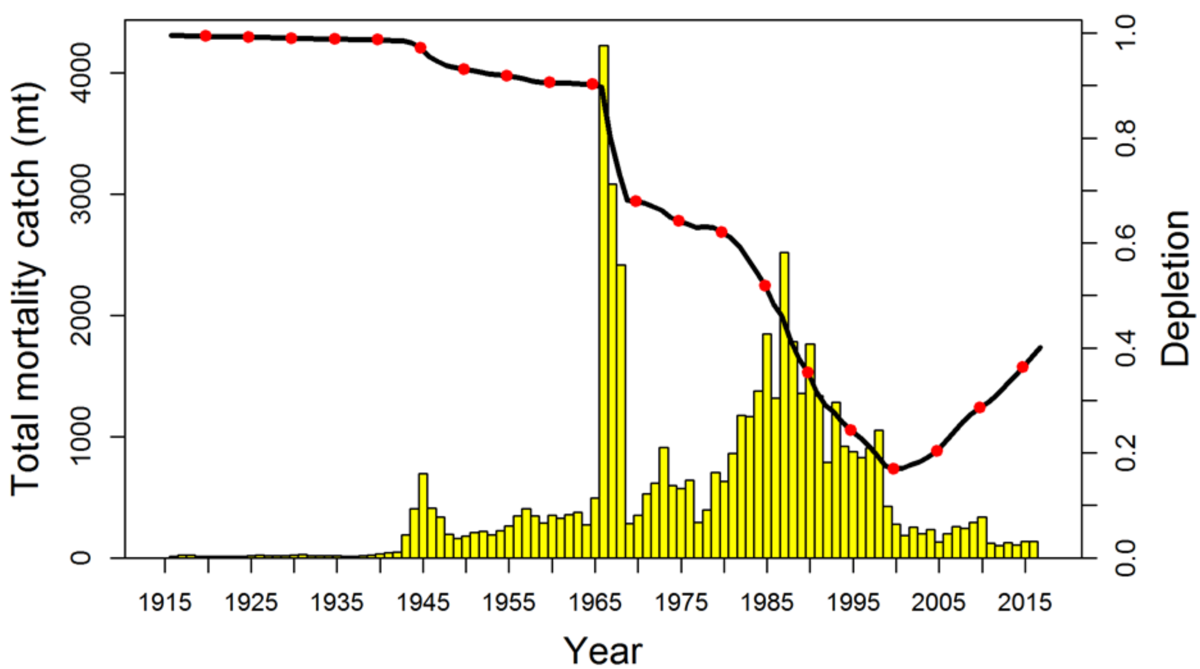

Figure 4. The time series of total mortality catch (bars) and estimated depletion (line) for darkblotched rockfish.

For more information on the darkblotched rockfish assessment, contact John Wallace at John.Wallace@noaa.gov

c) Status of Pacific ocean perch (*Sebastes alutus*) along the US west coast in 2017

Investigators: C. Wetzel, L. Cronin-Fine and K. Johnson

Pacific ocean perch (POP) were the target of distant-water foreign fishing fleets operating off the west coasts of U.S. and Canada during the mid-1960s to mid-1970s. This species also occurs off northern Japan but in the eastern Pacific the species is most abundant in the Gulf of Alaska and occurs as far south as Baja California. The portion of population off the U.S. West Coast, which has generally been treated as a single separate stock for assessment and management purposes, was declared overfished in 1999. The current assessment, as in the most recent previous assessment (Hamel et al. 2011), assumes that POP off the U.S. West Coast are a single, unit stock whose dynamics are independent of POP populations off Canada and in the Gulf of Alaska.

The stock assessment was conducted with Stock Synthesis. Data were compiled into three fishing fleets and several indices of relative abundance. The three fishing fleets were a commercial fleet (combining three gear-types: bottom trawl, midwater trawl and fixed gear), a historical foreign fleet, and the at-sea hake fleet. These fishing fleet definitions were based on discard practices, with unreported discards only assumed to occur in the commercial fleet. For this fleet the model included a retention curve and was informed by observer data on discard rates and length-compositions. Several indices of relative abundance were considered during development of the model, including fishery dependent CPUE indices and fishery independent surveys (POP survey, the Triennial survey, the AFSC slope survey, the NWFSC slope survey and the NWFSC shelf-slope survey). The NWFSC shelf-slope survey provides the longest the time series and is considered the most reliable information on population abundance and data. Selectivity was estimated for each modeled fleet using observations of age and/or length composition data, except for the historical foreign fleet, which assumed the same selectivity as the commercial fleet because no data were available for the foreign fleet to inform its own selection curve. The NWFSC shelf-slope survey age data were included as conditional age-at-length observations (CAAL). For some fleets both the age and length composition data were included. All fleets and surveys were modeled with double normal selectivity parameterizations except for the POP survey, which was forced to estimate an asymptotic selectivity pattern. The assessment model was structured to have two sexes and it started from an unfished non-equilibrium state in 1918 with annual recruitment deviations estimated to 2015.

The model estimates that the spawning output of POP at the start of 2017 was 5,280 million eggs and was at 72% of its unfished level. The trajectory of spawning output has been increasing steadily since about 1990 and underwent a rapid increase during the last three years, largely due to exceptionally large recruitment in 2008 and strong recruitment in 2013. The assessment estimates that the stock's spawning output hovered at or slightly below the Council's target level (40% of unfished) for a period extending from approximately the mid-1970s to the late-1990s with the stock never dropping below the below the Council's minimum stock size threshold (MSST, 25% of unfished, i.e., the stock was never overfished). The estimated dynamics from this stock assessment are considerably different from the prior assessment, which indicated the stock was in a depleted state below the MSST for a period extending from 1980 to 2011, reaching a low point of 14% depletion in 1998. The differing views of the stock from the two assessments was partly due to the inclusion of new data, but primarily driven by changes in key assumed life-history parameters (natural mortality and steepness).

The current data for Pacific ocean perch weighted according to the Francis weighting approach do not contain information regarding steepness or natural mortality and hence both were fixed within the final model. Natural mortality was fixed at the median of the prior, 0.054 yr^{-1}.

The estimated final status was highly dependent upon the assumed steepness value, as is typical for most US west coast groundfish assessments. The data available and the modeling approach applied in 2011 supported a steepness value of 0.40. However, the current data no longer support this value. Models that used the mean to the 2017 steepness prior (0.72) resulted in stock size estimates near unfished conditions leading to low survey catchability for the NWFSC shelf-slope survey that the Scientific and Statistical Committee (SSC) deemed implausible. A steepness value for the final model was determined by a form of model averaging. Spawning output was calculated across a range of steepness values (0.25-0.95) which were considered equally likely. The expected (i.e. arithmetic mean) ending spawning output was calculated and the steepness value most closely associated with the expected value was identified, a value of 0.50. Additional research for alternative approaches for determining steepness values when traditional approaches do not seem appropriate should be identified.

For more information, please contact Chantel Wetzel at Chantel.Wetzel@noaa.gov

d) Stock assessment of the yelloweye rockfish (*Sebastes ruberrimus*) in state and Federal waters off California, Oregon and Washington in 2017

Investigators: V. Gertseva and J.M. Cope
Yelloweye rockfish (*Sebastes ruberrimus*) are distributed in the northeastern Pacific Ocean from the western Gulf of Alaska to northern Baja California. The species is most abundant from southeast Alaska to central California. This assessment reports the status of the yelloweye rockfish resource off the coast of the United States from southern California to the U.S. - Canadian border. The species is modeled as a single stock, but with two explicit spatial areas: waters off California (area 1) and waters off Oregon and Washington (area 2). Each area has its own unique catch history and fishing fleets (commercial and recreational), but the areas are linked by a common stock-recruit relationship.

Yelloweye rockfish have historically been a prized catch in both commercial and recreational fisheries. Commercially, they have been caught by trawl and hook-and-line gear types. They have generally yielded a higher price than other rockfish and have largely been retained when encountered. Catches of yelloweye rockfish increased gradually throughout the first half of the 20th century, with a brief peak around World War II due to increased demand. The largest removals of the species occurred in the 1980s and 1990s and reached 552 mt in 1982.
After 2002 (when yelloweye were declared overfished), total catches have been maintained at much lower levels. Currently, yelloweye are caught only incidentally in commercial and sport fisheries targeting other species that are found in association with yelloweye. The recent fishery encounters a very patchy yelloweye rockfish distribution, and extensive effort is made to avoid all but a small amount of bycatch.

This current assessment, conducted in 2017, estimates that the stock of yelloweye rockfish off the continental U.S. Pacific Coast is currently at 28.4% of its unexploited level. This is above the overfished threshold of SB25%, but below the management target of SB40% of unfished spawning output. Both areas are above the overfished level of 25% (Figure ES-7). This is 7.4 percent higher than the estimated relative spawning output of 21.0% from the previous assessment, conducted in 2011.

This assessment estimates that historically, the coastwide spawning output of yelloweye rockfish dropped below the SB40% target for the first time in 1986, and below the SB25% overfished threshold in 1993 as a result of intense fishing by commercial and recreational fleets. It continued to decline, and dipped to 14.2% of its unfished output in 2000. In 2002, the stock was declared overfished. Since then, the spawning output is slowly increasing due to management regulations implemented for this and other overfished rockfish species.

The time series of total mortality catch (landings plus discards) and estimated depletion for darkblotched rockfish are presented in Figure 1.

The assessment model captures some uncertainty in estimated size and status of the stock through asymptotic confidence intervals estimated within the model. To further explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in key model assumptions, a variety of sensitivity runs were performed. A major source of uncertainty in the assessment is related to natural mortality, which was found to have a relatively large influence on the perception of current stock size. Natural mortality in the assessment is fixed at the value estimated outside the model, based on other life history characteristics of the species, while male natural mortality is estimated within the model. Uncertainty from natural mortality is reported via alternate states of nature in the decision table, bracketing the base model results.

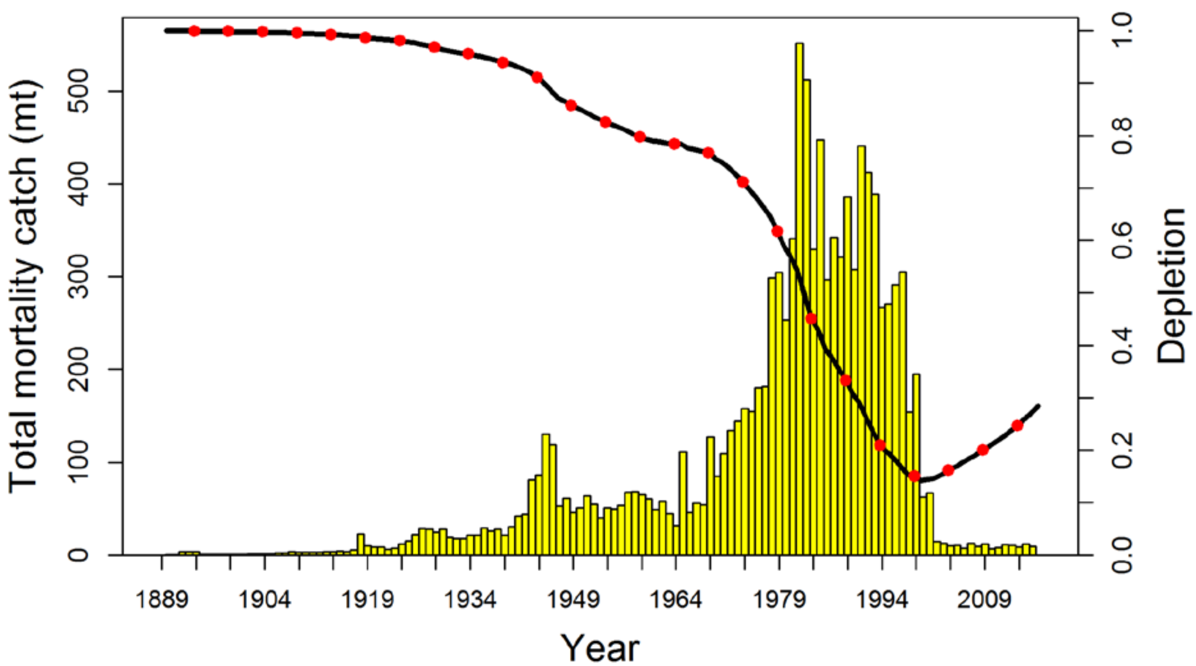

Figure 5. The time series of total mortality catch (bars) and estimated depletion (line) for yelloweye rockfish.

For more information on the darkblotched rockfish assessment, contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

e) Rebuilding analysis for yelloweye rockfish (*Sebastes ruberrimus*) based on the 2017 stock assessment

Investigators: V.V. Gertseva and J.M. Cope

This rebuilding analysis for the stock of yelloweye rockfish (*Sebastes ruberrimus*) in waters off California, Oregon and Washington is based on the 2017 stock assessment. The 2017 assessment model estimated the yelloweye rockfish resource to be at 28.4% of the unexploited equilibrium spawning output at the beginning of 2017. This rebuilding analysis compares the results of applying a suite of potential management actions to the stock for 2019 and beyond, assuming Annual Catch Limits (ACLs) of 20 mt (adopted by the Pacific Fishery Management Council) being removed in 2017 and 2018 and assuming 65% of the ACL (13 mt) being removed in 2017 and 2018.

The results of the analysis show that the value for T_{MIN}, the median year for rebuilding to the target level in the absence of fishing since the year of declaration (2002), is 2025 (revised downward from 2037 in the 2011 rebuilding analysis). The estimated generation time has decreased by one year to 45 years compared to the 2011 analysis. In conjunction with T_{MIN}, the mean generation time dictates the revised estimate of T_{MAX} to be 2070 (decreased from 2083 in the 2011 analysis). The harvest rate in the current rebuilding plan (SPR_{TARGET}) is 76% and T_{TARGET} = 2074. The SPR = 76% harvest rate generates a P_{MAX} (probability of recovery by T_{MAX}) of 100% in the current model, (in the 2011 analysis it was 72.9%).

Fishing at the current SPR target (SPR = 76%) results in an increase from the 20 mt ACL in 2018 to 29 mt in 2019. This harvest rate has a 100% probability of recovery by the year 2027, a 100% probability of recovery by T_{TARGET} = 2074 (the current rebuilding target), and a 100% probability of recovery by T_{MAX} = 2070.

In general, the faster rebuilding times in the 2017 analysis compared to the 2011 analysis are associated with the higher estimates of recruitment compensation (i.e., steepness) and stock status in the 2017 assessment compared to the 2011 assessment.

For more information, please contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

I. Thornyheads: No research or assessments in 2017

J. Sablefish: No assessments in 2017

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:

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 degraphic 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 NOAA's Northwest Fisheries Science Center, Jameal.Samhouri@noaa.gov.

b) Spatial demographic and life-history variation in Lingcod (Ophiodon elongatus) along the U.S. West Coast

Investigators: L. Lam, S. Hamilton, J. Samhouri, J.M. Cope and B. Brown

Fish populations are known to exhibit spatial variability in life history demography due to factors such as temperature, productivity, habitat, and fishing pressure. However, most stock assessment methods neglect to account for these differences and assume that life history traits are constant and unchanging across space and time. As a result, stocks are managed across broad geographic areas with catch quotas, size limits and other regulations applying equally in all places, running the risk of over-harvesting in one area while underharvesting in another. In this study, Lingcod were collected throughout their U.S. range from 7 geographically distinct regions (Alaska to Southern

California) in collaboration with volunteer anglers. We evaluated regional differences in Lingcod sizes and age structure, growth parameters, the timing at 50% maturity, and total mortality rates. Size structure, growth, and maturity rates were found to exhibit a latitudinal cline, where Lingcod in northern waters grew faster, larger, and matured at larger sizes than Lingcod in southern waters. Between sexes, females were found to grow slower, larger, and matured at larger sizes than males. There was no trend in total mortality. Overall, these findings demonstrate significant latitudinal and sex-based variability of life history traits and demography in Lingcod stocks. Implications for applying these findings to other groundfish species and stock assessment models will be discussed.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

2. Assessments

a) 2017 Lingcod Stock Assessment

Investigators: M.A. Haltuch, J.R. Wallace, C.A. Akselrud, J. Nowlis, L.A.K. Barnett, J.L. Valero, T.S. Tsou and L. Lam

This assessment applies to lingcod (*Ophiodon elongatus*) off the West Coast of the United States, and is conducted as two separate single stock assessment models, Washington and Oregon in the north, and California in the south. Four fisheries are modeled in the north: commercial trawl (including limited landings in other net gears), commercial fixed gears, and WA and OR recreational fisheries. Three fisheries are modeled in the south: commercial trawl (including limited landings in other net gears), commercial fixed gears, and CA recreational fisheries. Both models start in1889, at the onset of landings.

This assessment uses the Stock Synthesis (SS) fisheries stock assessment model, version 3.30.03.07. Lingcod has been modeled using various age-structured forward-projection models since the mid-1990s, with the most recent assessments conducted during 2005 (Jagielo et al. 2005) and 2009 (Hamel et al. 2009). Base model data sets include: landings data from each fleet; commercial discard data from the West Coast Groundfish Observer Program (WCGOP), NMFS Triennial bottom trawl survey, NWFSC bottom trawl survey, the NWFSC Hook and Line survey, PacFIN commercial logbook CPUE, OR nearshore commercial CPUE, both WA and OR recreational CPUE (North Only), commercial, recreational, and research length composition data, and survey age composition data (including CAAL data from the NWFSC bottom trawl survey).

The north base model indicates that the lingcod female spawning biomass off of Washington and Oregon declined rapidly in the 1980s and 1990s, hitting a low during the mid-1990s, and has subsequently recovered to levels above the target reference point. The south base model indicates that the lingcod female spawning biomass off of California declined rapidly in the 1970s and early 1980s, reaching a low point during the 1990s, but that the southern stock has recovered above the minimum stock size threshold and remains in the precautionary zone (i.e. below the target reference point).

Stock status is currently estimated to be above the target reference point (40% of the estimated unfished spawning biomass) at 57.9% (47.9–67.8, 95% asymptotic interval) in the north and in the precautionary zone at 32.1% (11.1–53.1, 95% asymptotic interval) in the south. Unfished spawning biomass was measured at 37,947 mt (25,776–50,172 mt, 95% asymptotic interval) in the north and 20,260 mt (15,304–25,215 mt, 95% asymptotic interval) in the south. Spawning biomass at the beginning of 2017 was estimated to be 21,976 mt (12,517-31,434 mt, 95% asymptotic interval) in the north and 6,509 mt (1,624–11,394 mt, 95% asymptotic interval) in the south. The north stock is estimated to have been below the target reference point from approximately the 1980s through the early 2000s, while the south stock is currently estimated to be in the precautionary zone.

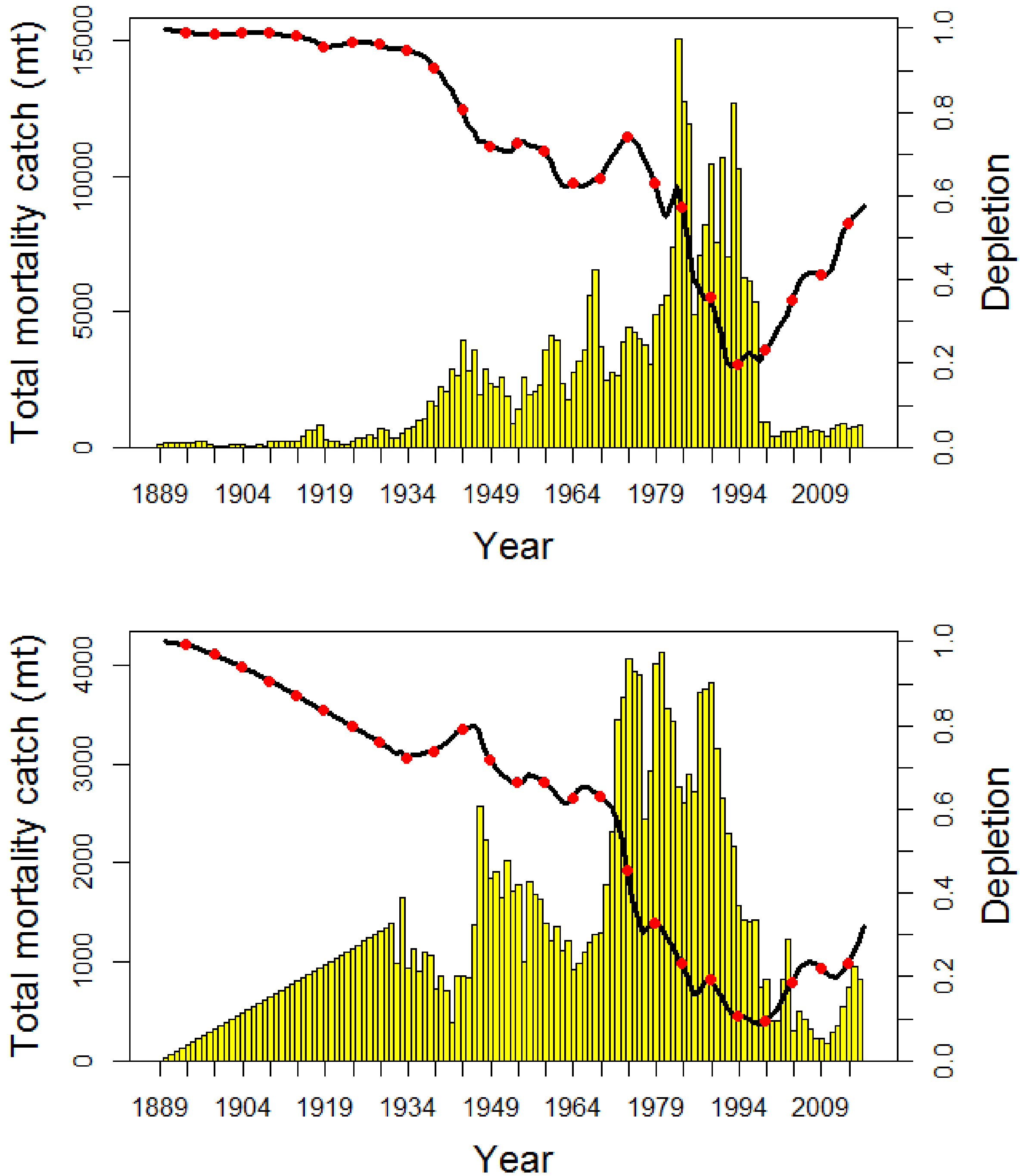

Figure 6. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for the Lincod north (upper panel) and south (lower panel) stocks.

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L. Atka mackerel: No research or assessments in 2017

M. Flatfish: No research or assessments in 2017

N. Pacific halibut & IPHC activities: No research or assessments in 2017

O. Other groundfish species: No assessments in 2017

1. Research

a) 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.

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VII. Ecosystem Studies

A. Assessment Science

1. Modeling

a) Addressing cryptic species issues in stock assessments as exemplified by Blue Rockfish (*Sebastes* mystinus) and Deacon Rockfish (*S.* diaconus)

Investigators: J. Bizzarro, E. Gilbert-Horvath, E.J. Dick, A. Berger, K. Schmidt, D. Person, C. Petersen, L. Katutzi, R. Miller, J. Field and John Garza

The discovery of cryptic species expands our understanding of biodiversity and provides avenues for further study but also presents significant management challenges, as exemplified in the 2017 stock assessment of the Blue and Deacon Rockfish stock complex. Genetic analyses recently demonstrated that the nominal Blue Rockfish, *Sebastes mystinus*, is actually a cryptic species pair that included Deacon Rockfish, *S. diaconus*. We utilized a variety of approaches to estimate and compare species-specific characteristics of the spatial distribution and life history traits of Blue and Deacon Rockfishes. Genetic assignment of modern fin tissues and historic otoliths to species facilitated subsequent analyses. Deacon Rockfish comprised the majority of individuals sampled between Half Moon Bay and Oregon and were uncommon in southern California. Blue Rockfish were more common from Monterey Bay to southern California. Overall, Deacon Rockfish females grew to larger sizes at slower growth rates than Blue Rockfish females but male growth parameters were similar by comparison. Within species, Deacon Rockfish reached larger sizes at slower growth rates in California. Blue Rockfish reached larger sizes at faster growth rates in Oregon, whereas those south of Point Conception grew larger at faster rates than those in northern California. The multidisciplinary nature of this study and the techniques and protocols we established may provide a model for future stock assessment work on cryptic species.

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b) Closing the Loop: On Stakeholder Participation in Management Strategy Evaluation

Investigators: D. Goethel, A. Berger, J. Deroba, S. Gaichas, M. Karp, S. Lucey, P. Lynch, S. Miller, J. Walter and M. Wilberg

Management strategy evaluation (MSE) is a simulation-based analytical approach used to examine the efficacy of various management options to achieve fishery- and ecosystem-related objectives while integrating over system uncertainties. As a form of structured decision analysis, MSE is amenable to stakeholder involvement which can be used to reduce implementation barriers associated with non-transparent decision-making procedures. In this paper, we outline the basic components that define MSE with focus on stakeholder engagement and provide suggestions to improve ownership of MSE results by all user groups involved in the fishery and broader ecosystem. Specifications that go into an MSE are often case-specific, including the aspirations of stakeholders involved, which can dictate the need for customized analytical, visual, and educational tools. No matter the context, communication and education are critical components to implementing a successful MSE. Communication breakdown can be avoided by clearly defining roles, responsibilities and terms of engagement for all involved, clearly laying out the goals and objectives of the MSE before modeling has begun, and providing opportunities to revisit the goals throughout the MSE process.

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c) Shifts in stock productivity: recruitment potential and static/dynamic reference points

Investigator: Aaron Berger

Reference points guide rational fishery management systems worldwide, and often form the basis for defining sustainable fishing levels and population sizes, population states that result in preferred fishery performance, and population states that trigger management action. Many reference points used for determining stock status are pre-supposed by equilibrium population assumptions, which may be inappropriate when stock productivity differs in space or through time as a result of persistent environmental change, variable management and fishing practices, predator-prey dynamics, and many other factors. Static reference points may not be robust to new equilibrium states (e.g., due to regime shifts), leading to a mismatch between the productive capacity of the population and the benchmarks used to guide management. Dynamic reference points, e.g. dynamic B_0, could be used to take into account shifts in the underlying productivity of the population, but careful consideration of the recruitment dynamics is warranted to ensure that management benchmarks are informed by current productivity potential, not cyclical, white noise, or other process-based errors in recruitment estimation. Static and dynamic reference points were calculated for 18 recent west coast groundfish stock assessments to first evaluate if differences in depletion-based stock status indicators were apparent between the two approaches. Second, a set of simulations were conducted to further compare differences between static and dynamic reference points under alternative states of nature driven by recruitment dynamics (productivity regime), fishing dynamics (mortality regime), and species biology and longevity. The use of dynamic B_0 often implies a different state of the stock under directional productivity regime shifts, but is more similar to static (equilibrium) B_0 under cyclic or white noise productivity scenarios. Despite the approach used to define reference points for current stock status and management, it remains unclear how best to forecast recruitment when developing stock rebuilding plans and is an area of future research.

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d) Fisheries management of spatially structured populations: addressing the quandary of allocating harvest quotas

Investigators: K.M. Bosley, A. Berger, D. Goethel, J. Deroba, K. Fenske, D. Hanselman, B. Langseth and A. Schueller

Ignoring spatial population structure in the development of fisheries management advice can affect population resilience and yield. However, the resources required to develop spatial stock assessment models that match the scale of spatial management are often unavailable. As a result, quota recommendations from spatially aggregated assessment models are commonly divided among management areas based on empirical or *ad hoc* methods. We applied a spatially explicit simulation model to two case studies (Pacific hake and sablefish) to explore how population structure and connectivity influence spatial distribution of harvest and to evaluate several empirical quota allocation methods for approximating maximum system yield. Although using spatially resolved data to inform catch allocation provided a reasonable approximation for maximizing system-level yield, area-specific harvest rates were often biased, which led to depletion within management units. When connectivity existed through post-recruitment movement of individuals, results demonstrated that multiple combinations of fishing mortality rate applied across management units produced the same maximum system yield, suggesting that socioeconomic factors could be important in determining which harvest scheme is truly ‘optimal’ with desired conservation outcomes.

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e) Estimating recruitment in spatially-explicit stock assessment models: the impacts of

population structure assumptions on recruitment bias

Investigators: K.M. Bosley, A. Berger, D. Goethel, J. Deroba, K. Fenske, D. Hanselman, B. Langseth and A. Schueller

Recruitment estimation within stock assessment models can be difficult when limited data on year class strength exist, and estimation difficulties may be exacerbated as demographic data become sparser (i.e., when data are disaggregated to perform a spatially explicit stock assessment). However, spatially explicit modeling techniques may improve estimates of population productivity by simultaneously assessing individual spawning components (along with the connectivity among them) instead of aggregating data and parameter estimates across multiple reproductive units, which commonly occurs with closed population models. Although spatial models can more accurately represent the underlying population dynamics, there has been little research into the potential risk associated with incorrect assumptions regarding population structure and how it might impact resulting productivity estimates. We develop a spatially explicit, tag-integrated assessment model that directly estimates movement and is able to account for a variety of population structure assumptions (e.g., panmictic, single population with spatial heterogeneity, metapopulation, and natal homing). A simulation framework is applied to compare bias in recruitment estimates when population structure is correctly or incorrectly specified for both spatially explicit and spatially aggregated assessment methods. We also investigate how recruitment and movement assumptions interact within spatially explicit models to determine whether certain parameterizations may act to reduce parameter correlation. When the underlying population structure is correctly specified, recruitment and movement are often well estimated. However, misspecification of spatial structure can lead to biases equivalent to or worse than assuming a panmictic population. Even when incorrectly specified, spatial models may be more useful than aggregated models, because outputs are provided on scales more likely to represent real-world biology and may better inform fine-scale spatial management.

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f) When to use spatially-explicit fishery stock assessments: Are good data good enough?

Investigators: K.M. Bosley, A. Berger, D. Goethel, J. Deroba, K. Fenske, D. Hanselman, B. Langset and A. Schueller

Spatially-explicit stock assessment models can provide information on spatiotemporal variation in population parameters, which are necessary to inform fine-scale fishery management decisions. However, spatial models often require spatially-explicit data that may be sparse or unavailable. While an increasing number of assessment methods employ spatially explicit techniques, simulation studies have yet to evaluate the potential biases associated with both the quality and quantity of data and the effect of mis-diagnosing spatial population structure. We develop a generalized spatially explicit, tag-integrated assessment model that directly estimates movement and is able to account for common spatial population structures (e.g., panmictic, single population with spatial heterogeneity, metapopulation, and natal homing). A simulation framework is then applied, which generates both tagging and population data, to determine the robustness of various parametrizations of the assessment model to a variety of data quality, quantity, and collection scenarios. Results indicate that incorporating tagging data can greatly improve estimation of movement rates and management quantities, but is not strictly required for robust management depending on the underlying population structure, connectivity and assessment parametrization. Based on these simulations, we provide general guidelines on the data needed to assess spatially structured populations, and provide recommendations about tag-recapture experimental design that can be used to better inform tag-integrated assessment frameworks. Appropriate data can allow informed decisions about population structure and connectivity that then make spatially explicit models valid, potentially achieving greater accuracy in parameter estimates than traditional spatially aggregated assessment models.

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g) Spatial growth variability in marine fish: example from northeast Pacific groundfish

Investigators: V.V. Gertseva, S.E. Matson and J.M. Cope

Life history parameters of marine fishes vary in space and time, often in response to multiple factors. Understanding this variability is vital to resource management and ecological knowledge. We examined spatial variability in growth of eight groundfish species in the northeast Pacific Ocean to identify shared spatial patterns and hypothesize about common mechanisms behind them. Growth parameters were estimated in different areas over the latitudinal range of the species and multiple hypotheses were tested as to whether growth parameters differ in all the areas, at specific area breaks or exhibit a latitudinal cline. Clear differences emerged among the species examined. Shelf species exhibited the highest growth rate between Cape Blanco and Cape Mendocino, which may in part be attributed to area-specific upwelling patterns in the California Current ecosystem, when nutrient rich deep water is brought to the surface southward of Cape Blanco and is uniquely distributed throughout this area, providing favorable conditions for primary productivity. Slope species showed a cline in asymptotic size (L_∞), with L_∞ increasing from south to north. This cline, previously attributed to fishery removals, also fits a specific case of the widely described Bergmann's rule, and we explore specific potential ecological mechanisms behind this relationship.

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h) Novel Catch Projection Model for a Commercial Groundfish Catch Shares Fishery

Investigators: S. Matson, I. Taylor, V.V. Gertseva and M. Dorn

Fishery catch projection models play a central role in fishery management, yet are underrepresented in the literature. A wide range of statistical approaches are employed for the task, including multiple regression models, autoregressive methods, different classes of generalized linear models, mixed model approaches and many others. However, the applicability of these statistical approaches can be limited in specific cases of complex fisheries. We developed a new catch projection model for quota-based fisheries on the West Coast of the U.S. to forecast annual catch and landings for a variety of groundfish species in the Northeast Pacific Ocean. The model projects total and landed catch of each species by individual vessel and for the entire fishing fleet, using a combination of weighted mean vessel attainment rates and historical catch rates, and generates uncertainty intervals. It demonstrated an ability to produce highly accurate predictions at both fleet (R^2=0.9847) and vessel levels (R^2=0.8447). The model framework contains much built-in versatility, is generalizable enough to serve a variety of quota based applications, and the approach can be tailored to other fisheries around the world. With the proliferation of quota based management of commercial fisheries, tools such as this one are increasingly useful for sustainable management of fishery resources.

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i) Incorporating Climate Driven Growth Variability into Stock Assessment Models: a Simulation-based Decision Table Approach

Investigators: Q. Lee, J. Thorson, V.V. Gertseva and A. Punt

Indices of annual growth variation are not routinely incorporated into fisheries stock assessment models, due to a lack of a general framework for deciding when to include these indices, and of a mechanistic understanding about growth drivers. Such incorporation may also not necessarily lead to improved estimation or management performance. We develop a way to incorporate such an index into an assessment model (Stock Synthesis), and use risk analysis to evaluate its management-related advantages and shortcomings. We applied this method to splitnose rockfish (*Sebastes diploproa*), where a previously-developed growth index is highly correlated with decadal-scale climate indices. We find that including a similar index in the simulated assessment increases precision and reduces bias of parameter estimates. However, not including an index or including a completely erroneous index led to highly imprecise estimates when growth was strongly climate-driven. Including this growth index when individual growth was actually constant did not lead to poorer estimation performance. The risk analysis approach can be applied to other stocks to evaluate the consequences of including time-varying growth indices.Indices of annual growth variation are not routinely incorporated into fisheries stock assessment models, due to a lack of a general framework for deciding when to include these indices, and of a mechanistic understanding about growth drivers. Such incorporation may also not necessarily lead to improved estimation or management performance. We develop a way to incorporate such an index into an assessment model (Stock Synthesis), and use risk analysis to evaluate its management-related advantages and shortcomings. We applied this method to splitnose rockfish (*Sebastes diploproa*), where a previously-developed growth index is highly correlated with decadal-scale climate indices. We find that including a similar index in the simulated assessment increases precision and reduces bias of parameter estimates. However, not including an index or including a completely erroneous index led to highly imprecise estimates when growth was strongly climate-driven. Including this growth index when individual growth was actually constant did not lead to poorer estimation performance. The risk analysis approach can be applied to other stocks to evaluate the consequences of including time-varying growth indices.

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j) Improving stock assessments of a wide-ranging species: Estimation of spatial and temporal variability in life history parameters of longnose skate (*Raja rhina*).

Investigators: T. Helser, T. Essington, V.V. Gertseva, O. Ormseth, J. King, B. Matta, C. Gburski

Skates are commonly taken as bycatch in Pacific groundfish fisheries, yet most species are managed as data-poor stocks because relatively little is known regarding their life history parameters. Increasing exploitation of this group is of concern because their biological traits (e.g., long life span, slow growth, low fecundity, and late age at maturity) make them vulnerable to overfishing and prone to slow recovery. The longnose skate (*Raja rhina*), a common large-bodied species ranging from the eastern Bering Sea to Baja California, is managed under U.S. and Canadian federal jurisdiction. Despite the regular occurrence of this species in fisheries catches throughout its range, stock assessments for longnose skate in its three main management regions (U.S. West Coast, British Columbia, and Gulf of Alaska) are considered data poor and/or highly uncertain. Key data limitations are the paucity of age estimates across all three regions and potential biases owing to inconsistency in age determination procedures among laboratories. However, due to recent cooperative efforts between the Alaska Fisheries Science Center (AFSC), Northwest Fisheries Science Center (NWFSC), and Canadian Department of Fisheries and Oceans (DFO), longnose skate age estimation at AFSC was found to be accurate based on bomb-derived radiocarbon (^{14}C) validation. Further, over 2,000 age structures have been collected from longnose skate across all three management regions since 2008 and are awaiting age determination. The goals of this international collaborative project are to: 1) standardize the age determination protocol across the three federal agencies responsible for skate management in the U.S. West Coast (NWFSC), British Columbia, Canada (DFO), and the Gulf of Alaska (AFSC) based on validated age determination criteria (King et al. 2015), 2) estimate ages for a backlog of longnose skate vertebrae and reexamine historically aged specimens based on the standardized protocol, and 3) estimate life history parameters and examine spatial and temporal variability in those vital rates for sensitivity analysis in stock assessments.

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k) 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 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 homogeneously distributed). Incorporating spatially generalized operating models, such as the one developed here, into management strategy evaluations will help develop management procedures that are more robust to spatial complexities.

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l) Space oddity: The mission for spatial integration

Investigators: A. Berger, D. Goethel, P. Lynch, T. Quinn, S. Mormede, J. McKenzie and A. Dunn

Fishery management decisions are commonly guided by stock assessment models that aggregate outputs across the spatial domain of the species. With refined understanding of spatial population structures, scientists have begun to address how spatiotemporal mismatches among the scale of ecological processes, data collection programs, and stock assessment methods (or assumptions) influence the reliability and, ultimately, appropriateness of regional fishery management (e.g., assigning regional quotas). Development and evaluation of spatial modeling techniques to improve fisheries assessment and management have increased rapidly in recent years. We overview the historical context of spatial models in fisheries science, highlight recent advances in spatial modeling, and discuss how spatial models have been incorporated into the management process. Despite limited examples where spatial assessment models are used as the basis for management advice, continued investment in fine-scale data collection and associated spatial analyses will improve integration of spatial dynamics and ecosystem-level interactions in stock assessment. In the near future, spatiotemporal fisheries management advice will increasingly rely on fine-scale outputs from spatial analyses.

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m) The performance and trade-offs of alternative harvest control rules to meet management goals for U.S. west coast flatfish fish stocks

Investigators: C. Wetzel and A. Punt

U.S. federal fisheries managers are mandated to obtain optimum yield while preventing overfishing. However, optimum yield is not well defined and the concept of maximum sustainable yield (MSY) has often been applied to provide an upper bound for the optimum yield value, but determining the MSY, identifying the relative biomass that produces MSY and the associated fishing rate required (F_{MSY}) is difficult. The Pacific Fishery Management Council, which manages groundfish stocks off the U.S. west coast, has employed proxy targets in lieu of species-specific estimates of MSY, B_{MSY}, and F_{MSY}. The proxy targets are life history specific, with flatfish stocks managed using a target B_{PROXY} of 0.25 of unfished biomass and a harvest control rule that applies an exploitation rate equal to a spawner-per-recruit harvest rate of $F_{0.30}$, with a linear reduction of catch to zero if the stock falls below 5% of unfished biomass (B_{LIMIT}). A management strategy evaluation was performed to explore the performance of the current harvest control rule applied to flatfish stocks to meet management goals, along with alternative harvest control rules that explore varying the values for B_{PROXY}, B_{LIMIT}, and F_{SPR}. Each of the harvest control rules explored maintained stocks at or near B_{PROXY} when stock-recruit steepness was 0.85 or greater, with very low probabilities of reducing relative biomass below a minimum stock size threshold (set at 0.50 B_{PROXY} of each harvest control rule). The most aggressive harvest control rule, which applied a B_{PROXY} of 0.20 and a target harvest rate of $F_{0.25}$, led to fishing rates that exceeded the operating model F_{MSY} values for low steepness (0.75), reducing the stock below B_{PROXY} with catches exceeding MSY. Trade-offs exist among alternative harvest control rules where the more aggressive harvest control rules resulted in higher average catches, but with an increase in the average annual variation in catches and a decrease probability of the relative biomass being with 10% of the B_{PROXY}. The trade-offs among the performance metrics and alternative harvest control rules coupled with the risk to the resource across a range of life histories should be carefully considered by fishery managers when selecting a harvest control rule that will meet the goals of management.

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n) Extending integrated stock assessment models to use non-depensatory three-parameter stock-recruitment relationships

Investigators: A. Punt and J.M. Cope

Stock assessments based on the integrated paradigm often include an underlying stock-recruitment relationship. This, along with estimates of fishery selectivity and biological parameters, 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 assumed in the harvest control rules that are 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 the commonly used Beverton-Holt or Ricker relationships. Use of 2-parameter stock-recruitment relationships (SRRs) consequently restricts the ability to fully quantify the uncertainty associated with estimating BMSY and FMSY because 2-parameter SRRs restrict the potential range of values for BMSY/B0. In principle, BMSY/B0 and FMSY can be more independent if the stock-recruitment relationship is more general than these 2-parameter SRRs. 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 while approaching the limit of zero population size. Bayesian assessments of three example groundfish species off the US west coast (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 allowing for a 3-parameter stock-recruitment relationship.

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o) Eliciting expert knowledge to inform stock status for data-limited stock assessments

Investigators: A. Chrysafi, J.M.Cope and A. Kuparinenc

Data-limited fisheries are a major challenge for stock assessment analysts, as many traditional data-rich models cannot be implemented. Approaches based on stock reduction analysis offer simple ways to handle low data availability, but are particularly sensitive to assumptions on relative stock status (i.e., current biomass compared to unperturbed biomass). For the vast majority of data-limited stocks, stock status is unmeasured. The present study presents a method to elicit expert knowledge to inform stock status and a novel, user-friendly on-line application for expert elicitation. Expert opinions are compared to stock status derived from data-rich models. Here, it is evaluated how experts with different levels of experience in stock assessment performed relative to each other and with different qualities of data. Both “true” stock status and expert experience level were identified as significant factors accounting for the error in stock status elicitation. Relative stock status was the main driver of imprecision in the stock status prior (e.g., lower stock status had more imprecision in elicited stock status). Data availability and life-history information were not identified to be significant variables explaining imprecision in elicited stock status. All experts, regardless of their experience level, appeared to be risk neutral in the central tendency of stock status. Given the sensitivity to stock status misspecification for some popular data-limited methods, stock status can be usefully elicited from experts, but expert subjectivity and experience should be taken under consideration when applying those values.

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p) Depletion-Based Stock Reduction Analysis estimates of sustainable yield for cabezon (*Scorpaenichthys marmoratus*) in waters off Washington State.

Investigators: J.M. Cope, E.J. Dick and J. Hastie

This report estimates yield for cabezon (*Scorpaenichthys marmoratus*) in waters off Washington State, using Depletion-Based Stock Reduction Analysis (DB-SRA) (Dick and MacCall 2011). This method requires annual removals, estimates of relative stock status for a given year y (SBy/SB0), natural mortality (M), the ratio of the fishing rate at maximum sustainable yield to M (FMSY/M) and age at maturity.

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q) Three problems with the conventional delta-model for biomass sampling data, and a computationally efficient alternative.

Investigator: J. Thorson

Ecologists often analyse biomass sampling data that result in many zeros, where remaining samples can take any positive real number. Samples are often analysed using a "delta model" that combines two separate generalized linear models, GLMs (for encounter probability and positive catch rates), or less often using a compound Poisson-gamma (CPG) distribution that is computationally expensive. I discuss three theoretical problems with the conventional delta-model: difficulty interpreting covariates for encounter-probability; the assumed independence of the two GLMs; and the biologically implausible form when eliminating covariates for either GLM. I then derive an alternative "Poisson-link model" that solves these problems. To illustrate, I use biomass samples for 113 fish populations to show that the Poisson-link model improves fit (and decreases residual spatial variation) for >80% of populations relative to the conventional delta-model. A simulation experiment illustrates that CPG and Poisson-link models estimate covariate effects that are similar and biologically interpretable. I therefore recommend the Poisson-link model as useful alternative to the conventional delta-model with similar properties to the CPG distribution.

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r) Predicting life history traits for all fishes worldwide.

Investigator: J. Thorson, S. Munch, J.M. Cope and J. Gao

Scientists and resource managers need to know life history parameters (e.g., average mortality rate, individual growth rate, maximum length or mass, and timing of maturity) to understand and respond to risks to natural populations and ecosystems. For over 100 years, scientists have identified "life history invariants" (LHI) representing pairs of parameters whose ratio is theorized to be constant across species. LHI then promise to allow prediction of many parameters from field measurements of a few important traits. Using LHI in this way, however, neglects any residual patterns in parameters when making predictions. We therefore apply a multivariate model for eight variables (seven parameters and temperature) in over 32,000 fishes, and include taxonomic structure for residuals (with levels for class, order, family, genus, and species). We illustrate that this approach predicts variables probabilistically for taxa with many or few data. We then use this model to resolve three questions regarding life history parameters in fishes. Specifically we show that (1) on average there is a 1.24% decrease in the Brody growth coefficient for every 1% increase in maximum size; (2) the ratio of natural mortality rate and growth coefficient is not an LHI but instead varies systematically based on the timing of maturation, where movement along this life history axis is predictably correlated with species taxonomy; and (3) three variables must be known per species to precisely predict remaining life history variables. We distribute our predictive model as an R package, FishLife, to allow future life history predictions for fishes to be conditioned on taxonomy and life history data for fishes worldwide. This package also contains predictions (and predictive intervals) for mortality, maturity, size, and growth parameters for all described fishes.

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s) Applying a new ensemble approach to estimating stock status of marine fisheries around the world

Investigators: A. Rosenberg, K. Kleisner, J. Afflerbach, S. Anderson, M. Dickey-Collas, A. Cooper, M. Fogarty, E. Fulton, N. Gutierrez, K. Hyde, E. Jardim, O. Jensen, T. Kristiansen, C. Longo, C. Minte-Vera, C. Minto, I. Mosqueira, C. Osio, D. Ovando, E. Selig, J. Thorson, J. Walsh and Y. Ye

The exploitation status of marine fisheries stocks worldwide is of critical importance for food security, ecosystem conservation, and fishery sustainability. Applying a suite of data-limited methods to global catch data, combined through an ensemble modeling approach, we provide quantitative estimates of exploitation status for 785 fish stocks. Fifty-three percent (414 stocks) are below BMSY and of these, 265 are estimated to be below 80% of the BMSY level. While the 149 stocks above 80% of BMSY are conventionally considered "fully exploited," stocks staying at this level for many years, forego substantial yield. Our results enable managers to consider more detailed information than simply a categorization of stocks as "fully" or "over" exploited. Our approach is reproducible, allows consistent application to a broad range of stocks, and can be easily updated as new data become available. Applied on an ongoing basis, this approach can provide critical, more detailed information for resource management for more exploited fish stocks than currently available.

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t) Producing distribution maps for informing ecosystem-based fisheries management using a comprehensive survey database and spatio-temporal models

Investigators: A. Grüss, J. Thorson, E. Babcock and J. Tarnecki,

Ecosystem-based fisheries-management (EBFM) is increasingly used in the United States (U.S.), including in the Gulf of Mexico (GOM). Producing distribution maps for marine organisms is a critical step in the implementation of EBFM. In particular, distribution maps are important inputs for many spatially-explicit ecosystem models, such as OSMOSE models, as well as for biophysical models used to predict annual recruitment anomalies due to oceanographic factors. In this study, we applied a recently proposed statistical modelling framework to produce distribution maps for: (i) younger juveniles (ages 0–1) of red snapper (Lutjanus campechanus), red grouper (Epinephelus morio), and gag (Mycteroperca microlepis), so as to be able to define the potential larval settlement areas of the three species in a biophysical model; and (ii) the functional groups and life stages represented in the OSMOSE model of the West Florida Shelf ("OSMOSE-WFS"). This statistical modelling framework consists of: (i) compiling a large database blending all of the encounter/non-encounter data of the GOM collected by the fisheries-independent and fisheries-dependent surveys using random sampling schemes, referred to as the "comprehensive survey database;" (ii) employing the comprehensive survey database to fit spatio-temporal binomial generalized linear mixed models (GLMMs) that integrate the confounding effects of survey and year; and (iii) using the predictions of the fitted spatio-temporal binomial GLMMs to generate distribution maps. This large endeavour allowed us to produce distribution maps for younger juveniles of red snapper, red grouper and gag and nearly all of the other functional groups and life stages represented in OSMOSE-WFS, at different seasons. Using Pearson residuals, the probabilities of encounter predicted by all spatio-temporal binomial GLMMs were demonstrated to be reasonable. Moreover, the results obtained for younger juvenile fish concur with the literature, provide additional insights into the spatial distribution patterns of these life stages, and highlight important future research avenues.

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u) Confronting preferential sampling in count and occupancy surveys: diagnosis and triage

Investigators: P.B. Conn, J. Thorson and D.S. Johnson

Population surveys are often used to estimate the density, abundance, or distribution of natural populations. Recently, model-based approaches to analyzing survey data have become popular because one can more readily accommodate departures from pre-planned survey routes and construct more detailed maps than one can with design-based procedures.

Spatial models for population distributions (SMPDs) often make the implicit assumption that locations chosen for sampling and animal abundance at those locations are conditionally independent given modelled covariates. However, this assumption may be violated when survey effort is non-randomized, leading to preferential sampling.

We develop a hierarchical statistical modelling framework for detecting and alleviating the biasing effects of preferential sampling in spatial distribution models fitted to count data. The approach works by specifying a joint model for population density and the locations selected for sampling, and specifying a dependent correlation structure between the two processes.

Using simulation, we show that moderate levels of preferential sampling can lead to large (e.g. 40%) bias in estimates of animal density and that our modelling approach can considerably reduce this bias. In contrast, preferential sampling did not appear to bias inferences about parameters informing species–habitat relationships (i.e. slope parameters).

We apply our approach to aerial survey counts of bearded seals (Erignathus barbatus) in the eastern Bering Sea. As expected, models with a preferential sampling effect led to lower abundance than those without. However, several lines of reasoning (better predictive performance, higher biological realism) led us to prefer models without a preferential sampling effect for this dataset.

When population surveys break from traditional scientific survey design principles, ecologists should recognize the potentially biasing effects of preferential sampling when estimating population density or occurrence. Joint models, such as those described in this paper, can be used to test and correct for such biases. However, such models can be unstable; ultimately the best way to avoid preferential sampling bias is to incorporate design-based principles such as randomization and/or systematic sampling into survey design.

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v) Global fishery dynamics are poorly predicted by classical models

Investigators: C. Szuwalski and J. Thorson

Fisheries dynamics can be thought of as the reciprocal relationship between an exploited population and the fishers and/or managers determining the exploitation patterns. Sustainable production of protein of these coupled human-natural systems requires an understanding of their dynamics. Here, we characterized the fishery dynamics for 173 fisheries from around the globe by applying general additive models to estimated fishing mortality and spawning biomass from the RAM Legacy Database. GAMs specified to mimic production models and more flexible GAMs were applied. We show observed dynamics do not always match assumptions made in management using "classical" fisheries models, and the suitability of these assumptions varies significantly according to large marine ecosystem, habitat, variability in recruitment, maximum weight of a species and minimum observed stock biomass. These results identify circumstances in which simple models may be useful for management. However, adding flexibility to classical models often did not substantially improve performance, which suggests in many cases considering only biomass and removals will not be sufficient to model fishery dynamics. Knowledge of the suitability of common assumptions in management should be used in selecting modelling frameworks, setting management targets, testing management strategies and developing tools to manage data-limited fisheries. Effectively balancing expectations of future protein production from capture fisheries and risk of undesirable outcomes (e.g., "fisheries collapse") depends on understanding how well we can expect to predict future dynamics of a fishery using current management paradigms.

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w) Uniform, uninformed or misinformed?: The lingering challenge of minimally informative priors in data-limited Bayesian stock assessments

Investigators: J. Thorson and J.M. Cope

A Bayesian approach to parameter estimation in fisheries stock assessment is often preferred over maximum likelihood estimates, and fisheries management guidelines also sometimes specify that one or the other paradigm be used. However, important issues remain unresolved for the Bayesian approach to stock assessment despite over 25 years of research, development, and application. Here, we explore the consequence of a common practice in Bayesian assessment models: assigning a uniform prior to the logarithm of the parameter representing population scale (log-carrying capacity for biomass-dynamics models, or log-unfished recruits for age-structured models). First, we explain why the value chosen for the upper bound of this prior will affect parameter estimates and fisheries management advice given two properties that are met for many data-poor stock assessment models. Next, we use three case studies and a simulation experiment to show a substantial impact of this decision for data-limited assessments off the US West Coast. We end by discussing four methods for generating an informative prior on the population scale parameter, but conclude that these will not be suitable for many assessments. In these cases, we advocate that maximum likelihood estimation is a simple way to avoid the use of Bayesian priors that are excessively informative.

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x) Inclusion of ecological, economic, social, and institutional considerations when setting targets and limits for multispecies fisheries

Investigators: A. Rindorf, C.M. Dichmont, J. Thorson, A. Charles, L.W. Clausen, P. Degnbol, D. Garcia, N.T. Hintzen, A. Kempf, P. Levin, P. Mace, C. Maravelias, C. Minto, J. Mumford, A. Pascoe, R. Prellezo, A.E. Punt, D. Reid, C. Röckmann, R.L. Stephenson, O. Thebaud, G. Tserpes and R. Voss

Targets and limits for long-term management are used in fisheries advice to operationalize the way management reflects societal priorities on ecological, economic, social and institutional aspects. This study reflects on the available published literature as well as new research presented at the international ICES/Myfish symposium on targets and limits for long term fisheries management. We examine the inclusion of ecological, economic, social and institutional objectives in fisheries management, with the aim of progressing towards including all four objectives when setting management targets or limits, or both, for multispecies fisheries. The topics covered include ecological, economic, social and governance objectives in fisheries management, consistent approaches to management, uncertainty and variability, and fisheries governance. We end by identifying ten ways to more effectively include multiple objectives in setting targets and limits in ecosystem based fisheries management.

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y) Integrating count and detection–nondetection data to model population dynamics.

Investigators: E. Zipkin, S. Rossman, C. Yackulic, J.D. Wiens, J. Thorson, R.J. Davis and E.H.C. Grant

There is increasing need for methods that integrate multiple data types into a single analytical framework as the spatial and temporal scale of ecological research expands. Current work on this topic primarily focuses on combining capture–recapture data from marked individuals with other data types into integrated population models. Yet, studies of species distributions and trends often rely on data from unmarked individuals across broad scales where local abundance and environmental variables may vary. We present a modeling framework for integrating detection–nondetection and count data into a single analysis to estimate population dynamics, abundance, and individual detection probabilities during sampling. Our dynamic population model assumes that site-specific abundance can change over time according to survival of individuals and gains through reproduction and immigration. The observation process for each data type is modeled by assuming that every individual present at a site has an equal probability of being detected during sampling processes. We examine our modeling approach through a series of simulations illustrating the relative value of count vs. detection–nondetection data under a variety of parameter values and survey configurations. We also provide an empirical example of the model by combining long-term detection–nondetection data (1995–2014) with newly collected count data (2015–2016) from a growing population of Barred Owl (Strix varia) in the Pacific Northwest to examine the factors influencing population abundance over time. Our model provides a foundation for incorporating unmarked data within a single framework, even in cases where sampling processes yield different detection probabilities. This approach will be useful for survey design and to researchers interested in incorporating historical or citizen science data into analyses focused on understanding how demographic rates drive population abundance.

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z) 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.

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aa) Comparing estimates of abundance trends and distribution shifts using single- and multispecies models of fishes and biogenic habitat.

Investigators: J. Thorson and L. Barnett

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.

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bb) 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.

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cc) 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.

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dd) 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.

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ee) 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.

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.

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ff) Assessing the effects of climate change on U.S. West Coast sablefish productivity and on the performance of alternative management strategies

Investigators: M.A. Haltuch, T. A'mar, N. Bond and J.L. Valero

U.S. west coast sablefish are commercially valuable, making assessing and understanding the impact of climate change on the California Current (CC) stock a priority for (1) forecasting future stock productivity, and (2) testing the robustness of management strategies to climate variability and change. The horizontal-advection bottom-up forcing paradigm describes large-scale climate forcing that drives regional changes in alongshore and cross-shelf ocean transport and directly impacts the transport of water masses, nutrients, and organisms. This concept describes a mechanistic framework through which climate variability and change alter sea level (SL), zooplankton community structure, and sablefish recruitment, all of which have been shown to be regionally correlated. This study forecasts potential future trends in sablefish productivity using SL from Global Climate Models (GCMs) as well as explores the robustness of harvest control rules (HCRs) to climate driven changes in recruitment by conducting a management strategy evaluation (MSE) of the currently implemented 40-10 HCR as well as an alternative Dynamic Unfished Biomass 40-10 HCR. A majority of the GCMs suggest that after about 2040 there will be a slight trend towards generally lower SLs relative to the global mean, with an increasing frequency of low SLs outside of the range of the historical observations, suggesting favorable conditions for sablefish in the northern CC by 2060. Projected SLs from the GCMs suggest that future sablefish recruitment is likely to fall within the range of past observations but may be less variable and is likely to exhibit decadal trends that result in recruitments that persist at lower levels (through about 2040) followed by somewhat higher levels (from about 2040 through 2060). Although this MSE suggests that spawning biomass and catches will decline, and then stabilize, into the future under both HCRs, the sablefish stock is not projected to fall below the stock size that would lead to a fishery closure during the period analyzed (through 2060). However, the 40-10 HCR triggers stock rebuilding plans more frequently than the alternative Dynamic Unfished Biomass 40-10 HCR (based on the concept of a dynamic, rather than static, baseline stock size), suggesting that the alternative HCR is more robust to potential future climate driven changes in sablefish productivity.

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gg) Investigating California Current petrale sole spawning dynamics and oceanographic recruitment drivers

Investigators: M.A. Haltuch, J.R. Wallace, N. Tolimeri, Q. Lee, M.G. Jacox, C. Parada, E. Churchitser

The horizontal-advection bottom-up forcing paradigm, in which large-scale climate forcing drives regional changes in alongshore and cross-shelf ocean transport that directly impact ecosystem functions, provides a mechanistic framework for testing the hypothesis that cross-shelf and alongshore advection are drivers of petrale sole recruitment strength. Petrale sole is the most commercially valuable flatfish targeted in the California Current and form offshore, localized, winter spawning aggregations routinely targeted by trawl fisheries. This study takes a three-prong approach to investigating petrale sole spawning dynamics and oceanographic recruitment drivers. First, winter fishery log-book data provide the basis for investigating annual spatio-temporal changes in spawning aggregation locations and the proportion of the stock occupying each spawning ground. Next, a stage- and spatio-temporally specific conceptual life-history model for petrale sole provides the foundation to posit hypotheses regarding the oceanographic variables likely to influence survival at each life stage, with testing via statistical model fitting. Finally, which spawning grounds contribute the most to recruitment success and variability via on-shore transport through time are quantified by using the winter commercial spawning aggregation fishery data and the conceptual life history model, to parameterize a biophysical individual-based model driven by ROMS.

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hh) 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. Most radiocarbon ages have been processed for canary and black rockfish, data analyses and manuscript preparation are underway.

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ii) Spatial growth variability in marine fish: example from northeast Pacific

Investigators: V.V. Gertseva, S. Matson and J.M. Cope

Groundfish Life history parameters of marine fishes vary in space and time, often in response to multiple factors. Understanding this variability is vital to ensure sustainability of marine resources and ecosystem services provided by the ocean. We examined spatial variability in growth for a number of groundfish species in the northeast Pacific Ocean to identify shared spatial patterns and hypothesize about common mechanisms behind them. Growth parameters were estimated in different areas over the latitudinal range of the species and multiple hypotheses were tested as to whether growth parameters differ in all the areas, at specific area breaks or exhibit a latitudinal cline. Clear differences in spatial growth variability emerged among the species examined. Shelf species exhibited the highest growth rate between Cape Blanco and Cape Mendocino, which may in part be attributed to area-specific upwelling patterns in the California Current ecosystem, when nutrient rich deep water are brought to the surface southward of Cape Blanco and are uniquely distributed throughout this area, providing favorable conditions for primary productivity. Slope species showed a cline in asymptotic size (Linf), with Linf increasing from south to north. This cline, previously attributed to fishery removals, also fits a specific case of the widely described Bergmann's rule, and we explore specific potential ecological mechanisms behind this relationship.

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jj) Challenges in the dockside sampling of species composition in changing groundfish fisheries

Investigators: TS Tsou, J.M. Cope, K. Privitera-Johnson and J. Fuller

Groundfish species composition sampling is a key activity for collecting information to prorate multispecies market category landings into single species landings that ultimately inform catch estimates. The treatment of species compositions is difficult, though, because sampling designs, protocols, and data processing algorithms vary among the agencies and through time. This presentation will focus on current issues associated with sampling commercial groundfish landed in Washington State. We will discuss the mismatches between our current sampling design and fishing practices, and the impacts of these mismatches on single species catch estimates.

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kk) Accounting for variable recruitment and fishing mortality in length-based stock assessments for data-limited fisheries

Investigators: M. Rudd and J. Thorson

In fisheries with limited capacity for monitoring, it is often easier to collect length measurements from fishery catch than quantify total catch. Conventional stock assessment tools that rely on length measurements without total catch do not directly account for variable fishing mortality and recruitment over time. However, this equilibrium assumption is likely violated in almost every fishery, degrading estimation performance. We developed an extension of length-only approaches to account for time-varying recruitment and fishing mortality. This Length-based Integrated Mixed Effects (LIME) method at a minimum requires a single year of length data and basic biological information but can fit to multiple years of length data, catch, and an abundance index if available. We use simulation testing to demonstrate that LIME can estimate how much fishing has reduced spawning output in the most recent year across a variety of scenarios for recruitment and fishing mortality. LIME improves data-limited fisheries stock assessments by its flexibility to incorporate additional years or types of data if available and obviates the need for equilibrium assumptions.

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2. Survey and Observer Science

a) Investigating bias associated with hook saturation, hook competition, and fixed-site design in the Southern California hook-and-line survey

Investigators: P.T. Kuriyama, T.A. Branch, A.C. Hicks, J.H. Harms and O.S. Hamel

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 8 groundfish species, including bocaccio (*Sebastes paucispinis*), vermilion rockfish (*s. miniatus*), cowcod (*S. levis*), and lingcod (*Ophiodon elongatus*). 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.

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b) Development of a high-throughput approach for descending shelf rockfish

Investigators: J.H. Harms, J. Benante, C. Jones, A. Chappell, V. Simon, and J. Villareal

Since 2004, the Northwest Fisheries Science Center's (NWFSC) Hook and Line Survey has monitored a network of fixed sites throughout the Southern California Bight to provide data to support stock assessments for shelf rockfish populations in the region's untrawlable habitats. When no-take marine reserves within the Channel Islands National Marine Sanctuary (CINMS) were expanded in 2007-2008 to encompass existing survey sites, NWFSC and CINMS staff discussed ways to continue sampling these locations to maintain the data time series while minimizing impacts to the reserves' living resources. In 2016, survey protocols were modified so captured individuals are descended after expedited collection of biological data. To reduce potential mortality to captured specimens, we needed to minimize the amount of time fish spent out of the water by descending fish more rapidly than is feasible using traditional descending methods. We developed a downrigger approach using a recreational crab pot puller to lower a downline and cannonball weight most of the way to the seafloor. After basic data are collected, fish are attached to a SeaQualizer™ Recompression Device affixed to a customized bracket which is then clipped onto the downline and dropped into the water. Fish are released when the bracket assembly reaches the depth setting selected on the SeaQualizer. All descended fish are tagged prior to release to provide a secondary measure of abundance and to provide information about fish movement and potential post-release mortality. We discuss our approach in detail and share some of the lessons we learned in developing and implementing this approach.

For more information, please contact John Harm at John.Harms@noaa.gov

c) *HookLogger*: An Integrated and interactive three-station, portable, rugged data collection platform

Investigators: V. Simon, T. Hay, J. Benante, C. Jones, A. Chappell and J.H. Harms

Since 2004, the Northwest Fisheries Science Center (NWFSC) has annually monitored an array of fixed sampling sites over high relief habitat using rod and reel gear in the Southern California Bight. Pencil and paper forms were used for capturing all back deck information such as catch, effort, and biological sampling details. These hard to read forms were transcribed into approximately 150,000 unique data fields and manually entered into a relational database in the offseason. In 2017 a portable, rugged, wireless, integrated and interactive data collection platform was deployed. The new three-station system is named *HookLogger* and it utilizes Windows tablets, barcode label printers, barcode scanners, and motion compensated digital scales to input data over TCP/IP using virtual comports. The tablets communicate with a centralized SQLite database located at the primary event logging *Galley-station*. The benefits of this digital data collection capability include faster and streamlined field data collection, on-entry data validations, and the elimination of approximately 320 hours of post-season data entry.

For more information, please contact Victor Simon at Victor.Simon@noaa.gov

d) The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey: Survey History, Design, and Description

Investigators: A. Keller, J.R. 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

e) West Coast Observer Program

The FRAM West Coast Groundfish Observer Program (WCGOP) continued collecting fishery-dependent data during 2017 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 2017

2016	
Number of catch share observers	54
Number of non-catch share observers	48
Number of A-SHOP Observers	45

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 during 2017

DESCRIPTION	SS IFQ Trawl	SS IFQ Fixed Gear	SS Hake	MSCV	A-SHOP
Number of vessels	64	9	4	1	14
Number of trips	907	55	137	3	88
Number of Sea days	3,061		264	58	1902
Number of Observers	54				45

*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 2,537 sea days in the non-catch share fisheries in 2017 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 during 2017:

NCS Sea Days	
FISHERY DESCRIPTION	SEA DAYS
OR Blue/Black Rockfish Nearshore	136
OR Blue/Black Rockfish	72
OR Pink Shrimp	542
WC Open Access Fixed Gear	170
WA Pink Shrimp	244
Limited Entry Sablefish	447
CA Emley-Platt EFP	31
Electronic Monitoring EFP	170
PSMFC Discard Handling Research	16
Trawl Gear Modification EFP	141
CA Cucumber Trawl	22
IPHC Directed Commercial Halibut	28
Trawl Gear Modification EFP (EM)	3
Limited Entry Zero Tier	52
CA Halibut	186
CA Nearshore	152
CA Ridgeback Prawn	70
CA Pink Shrimp	55

*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.

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 2017, CAP production aged 23,150 age structures, production double read 6,280 age structures. The lab also completed over 1,000 training and recalibration reads. The lab hosted age readers from Washington Department of Fisheries and Wildlife to define differences of ageing methodology for yelloweye rockfish. Production ages supported the 2017 assessments on arrowtooth flounder, California scorpionfish, darkblotched rockfish, lingcod, Pacific hake, Pacific Ocean perch, yelloweye rockfish and yellowtail rockfish. The lab cored 42 canary rockfish otoliths that were sent to NOSAMS for C14 analysis. A total of 600 canary 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 most specimens when possible. Over 18,500 otolith weights were collected in 2017 to support of research into alternative methods of age determination. Five CAP personnel attended the 2017 C.A.R.E conference (Committee of Age Reading Experts) in Seattle Washington.

For more information, please contact Jim Hastie at Jim.Hastie@noaa.gov

b) Assessing reproductive strategies in marine fishes: applications to management

Investigator: M.A. Head

By incorporating accurate estimates of life history parameters into population models, we 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, data collections restricted by seasonal surveys 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. Starting in 2009, the FRAM division instituted ovary collections on annual surveys, after fisheries managers identified a need for updated life history information for several groundfish species along the U.S. West Coast. Currently, the FRAM reproductive biology program has sampled from over 36 groundfish species along the coast, and collected over 15,000 ovaries using six sampling platforms: West Coast groundfish bottom trawl survey (WCGBT), Southern California Bight Hook and Line survey (H&L), At-sea hake observer program (ASHOP), Acoustics summer and winter survey, Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW).

We have examined the reproductive biology of multiple groundfish species using ovaries collected from fishery independent surveys and fishery dependent sources (port sampling of offloads and on board observer samples). These collections 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) the effects of oceanographic conditions on reproductive patterns related to skip spawning and abortive maturation, and (3) the estimation of biological (physiological) 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 reproduction can provide useful information for predicting the influence of shifting oceanographic conditions on the spawning output of groundfish stocks.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

e) Re-evaluation of the single genetic stock hypothesis for Pacific Hake (*Merluccius productus*)

Investigator: M.A. Head, S. Parker-Stetter, K. Nichols, I. Taylor and M. McClure

Pacific Hake (*Merluccius productus*, hereafter “hake”) are the most abundant groundfish in the California Current Ecosystem off the West Coast of the U.S. and Canada. The coastal stock supports a large commercial fishery that has had an average annual catch of over 250,000 mt over the past 30 years and was valued at US$59 million in 2014[1]. Catch limits used in the management of hake are informed by an acoustic-trawl survey conducted jointly by the U.S. and Canada that estimates total biomass for the entire West Coast. Its spatial extent is adapted to cover the full latitudinal range of the species in any survey year under the assumption that all fish within this range are part of a single coastal stock. If the survey area either includes fish from multiple stocks or does not include areas that are part of the coastal stock, it could bias the stock assessments, causing either potential harvest to be foregone, or unnecessarily jeopardizing smaller stocks. Previous genetic work, done with limited spatial samples (see Fig. 1), identified that the coastal Northeast Pacific Ocean hake were genetically distinct from hake in the Strait of Georgia and Puget Sound, and no differences within the coastal samples were identified[2].

Recent observations, however, suggest the assumption of a single coastal hake stock requires validation. Hake collected south of 34.5º latitude (~Point Conception, CA) matured at a smaller size than those collected farther north[3]. Moreover, winter surveys in 2016 and 2017 observed hake much further north than suggested by the conventional hypothesis that hake spawn offshore of Mexico in the winter[4]. Environmental conditions, such as El Niño/La Niña, may influence latitudinal trends in maturation, timing of spawning, or winter distribution, or by genetic variation underlying different growth regimes among hake stocks[5]. Using a spatially and temporally comprehensive set of genetic samples, we propose to test the single stock assumption and evaluate associations of genetic variation with life history trends within hake.

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

We investigated the associations between structure-forming invertebrates (SFIs: corals, sea pens and sponges) and demersal fish using bottom trawl survey data from the Northwest Fisheries Science Center's bottom trawl survey (2003-2015). General linear models (GLMs) showed that average species richness was slightly lower and finfish biomass slightly higher in hauls with no SFIs. Generalized additive models (GAMs) indicated a weak, non-linear relationship between species richness and sponge density (<1% of deviance explained). Slightly higher finfish biomass occurred in hauls with few or no sea pens or sponges. We used multivariate analyses to examine relationships between fish community structure, SFI densities, and environmental parameters (depth, latitude and bottom temperature). No strong correlations occurred between community structure and SFI densities, but bottom temperature and depth were the primary drivers of community composition. However, indicator species analysis, based on three SFI levels (high, low and none), showed various species-specific associations. Depending on species, flatfishes exhibited relationships with high and low densities of corals and sea pens or the absence of sponges. Thornyheads and some rockfishes were associated with high sponge densities but low or zero coral and sea pen densities. Sablefish exhibited opposite trends. These results provide information about broad-scale associations between SFIs and demersal fish that may be useful for developing studies specifically focused on the function of SFIs as essential fish habitat and the role they may play in the life-histories of groundfishes.
For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

b) National Marine Fisheries Service, Untrawlable Habitat Strategic Initiative (UHSI)

Investigator: W. Wakefield

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. A final field experiment was conducted in October 2017 at the Southern California Bight study site. Data analysis is underway.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

c) Revising the Essential Fish Habitat Conservation Areas and Rockfish Conservation Area of the Pacific Coast Groundfish Fishery Management Plan

Investigators: G. Hanshew, J. Stadler, W. Wakefield and K. Griffin

The Pacific Fishery Management Council (PFMC) designated essential fish habitat (EFH) for 82 groundfish species in the Pacific Coast Groundfish Fishery Management Plan in 2005. At the same time, the PFMC designated a number EFH Conservation Areas (EFHCAs), covering 70% of the area designated as EFH. The EFHCA prohibit certain types of bottom-contact gear, primarily bottom trawls, to minimize the adverse effects of fishing on EFH. In 2010, NOAA Fisheries and the PFMC began an effort to review and revise the EFH components of the FMP. The review compiled and summarized new information on EFH for groundfishes (now with 91 FMP Species plus 26 Ecosystem Component Species), including information on seafloor habitats, bathymetry, groundfish fishing effort, distribution of deep-sea corals and sponges, prey species, and habitat associations. Subsequent to the review, the PFMC issued a request for proposals seeking public input on potential changes to the EFH components of the plan. The Council is now revising those components, with an emphasis on proposed modifications to Pacific Coast groundfish essential fish habitat conservation areas (EFHCAs), trawl rockfish conservation areas (RCAs), and proposed closure of waters deeper than 3,500 meters. The Council is analyzing a range of alternatives drawn from the public proposals or developed by the Council and NOAA Fisheries.

d) Fine-scale benthic habitat classification using a towed video camera-sled

Investigators: A. Chappell, C. Whitmire, J.H. Harms, J. Benante, A. Keller and C. Jones

The Northwest Fisheries Science Center's Southern California Shelf Rockfish Hook and Line Survey samples hard bottom habitats within the Southern California Bight via rod and reel gear to provide management information for multiple demersal rockfishes (*Sebastes* sp.). The survey, initiated in 2004, consists of 202 fixed stations sampled annually from Pt. Arguello (34.6^0 N) to the Mexican border (32.1^0 N) at depths of 37 – 229 m. We analyzed benthic habitat observations collected during 90 dives representing 70 unique sites via deployment of a towed video camera-sled. Benthic habitat observations were categorized both by major strata (primary, ≥ 50% of the field of view; secondary habitat ≥ 20% of the next most abundant habitat; and all other habitats in the field of view), and by eight previously-defined substrata categories: mud, sand, pebble, cobble, boulder, continuous flat rock, diagonal rock ridge and vertical rock-pinnacle top. When compared with existing NOAA's Essential Fish Habitat maps, we found significantly different habitat classification values, especially of hard substrates. Depending on method of collection and equipment type, the available Essential Fish Habitat maps contain varying degrees of resolution, or use algorithms to predict benthic habitat composition. Overall, our analysis of camera-sled tows showed 47% hard bottom habitats and 53% soft bottom habitats. Essential Fish Habitat designations in the same areas of our camera-sled tows were comprised of 27% hard bottom substrates, and 73% soft bottom substrates, both significantly different. Our findings indicate hard-bottom habitat features, especially smaller reefs, are not adequately resolved within available habitat maps.

For more information, please contact Aaron Chappell at Aaron.Chappell@noaa.gov

2. Ecosystems

a) Integrated Ecosystem Assessment of the California Current

Investigators: C.J. Harvey, N. Garfield, E.L. Hazen and G.D. Williams, eds.; numerous contributors from the NWFSC, SWFSC and partner institutions

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 2018.

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 NOAA's Northwest Fisheries Science Center, Chris.Harvey@noaa.gov.

b) 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 collected 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. Additional samples collected during the 2016 FRAM groundfish trawl survey are now being processed.

For more information please contact Dr. Chris Harvey at NOAA's Northwest Fisheries Science Center, Chris.Harvey@noaa.gov.

c) Use of eelgrass and kelp habitats by post-settled juvenile rockfish in Washington state

Investigators: A.O. Shelton, N. Tolimieri, J.F. Samhouri, C.J. Harvey, G.D. Williams, K.S. Andrews, K.E. Frick and B.E. Feist.

Nearshore biogenic habitat is potentially valuable foraging or refuge habitat for recently settled age-0 rockfish (*Sebastes* spp.). We are conducting numerous scuba-based surveys in coastal waters of Washington state to explore spatiotemporal dynamics of juvenile rockfish occurrence, habitat characteristics, and overall community structure within these habitats. Inside Puget Sound, we conduct seasonal scuba surveys in nearshore beds of native eelgrass (*Zostera marina*) and also in treatment and reference sites near kelp mariculture projects. On the outer coast, we conduct annual scuba surveys in kelp forests along the Olympic Coast. We are establishing baselines of juvenile rockfish abundance and variability and also exploring correlations and mechanisms that may influence rockfish occurrence. This information may inform habitat conservation practices and also provide indicators of year class strengths for rockfish populations both in Puget Sound and along the outer coast.

For more information please contact Dr. Nick Tolimieri at NOAA's Northwest Fisheries Science Center, Nick.Tolimieri@noaa.gov.

d) 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 and 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. Ongoing research (E.E. Hodgson et al. *in review*) identifies northern ports as most economically impacted by the projected declines in groundfish and Dungeness crab. 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 Drs. Kristin Marshall or Isaac Kaplan at NOAA's Northwest Fisheries Science Center, Kristin.Marshall@noaa.gov, Isaac.Kaplan@noaa.gov

e) 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 and 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 NOAA's Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov.

f) Spatio-temporal changes in groundfish communities: patterns of diversity and responses to anthropogenic disturbances in the Gulf of Alaska

Investigators: A.O. Shelton, M.E. Hunsicker, E.J. Ward, B.E. Feist, R. Blake, C.L. Ward, B.C. Williams, J.T. Duffy-Anderson, A.B. Hollowed and A.C. Haynie

Toxic pollutants such as crude oil have direct negative effects for a wide array of marine life. While mortality from acute exposure to oil is obvious, sub-lethal consequences of exposure to petroleum derivatives for growth and reproduction are less evident and sub-lethal effects in fish populations are obscured by natural environmental variation, fishing, and measurement error. We use fisheries independent surveys in the Gulf of Alaska to examine the consequences of the 1989 Exxon Valdez oil spill (EVOS) for demersal fish. We delineate areas across a range of exposure to EVOS and use spatio-temporal models to quantify the abundance of 53 species-groups over 31 years. We compare multiple community metrics for demersal fish in EVOS and Control areas. We find that areas more exposed to EVOS have more negative trends in total groundfish biomass than non-EVOS areas, and that this change is driven primarily by reductions in the abundance of the apex predator guild. We show no signature of increased variability or increased levels of synchrony within EVOS areas. Our analysis supports mild consequences of EVOS for groundfish communities, but suggests that long time-series and assessments of changes at the community level may reveal sub-lethal effects in marine communities.

For more information please contact Dr. Ole Shelton at NOAA's Northwest Fisheries Science Center, ole.shelton@noaa.gov.

g) Patterns of diversity, stability and community composition in the groundfish community of the Gulf of Alaska

Investigators: R.E. Blake, C. Ward, M. Hunsicker, A.O. Shelton and A.B. Hollowed.

The mechanisms structuring patterns of diversity and community composition can be difficult to identify, and much of our knowledge stems from study of local ecological systems. It is important to understand these patterns and their drivers at larger scales, especially in the face of climate change and other perturbations. The Gulf of Alaska (GOA) has complex topography, climate-driven variability, and a well-studied groundfish community, making it an ideal study system. We examined patterns of diversity, stability, and community composition in the groundfish community across 10 sites in the GOA using geostatistically modeled groundfish abundance and biomass from the Alaska Fisheries Science Center trawl survey data (1984 – 2015). We found that species richness, and alpha, beta, and functional diversity varied little both within and between study areas, and were conserved across the central GOA. However, community composition varied significantly along a longitudinal gradient, with differences driven by lower-density species indicating functional redundancy among individual study areas. The regional community was also less variable, suggesting a spatial portfolio effect across this ecosystem. Overall, environmental heterogeneity and functional redundancy drive conserved community structure and patterns of groundfish diversity across the GOA large marine ecosystem.

For more information please contact Dr. Ole Shelton at NOAA's Northwest Fisheries Science Center, ole.shelton@noaa.gov.

h) 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 NOAA's Northwest Fisheries Science Center, lewis.barnett@noaa.gov.

i) Why are whale entanglements with fishing gear increasing on the west coast of the US?

Investigators: B. Feist, J. Samhouri and E. Fuller

Over the past few years, cetacean entanglements with commercial fishing gear off the US west coast have increased dramatically. Trap and pot gear types account for much of the entanglement observed, affecting humpback and gray whale disproportionately, but many of the gear types associated with entanglements are unknown. Surprisingly, the 2015 Dungeness crab fishery saw unprecedented closures due to above standard domoic acid levels, suggesting effort was, in fact, much lower than average. To further complicate matters, recreational whale watching activity is difficult to quantify, so changes in observation intensity of cetaceans over time are largely unknown. Here, we use vessel monitoring system (VMS) data, linked to landings data to characterize spatio-temporal patterns of vessels fishing off the west coast of the US that use trap and pot gear to catch Dungeness crab, spiny lobster, sablefish or spot prawn. We then link these analyses spatially with gridded models of cetacean abundance. Finally, we use data from social media outlets and from state park beach attendance records to characterize patterns in entanglement observation effort over time.

For more information please contact Dr. Blake Feist at NOAA's Northwest Fisheries Science Center, Blake.Feist@noaa.gov.

j) The Pacific Coast Groundfish Fishery Social Study

Investigators: Suzanne Russell, Max Van Oostenburg, Ashley Vizek, Brian 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 NOAA's Northwest Fisheries Science Center, suzanne.russell@noaa.gov.

C. Bycatch Reduction Research

Overview: In 2017, the Pacific States Marine Fisheries Commission and project collaborators, including the Northwest Fisheries Science Center, conducted studies using artificial illumination to reduce bycatch in two US West Coast trawl fisheries; the Pacific hake (Merluccius productus) midwater trawl fishery and the ocean shrimp (Pandalus jordani) otter trawl fishery. In general, findings among our studies were similar in that the presence of artificial illumination appears to enhance fishes optomotor response and their ability to perceive escape areas in and around the trawl gear that they would not be able to perceive as well under dark conditions. Upcoming in 2018, we have two studies occurring. The first study will evaluate the efficacy of elevated trawl sweeps in the West Coast LE groundfish bottom trawl fishery, while the second study seeks to measuring the overall effectiveness of LED fishing lights to reduce fish bycatch in the ocean shrimp trawl fishery. Further summarizes of the 2017 projects appear below.

1. Effects on the bycatch of eulachon and juvenile groundfishes by altering the level of artificial illumination along an ocean shrimp trawl fishing line

Investigators: M.J.M. Lomeli, S.D. Groth, M.T.O. Blume, B. Herrmann and W. Wakefield

This study examined how catches of eulachon (Thaleichthys pacificus), juvenile groundfishes, and ocean shrimp (Pandalus jordani) could be affected by altering the level of artificial illumination along an ocean shrimp trawl fishing line. In the ocean shrimp trawl fishery, catches of eulachon are of special concern as their southern distinct population segment (DPS) is listed as "threatened" under the U.S. Endangered Species Act (ESA). Using a double-rigged ocean shrimp trawl vessel, with one trawl serving as the treatment and the other as the control, we compared the catch efficiencies for eulachon, juvenile groundfishes, and ocean shrimp between alternating treatment trawls configured with 5-, 10-, and 20-LED fishing lights along the trawl fishing line and the control trawl (unilluminated). Findings showed that the addition of artificial illumination along the trawl fishing line significantly affected the average catch efficiency for eulachon, juvenile rockfishes (Sebastes spp.) and flatfishes with the three LED configurations tested each catching significantly fewer individuals than the control trawl, without impacting ocean shrimp catches. For Pacific hake, the 10-LED configured trawl caught significantly more fish than that control trawl. For the 5-LED configuration, mean Pacific hake catches did not differ from the control trawl whereas results for the 20-LED configuration were inconclusive due to large uncertainties in the estimated effect. Aside from Pacific hake, the three LED configurations tested generally performed equally at reducing fish bycatch while not affecting ocean shrimp catches. As the southern DPS of eulachon faces many uncertainties in their ESA recovery, our study contributes new data on how artificial illumination along an ocean shrimp trawl fishing line can affect eulachon catches (and other fishes) and contribute to their conservation. Funding for this study was provided by NOAA NMFS Saltonstall-Kennedy Competitive Research Program.

For more information, please contact Mark Lomeli at mlomeli@psmfc.org.

2. Influencing the behavior and escapement of Chinook salmon out a midwater trawl using artificial illumination

Investigators: M.J.M. Lomeli and W. Wakefield

The Pacific hake midwater trawl fishery is the largest groundfish fishery off the U.S. west coast by volume. While catches comprise mainly of Pacific hake, bycatch of Chinook salmon (Oncorhynchus tshawytscha) can be an issue affecting the fishery as ESA listed fish are caught at times. We conducted two separate experiments evaluating the influence of artificial illumination on Chinook salmon behavior and escapement out a bycatch reduction device (BRD) in a Pacific hake midwater trawl. In experiment-1, we tested if Chinook salmon could be attracted towards and out specific escape windows of a BRD (equipped with multiple escape windows) using artificial illumination. In experiment-2, we compared Chinook salmon escapement rates out the BRD between tows conducted with- and without-artificial illumination on the BRD to determine if illumination can enhance their escapement overall. In experiment-1, we found the proportion of Chinook salmon to exit out an illuminated escape window was significantly greater than the proportion of Chinook salmon to exit out a non-illuminated escape window. In experiement-2, our results showed the proportion of Chinook salmon to exit the BRD when artificial illumination was present was significantly greater than the proportion of Chinook salmon to exit the BRD when artificial illumination was absent. Findings from this study demonstrate that artificial illumination can influence where Chinook salmon exit out the BRD we tested, but also that illumination can be used to enhance their escapement overall. As conservation of ESA listed Chinook salmon is a management priority, our research contributes new information on how artificial illumination can minimize adverse interactions between Pacific hake trawls and Chinook salmon. Funding for this study was provided by NOAA NMFS Bycatch Reduction Engineering Program.

For more information, please contact Mark Lomeli at mlomeli@psmfc.org.

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NMFS Southwest Fisheries Science Center

Agency Report to the Technical Subcommittee of
the Canada-U.S. Groundfish Committee

April 2018

Edited by Melissa Monk

With contributions from John Field, Tom Laidig, Aaron Mamula,
Nick Wegner, and William Watson

Contents

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 Science and Research 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) in Santa Cruz is directed by Dr. Steve Lindley, and four of the six research branches conduct studies focused on groundfish. Dr. Steve Lindley is currently the acting supervisor of the Early Life History and Habitat Ecology teams. The Early Life History team (led by Dr. Susan Sogard through March 2018) focuses on early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. The Habitat Ecology team (led by Dr. Mary Yoklavich through December 2017) utilizes a number of survey tools, e.g., visual surveys conducted with remotely operated vehicles (ROV), human-occupied submersibles, autonomous underwater vehicles (AUV), scuba, etc., to study deep-water demersal communities. The Molecular Ecology team (led by Dr. Carlos Garza) studies the molecular ecology and phylogeny salmonids and groundfish. The Fisheries Assessment group (led by Michael Mohr) conducts research and stock assessments in salmon population analysis, economics, groundfish, and fishery oceanography of salmonids and groundfish. Dr. John Field leads the Groundfish Analysis team within the Fisheries Assessment group, which supports the needs of NMFS and the Pacific Fishery Management Council, one of which is groundfish stock assessment. The Groundfish Analysis team also conducts the annual pelagic juvenile rockfish recruitment and ecosystem assessment survey along the West Coast. 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. A scientist from the Ichthyoplankton Lab in La Jolla currently 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. Research on larval rockfish at the SWFSC

Contact: William Watson (william.watson@noaa.gov)
Over the past year (2017-2018) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla completed a project that used molecular methods to identify larval rockfishes collected from winter core CalCOFI stations between 1998 and 2013. The overall aim of this research was 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. We found that the mean abundances of 6 of 8 rockfishes targeted by fishers and 3 of 7 non-targeted species increased significantly between 1998 and 2013 throughout southern California. We also found that 75% 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 research were published in a University of San Diego MS thesis (Chen 2017) and in an article in the Royal Society Open Science (Thompson et al. 2017)

We began a project to extract otoliths from the genetically-identified rockfish larva and measure otolith band widths and core size. We will then test the hypothesis that higher maternal investment (larger core) and recent growth (wide outer bands) correlate positively with recruitment success between 1998 and 2013 in southern California. This project is being led by Noah Ben-Aderet, a FATE-funded postdoctal fellow.

We continued a project that is using next generation sequencing to bulk-identify rockfish (and other fish) species presence/absence from plankton samples. We collected plankton samples for this research from CalCOFI stations, in the Santa Barbara Channel, in Santa Monica Bay and along transects spanning northern California, Oregon and Washington. We first manually identified fish eggs and larvae under the microscope and by sequencing small amounts of tissue from individuals. We then returned the ichthyoplankton into the appropriate plankton sample and masticated contents of several samples. After extracting DNA from each sample we conducted Mi-seq metabarcoding runs to sequence part of the mitochrondrial 12S gene. Comparison of metabarcoding sequence to reference sequences available on GenBank indicated that metabarcoding was able to identify with high precision which fish species, including rockfishes, which were present in each sample. However, reference sequences were not available for some species and these were only capable of being identified to the genus or family level. We are currently preparing additional samples for Mi-seq runs and building up a 12S reference library using tissue from fishes of known identity. This research is being led by Dovi Kacev, a NRC postdoctoral researcher.

Finally, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from July 1962 through 2014, and by the end of this year expect to have completed analysis of samples collected in winter and spring of 2015 and 2016. This will provide a 52-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*).

B2. Pelagic Juvenile Rockfish Studies

Several studies have been published or are in press related to ongoing studies of both the role of pelagic juvenile rockfish in the ecosystem as forage, particularly relative to other pelagic juvenile and forage species (Wells et al. 2017, Ainley et al. 2017, Friedman et al. in press). Other studies have focused on the high abundance levels, and trends in the diversity of pelagic juvenile rockfish and other groundfish, as well as other components of the forage assemblages over time, specifically with respect to the unusual diversity observed during the marine heatwave of 2014-2016 (Sakuma et al. 2016, Santora et al. 2017). Several of these studies (and others that are in preparation or review) have focused The Wells et al. (2017) manuscript in particular highlights the complex role of climate as a forcing mechanism of trophic interactions in the Central California region (particularly the Gulf of the Farallons). That analysis demonstrated that variable ocean conditions (such as reduced upwelling) can lead to poor survival and abundance of pelagic juvenile rockfish, which in turn leads common murres (*Uria aalge*) who rely on pelagic juvenile rockfish during the breeding season in most years to switch feeding instead on adult northern anchovies, which are found closer to shore. This in turn leads to an increase in predation of outmigrating juvenile salmon, which co-occur with anchovies, which has the potential to result in substantive increases in early ocean survival of commercially and ecologically important salmon populations, particularly as the seabird colonies recover from historical population impacts (Figure 1).

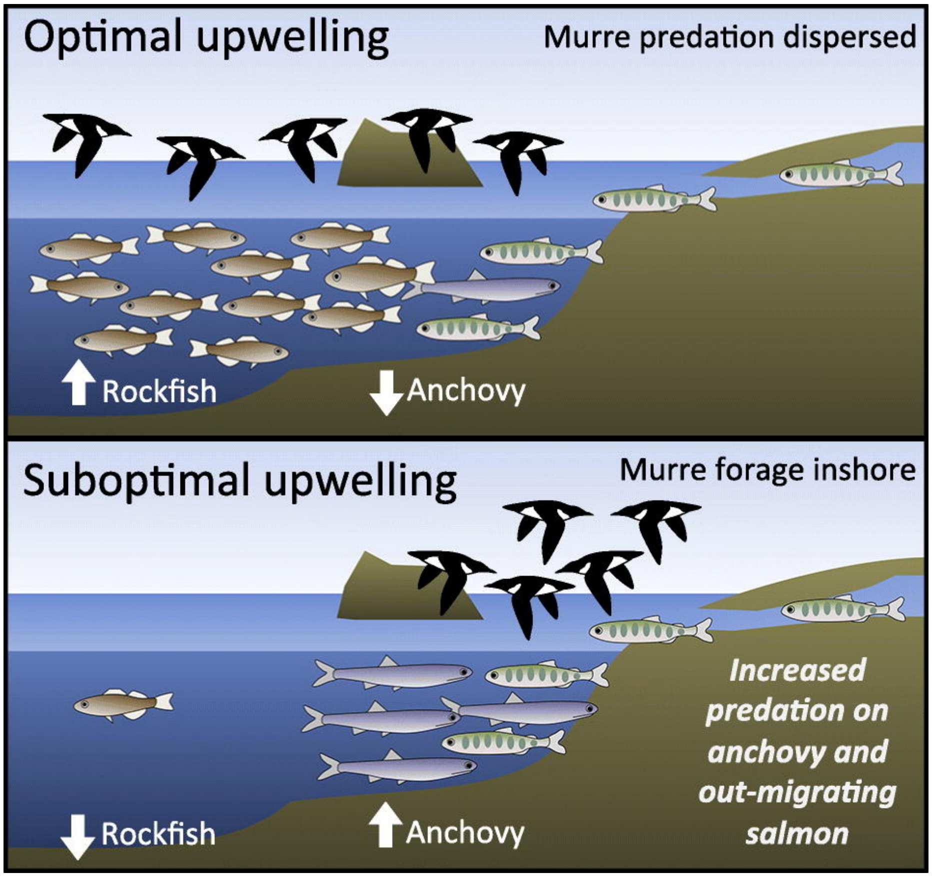

Figure 1: Conceptual figure of the complex interactions among pelagic juvenile rockfish, northern anchovy, outmigrating ocean entry salmon and common murres in the Gulf of the Farallons ecosystem (Central California).

C. BY SPECIES, BY AGENCY

C.1.Rockfish barotrauma and release device research at SWFSC La 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 in order to monitor long-term survival and recovery from barotrauma. This work reveals relatively high survival rates, although there are differences between the five species studied (Bank Rockfish, *S. rufus*, Bocaccio, *S. paucipinis*, Cowcod, *S. levis*, Starry Rockfish, *S. constellatus*, Sunset Rockfish, *S. crocotulus*). Over the two years we have focused efforts on examining post-release survival of juvenile Cowcod, 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. This work currently being prepared for publication.

C.2. Reproductive Ecology Studies

Several studies related to the reproductive ecology of rockfishes were published over the past year. Dick et al. (2017) completed a meta-analysis of fecundity in the genus *Sebastes*, in which a hierarchical modeling framework was developed to produce robust estimates for data informed species as well as predictive distributions for unobserved species and subgenera. Importantly, the result documents that weight-specific fecundity increases with size in nearly all observed Sebastes species, confirming that the assumption of proportionality between mature female biomass and total egg production is inappropriate for most *Sebastes* stock assessments. The results are now considered to be the most appropriate fecundity values for use in West Coast stock assessments. Lefebvre et al. (2018) followed on the theme with a manuscript documenting both multiple brooding and abortive maturation in chilipepper rockfish (*S. goodei*) using macroscopic and histological methods. That analysis also provides a revised fecundity function for use in stock assessments that accounts for the both greater fecundity and increased probability of producing multiple broods with size. A closely related laboratory study in preparation by Susan Sogard and Sabrina Beyer (FED/SWFSC) has also found that in rosy rockfish (*S. rosaceus*), larger females also produced disproportionately more larvae, as well as more overall broods, with up to five broods per year documented I some individuals. Moreover, females in a low ration treatment produced 60% fewer larvae a year compared with well-fed females in a high ration treatment. These studies highlight the importance of continued studies in reproductive ecology to better inform stock assessment models, and data collected during continued research sampling of relative fecundity of chilipepper and yellowtail rockfish continued in the 2017-2018 spawning season, with analysis and publication of the time series expected in late 2018 or early 2019.

C3. Stock Assessments

In 2017, SWFSC staff led benchmark stock assessments on Blue/Deacon rockfish (Dick et al. 2017) and California Scorpionfish (Monk et al. 2017), as well as update assessments on Bocaccio (Xi and Field 2017) and Blackgill rockfish (Field and Xi 2017). All were done using the Stock Synthesis 3 assessment framework.

Blue and Deacon Rockfishes (*Sebastes mystinus* and *Sebastes diaconus*, respectively) are two genetically distinct species, with the Blue Rockfish dominant in the species composition from Monterey Bay, CA and south and Deacon Rockfish prominent from Monterey Bay, CA and north through Oregon. Catches of Blue and Deacon Rockfishes cannot be separated in either the commercial or recreational catches and it is not possible to disentangle the landings of the two species. Two independent stock assessments were conducted to approximate spatial variations in species composition, exploitation history, and other factors affecting the dynamics.

Spawning output of Blue/Deacon Rockfish in California was estimated to be 37% of unfished spawning output. In California, spawning output declined rapidly in the 1970s and early 1980s, falling below the minimum stock size threshold in the early 1980s, followed by a steady recovery since the late 2000s. In Oregon, spawning output was estimated to be 296 million eggs in 2017, which when compared to unfished spawning output equates to a depletion level of 69% in 2017. In general, spawning output has been trending slightly downwards, with the exception of an increase in the 1990s due to several high recruitment years. Stock size is estimated to be at the lowest level throughout the historic time series in 2017, but the stock is estimated to be well above the management target of B40%.

The stock of California Scorpionfish (*Scorpaena guttata*) was assessed in 2017 in in U.S. waters off the coast of southern California (south of Pt. Conception) to the U.S./Mexico border. California Scorpionfish was previously assessed in 2005 with not age and growth data. The 2017 assessment incorporated age data from the NWFSC bottom trawl survey, and a number of fishery-independent sources of data including all of the southern California Publicly Owned Treatment Works monitoring trawl surveys. The predicted spawning biomass from the base model generally showed a slight decline prior to 1965, when information on recruitment variability became available. A short, but sharp decline occurred between 1965 and 1985, followed by a period cyclical variation in spawning biomass, and then a decline from 2000 to 2015. The stock showed increases in stock size in 2015 due to a combination of strong recruitment and smaller catches in 2015 and 2016. The 2016 estimated spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass at 54.3%.

The southern stock of Bocaccio (*Sebastes paucispinis*), from the U.S./Mexico Border ot Cape Blanco, OR) was declared rebuilt in 2017, as the stock assessment update indicated a 2017 spawning output of 48.6% of the estimated unfished level. The stock had been increasingly steadily since the early 2000s, driven initially by a very strong 1999 year class, and most recently with a very strong 2013 year-class, estimated to be the largest since 1980. Since being declared overfished in 1999 a total of six benchmark assessments and three assessment updates have been conducted to determine bocaccio status and trends and evaluate rebuilding progress. In addition to limited age composition data and considerable length composition data from commercial and recreational indices, the assessment used a number of relative abundance indices, including CalCOFI larval abundance estimates from 1951 through 2016, the SWFSC pelagic juvenile abundance survey, the NWFSC bottom trawl survey, the NWFSC hook and line survey, and several recreational CPUE indices.

For Blackgill Rockfish (*Sebastes melanostomus*), the stock assessment update was consistent with the previous full assessment, which indicated that the spawning output was at relatively high levels in the mid-1970s; began to decline steeply in the late 1970s through the 1980s (consistent with the rapid development and growth of the targeted fishery); and reached a low point of approximately 20% of the unfished level in the mid-1990s. Since that time, catches have declined sharply and spawning output has increased, such that the 2017 estimated larval production is nearly to the target level of 40% of the unfished larval output. Recruitment in the assessment is assumed to be deterministic, and the assessment is primarily informed by fishery age and length compositional data from commercial fisheries, as well as a relative abundance index and age and length data from the NWFSC Bottom Trawl Survey.

C4. Flatfish

The Groundfish Analysis Team at FED is currently concluding a study of fecundity of Petrale sole, for which the assessment is currently informed by a single study with data collected in the 1950s. We have processed and examined histology slides from 153 female petrale, primarily to support fecundity work but also to examine the seasonality of ovarian development, confirm homogenous development throughout the ovary, and confirm the fecundity type of the species. Based on histology, Petrale appear to be determinate batch spawners, with potential annual fecundity (maximum number of eggs to be spawned in the entire season; doesn't account for down regulation) set prior to the onset of spawning and eggs being released in several spawning events throughout the reproductive season. To date 93 fecundity subsamples from 20 females have been counted for potential annual fecundity, including samples used to verify development throughout the ovary is homogenous. Estimates range from approximately 1 million to 2.5 million eggs being released in an unknown number of spawning events throughout the season. Additionally, 43 fecundity subsamples from 14 females have been counted for estimating batch fecundity (the number of eggs released in a single spawning event). Variability is higher in batch fecundity samples, resulting in more estimates from individual females being thrown out due to high coefficients of variations between subsamples. Batch fecundity estimates range from 72,000 to 180,000 and appears to be weakly related to maternal size. Due to the variability and as batch fecundity only tells us how many eggs are released in a single event, efforts are being focused on quantifying potential annual fecundity.

D. OTHER RELATED STUDIES

D1. Demersal Communities

Contact: Tom Laidig (tom.laidig@noaa.gov)
FED HET Investigators: 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 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 DSC 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. Mapping and Visual Surveys of Seafloor Habitats and Fishes, 9-26 October 2017
Contact: Diana Watters (diana.watters@noaa.gov)
Aboard the NOAA R/V *Bell M. Shimada*, scientists used the vessel's ME70 multibeam echosounder to collect high-resolution bathymetric and backscatter (seafloor scattering strength) data at depths 30-350 meters in three areas (Figure 2) off Santa Cruz and Anacapa Islands in the vicinity of Channel Islands National Marine Sanctuary in Southern California. Approximately 96 km2 of seafloor were mapped during 13 nights of surveying. Thirty-two expendable bathythermograph (XBT) probes were deployed during the ME70 survey to obtain water column sound velocity profiles for improved accuracy of depth measurements. NMFS's SeaBED autonomous underwater vehicle (AUV), equipped with 3 cameras and strobe light, was deployed from the *Shimada* and used to survey seafloor communities and groundtruth habitat interpretations of mapped areas. Four 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. CTD casts were made in association with the AUV dives to obtain water column sound velocity profiles for optimal communications with the AUV during dives.

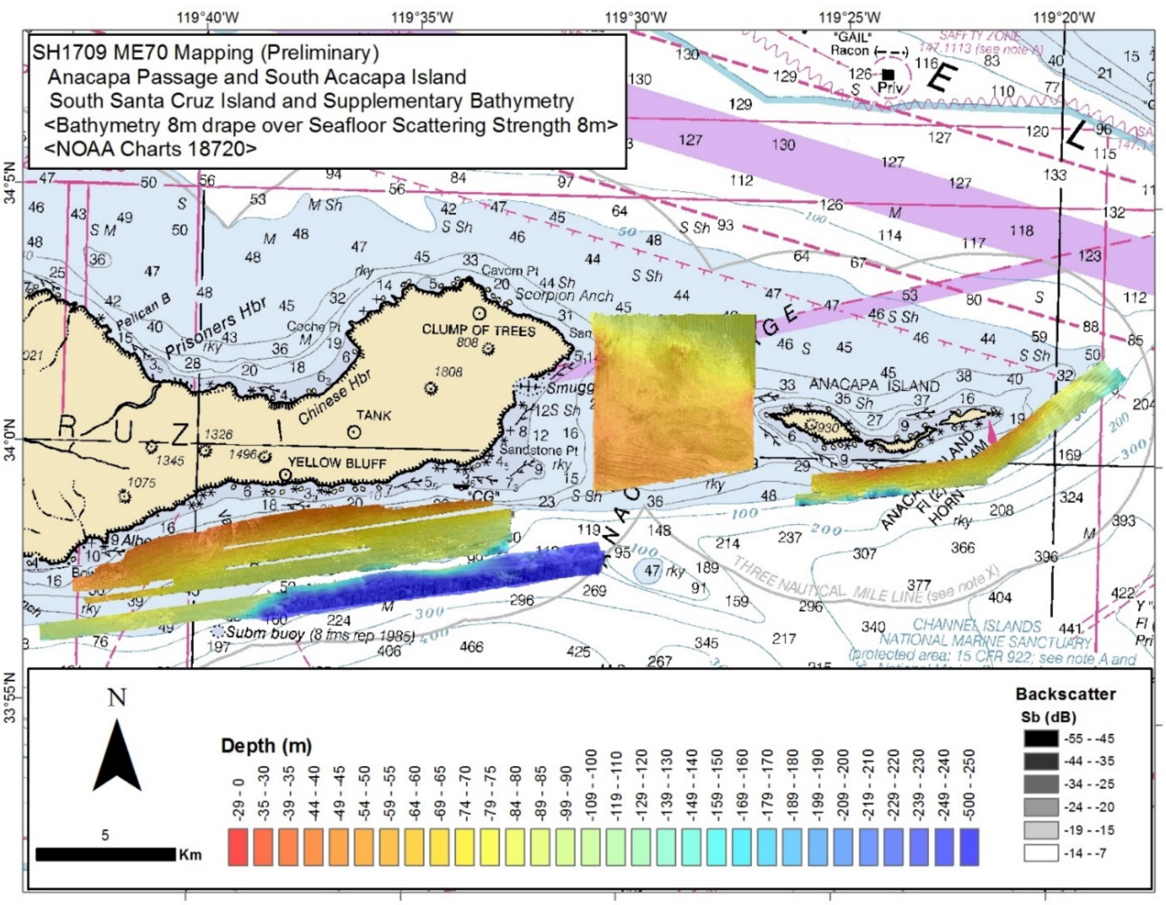

Figure 2. Study sites off Santa Cruz and Anacapa Islands in Southern California, indicating areas of bathymetric and backscatter (seafloor scattering strength) surveys using the ME70 multibeam echosounder from NOAA R/V *Bell M. Shimada* 13-25 October 2017.

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 fish and habitat data from the AUV dives (Figure 3).

Figure 3. An AUV image of the seafloor with a large golden gorgonian (*Acanthogorgia* spp.) west of Footprint Bank in 285 m of water.

D3. FY17-18 NMFS Untrawlable Habitat Strategic Initiative: Southern California Bight Test Bed, 7-26 October 2017

Contact: Tom Laidig (tom.laidig@noaa.gov)
NMFS Untrawlable Habitat Strategic Initiative (UHSI) Team completed the second 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 4). Data collected from these platforms will be used to determine rockfish movement and behavior in response to a SeaBED AUV (launched from NOAA R/V *Bell Shimada*), an MLML drop camera (launched from the NOAA R/V *Shearwater*), and a manned submersible (launched from the *Velero*) in order to estimate the efficiency of these survey tools to count and measure demersal rockfish species.

Figure 4. Top image: 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. Bottom image: The surveillance platform (with strobe flashing) as viewed from the MLML drop camera.

Three surveillance platforms were deployed each day during daylight hours on the top of Footprint Bank at depths of 120 - 130 m. To test the fish reactions, the AUV and submersible were flown past the surveillance platforms at a similar speed and height above the seafloor used during visual rockfish surveys and the MLML drop camera was deployed within 10m of the front of the platforms. During the study, we successfully completed 20 drop camera deployments, 33 passes near the platforms with the AUV, and 43 passes with the manned submersible. Over 450,000 paired images (one color and one black & white) were shot from the platform cameras and 100 hours of DIDSON readings were taken during the study.

For each vehicle pass, we will count the number of fishes of each species, determine their height above the sea floor, and measure the total length for all individuals >15 cm for all fishes within 5 m of the platforms. Counts will begin 4 min before and continue until 4 min after a vehicle pass. An example of the change in fish counts is shown in Figure 5. This represents the number of fish observed for 4 min before the drop camera reached the sea floor. A large increase in the number of fishes present is observed starting 30 sec before the drop camera reached the sea floor. Finally, we will ascertain the fish's reaction (using the DIDSON sonars) by measuring the distances and directions travelled by individual fishes in response to the presence of survey vehicles.

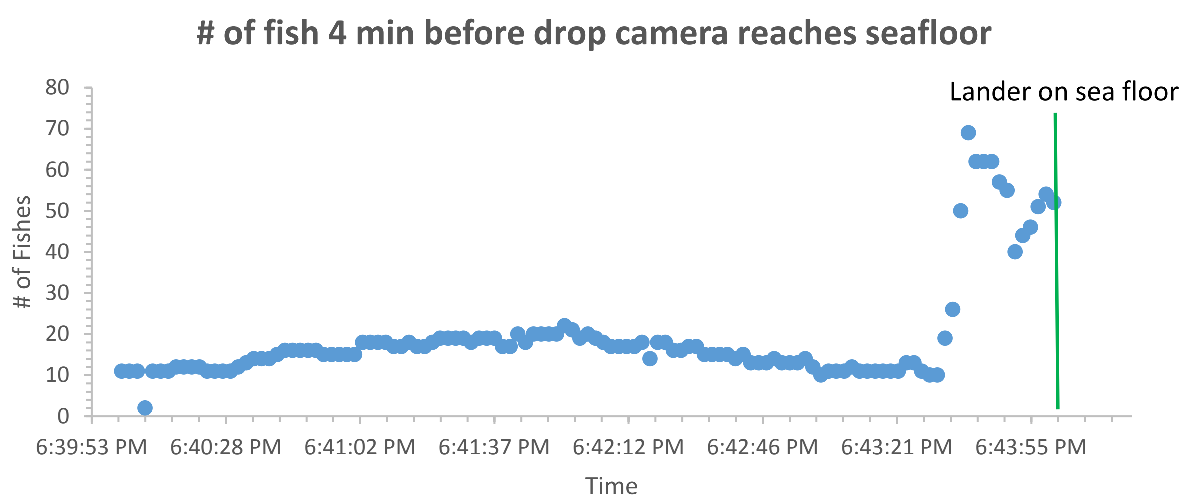

Figure 5. The number for fish over time counted from images taken from surveillance platforms before the drop camera reaches the sea floor. There is a large uptick in the number of fish observed starting about 30 second before the drop camera touches down on the sea floor.

This is the second year of a two-year field season study by the UHSI team in southern California. During the remainder of FY18, we will continue to collect fish count data from the stereo camera images and movement data from the DIDSON sonars. Once all the data is collected, we will analyze trends and produce a report with recommendations and possible biases for each vehicle.

In a related study, members of the AFSC and the UHSI team aboard the Shimada deployed stereo camera systems (developed at AFSC) across Footprint Bank. These camera systems recorded an image every 30 seconds and were left on the sea floor for up to 24 hours. Over the course of the cruise, there were 32 deployments of the camera systems. Using this data, the researchers will develop an independent density of rockfishes across the bank and compare these densities to ones previously estimated for certain rockfish species on Footprint Bank. This is a trial of their camera system to determine if it can be used to make detailed density estimates in a localized area using this relatively simple and inexpensive method.

D4. Anthropogenic noise generated by mobile survey vehicles

Contact: Tom Laidig (tom.laidig@noaa.gov)

During our UHSI cruise in southern California, HET members and researchers at Moss Landing Marine Laboratories placed acoustic devices on each surveillance platform to record ambient sound. The sounds created by each survey vehicle and support vessel were distinct and could be identified from the acoustic sonogram. This data will be examined in conjunction with the DIDSON and imagery data to determine how sound may influence rockfish behavior. These data also help to corroborate vehicle position and when each vehicle made its nearest pass to the surveillance platforms. Three times the platforms were left overnight due to poor sea conditions for retrieval. Interestingly, during these overnight times, the hydrophones picked up rockfish calls.

D5. Complete Habitat Use Database (HUD) Upgrade

Contact: Joseph Bizzarro (joe.bizzarro@noaa.gov)

During 2017, data entry was completed for all 117 species of groundfish identified in the current PFMC Groundfish Fishery Management Plan (FMP). Dr. Bizzarro will begin working with Todd Hay (NWFSC) during May 2018 to finalize the HUD, link it to a mapping program, and make it publically available through the NWFSC/FRAM Data Warehouse (https://www.nwfsc.noaa.gov/data/map).

D6. Update California Substratum Map for Cross-Shelf Benthic Habitat Suitability Modeling

Contact: Joseph Bizzarro (joe.bizzarro@noaa.gov)

A collaborative effort between NOS, NMFS, and BOEM personnel was initiated in 2016 to create habitat suitability models for corals and infaunal invertebrates and will continue until through 2018. 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; however, the California portion of this coast-wide map has not been updated since. The region off Washington and Oregon, however, has been substantially updated with new information, and contains a more detailed estimation of seafloor induration (soft, mixed, hard categories) than the California portion (soft, hard). During 2017, the entire coast-wide substratum map (25 m x 25 m raster) was updated to include all newly acquired seafloor induration collected since the last such effort during the 2012 EFH synthesis, and to include hard, mixed, and soft habitat types in California waters. A data quality layer is now being compiled to improve the utility of the map for modeling purposes by weighing the reliability of various seafloor induration data. This update was a necessary precursor to coral and infauna modeling efforts, which are currently being conducted, but the new West Coast Substratum Map has widespread utility for any similar spatial study that incorporates induration data off the U.S. West Coast.

D7. Create Diet Composition Database

Contact: Joseph Bizzarro (joe.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. This work is ongoing with an expected completion date by the end of the calendar year.

D8. Investigate Ecological Relationships among U.S. Pacific Coast Groundfishes

Contact: Joseph Bizzarro (joe.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 2017). 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 to 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. This work is ongoing, and the findings of this research will be submitted to a leading, peer-reviewed journal for publication during late 2018 or early 2019.

D9. Catch estimation methods in sparsely sampled mixed stock fisheries

Contact: E.J. Dick (Edward.Dick@noaa.gov)

An ongoing project led by Nick Grunloh (UCSC/Center for Stock Assessment Research) and E.J. Dick (FED), with participation by Don Pearson (FED), John Field (FED) and Marc Mangel

(UCSC/CSTAR) is focusing on the development of Bayesian hierarchical modeling approaches to be applied to historical and recent rockfish catch data and species composition samples in California fisheries, in order to improve estimates and quantify uncertainty in those estimates. Furthermore, the team has developed a Bayesian model averaging approach for inferring spatial pooling strategies across the over-stratified port sampling system. This modeling approach, along with a computationally robust system of inference and model exploration, will allow for objectively comparing alternative models for estimation of species compositions in landed catch, quantification of uncertainty in historical landings, and an improved understand the effect of the highly stratified, and sparse, sampling system on the kinds of inference possible, while simultaneously making the most from the available data. The methodology, currently a work in progress, was reviewed by a PFMC SSC methodology review panel (which included reviewers from the Center for Independent Experts) in March of 2018.

D10. Community sustainability cooperatives
Contact: Aaron Mamula (aaron.mamula@noaa.gov)
Investigators: Rosemary Kosaka (FED, SWFSC) and Aaron Mamula (FED, SWFSC)
This project began in 2016 and was detailed in last year's TSC report. In FY2018, we plan to finalize a NOAA Technical Memorandum detailing results from our study of the Monterey Bay Fisheries Trust and Morro Bay Community Quota Fund. We have also started a second phase of this project which will add data from the Half Moon Bay, CA area.

D11. Social networks and peer effects among groundfish fishermen
Contact: Aaron Mamula
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. A manuscript from this work is currently in review at the journal, *Land Economics*.

D12. VMS logbook matching update
Contact: Aaron Mamula
Investigators: Alice Thomas-Smyth (UCSC, FED, SWFSC), Cameron Speir (FED, SWFSC), Rosemary Kosaka (FED, SWFSC), Aaron Mamula (FED, SWFSC)

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. The focus of this project for FY2018 we will be completing a set of software tools that facilitate spatial analysis of VMS data in the ArcGIS environment.

D13. California Saltwater Sportfishing Survey

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 ongoing.

D14. The Western Groundfish Conference

The 20th Western Groundfish Conference was held in Seaside, CA, February 13-16 of 2018, and included nearly 200 participants, over 80 presented papers and over 50 presented posters. Sue Sogard, Tom Laidig and John Field (FED) were on the conference organizing committee and did considerable planning for this event along with colleagues from the International Pacific Halibut Commission, the California Department of Fish and Wildlife, local academic institutions (Moss Landing Marine Labs, UCSC, UCSB), and non-governmental organizations (The Nature Conservancy). Many other FED staff helped to plan and host the conference. The TSC also sponsored the opening session of the conference entitled "*Ups and downs of descending device policy and science*," other sessions included biology, ecology, habitat, stock assessment and management.

D15. Collaborative Research Efforts to Collect Biological Data

Contact: Melissa Monk (Melissa.monk@noaa.gov)

We have been working with two collaborative research programs to collect much needed biological data on nearshore rockfishes. The California Collaborative Fisheries Research Project (led by Dr. Rick Starr at Moss Landing Marine Lab and Dr. Dean Wendt at Cal Poly) is a fishery-independent hook-and-line survey to monitor the rockfish stock within the Marine Protected Area (MPA) network along the California Coast. The CCFRP charters Commercial Passenger Fishing Vessels (CPFVs or charter/party boats) and samples fixed grid cells both within the MPAs and at adjacent reference sites. In 2017 the CCFRP expanded from MLML and

Cal Poly to a coastwide project and now includes 5 universities. We are working with each of these universities to collect both otoliths for age and growth and also fin clips for genetic analysis. In 2017, MLML and Cal Poly collected approximately 330 pairs of otoliths, and Humboldt State University collected 221 pairs of rockfish otoliths.

Dr. Dean Wendt's research group at Cal Poly conducts an onboard observer survey aboard the CPFV vessels that uses the same methodology as the CDFW's California Recreational Fisheries Survey (CRFS). In addition to observing approximately 40 trips per year, the research group has started collecting otoliths from rockfish species aboard the CPFV vessels. The group collected 445 pair of otoliths from CPFVs in 2017.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2017 – PRESENT

E1. Primary Literature Publications

Ainley, D.G., Santora, J.A., Capitolo, P.J., Field, J.C., Beck, J.N., Carle, R.D., Donnelly-Greenan, E., McChesney, G.J., Elliott, M., Bradley, R.W. and Lindquist, K. 2018. Ecosystem-based management affecting Brandt's Cormorant resources and populations in the central California Current region. Biological Conservation 217:J 407-418.

Bizzarro, J.J., Carlisle, A.B., Smith, W.D., and E. Cortés. 2017. Trophic ecology of Northeast Pacific sharks, pp. 111–148. In: Advances in Marine Biology Vol. 77. Northeast Pacific shark biology, research, and conservation (Larson, S, and Lowry, D., eds.). Elsevier. Amsterdam, Netherlands.

Bizzarro, J.J.,Yoklavich, M.M. and W.W. Wakefield. 2017. Diet composition and foraging ecology of U.S. Pacific Coast groundfishes with applications for fisheries management. Environmental Biology of Fishes 100(4):375-393.

Dean, M.N., Bizzarro, J.J., Clark, B., Underwood, C.J., and Z. Johanson, 2017. Large batoid fishes frequently consume stingrays despite skeletal damage. Royal Society Open Science 4: 170674.

Dick, E.J., Beyer, S., Mangel, M. and S. Ralston. 2017. A meta-analysis of fecundity in rockfishes (genus Sebastes). Fisheries Research 187:73-85.

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STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2017

Prepared for the Fifty-Ninth Annual Meeting of the Technical Subcommittee
of the Canada-United States Groundfish Committee

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ALASKA DEPARTMENT OF FISH AND GAME
DIVISION of COMMERCIAL FISHERIES & DIVISION of SPORT FISH
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STATE OF ALASKA GROUNDFISH FISHERIES AND ASSOCIATED INVESTIGATIONS IN 2017

I. Agency Overview

1. Description of the State of Alaska commercial groundfish fishery program (Division of Commercial Fisheries)

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 140° W. longitude. The North Pacific Fisheries Management Council (Council) acted in 1997 to remove black and blue (now called deacon) rockfish from the GOA FMP. In 2007, 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 144° 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 are 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 one full-time fishery biologist, and Petersburg staff includes two fishery biologists and a seasonal fishery technician. In addition, the project provides support for port samplers in Ketchikan to allow sampling of groundfish landings. 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 GOA as well as in federal waters for demersal shelf rockfish DSR; black, deacon, and dark rockfishes; and lingcod. The project cooperates with the federal government for management of the waters of the adjacent EEZ. The project leader attends annual meetings of the Council's GOA 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 2017. 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 2017.

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 GOA 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 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 and PWS areas, as well as in federal waters for black, deacon, 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 are 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, an assistant groundfish research project biologist, a groundfish dockside sampling program coordinator, a groundfish dockside sampling program assistant biologist, a lead trawl survey biologist, an assistant trawl survey biologist, two seasonal fish ticket processing technicians, and several seasonal dockside sampling technicians. An 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's GOA Groundfish Plan Team (Nathaniel Nichols).

d. Headquarters

a. Alaska Fisheries Information Network

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 ADF&G statewide, AKFIN contract, and the PSMFC sponsored AKFIN Support Center (AKFIN-SC) in Portland, Oregon. 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 FMPs for groundfish and crab. The specific objectives related to the groundfish fisheries are: to collect groundfish fishery landing information, including catch and biological data, from Alaskan marine waters extending from Dixon Entrance to the BSAI;

1) 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;
2) to provide the support mechanisms needed to collect, store, and report commercial groundfish harvest and production data in Alaska;
3) to integrate existing fishery research data into secure and well-maintained databases with consistent structures and definitions;
4) 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;

5) 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
6) 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 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 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 GOA Groundfish FMP and the BSAI 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 ADF&G within seven days of landing. Data are reviewed, compared to other observations, edited, and verified. Once data are processed by local staff members, the fish ticket data are pulled into the ADF&G database of record; the statewide groundfish fish ticket database. Fish ticket data are immediately available to in-season management via the analysis and reporting tool, OceanAK. Verified fish ticket data are 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 2017, ADF&G AKFIN personnel processed 15,433 groundfish fish tickets, collected 27,509 groundfish biological samples and measured 13,977 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 2017

ADF&G Region	
1 - Southeast	2,539
2 - Central	2,340
4 - Westward; Kodiak, AK Pen.	8,520
4 - Westward; BSAI	1,172
Total	14,571

Groundfish Biological Data Collection - Calendar Year 2017

ADF&G Region	AWL Samples Collected	Age Estimates Produced by Regional Personnel	Age Estimates Produced by the Age Determination Unit
1 - Southeast	6,171	none	5,096
2 - Central	11,637	1,634	773
4 - Westward	9,240	3,737	n/a
Total	27,048	5,371	5,869

b. 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 statewide staff via the OceanAK reporting tool. 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 AKFIN support center, then summarized and made available to 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 successfully operated in Alaska's commercial fisheries since August 2005. To date, more than 900,000 landing reports have been submitted to the eLandings repository database. More than 99% of all groundfish landings are submitted electronically.

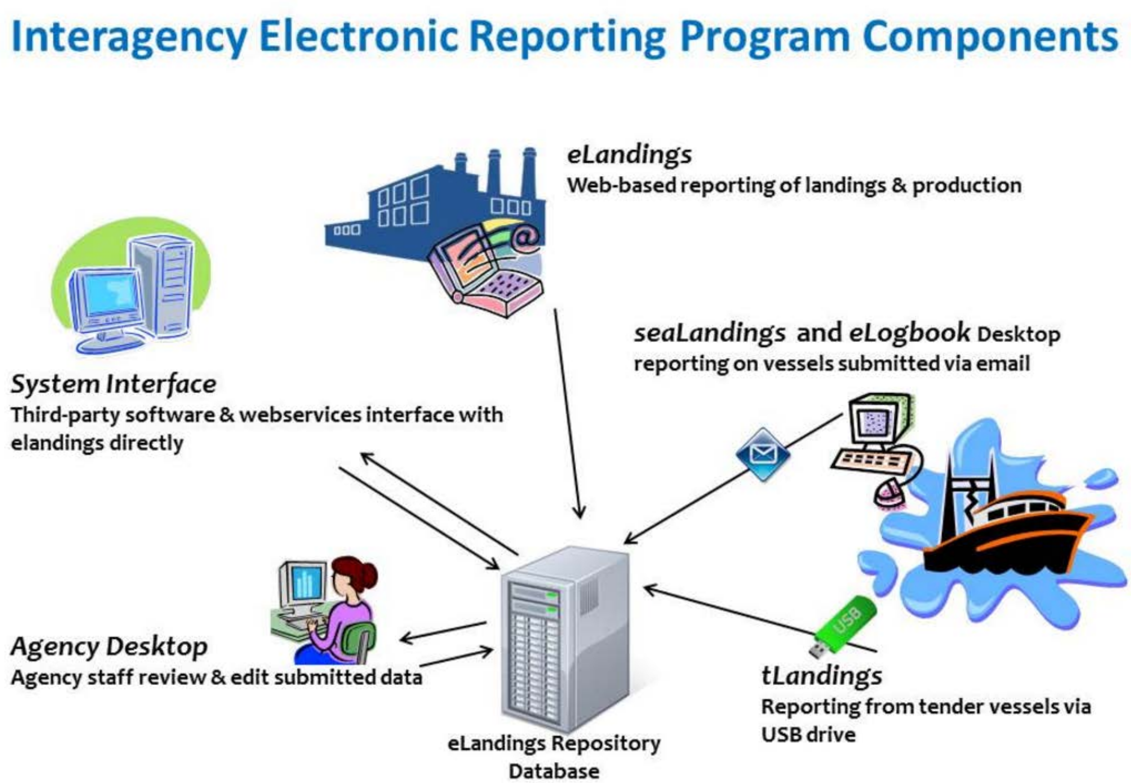

Figure 16. Data are reported by the seafood industry using eLandings web, seaLandings and tLandings. Agency staff review, edit and verify landing and production reports within the eLandings agency desktop tool. Industry can pull harvest data for their company from the database using the eLandings system interface tools.

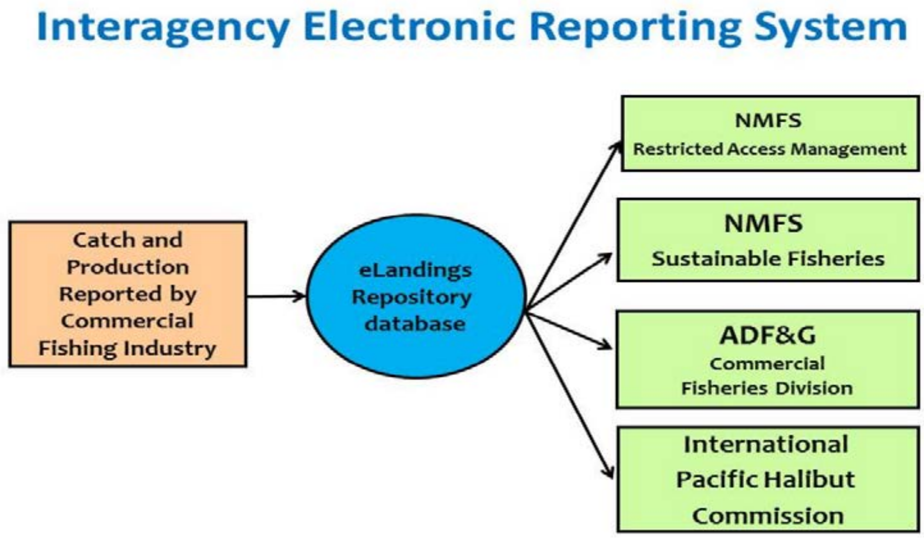

Figure 17. Interagency staff have established methods to pull data from the repository database into their databases of record. The ADF&G fish ticket records are pulled into the commercial fisheries fish ticket database once data verification has occurred.

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. ADF&G will always support conventional, paper-based reporting for smaller buyers and processors. In November 2015, 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 2017 salmon season, 95.4% percent of all salmon landings were submitted electronically. Implementation of statewide electronic reporting of 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 2017, the IERS recorded 207,213 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 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 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 2017, the ADU received 9,868 otolith sets from central and southeast Alaska commercial and survey sampling (representing 16 groundfish species). The ADU produced 9,050 ages and distributed 7,907 ages to region managers, including data from samples received in previous years but processed in 2017. 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 2017, quality control procedures resulted in an additional 5,552 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 1,060 age estimates. Given production, quality control, and training procedures, the ADU recorded 15,662 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 (21,710 otoliths in 2017, representing 17 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 2017, ADU personnel attended the 2017 CARE meeting, contributed to CARE documents, functioned in CARE working groups, and participated in age structure exchanges to address agency and TSC concerns. Both K. McNeel and A. Rebert attended the 2017 CARE meeting at the Alaska Fisheries Science Center (AFSC) Sand Point facility in Seattle, WA. At the meeting, personnel reviewed yelloweye and rougheye rockfish otolith annual pattern criteria with other agencies, presented research on shortraker rockfish otolith analyses and crustacean age assessment, and attended workshops on lingcod age structure preparation as well as rougheye rockfish pattern interpretation and shape analysis. During the meeting, K. McNeel fulfilled his role as the CARE secretary by recording the meeting minutes for TSC and CARE reporting, was elected as the chair of CARE for the 2017-2019 term and presented the online CARE database for age related publications developed by the MTAL. In addition to the meeting, the ADU initiated two rougheye rockfish otolith exchanges with AFSC and the Northwest Fisheries Science Center in Newport, OR (NWFSC), one yelloweye rockfish exchange with NWFSC, Washington Department of Fish and Wildlife (WDFW), and ADF&G-Homer, and one lingcod otolith exchange with WDFW.

The ADU is funded by State of Alaska, AKFIN, and special project support. In fiscal year 2017 and 2018, approximately 51% of funding was provided by the State of Alaska, 30% by AKFIN, and 19% from research grants. During 2017, the ADU employed seven people (approximately 77 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 (Division of Sport Fish)

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 FMP or other applicable federal regulations. No sport fisheries are included in the GOA FMP.

Most management and research efforts are directed at halibut, rockfish, and lingcod; the primary bottomfish 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) addresses 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

The Southeast Region extends from the EEZ boundary in Dixon Entrance north and westward to Cape Suckling, at approximately 144° W. longitude. Regional staff in Douglas coordinate 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 of lingcod, sex of black rockfish at Sitka, the sport fishery 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 in 2016 and 2017. 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

The Southcentral Region includes state and federal waters from Cape Suckling to Cape Newenham, including 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 seven 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 that include the sport and commercial sectors.

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.

II. Surveys

Fishery surveys, where applicable, are addressed in research sections by species

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III. Marine Reserves

Nothing to report for 2017.

IV. Groundfish Research, Assessment, and Management

1. Hagfish

1. Research

In 2016, the Southeast Region began an opportunistic survey for *Eptatretus stoutii* and *E. deani* during the annual shrimp pot surveys to gather information on distribution and life history information including: size at maturity, fecundity, sex ratio, length, and weight frequencies. Survey sampling continued in 2017 and stations were expanded to Clarence Strait based bycatch occurrence of hagfish during the sablefish longline survey. 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 length recordings for *E. deani* at 770 mm for females and 620 mm for males (Contact Andrew Olson).

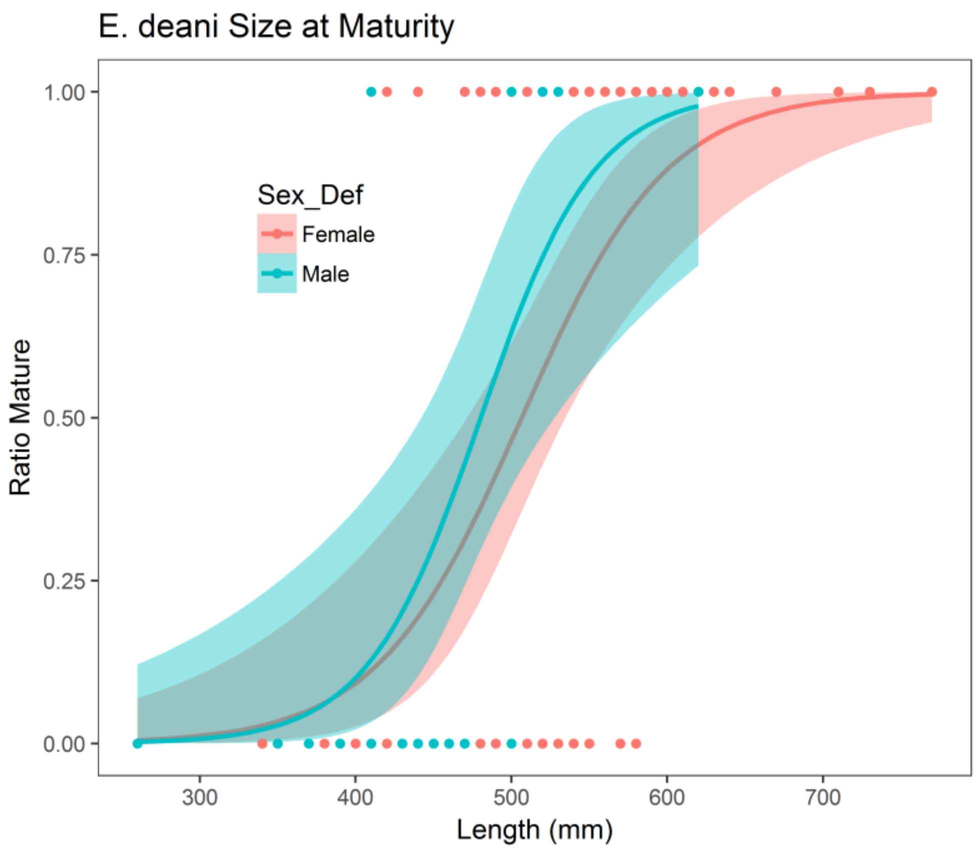


Figure 18. Preliminary size at 50% maturity with 95% confidence intervals for male (480.3 mm, n=36) and female (506.6 mm, n=74) *E. deani* in southern Southeast Alaska.

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. Gear is restricted to 3,000 gallons in volume using any combination of gear types included Korean style traps, buckets, and barrels per vessel. In 2017, two commissioner's permits were issued for directed fishing of hagfish in the **Southeast Region**.

4. Fisheries

The developing directed fishery for hagfish in the Southeast region has a total guideline harvest level (GHL) of 60,000 lbs. The primary species caught is *E. deani* and a market has been developing for Alaskan hagfish where they are sold for food and their skin is used to make leather products. 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

Central Region Commercial Fisheries Division initiated research project examining the energetics of salmon sharks in the summer of 2012, which includes the concurrent application of temperature/depth transmitters and accelerometers. The department hopes to continue that work in the future. (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 2,222 boat-trips and 11,525 angler-days of effort targeting all species in 2017. Interviewed anglers caught 29 salmon sharks but kept only one and caught 1,482 spiny dogfish and kept 35. Length measurements were obtained from two salmon sharks and four spiny dogfish (Contact Martin Schuster).

b. Assessment

There are no stock assessments for dogfish or sharks.

c. Management

Directed fisheries for spiny dogfish in the Central and Southeast Regions are allowed under terms of a commissioner's permit. The commercial bycatch allowance in the **Southeast Region** is 35% round weight of the target species in longline and power or hand troll fisheries. Full retention of dogfish bycatch is permitted in the salmon set net fishery in Yakutat. 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, from 2014 through 2017, allowable bycatch levels of all shark species in aggregate (includes spiny dogfish) were set at 15% by emergency order.

The practice of "finning" is prohibited; 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 2017.

d. Fisheries

No applications for commissioner's permits were received in 2017, and no permits have been issued in **Central Region** since 2006. During 2017 in the Cook Inlet Area, there was zero harvest of spiny dogfish and very low harvest in PWS (0.05 mt).

Estimates of the 2017 sport harvest of sharks are not yet available, but harvest in 2016 was estimated at 24 sharks of all species in Southeast Alaska and 235 sharks in Southcentral Alaska. The precision of these estimates was relatively low; the Southeast estimate had a CV of 53% 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 most of the sport salmon shark harvest. Logbooks indicated a charter harvest of two salmon sharks in Southeast Alaska and eight salmon sharks in Southcentral Alaska in 2016.

3. Skates

1. Research

A population abundance index from the PWS bottom trawl survey is generated for three skate species each year of that survey. The survey occurs in Eastern PWS and the time series begins in 1999 for big and longnose skates and 2001 for Bering skate. Aleutian skates are also captured in the survey, but their occurrence is too low to estimate abundance. Bering skate catch per unit effort (CPUE) in 2017 continued an increasing trend since 2007. Big skate CPUE in 2017 was similar to the previous two surveys being at time-series highs. Longnose skate CPUE fell to a survey low in 2017 (Contact Dr. Kenneth J. Goldman and Mike Byerly).

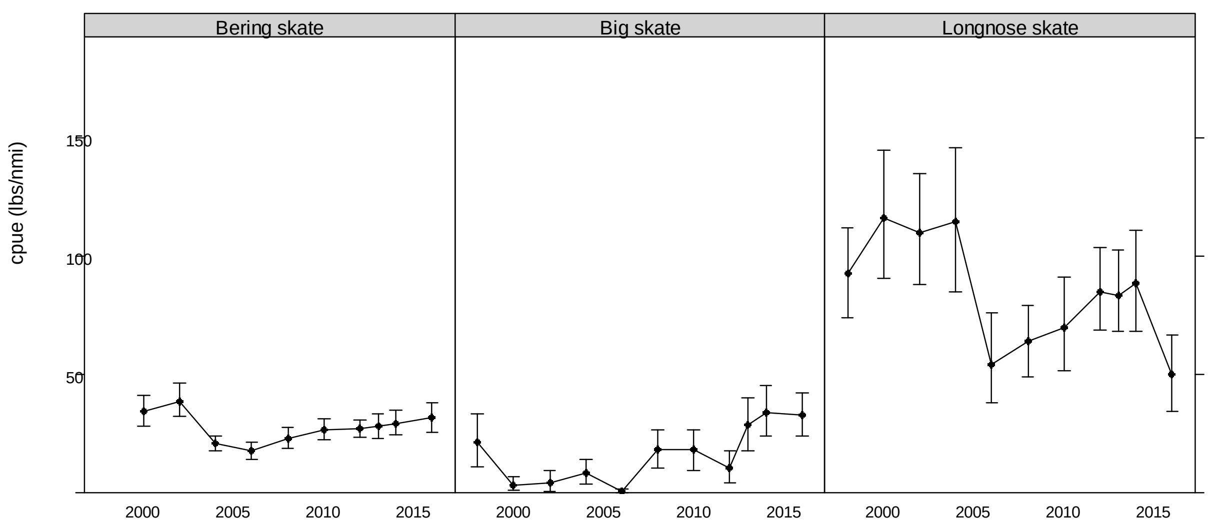


Figure 4. Trawl survey CPUE estimates of skates with 90% confidence intervals in Eastern PWS.

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% to align with the National Marine Fisheries Service (NMFS) change in maximum retainable allowances for skates in the GOA. A directed fishery in the PWS 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 12.5 mt in 2017, nearly half the 2016 harvest, and continuing a steady decline since 2015. In PWS, skate harvest was 18.1 mt, less than half the 2016 harvest, also continuing a steep decreasing trend since 2015. Due to bycatch limits being set as a percentage of the targeted species, harvest levels of the target species may affect the amount of bycatch that are legally harvested.

In **Southeast Region**, skate landings in internal waters of Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) fluctuated with low harvest in 2017 of 8.2 mt and a high in 2016 of 16.5 mt. Skate harvest fluctuates with current market value.

4. Pacific cod

Catch rate and biological information are 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

Pacific cod are captured in **Central Region** Tanner crab bottom trawl surveys. A population abundance index from the PWS bottom trawl survey is generated each year with coefficient of variation's (cv's) ranging from 0.16 to 0.36 and averaging 0.26. The survey occurs in Eastern PWS and the Pacific cod time series begins in 1991. Estimated CPUE was down in 2017 to the third lowest in the time series.

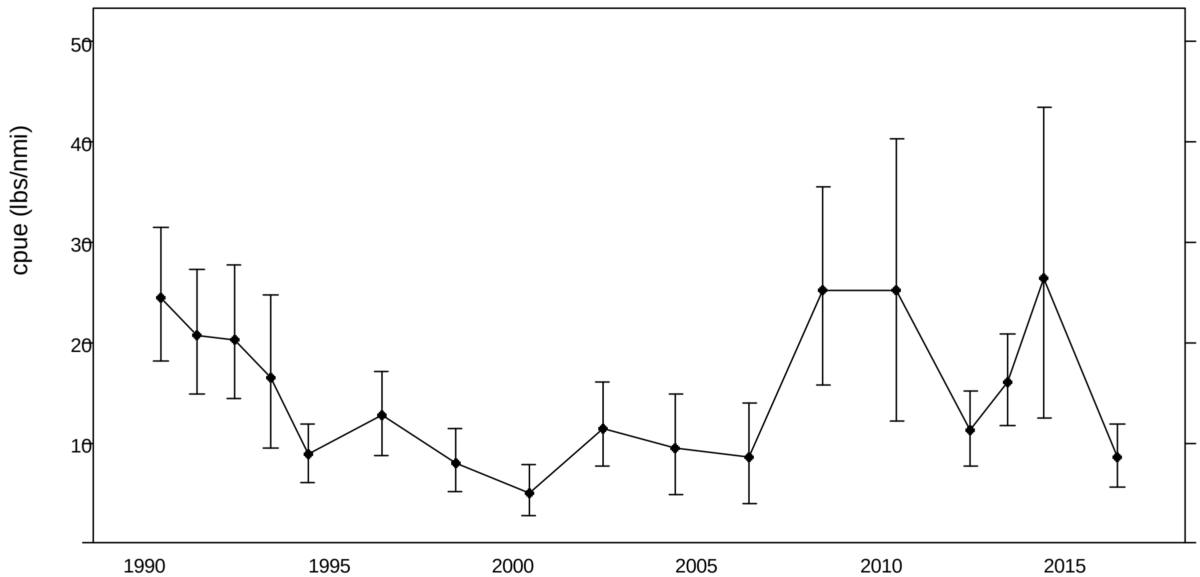


Figure 5. Trawl survey CPUE estimates of Pacific cod with 90% CIs in Eastern PWS.

In the **Central Region**, skipper interviews and biological sampling of commercial Pacific cod deliveries from PWS and Cook Inlet areas during 2017 occurred in Homer, Seward, and Whittier. 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 are provided to NMFS for use in stock assessment (Contact Elisa Russ).

2. Assessment

No stock assessment programs were active for Pacific cod during 2017.

3. Management

The internal waters of Southeast Alaska are comprised of two areas, NSEI Subdistrict and 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 the GOA, Pacific cod Management Plans area established for fisheries in five groundfish areas: **Prince William Sound**, **Cook Inlet**, **Kodiak**, **Chignik** and **South Alaska Peninsula**. Included within the plans are season, gear and harvest specifications. Initially the state-waters fisheries were restricted to pot or jig gear to minimize halibut bycatch and avoid the need to require onboard observers in the fishery. However, in PWS the use of longline gear has been permitted since 2009 in response to the very low levels of effort and harvest by pot and jig gear and the high level of interest from the longline gear group. Guideline harvest levels (GHL) are further allocated by gear type.

The annual GHLs are based on the estimate of 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, 25% of the Eastern Gulf ABC for the PWS Area, and 30% of the Western Gulf Pacific cod ABC for the South Alaska Peninsula Area.

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. 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 the **Bering Sea/Aleutian Islands area**, a Pacific cod Management Plan for a nonexclusive Aleutian Islands District, west of 170° W longitude, state-waters fishery has been adopted. Included within the plan are season, gear and harvest specifications. The fishery GHL is set by regulation at 27% of the Aleutian Islands ABC for Pacific cod.

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.

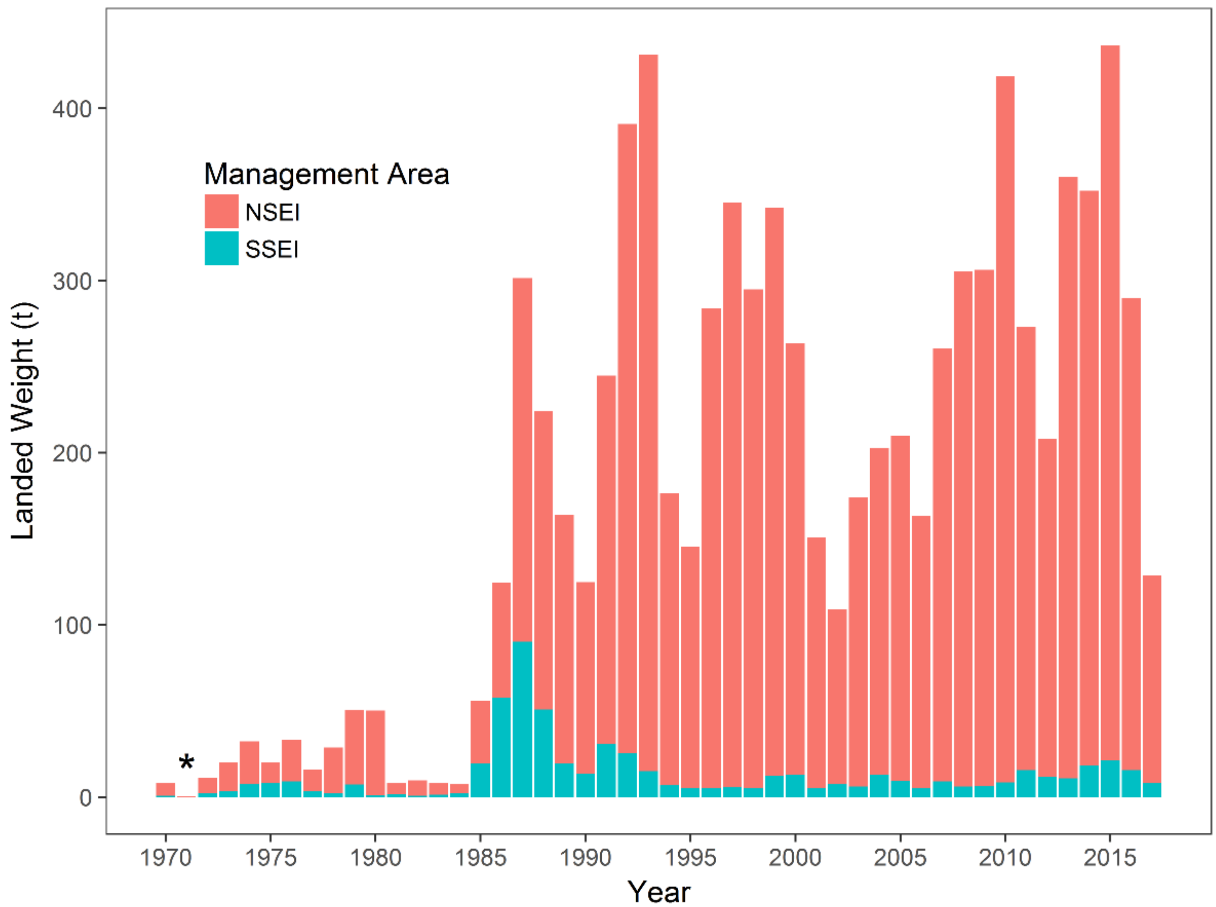
A state-waters Pacific cod fishery management plan has also been adopted in waters of the Bering Sea near Dutch Harbor. The **Dutch Harbor Subdistrict** Pacific cod season is open to vessels 58 feet or less OAL using pot gear, with a limit of 60 pots. The fishery GHL is set at 6.4 percent of the Bering Sea ABC for Pacific cod. 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, the dominate gear type has been pot gear in **Cook Inlet** and longline gear in **PWS** fisheries. In 2017 in the **Westward Region** parallel Pacific cod fisheries, pot gear vessels take 69% 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 took more than 99% of the total 2017 state-waters Pacific cod catch in these areas. In 2017 in the Aleutian Islands, trawl gear took 12%, longline gear took 26%, and pot gear took 62% of the harvest.

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. A total of 129 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2017 with 107 mt harvested from the directed fishery.



*Indicates harvest by less than 3 permit holders, therefore information is confidential.

Figure 6. Annual harvest of Pacific cod in the Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) management areas in Southeast Alaska from 1970–2017 for the direct and bycatch fisheries.

The 2017 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and PWS areas of the **Central** Region were 1,657 mt and 1,968 mt, respectively. The Cook Inlet GHL was down 12% from 2016 while the PWS GHL decreased 7%. Pacific cod harvest from the state-waters seasons was 742 mt from Cook Inlet and minimal harvest (confidential) from PWS. Low harvests in Cook Inlet were attributed to a low CPUE during the fishery, and similarly for PWS, although it was compounded in PWS because the state-waters season for longline did not open until June 17 due to the federal season in the Central GOA remaining open until the regulatory closure, leaving little to no fishing time for longline vessels to participate during the peak fishing period and also before diversifying into other fisheries (e.g. halibut, salmon). Pacific cod harvest during the 2017 parallel seasons was 775 mt from Cook Inlet and 384 mt from PWS, both down significantly from 2016. In Central Region in 2017, state-waters GHLs were not achieved by pot, longline, or jig gear, and fishing with jig was open all year in parallel fisheries. For combined Pacific cod fisheries, in Cook Inlet pot gear harvested 80% and longline gear 20% with jig gear harvesting a negligible amount, and in PWS, longline gear harvested over 99%.

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 2017 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 2017 Pacific cod GHLs were 5,523 mt in the Kodiak Area, 3,866 mt in the Chignik Area and 10,887 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik and South Alaska Peninsula was 1,741 mt, 1,428 mt and 9,158 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 2017 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 Bering Sea Pacific cod ABC and is open to pot gear only. In 2017, the total state-waters catch for the Dutch Harbor Subdistrict was 15,081 mt.

Estimates of the 2017 sport harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2016 estimates were 12,333 fish in **Southeast** and 31,183 fish in **Southcentral Alaska**. The estimated annual harvests for the recent five-year period (2012-2016) averaged about 15,015 fish in **Southeast** Alaska and 33,410 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 2017 occurred in Seward and Kodiak. 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 700 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 PWS, 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.

Pollock are captured in Central Region Tanner crab bottom trawl surveys. A population abundance index from the PWS bottom trawl survey is generated each year of that survey with cv's ranging from 0.15 to 0.49 and averaging 0.24. The survey occurs in Eastern PWS and the pollock series begins in 1994. Estimated CPUE was down in 2017 to a survey low.

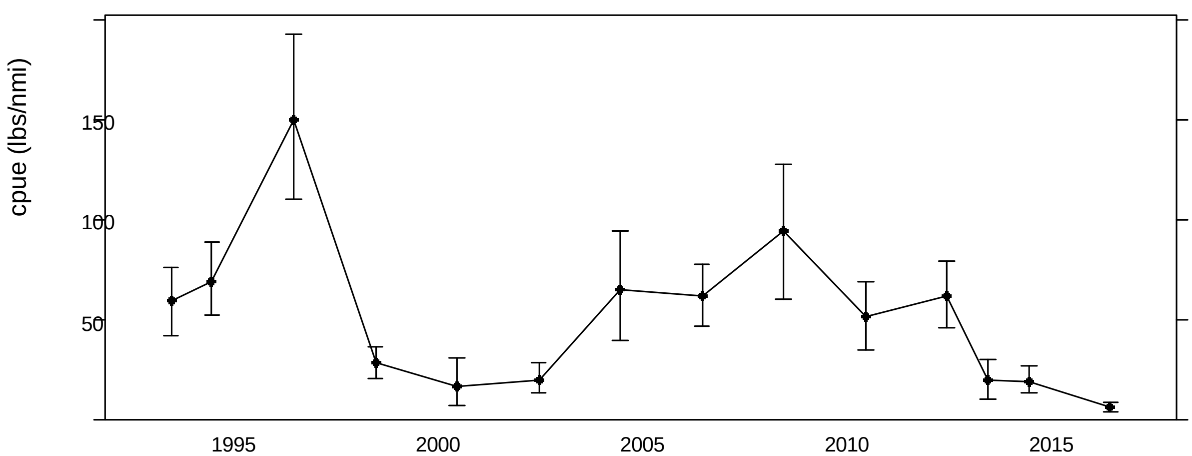


Figure 7. Trawl survey CPUE estimates of Walleye pollock with 90% confidence intervals in Eastern PWS.

b. Assessment

No stock assessment work was conducted by the department on pollock in 2016.

c. Management

Prince William Sound Area pollock pelagic trawl fishery regulations include a January 13 registration deadline, logbooks, catch reporting, check-in and check-out provisions, and accommodation of a department observer upon request. The PWS 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,** 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 was prosecuted through 2016. In **Central Region**, pollock is also retained as bycatch to other directed groundfish fisheries, primarily Pacific cod (Contact Jan Rumble).

d. Fisheries

The 2017 PWS pollock pelagic trawl fishery opened January 20 and continued until the regulatory closure on March 31. There were 15 landings made by eight vessels with a total harvest of 1,879 mt, only 40% of the 4,672 mt GHL, perhaps attributable to the smaller than average fish size (600 gram average) and low exvessel value. Rockfish bycatch during the fishery totaled 2 mt well below the 9 mt allowed as bycatch to the pollock harvested. In the Cook Inlet Area, no seine pollock commissioner's permits were issued in 2017. Pollock was harvested in **Central Region** as bycatch to other groundfish fisheries at low levels; in 2017, 3.7 mt was harvested in Cook Inlet and 1.7 mt in PWS (Contact Jan Rumble).

In Southeast, one commissioner's permit was issued to fish for pollock by purse seine. However, no fishing occurred in 2017 (Contact Mike Vaughn).

6. Pacific Whiting (hake)

1. Research

There was no research conducted on Pacific whiting (hake) in 2017.

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 2017. 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 2017.

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 2017. 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: DSR, pelagic shelf (PSR), and slope rockfish. DSR include the following species: yelloweye, quillback, China, copper, rosethorn, canary, and tiger. PSR include black, deacon, 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. In 2017, length, weight and age structures were collected from 1,573 yelloweye rockfish caught in the directed and halibut commercial longline fisheries. Bone and tissue samples were taken from five 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).

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2017 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 has been the focus of rockfish sampling during the last half of the year. Limited fishing effort drastically reduced sampling opportunities from 2006-2009 until an increase in effort resulted in additional sampling opportunity with sampling goals for Cook Inlet black rockfish being met 2014-2017. Additional rockfish samples were collected from bycatch fisheries in Cook Inlet and PWS with the sampling goal achieved or nearly achieved for yelloweye rockfish in both areas. 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 Cook Inlet 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).

Funding for **Central Region** DSR and lingcod ROV surveys ended in 2016 and no surveys were conducted in 2017. Staff participated in the ADF&G Interdivisional Rockfish Workshop in September 2017 (see rockfish management section for details).

Rockfishes are captured in Central Region bottom trawl surveys for Tanner crab. All rockfish are sampled for length, weight, sex, and age structures. A population abundance index from the PWS bottom trawl survey is estimated for rougheye/blackspotted rockfish each year of that survey with cv's ranging from 0.16 to 0.37 and averaging 0.24. The survey occurs in Eastern PWS and the time series begins in 1991. Estimated CPUE in 2017 was the lowest in the time series. (Contact Ken Goldman or Mike Byerly).

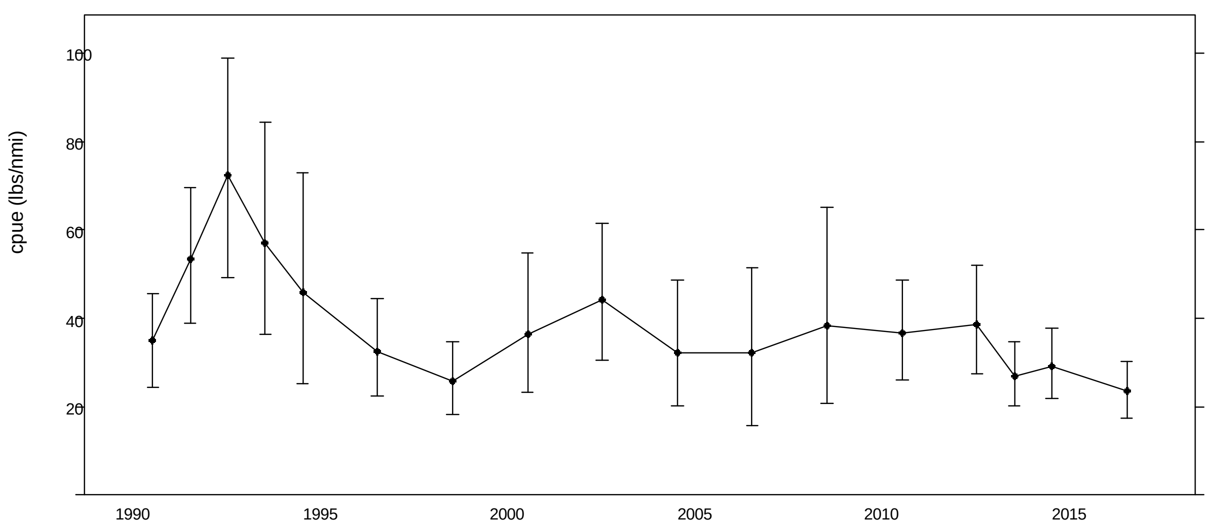


Figure 8. Trawl survey CPUE estimates of rougheye/blackspotted rockfish with 90% confidence intervals in Eastern PWS.

The **Westward Region** continued port sampling of several commercial rockfish species and Pacific cod in 2017. 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 2016 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, Southeast, Southwest, Westside, and Mainland districts of the Kodiak Management Area in 2017 to generate biomass estimates for both black and dark rockfish. Surveys of Northeast, Afognak, Eastside, and Southeast districts in the Kodiak Management Area will continue in 2018 (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 9,046 rockfish was obtained from the sport harvests at Ketchikan, Craig, Klawock, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2017 (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 2017 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, and Homer was 5,041 rockfish (Contact Martin Schuster).

The Division of Sport Fish conducted research in PWS on survival of rockfish following recompression from 2012-2017. During this time, 185 rockfish of six species (copper, quillback, yelloweye, silvergray, dark, and dusky) 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. From this study it was estimated that post-recompression survival for all six species combined was >84%, which is consistent with results from studies that indicated high survival for yelloweye rockfish in PWS and other species in the Pacific Northwest. Results will be published as an ADF&G Fishery Data Series report in the coming months titled "Post-Recompression Survival of Rockfish in PWS (Contact Brittany Blain-Roth or Jay Baumer).

The **Age Determination Unit** researched Southeast Alaska yelloweye and PWS rougheye, blackspotted, and shortraker rockfish age structures. In 2017, ADF&G personnel sampled opercula and otoliths from female yelloweye rockfish collected during the NMFS Sablefish Longline Survey. Ages were estimated using otoliths and annual bands were identified on opercula. Opercula were then sent to Baylor University to be analyzed for progesterone and cortisol concentrations extracted from annual bands within a given structure. Preliminary results suggested that hormone estimates vary between annual bands and reproductive life histories may be reconstructed from the fluctuating annual concentrations (Figure 5). The Mark, Tag, and Age Laboratory is seeking funding to further investigate hormone extraction from incrementally grown hard structures as a method to reconstruct life histories of long-lived fishes (Contact Dion Oxman).

During 2017, the Age Determination Unit also continued investigating methods to identify rougheye, blackspotted, and shortraker rockfish using otolith shape analysis and to identify correlations between shortraker rockfish otolith growth and climatic events to corroborate ages and suggest climates that favor rockfish growth (Contact Kevin McNeel).

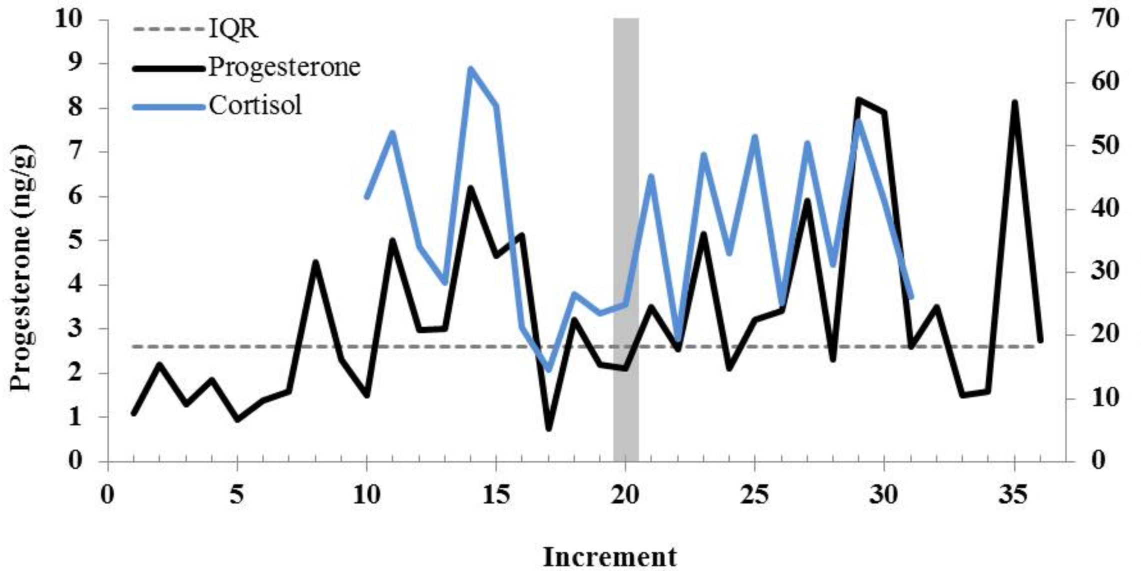


Figure 9. Progesterone (black) and cortisol (blue) concentrations recovered from annual growth increments within the operculum of a 36-year old female yelloweye rockfish via immunoassay extraction. Peak concentrations of progesterone that exceed the interquartile range (IQR; dashed line) were considered to be indicative of reproductive activity. The currently accepted age of maturity for yelloweye is highlighted in gray. Data are missing from the cortisol profile because they were used to validate immunoassay extractions.

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 Eastern Yakutat (EYKT), 2005 in SSEO, 2007 in CSEO, and 2001 in NSEO; density estimates were derived from each of these surveys except for the NSEO management area where data were too limited to obtain a valid density estimate. 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 (Figure 6). Yelloweye rockfish density was, 701 yelloweye per km^2 (CV=20%) for NSEO in 2016, 1,101 yelloweye per km^2 (CV=14 %) for CSEO in 2016, 986 yelloweye per km^2 (CV=22%) in SSEO in 2013, and 1,072 yelloweye per km^2 (CV=21%) for EYKT in 2017. In addition, from ROV video data, we can measure fish lengths for yelloweye rockfish, lingcod, and halibut using stereo camera imaging software (SeaGIS, Ltd).

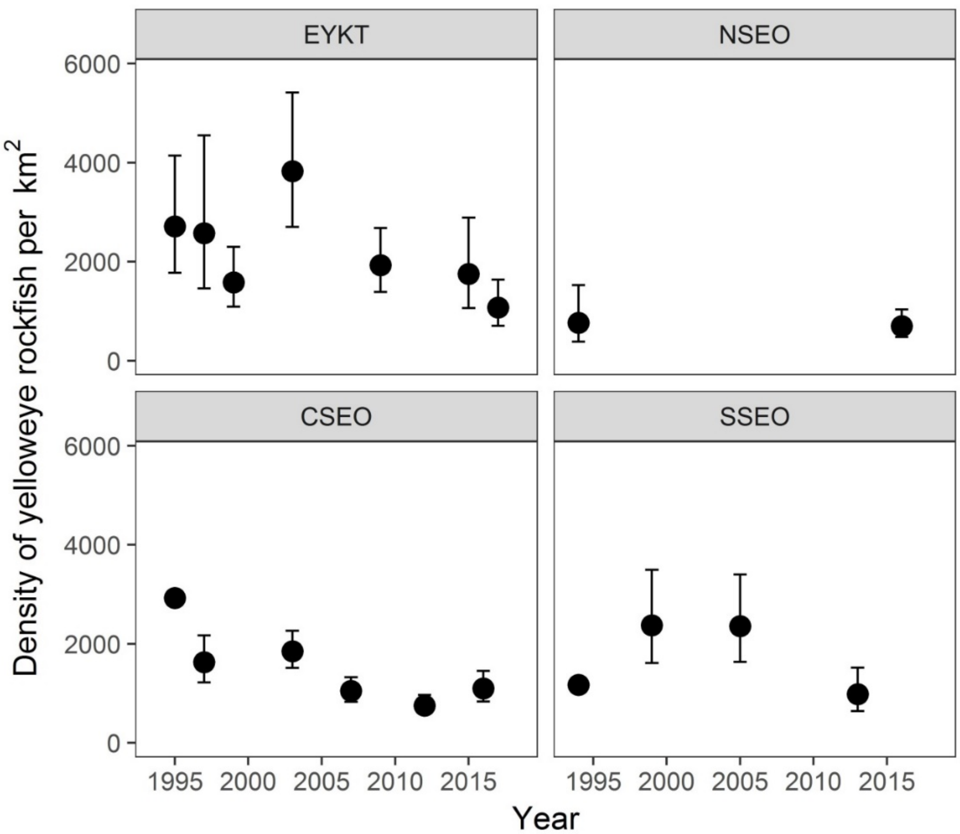


Figure 10. Density estimates of yelloweye rockfish with 90% confidence intervals in the Eastern Gulf of Alaska management areas. Management areas include: Eastern Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (CSEO).

Central Region conducts ROV surveys along the northern Gulf of Alaska coast from the Kenai Peninsula to PWS to monitor the local abundance of DSR in selected index sites. No assessment surveys were conducted in 2017 (Contact Mike Byerly or Dr. Kenneth J. Goldman).

In the **Westward Region** rockfish surveys using hydroacoustic equipment were deployed to assess black and dark rockfish stocks in the Kodiak Management Area. Surveyed areas included the Northeast, Afognak, Eastside, Southeast, Southwest, Westside, and Mainland 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. The DSR directed fishery season in SEO occurs only in the winter from January 5 until the day before the start of the commercial halibut IFQ season, or until the annual harvest limit is reached whichever occurs first. Total allowable catch (TAC) is set for DSR is set after decrementing estimated subsistence harvest and the remainder is allocated 84% to the commercial sector and 16% to the sport sector. The 2017 ABC for DSR was 227 mt, which resulted in a TAC of 220 mt with allocations of 185 mt to commercial fisheries and 35 mt to sport fisheries. The 2018 ABC is set at 250 mt, resulting in a TAC of 243 mt of which 204 mt is allocated to commercial fisheries and 39 mt is allocated to sport fisheries. Estimated subsistence harvest for 2017 and 2018 was 7 mt. 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 determining if a directed fishery is manageable.

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 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 (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 Cook Inlet 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 0.05% 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. 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 2017, 49 mt of black rockfish were harvested from seven sections in the Kodiak Area. GHLs were attained in four sections of the Kodiak Area. In the South Alaska Peninsula Area, the 2017 black rockfish harvest was 20 mt. Harvest in the Chignik Area is confidential. In 2017, no vessels made directed black rockfish landings in the Aleutian Islands Area and all harvest was incidental retention. Fishers may retain up to 5% of black rockfish by weight incidentally during other fisheries. In 2017, 1.4 mt of black rockfish and 3.1 mt of dark rockfish were harvested incidental to other groundfish species. 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, most 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 of the genus *Sebastes*. For the 2017 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 March 27 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>All Southeast Alaska Waters</u>: 1) all non-pelagic rockfish caught were required to be retained until the bag limit was reached; 2) resident bag and possession limit was one rockfish of any species; 3) nonresident bag limit was one fish, with an annual limit of one yelloweye rockfish.

<u>Southeast Alaska Outside Waters</u>: 1) Retention of nonpelagic rockfish was prohibited in all Southeast Outside waters from August 1 through August 21, 2017; 2) All anglers fishing from a vessel in Southeast Outside waters during this period were required to have a functional deep water release mechanism on board and release nonpelagic rockfish at the depth of capture or at least 100 feet using the deep water release mechanism.

For the entire Southeast Alaska region, charter operators and crewmembers were not allowed to 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 deep water 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).

Sport 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 PWS 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 PWS 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.

In 2017 the department began an interdivisional process to develop comprehensive harvest strategies for groundfish, beginning with black and yelloweye rockfish using information from all fisheries. A workshop was held in September 2017 with approximately 30 participants from the Commercial Fisheries and Sport Fish divisions. Staff summarized harvest trends and management procedures used in each fishery. Commercial and sport fisheries are currently managed separately, and several areas of the state lack annual harvest targets for the sport fishery. There was agreement on the need to develop harvest strategies that applied to all removals and an integrated approach to management, at least to set harvest guidelines and control rules. The department is committed to developing abundance-based goals where assessment is possible and simpler strategies where information is lacking. The initial focus on black and yelloweye rockfish is to address immediate management needs and serve as models for other groundfish species.

d. Fisheries

Directed fisheries for DSR and black rockfish occurred in **Southeast** in 2017. The directed fishery for DSR in SEO only opened in EYKT, while 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 a manageable fishery. Directed fishing for DSR was also opened in internal waters. The 2017 harvest of DSR by directed fisheries in EYKT was 32.2 mt and in internal waters was 5.7 mt. In addition, DSR was taken as bycatch with 96.8 mt harvested in SEO and 24.3 mt in internal waters. Harvest in the directed black rockfish fishery in Southeast Outside District (SEO) was 5.2 mt and black rockfish harvest in all groundfish, halibut, and salmon troll fisheries in SEO was 10.6 mt. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 65.6 mt harvested in 2017.

In **Central Region**, both the Cook Inlet and PWS areas have a rockfish GHL of 68 mt, which includes both directed and bycatch harvest. In the Cook Inlet Area in 2017, the total rockfish harvest, including the directed PSR jig fishery and bycatch, was 53 mt. PSR harvest comprised

55% of the total harvest, with the majority of harvest coming from the directed PSR fishery. There had been a steady increase in harvest and effort in the Cook Inlet directed fishery in recent years, and although harvest decreased in 2017, it was still the third highest since 2005, with highest harvests in 2016 and 2015, respectively. In PWS, rockfish are only harvested as bycatch, as there is no directed fishery. For PWS in 2017, rockfish harvest was 27 mt, down significantly from 2016 when the GHL was exceeded. The majority of rockfish bycatch in PWS was caught by longline gear (92%) followed by trawl gear (7%) with the minimal remaining harvested by jig gear.

Overall **sport harvest** (guided and unguided) is estimated primarily through the 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 harvest 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 2017 harvest are not yet available from the SWHS, but the 2016 estimates for all species combined were 173,847 fish in Southeast and 173,591 fish in Southcentral Alaska. The average annual harvest estimates for the recent five-year period (2012-2016) were 164,418 rockfish in Southeast Alaska and 135,519 fish in Southcentral Alaska.

9. Thornyheads

1. Research

There was no research conducted on thornyheads in 2017.

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 2017. 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 in PWS for the bycatch allowance for the directed sablefish fishery (20%), Pacific cod (5%), and directed pollock trawl fishery (0.05%). 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 2017, 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 2017 seven commercial fishermen participated in the surveys and were allowed to sell their Personal Quota Share (PQS); thus, reducing the impact on the quota by for fish harvested and sold by the state. The department plans to allow permit holders to harvest their PQS aboard future NSEI longline surveys.

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 2017, 7,096 fish were marked and released in NSEI over the course of the tagging survey. Over the 21-day survey, 29 longlined 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 2018 (Contact Andrew Olson).

Central Region, ADF&G conducted longline surveys for sablefish from 1996 through 2006 in PWS. 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, 329 fish have been recaptured from the 2011 survey and 56 were captured from the 2013 survey and 5 from the 2015 survey. Of all tagged releases, 57% have been recaptured within PWS and 29% outside in the GOA with the remainder of unknown location. There have been no PWS sablefish tagging surveys since 2015 (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 and 2017 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 2017 recommended ABC of 385 mt for the NSEI fishery was calculated by applying the 2016 fishery mortality at age (based on a harvest rate of 6.8% using the $F_{50\%}$ biological reference point (BRP)) to the 2017 forecast of total biomass at age and summing across all ages. The 2017 ABC was a 5.3% decrease from the 2016 ABC (366 mt), which was also based on the $F_{50\%}$ BRP (the harvest rate was 6.8% for 2016). 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 PWS 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 2017 in NSEI and 23 permit holders eligible to fish in SSEI. The NSEI fishery is restricted to longline gear only while SSEI has separate seasons for longline and pot gear with 20 longline permits and 3 pot permits. In 2017, the CFEC approved a public petition for SSEI longline permits the ability to fish pot gear due to whale depredation and rockfish bycatch, thus making the permit a longline/pot permit.

The NSEI quota was set at 327 mt and the SSEI quota was set at 234 mt for 2017.
During the February 2009 BOF meeting, the BOF made no changes affecting the regulation of commercial sablefish fisheries, however bag and possession limits were established for the sablefish sport fishery. At the 2012 BOF meeting, a regulation was passed to require personal use and subsistence use sablefish household permits, and at the 2015 BOF meeting, limits were defined for personal use sablefish fisheries for the number of fish (50 fish per permit), 200 fish vessel limit

when four or more permits are present on a vessel, and number of hooks (no more than 350 hooks in aggregate per permit).

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 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 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 2017. 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 reverting them back to coincide with the federal IFQ season.

The Southeast Alaska **sport fishery** for sablefish was regulated for the first time in 2009. Sport limits in 2017 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 2017 sampled 387 sablefish, reflecting the relatively small harvest relative to other species. The sablefish sport fishery in the remainder of Southcentral Alaska was unregulated, with no bag, possession, or size limits. Port samplers in Southcentral Alaska measured no sablefish from the sport harvest, again reflecting the relatively small harvests.

d. Fisheries

In the **Southeast Region** the 2017 NSEI sablefish fishery opened August 15 and closed November 15. The 78 permit holders landed a total of 324 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 4.2 mt. The 2017 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 191 mt of sablefish, each with an equal quota share of 10.2 mt (Contact Andrew Olson).

In the **Central Region,** the 2017 Cook Inlet Area sablefish fishery opened at noon July 15 with a GHL of 24.5 mt. Eight vessels participated in CI and harvested just under 70% of the GHL. The 2017 PWS sablefish fishery opened April 15 with a GHL of 53.1 mt and closed by regulation on August 31. PWS sablefish harvest totaled 33.2 mt, steadily increasing since the 7.7 mt historical low in 2015, although still the third lowest harvest on record and less than 30% 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 2017 Aleutian Island fishery opened concurrent with the IFQ season, on March 11 with pot, longline, jig and hand troll gear allowed. Additional requirements for the fishery include registration and logbook requirements. The GHL was set at 173 mt for the state-waters fishery. The harvest from the 2017 Aleutian Islands sablefish fishery was 54 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 2016. The estimated harvest was 10,316 fish in Southeast Alaska and 5,035 fish in Southcentral Alaska. SWHS estimates are suspected to be biased due to misidentification and misreporting. Sablefish are not commonly taken by anglers in most areas of the state, 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 6,430 sablefish in Southeast Alaska and 815 sablefish in Southcentral Alaska in 2016 (Contact Bob Chadwick, Dan Bosch).

K. Lingcod

a. Research

Since 1996, 9,189 lingcod have been tagged and 487 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 2017 in Sitka with 1,252 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).

Funding for **Central Region** lingcod ROV surveys ended in 2016 and no surveys were conducted in 2017 (Contact Mike Byerly or Josh Mumm).

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 2017 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,590 lingcod in 2017, 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 382 lingcod from the sport harvest at Seward, Valdez, Whittier, Kodiak, and Homer in 2017. These ports accounted for most of the sport lingcod harvest in Southcentral Alaska (Contact Martin Schuster).

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 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 the last four years CPUE has been the lowest since 2000. Compared to other areas, CPUE in EYKT is high, 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 PWS for to estimate local abundance and biomass of lingcod concurrently with DSR. No surveys were conducted in 2017 (Contact Mike Byerly or Dr. Kenneth J. Goldman).

c. Management

Management of commercial lingcod fisheries 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 reduced in 2000 in all areas and allocations were made between directed commercial fishery, sport fishery, longline fisheries, and salmon troll fisheries. This was the first year that 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 their allocations. The directed fishery is limited to jig or dinglebar troll gear. In 2003 the Alaska 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 areas. Regulations for the commercial lingcod fishery include open season dates of July 1 to December 31 and a minimum size requirement of 35 inches (89 cm) overall or 28 inches (71 cm) from the front of the dorsal fin to the tip of the tail. The directed lingcod fishery in the Cook Inlet Area is limited to jig gear only. Guideline harvest levels (GHLs) are 24 mt for Cook Inlet Area 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 limit 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 2017 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:

(1) In the Yakutat vicinity, nonresidents were allowed one fish daily or in possession, the fish must be 30-45 inches in length or at least 55 inches in length, and the annual limit was two fish, only one of which could be 55 inches or greater in length;

(2) In the Northern Southeast area, nonresidents were allowed one fish daily or in possession, the fish must be 30-35 inches in total length or at least 55 inches in length, and the annual limit was two fish, of which one must be 30-35" in length and one must be at least 55 inches in length;

(3) In the Southern Southeast area, nonresidents were allowed one fish daily and two in possession, the fish must be 30-45 inches in length or at least 55 inches or greater in length, and the annual limit was two lingcod, of which one must be 30-45 inches in length and one must me at least 55 inches in length.

Notwithstanding the limits for each area, the nonresident annual limit in the combined waters of Southeast Alaska was four fish of which only one may be 55 inches or greater in length. In addition, the Pinnacles area near Sitka has been closed to sport fishing year-round for all groundfish since 1997 (Contact Bob Chadwick).

A suite of regulations was established in 1993 for sport lingcod fisheries in **Southcentral Alaska** considering 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 2017 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. The directed fishery landed 108 mt of lingcod in 2017. An additional 70 mt was landed as bycatch in halibut and other groundfish fisheries and 9 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 2017 totaled 22.1 mt in Cook Inlet Area, over twice the 2016 harvest due to a significant increase in effort in the directed fishery. In PWS, lingcod harvest in 2017 was 6.2 mt in PWS, similar to harvest in 2016. Approximately 92% of the lingcod harvest from Cook Inlet Area resulted from participation in the directed lingcod jig fishery. Cook Inlet harvest increased more than seven-fold from 2015 to 2017; vessels fishing in the directed fishery typically participated concurrently in the directed rockfish, which also had an increase in harvest and effort in recent years. In PWS, approximately 91% 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. Cook Inlet and PWS area fisheries remained open through December 31 (Contact Jan Rumble).

In the **Westward Region**, no directed lingcod effort occurred during 2017. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2017 harvest totaled 11 mt in the Kodiak Area and <1 mt in the Chignik and South Alaska Peninsula areas combined.

Sport lingcod harvest estimates from the SWHS for 2016 (the most recent year available) were 12,107 lingcod in Southeast Alaska and 13,506 lingcod in Southcentral Alaska. The average estimated annual harvest for the recent five-year period (2012-2016) was 13,050 fish in Southeast Alaska and 17,530 fish in Southcentral Alaska.

L. Atka Mackerel

1. Research

There was no research on Atka mackerel during 2017.

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 2017. 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 2017.

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 condition determined to be necessary for conservation or management purposes.

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 1998/99 season only one 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. In **Central Region** during 2017, one commissioner's permit to catch flatfish was issued in the Cook Inlet Area and none in PWS. The purpose of the Cook Inlet permit was to test the viability of pot gear; however, no harvest was allowed under the permit, and only a single trip was made with limited success.

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.

V. Ecosystem Studies – N/A

VI. 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.

A. 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.

VII. Publications

Blain-Roth, B., J. Baumer, and S. Meyer. 2017. Sport fisheries in the Prince William Sound Management Area, 2014-2016. Alaska Department of Fish and Game, Fishery Management Report No. 17-44, Anchorage.

Chadwick, R. E., T. Tydingco, and P. Fowler. 2017. Overview of the sport fisheries for groundfish and shellfish in Southeast Alaska through 2017. Alaska Department of Fish and Game, Special Publication No. 17-16, Anchorage.

Green, K. and J. Stahl. 2017. Demersal shelf rockfish remotely operated vehicle stock assessment survey. Alaska Department of Fish and Game, Regional Operational Plan ROP.CFIJ.2017.02, Anchorage.

Meyer, S. and R. Powers. 2017. Analysis of management options for the Area 2C and 3A charter halibut fisheries for 2018. Unpublished report prepared for the North Pacific Fishery Management Council, December 2017. Available online at:
http://npfmc.legistar.com/gateway.aspx?M=F&ID=fef2951a-8a6c-46b0-af91-2d95e32cadd8.pdf

Olson, A. and K. Carroll. 2017. Southern Southeast Inside (Clarence Strait) Sablefish Longline Survey. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.IJ.2017.03, Anchorage.

Olson, A., J. Stahl, M. Vaughn, K. Carroll, and A. Baldwin. 2017. Annual management report for the Southeast Alaska and Yakutat groundfish fisheries, 2017. Alaska Department of Fish and Game, Fishery Management Report No. 17-54, Anchorage.

Olson, A., J. Stahl, B. Williams, M. Jaenicke, and S. Meyer 2017. Chapter 14: Assessment of the demersal shelf rockfish stock complex in the Southeast Outside District of the Gulf of Alaska. Pages 1153-1168 in Appendix B, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, Anchorage, Dec. 2017.

Rumble, J., E. Russ, C. Russ, and M. Byerly. 2017. Prince William Sound Registration Area E groundfish fisheries management report, 2014–2017. Alaska Department of Fish and Game, Fishery Management Report No. 17-40, Anchorage.

A. 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).

B. **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/2017/GOAdsr.pdf

Groundfish charts:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps

APPENDICES

Appendix I. Alaska Department of Fish and Game Full-time Groundfish Staff (updated 4/18)

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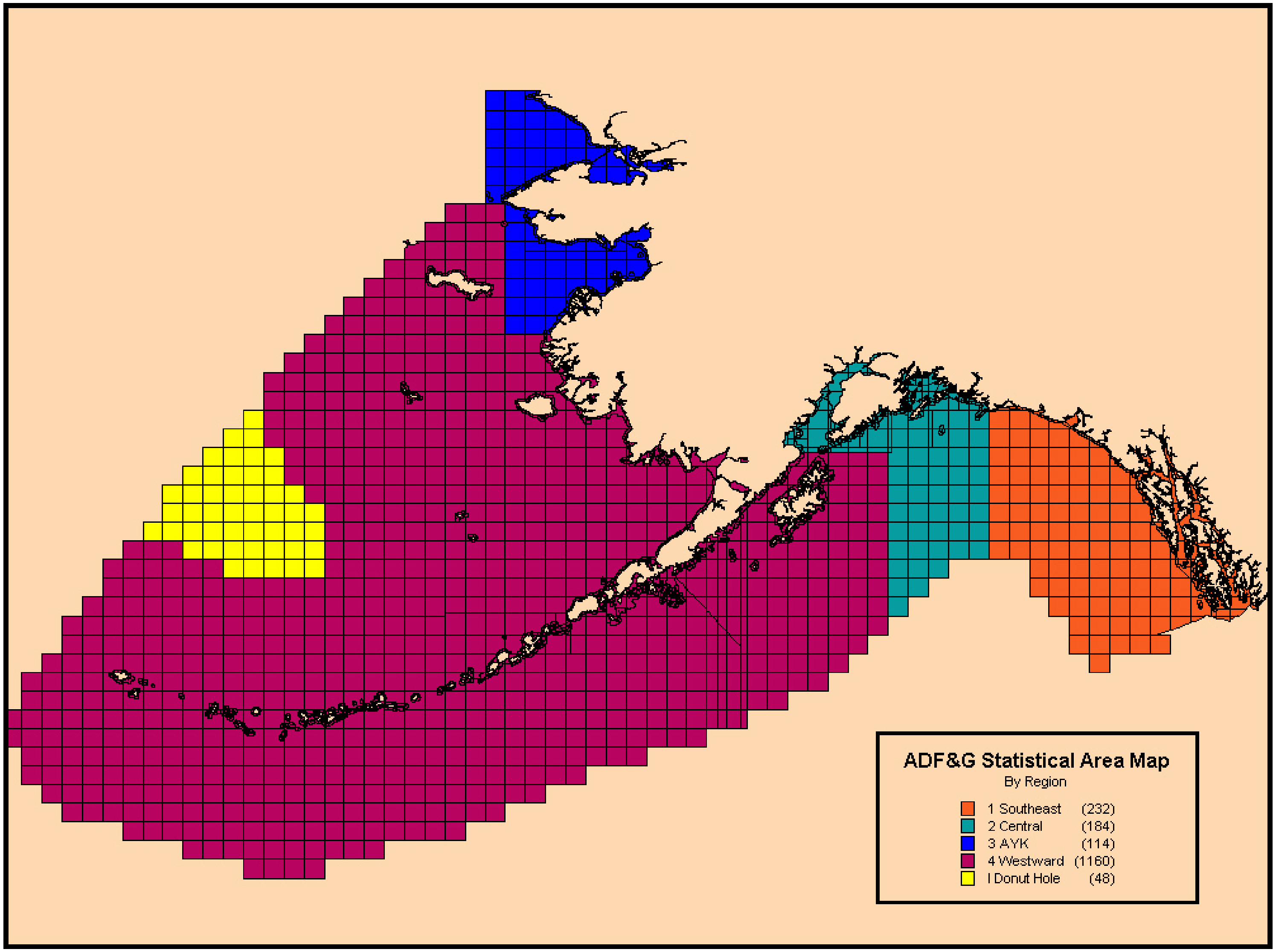

Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions.

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 2018

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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. 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 remotely operated vehicle (ROV) work that 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

ROV Visual Survey and Analysis for MPA and Fishery Data Needs

CDFW Marine Region's Statewide Marine Protected Area (MPA) Management Project collaborated with Marine Applied Research and Exploration to complete a statewide visual survey using ROV (see 2015 and 2016 TSC reports for description of the program). A total of 142 sites were surveyed from Pt. Saint George (Crescent City) in the north to Point Cabrillo (San Diego); completing 370 kilometers (230 miles) of quantitative transects during 2014-2016. Over 400 hours of video and 45,000 high resolution digital still images were recorded during these transects. Currently, data from all three years of surveys are being analyzed to inform California's MPA and fishery specific management activities. This extensive effort provides much needed fishery independent data for multiple management uses and establishes an unprecedented set of index sites across the entire California coast.

In February 2017, CDFW entered a partnership with University of California Davis, funded by the Ocean Protection Council, creating a postdoctoral fellowship to develop and integrate spatial modeling techniques for MPA monitoring using CDFW's ROV survey data. Dr. Nicholas Perkins from the University of Tasmania was hired for the fellowship and is currently working with CDFW in Eureka, California. Along with examining MPA performance questions, this work will provide the basis for spatially specific abundance models and expansions, by combining ROV based visual survey data and bathymetric mapping product covariates. Utilizing spatial point process models, the precise location of fish observations and associated habitat covariates can be used to predict total abundance and map species distributions across sites while accounting for spatial autocorrelation in the data. These models perform better than models that use bathymetry derived covariates without accounting for spatial correlation between observations. Model parameter estimates from the spatial point process models are being used to run simulations of sampling effort needed to detect changes over time inside and outside of MPAs. These simulation based power analyses will provide explicit recommendations regarding the sampling effort needed to effectively monitor changes in abundance and size-structure of populations through time. Preliminary results of this work were presented at the 2018 Western Groundfish Conference, and indicated that for some species, a reasonable increase in sampling effort may provide high statistical power for detecting expected changes 3-5 years earlier than with current levels of sampling.

CDFW will present the methods for estimating density of fish per square meter as an index of abundance and total biomass from expansions with data from habitat mapping for select species using design and model based approaches to the PFMC's Scientific and Statistical Committee's off year science and stock assessment methodology review in early 2019. This review will focus on methods to utilize visual based ROV survey data for stock abundance and biomass estimations of select nearshore species. The survey estimates will be evaluated for use in stock assessments as: 1) density estimates as an index of relative abundance, 2) estimates of abundance from habitat area expansions as an index of absolute abundance, 3) absolute estimates of abundance used to scale integrated assessments, and 4) independent estimates of absolute abundance multiplied by current F_{MSY} proxies to derive overfishing limits.

Contributed by Michael Prall (michael.prall@wildlife.ca.gov)

III. Reserves

Marine Protected Areas Research and Monitoring

California's 124 MPAs were sequentially implemented over four coastal regions (central in September 2007, north central in May 2010, south in

January 2012, and north in December 2012) to create a redesigned statewide network of MPAs. California's MPA network is managed collaboratively through the MPA Management Program, which includes four focal areas: outreach and education, enforcement and compliance, research and monitoring, and policy and permitting. With respect to research and monitoring, following regional MPA implementation, each region subsequently entered into Phase 1 of 2 of California's Statewide MPA Monitoring Program.

Phase 1 – Regional baseline monitoring

In early 2018, Phase 1 of the MPA Monitoring Program was completed, yielding an unprecedented amount of high quality scientific information across the state's coastal habitats. Comprehensive ecological, oceanographic, and socioeconomic data were collected, including data from areas that had previously not been extensively characterized. Data and results from Phase 1 are found in individual technical reports for each funded project, as well as a summarized "State of the Region" report (Table 1). This information informed CDFW's 5-year management review regarding the regional MPA implementation. Phase 1 benchmark data and reports provide a resource against which future ecological and socioeconomic changes across the MPA network can be measured.

Table 1. Phase 1 products by region.

North Coast (completed 2018)	North Central Coast (completed 2015)	Central Coast (completed 2013)	South Coast (completed 2017)
Baseline Monitoring Projects (2014-2018)	Baseline Monitoring Projects (2010-2016)	Baseline Monitoring Projects (2007-2013)	Baseline Monitoring Projects (2011-2017)
State of the California North Coast report	State of the California North Central Coast report	State of the California Central Coast report	State of the California South Coast report
CDFW's Management Review	CDFW's Management Review	CDFW's Management Review	CDFW's Management Review

Phase 2 – Statewide long-term monitoring

Building on the local knowledge, capacity, and unique considerations for each region, California is now implementing Phase 2. A Statewide MPA Monitoring Action Plan is currently in development and when finalized will guide future cost-effective long-term monitoring. The Action Plan will take into account MPA design and planning criteria, Phase 1 information, and additional expert input and analyses, in order to identify a priority list of indicator species and index sites for long-term monitoring.

Upon completion of the Action Plan, requests for proposals will be released in Fall 2018. These requests for proposals will fund monitoring projects across a range of habitats spanning the statewide network, and will aid in the evaluation of MPA network performance at meeting the six goals of the Marine Life Protection Act. For those interested in getting involved in Phase 2 development, a public comment period for the draft Action Plan is anticipated in August 2018. You can sign up for the MPA Management Program mailing list to receive updates about the program.

Contributed by Amanda Van Diggelen (Amanda.VanDiggelen@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 (*E. deani*). Of the two, the Pacific Hagfish (hagfish) is the preferred species for California's export-only fishery. Using traps, fishers 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, CDFW'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 to determine spawning status by sex and length frequency. Landings have been relatively stable from 2010 to 2016, fluctuating between 360 and 833 metric tons (0.8 and 1.8 million pounds) annually with an ex-vessel value of $565,000 to $1.56 million. In 2017 there were 948 metric tons landed for an ex-vessel value of $1.80 million. Fishing effort and export demand is market driven by the South Korean economy and can be influenced by the price and availably of bait and by the fishing activities of Washington and Oregon hagfish fishers.

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 barrel traps with dimensions up to 1.14 m (45 in.) long and 0.64 m (25 in.) outside diameter. The maximum number of traps allowed is 200 bucket, 500 Korean, or 25 barrel traps. Fishers 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 in.). 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.

   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. During 2017, Marine Region staff reviewed 92 Scientific Collecting Permits requesting to take groundfish species; an increase of one third compared to the recent annual average number of permits reviewed. 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.

   Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

2. CDFW Research
   In 2017, 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 Fisheries Survey Program; CRFS) to collect Yelloweye Rockfish that are that mistakenly landed by recreational anglers.

In 2017, CDFW collected 71 Yelloweye Rockfish from the recreational fishing sector. Length, weight, sex, and otoliths were collected from specimens. Fish ranged in length from 249-632 mm in total length, and were approximately 40 percent male, 40 percent female, and 20 percent unknown. Data from these fish will be used to inform future stock assessments on Yelloweye Rockfish.

Beginning in late 2017, CDFW began collecting ageing structures from recreationally caught Lingcod (*Ophiodon elongatus*) south of Cape Mendocino for use in the next Lingcod stock assessment. Collection activities will continue in 2018.

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; spatial closures to protect overfished species) 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 (*S. entomelas*) rockfishes) while avoiding overfished species. Catch of overfished species Bocaccio (*S. paucispinis*), Canary (*S. pinniger*) and Yelloweye Rockfish was minimal. In 2015, the geographic extent of the EFP was expanded to Point Conception and additional vessels were added to allow for additional data collection in more southerly areas. This EFP has been extended through 2018 with minor changes.

Contributed by Joanna Grebel (Joanna.Grebel@wildlife.ca.gov)

4. Assessment

CDFW contributed Yelloweye Rockfish otoliths collected between 2010 and 2016 for use in the stock assessment conducted in 2017. The addition of these new age data from California waters contributed to the more optimistic outlook of the stock. CDFW was also involved in the formal review process of several stock assessments conducted in

2017, including Yelloweye Rockfish, Blue Rockfish, Lingcod, and California Scorpionfish.

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, harvest guidelines, fishery sector allocations, commercial trip limits and recreational management measures (e.g., bag limits, season limits, RCAs) are established by the PFMC and implemented by National Marine Fisheries Service (NMFS).

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 (CFIS). 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.

   Inseason monitoring of California commercial species landings is conducted by CDFW biologists. This work is done in conjunction with inseason monitoring, management and regulatory tasks conducted by the PFMC's Groundfish Management Team. Weekly and monthly tallies of landing receipts in CFIS are used for inseason monitoring.

7. Recreational Fishery Monitoring
   CDFW conducts weekly recreational fishery monitoring for several species of concern, including Yelloweye Rockfish, Cowcod (*Sebastes levis*), Canary Rockfish, and Black Rockfish (*S. melanops*). To track catches inseason, CDFW generated an Anticipated Catch Value by using sample information directly from CRFS weekly field reports to approximate interim catch during the six week time lag until monthly CRFS catch estimates are available. Recreational regulations in 2017 allowed increased fishing depths for much of the state, a reduction to the Black Rockfish sub-bag limit from five to three fish, and allowed limited retention of Canary Rockfish for the first time in more than a decade as a result of the stock being declared rebuilt.

Catches of Yelloweye Rockfish were higher than anticipated during late summer and early autumn, prompting the need to implement more restrictive fishing depths north of Point Conception on October 16, 2017. This change allowed the fishery to remain open through the remainder of the calendar year, but constrained anglers to depths where encounters with Yelloweye Rockfish would be reduced.

Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

C. Pacific Halibut & International Pacific Halibut Commission 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). The IPHC conducted research surveys in California in 2017, and for the first time extended the survey to include waters off San Francisco. The prior surveys off California in 2013 and 2014 only extended as far south as Cape Mendocino and Point Arena, respectively. CDFW staff met the IPHC vessel when offloads occurred to collect biological information from rockfish that were incidentally caught while targeting Pacific Halibut. This rockfish biological information, especially for Yelloweye Rockfish, is used in stock assessments.

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.

3. Commercial Fishery Monitoring
The directed commercial fishery for Pacific Halibut is managed under a coastwide quota and operates as a derby fishery. The fishery opened on June 28 and is structured based on 10 hour openers that are spaced two weeks apart. The fishery continues to operate until the coastwide quota has been met, which usually allows for two to three fishery openings per year. California effort in this fishery continued to increase in 2017 with five vessels participating in the fishery and 3,782 dressed pounds (1,717 dressed kilograms). CDFW staff met vessels offloading Pacific Halibut to collect biological samples for the IPHC's fishery monitoring program. In 2017 the IPHC conducted a pilot study to gather sex ratio information in the commercial fishery. The program was voluntary and involved externally marking the fish based on sex to facilitate data collection by dockside port samplers.

4. Recreational Fishery Monitoring
   The recreational fishery was scheduled to be open May 1-June 15, July 1-15, August 1-15, and September 1 through October 31, or until the quota was met, whichever was earlier. This was an increase of 16 days compared to the 2016 season due to an increased quota.

   To track Pacific Halibut catch, CDFW generated an interim preliminary projected catch value using sample information directly from CRFS weekly field reports to approximate catch during the lag time until monthly CRFS catch estimates are available. This information was made available online so the public could track the progress of the fishery. Using this inseason tracking methodology, the fishery closed early on September 11, 2017. Final season catch estimates were 30,541 net pounds (13,866 net kilograms), 88 percent of the 34,580 net pound (15,699 net kilogram) quota.

   Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

V. Publications

CDFW. 2018. California Department of Fish and Wildlife Report to the International Pacific Halibut Commission on 2017 California Fisheries. 14 p. Available at:https://iphc.int/uploads/pdf/am/2018am/iphc-2018-am094-ar08.pdf.

OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2017

OREGON DEPARTMENT OF FISH AND WILDLIFE

2018 AGENCY REPORT
PREPARED FOR THE 24-25 APRIL 2018 MEETING OF THE TECHNICAL SUB-COMMITTEE OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE

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Contents

I) Agency Overview

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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's main office is located at the Hatfield Marine Science Center and also includes two additional offices in Newport. There are also 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, the International Pacific Halibut Commission, and the North Pacific Fishery Management Council. 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 $9 million, with about 76% 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 approximately 24% of the annual program budget.

II) Surveys

a. Recreational Fisheries Monitoring and Sampling

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2017. Starting in November 2005, major ports were sampled year-round and minor ports for peak summer-fall season. Catch is estimated 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 2017. Since 2003, as part of a related marine fish aging 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 at-sea 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. In 2011, ORBS samplers also began collecting information on at-sea discarded rockfish, including species composition, depth of capture and whether a descending device was used.

Other ODFW management activities in 2017 include participation in the U.S. West Coast Recreational Fish International Network (RecFIN) process, data analysis, public outreach and education, and substantial public input processes to discuss changes to the management of groundfish and Pacific halibut fisheries for 2018, 2019-2020, and beyond.

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b. Commercial Fisheries Monitoring and Sampling

Commercial fisheries monitoring data from commercial groundfish landings are collected throughout the year and analyzed by ODFW to provide current information on groundfish fisheries and the status of the stocks off Oregon's coast. This information contributes to fisheries management decisions, stock assessments, in-season adjustments to nearshore fisheries, and economic analyses.

Commercial fishery data, including logbooks, fish tickets, and biological data, are uploaded to the Pacific Fisheries Information Network (PacFIN) on a regular basis and are used for in-season monitoring and as a primary commercial data source for stock assessment. In 2017, preparations were made to add fixed gear fishery logbooks to the PacFIN database. Species composition sampling of rockfish and biological sampling of commercially landed groundfish continued in 2017 for commercial trawl, fixed gear and hook and line landings. The majority of the landings were monitored at the ports of Astoria, Newport, Charleston, Port Orford and Brookings, with additional sampling occurring routinely at Garibaldi, Pacific City, Depoe Bay, Bandon, and Gold Beach. Biological data including length, weight, age (from collected age structures: otoliths, vertebrae, and fin rays), sex, and maturational status continued to be collected from landings of major commercial groundfish species.

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c. Pilot Study – Using Electronic monitoring in Commercial Fishery sampling

Port biologists sampling commercially-caught finfish in Oregon's ports have been successfully collecting valuable biological data using pencil and paper for many years, but improving accuracy and efficiency are potential benefits to electronic sampling systems that were explored in this pilot study. Program staff evaluated various electronic data collection systems, and opted to purchase a system offered by Big Fin Scientific in late 2015. The development of a suitable master electronic template and support software required to upload electronically collected biological sample data from the application lasted from January through December of 2016, taking much longer than initially planned. A functional import process from the application into the current ODFW sampling database was completed in March 2017.

In early 2016, a preliminary experiment was conducted to evaluate the precision and efficiency of the two measuring methods under experimental conditions. Results indicated that there were no differences in the data captured by the electronic system when compared to the manual system, though there were inadvertently differences in fish length after freezing samples. Initial field trials to evaluate the data collection process and software application began as scheduled in mid-2016 in the port of Astoria. The goal was to collect representative samples of the variety of fish and fisheries typically encountered during port sampling activities and data was evaluated for differences among fish lengths and sampling time between systems. A focus species from three species assemblages, representing different morphology characteristics, including rockfish, flatfish, and roundfish, was selected for analysis. Required sample sizes were estimated using a series of power analyses. In order to evaluate differences in the length distributions of species by system, a randomized block design was implemented throughout the field testing season. A total of 133 timed samples were collected throughout the field testing phase. There were 2,220 fish sampled with the electronic system and 1,228 fish sampled with the manual system.

Overall, there were no differences found between the electronic system and the manual system in either the total time per sample or the total time per fish in sample in directly comparable samples with identical sampling activities. Multiple factors were found to affect the mean length of each of the focus species, though these factors differed by species. Regardless of whether mean lengths were affected by the choice of system, the shape of the length distribution curve was found to be significantly different for all three of the focus species. It is worth noting that the basis for comparison is the data collected concurrently with the manual system, and there was no clear evidence of a systematic bias with the electronic system. Evaluating length distributions from a similar time period in previous years may provide a better metric for direct comparison, as there is certainly intra-annual variability in the length compositions encountered in commercial fishing.

An electronic sampling system shows potential to provide a more efficient, accurate, and flexible way of port sampling. More work is needed to make a reliable system with a simple, streamlined process before ODFW will move forward with incorporating electronic sampling into our current sampling methods. This pilot study has yielded many valuable conclusions that will help ODFW inform future decisions and will provide insights to other agencies exploring electronic fisheries sampling.

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d. Pilot Study – Reinitiating the Shore and Estuary Boat Survey

The Marine Resources Program received funding to re-implement a pilot Shore and Estuary Boat Survey in 2015. Sampling was conducted in 2016 and the final report from the project was completed in 2017. An angler intercept survey was utilized to collect on-site interview data from anglers that fish for marine finfish from shore or in the estuary by boat. Sampling only occurred in Lincoln County on the central Oregon coast due to funding limitations. The objective was to intercept anglers in the field to obtain catch, effort, and biological data without the sampling biases present in the original survey. This project implemented strict field sampling schedules for personnel that removed subjectivity in an attempt to create unbiased estimates of estuary and shore-based catch. Sample design changes did not significantly impact sampling efficiency. Mean interviews per day for the new design were similar to those collected during previous shore and estuary surveys. Estimates of catch and CPUE were produced, but measurements of variance and error were not completed and further analysis is necessary.

In addition to the angler intercept survey, phone and mail surveys were executed simultaneously to create estimates of statewide recreational fishing effort for marine target species. The goal of this portion of the pilot study was to evaluate potential bias and precision of phone and mail surveys and compare effectiveness and expense. Results demonstrate that a mail survey was a practical alternative to a phone survey, however, further evaluation of survey error sources are needed, as both surveys produce different biases in their estimates. Mail survey effort estimates were more precise than those created by a phone survey, with reduction in the percent standard error for all modes of fishing, and the inclusion of an incentive decreased overall mail survey costs per returned response by 21%. Mail survey costs were greater than phone survey costs, however, response rates for the mail survey, with the inclusion of an incentive, were nearly double those of the phone survey.

This project was designed to assess the need and cost of implementing an improved shore and estuary boat survey statewide. ODFW is currently seeking funding to expand and continue this pilot project.

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III) Marine Reserves

The ODFW Marine Reserves Program is responsible for overseeing the management and scientific monitoring of Oregon's five marine reserve sites. These sites, from north to south, include: Cape Falcon, Cascade Head, Otter Rock, Cape Perpetua and Redfish Rocks. Reserves are a combination of marine reserves and marine protected areas with some types of fishing activities allowed, as determined by public process. Each reserve has distinct habitat and biological characteristics, and as such, requires site-specific monitoring and research planning. This section presents an update on management and ecological monitoring and research activities from 2017. More information is available on the Oregon Marine Reserves website at OregonMarineReserves.com.

a. Management – 5 Year Program Review

Harvest restrictions began in specific reserve sites in 2012, and as of the beginning of 2016, all reserves have areas fully closed to resource extraction and ocean development. Monitoring and research for the oldest marine reserves began prior to harvest restrictions in 2010.

The Marine Reserves Program met with the Oregon Scientific and Technical Advisory Committee (STAC) in Corvallis, Oregon on Thursday April 13, 2017 to discuss:

- The ODFW Marine Reserves Program's management, research, and monitoring activities accomplished and lessons learned since the program's inception in 2009.
- Planning for the Marine Reserves Program evaluation due in the year 2023, as required by the state legislature

A copy of the meeting agenda, a summary of the discussions had throughout the day, a timeline for the Program evaluation, and copies of the presentations given by ODFW staff are available on the Oregon Marine Reserves website at http://oregonmarinereserves.com/2017/05/15/review_updates/.

b. Monitoring

We conducted monitoring and research at four marine reserve sites this past year at Cape Falcon, Cascade Head, Otter Rock, and Redfish Rocks. Sampling was conducted both in the reserves, and in comparison areas outside of the reserves still open to fishing. Surveys conducted this year as part of our ongoing long-term monitoring included:

- Hook and line surveys
- Longline surveys
- SCUBA surveys
- ROV surveys (led by the ODFW Marine Habitat Project)
- Juvenile fish recruitment surveys (led by Oregon State University)
- Ocean acidification monitoring in rocky intertidal areas (led by PISCO-Oregon State University)
- Sea star wasting disease recovery monitoring in rocky intertidal areas (ODFW and The Nature Conservancy)

In addition, an Ecological Monitoring plan was updated in 2017 (ODFW 2017) that details the Marine Reserve program goals, ODFW's general approach to ecological monitoring and research in the marine reserves, and site-specific monitoring plans for each of the five Oregon marine reserves. The Human Dimensions Monitoring plan was also updated in 2017. This plan describes the Marine Reserve program's approach to socioeconomic research and monitoring of Oregon's marine reserve system, and includes studies relating to the social and economic characterization of the reserves, attitudes and perceptions of Oregon residents towards marine reserves, and an evaluation of the value of the reserves to both local residents and to the state of Oregon. Both of these plans are available at oregonmarinereserves.com.

c. Research

The Marine Reserve program completed a pilot study looking at the use of a stereo video system for use in our video lander and SCUBA surveys. The pilot study looked at whether this technology might be used in these surveys to provide more accurate fish length data. The pilot study is currently being written up as an ODFW Information Report (Huntington and Watson in prep).

IV) Review of Agency Groundfish Research, Assessment and Management

a. Hagfish

i. Research

No research on hagfish was conducted by ODFW in 2017.

ii. Assessment

No hagfish assessments were completed by ODFW in 2017.

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 2017 were 1,630,061 pounds, higher than 2016 landings, which were the lowest on record since hagfish were first reported on fish tickets in 2010. No major management actions were taken in 2017 by ODFW.

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b. Dogfish and other sharks

There were no research, assessment or management activities related to dogfish or other sharks by ODFW in 2017.

c. Skates

There were no research, assessment or management activities related to skates by ODFW in 2017.

d. Pacific cod

There were no research, assessment or management activities related to Pacific cod by ODFW in 2017.

e. Walleye Pollock

There were no research, assessment or management activities related to Walleye pollock by ODFW in 2017.

f. Pacific Whiting

There were no research, assessment or management activities related to Pacific whiting by ODFW in 2017.

g. Grenadiers

There were no research, assessment or management activities related to grenadiers by ODFW in 2017.

h. Rockfish

i. Research: Deacon Rockfish Offshore/Nearshore Population Comparison Study

It has recently been acknowledged that fish previously referred to as blue rockfish (*Sebastes mystinus*) throughout California and Washington marine waters are actually a pair of cryptic species, the blue rockfish and the recently described deacon rockfish (*Sebastes diaconus*). The two species look very similar, however, diagnostic characteristics for species identification have been determined. Recently some new, species-specific life history information, including data on growth and female length and age at maturity, have been developed to facilitate stock assessments for the two species.

Video lander observations of deacon rockfish from Oregon waters suggest that while adult and juvenile deacon rockfish are frequently seen together in nearshore waters, offshore schools from about 40-70 fathoms are comprised of mostly large individuals (ODFW unpublished data). Deacon rockfish exhibit strong sexual dimorphism in size, with males being smaller than females at all ages (Hannah et al. 2015, Love et al. 2002), raising the question of how this apparent ontogenetic migration influences the age and sex composition of nearshore and offshore segments of the population. Fishery-dependent data used in stock assessment of these two species is almost exclusively from the hook and line commercial and recreational catch taken from the nearshore segment of the population. Data on the size, age and sex composition of the offshore segment of the population therefore may aid in determination of the structure of stock assessment models. Gathering such information is the objective of this research.

Deacon rockfish were collected monthly at offshore and nearshore sites during favorable weather periods out of Newport, Oregon. So far samples have been collected on multiple dates from December 2016 to November 2017. The offshore study area is Stonewall Bank and the surrounding area out to 146 m of water depth. The central coast, nearshore study area includes Seal Rock reefs and Siletz reefs. Recreational hook and line gear is used for all collections. Terminal gear included a variety of plastic baits, small to medium sized flies and Sabiki rigs (herring jigs). Prior efforts to collect small deacon and blue rockfish in nearshore waters off Oregon have shown that Sabiki rigs are capable of capturing deacon rockfish from adult sizes down to as small as about 8 cm, helping to offset gear-related bias in size-selectivity of typical hook and line fishing gear.

Approximately 50 deacon rockfish are collected per reef area per sampling day. Samples from the chosen nearshore reefs and Stonewall Bank are collected within 24 hours, except on 8/08/17 at Seal Rock when samples were difficult to obtain and had to be augmented with additional samples collected on 8/16/17 at Siletz Reef. Fish are be placed on ice at sea and sampled in the laboratory after returning to port.

Fish were measured (cm, fork length) and sexed and otoliths collected for age determination. Ovaries and testes were examined and assigned a maturity stage following the criteria of Westrheim (1975). For females, a small section of ovary from fish in stages 1, 2, 3, 6 and 7 are collected and placed in cassettes for histological preparation and microscopic evaluation of maturity. Ovary samples are preserved in 10% buffered formalin and later transferred to 70% ethanol for storage. Ages are determined using the break and burn technique applied to sagittal otoliths (Chilton and Beamish 1982) or a variation of the technique in which sagittal otoliths are broken and “baked” for several minutes prior to age determination. For all fish 21 cm and under in length, a caudal fin snip was taken and stored in 100% ethanol (molecular grade) for DNA analysis to confirm species identification. Finally, on both 10/05/17 and 11/06/17, 50 fin clips (25 nearshore and 25 offshore) were preserved in ethanol. These samples were used for RAD-seq analysis of potential nearshore and offshore population structure. Age and sex composition was compared for the two segments of the population.

Preliminary analysis of these data suggest the offshore segment of the population is, as hypothesized, older and larger; however, it should be noted small young-of-the-year specimens were collected offshore, suggesting settlement does occur offshore. Length at age fits with von Bertalanffy growth curves differed with sex and area. However it is likely the differences in area are due to the lack of small fishes in the offshore segment of the population anchoring the curve close to the origin. Calculation of a length-weight residual condition index, indicates that the offshore segment of the population is, in general, in poorer condition than the nearshore segment of the population. Average monthly gonadosomatic index values and mean oocyte diameters indicate that October-December are the best months for histological examination of female ovaries. Using the histological analysis from these months suggests there is little difference in age or length at 50% maturity between the offshore and nearshore segments of the population. Finally, very preliminary analysis of the genetic population structure indicates the nearshore and offshore segments of the population mix and are ultimately a single population.

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ii. Research: Movements of Deacon Rockfish (*Sebastes diaconus*).

In May 2016, the At-Sea Research team initiated 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 a number of techniques were utilized to mitigate this challenge. First, large fish were used to compensate for the weight and size of the tag, so fish tagged were females ranging in size from 33-41 cm. Second, 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.* Finally, external tagging methods were employed 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 six 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 six fish remained within the array, demonstrating very high detectability and high site fidelity for the entire seven month study period. 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 six fish, during a period of summertime hypoxia.

The deacon rockfish acoustic telemetry array continued to provide movements data on fish throughout the winter of 2016 through March 2017, when the tag battery life ended, as predicted. We reduced the original array to nine Vemco VR2W acoustic receivers spaced approximately 450 m apart, and placed it within the original rocky reef array area to serve as a presence/absence type detection system. This wintertime receiver array covered an area approximately 1.35 km^2 and was deployed 9/30/2016 and remained through April 18, 2017, with downloads on 11/18/16, 1/29/17, and 4/18/17. One mooring was found missing on the final grid removal. Five deacon rockfish remained present and well-detected in the grid through the duration, and tags provided consistent activity and depth data during that time. One fish tag was no longer detected on 1/18/17, suggesting departure from the array area.

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iii. Assessment

Marine Resources Program staff contributed to federal stock assessments for multiple rockfish species in 2017. These species include assessments for: Pacific Ocean perch, darkblotched rockfish, yelloweye rockfish, yellowtail rockfish and a combined blue and deacon rockfish assessment. MRP staff took part in a groundfish pre-assessment workshop with federal stock assessors and Pacific Fishery Management Council staff in March 2017. This workshop detailed available data sources and provided preliminary staff input for each of the assessments. Staff were formal members of Stock Assessment Teams and participated in multiple Stock Assessment Review (STAR) panels throughout the summer of 2017. The level of involvement differed depending on the assessment, and ranged from data creation and contribution, providing input on model structure and development, and co-authorship (Dick et al. 2017). Assessments are available from the Pacific Fishery Management council website: https://www.pcouncil.org/groundfish/stock-assessments/by-year/gf-2017/. Finally, MRP staff also participated in a stock assessment process review workshop in December 2017 to review the process and recommend improvements for the following assessment cycle.

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iv. Management: Commercial fishery

Nearshore rockfish compose the majority of take in the commercial nearshore fishery. In Oregon, this fishery 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 effectively manage the fishery in-season. Landings from 2016 commercial nearshore fishing, logbook compliance, economic data, and biological data were published in the 2016 Commercial Nearshore Fishery Summary (Rodomsky & Calavan 2017). 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 continue to comprise the majority of landings.

ODFW also analyzed a mailer survey that gauged permit holders' satisfaction levels with current commercial nearshore management and learned permit holders generally support the current State limited entry management system. Detailed results from that survey are available in the 2016 Commercial Nearshore Fishery summary.

In 2017, commercial harvest guidelines changed from 2016 levels for Black Rockfish, Other Nearshore/Blue/Deacon Rockfishes and Greenling. The commercial Black Rockfish harvest guideline was cut by approximately 10% as a result of the 2015 federal stock assessment. 2017 in-season management resulted in increases to two-month trip limits for only black rockfish with no decreases to other species groups. The 2017 federal Minor Nearshore Rockfish ACL was increased as a result of the 2015 China rockfish stock assessment. As a result, the State commercial harvest guideline for Other Nearshore, Blue and Deacon Rockfishes increased 25% allowing for higher trip limits for Other Nearshore, Blue and Deacon Rockfishes relative to 2016. Landings of Other Nearshore, Blue and Deacon Rockfishes exceeded the combined 2017 harvest guideline for these species by 0.6% due to the exceptional weather driving record effort and greater than projected landings in December. Commercial landings of Other Nearshore rockfish total 9.0 metric tons and landings of blue and deacon rockfish total 5.3 metric tons. Commercial landings of black rockfish did not exceed the 2017 harvest guideline. Commercial landings of black rockfish, including estimated discard mortality, total 125.9 metric tons.

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v. Management: Recreational fishery

Black rockfish (*Sebastes melanops*) remains the dominant species caught in the recreational ocean boat fishery; however, the black rockfish harvest limit decreased in 2017 and will continue to decrease for the next several years as a result of the 2015 federal stock assessment. 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. However, in 2017, black rockfish became as much of a limiting factor as yelloweye rockfish. The fishery season structure and regulations, such as bag limits (species specific sub-bag limits) and depth restrictions, attempted to balance impacts, as what reduces impacts on one species may increase impacts to the other. New in 2017, the retention of canary rockfish (*S. pinniger*) was allowed, due to the stock being declared rebuilt from its 2015 federal stock assessment, and the annual catch limit increasing substantially.

Even with pre-season adjustments, the recreational bottomfish fishery closed in mid-September due to the attainment of several harvest limits. The federal annual catch limit for black rockfish in Oregon was exceeded by 16.1 metric tons (3.1%) in 2017, due to the recreational fishery exceeding its state harvest guideline. The commercial nearshore fishery did not exceed its harvest guideline for black rockfish in 2017. Changes to the management of the recreational fishery will be explored in 2018, with input from stakeholders, in order to prevent exceeding harvest guidelines in the future.

Beginning on October 1, targeting of flatfish species (flounders, soles, sanddabs) and mid-water rockfish species with longleader gear only was allowed outside of 40 fathoms. The groundfish bag limit was increased to 10 fish during this time period. This gear type targets underutilized stocks of primarily yellowtail and widow rockfish, while maintaining low bycatch levels of nearshore species and benthic-associated overfished species, such as yelloweye rockfish. Longleader gear has been allowed for recreational fishing since 2007, however, effort has been limited. There were numerous outreach activities to promote the opportunities available from the longleader fishery in 2017, as detailed below.

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vi. Management: Outreach

To reduce bycatch mortality of overfished rockfish species in the recreational 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 very 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 at approximately 60 percent over the last two years.

To further increase usage, anglers requested that ODFW make descending devices mandatory for any vessel fishing the ocean for bottomfish or halibut. This regulation went into place beginning January 1, 2017, and increased the usage rates to approximately 94 percent for 2017. 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.

Additionally, ODFW has been educating anglers on a new opportunity to use what is termed longleader gear to target underutilized midwater rockfish species such as yellowtail (*S. flavidus*) and widow (*S. entomelas*), while avoiding more benthic species such as yelloweye rockfish. The longleader gear requires a minimum of 30 feet between the weight and the lowest hook, along with a non-compressible bloat above the hooks, to keep the line vertical in the water column. ODFW has produced informational handouts with the gear specifics, species allowed, and other associated regulations.

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i. Thornyheads

There were no research, assessment or management activities related to thornyheads by ODFW in 2017.

j. Sablefish

There were no research, assessment or management activities related to sablefish by ODFW in 2017.

k. Lingcod
   i. Research

There were no research activities related to lingcod conducted by ODFW in 2017.

ii. Assessment

Marine Resources Program staff contributed to the federal stock assessment for lingcod in 2017. MRP staff took part in a groundfish pre-assessment workshop with federal stock assessors and Pacific Fishery Management Council staff in March 2017. This workshop detailed available data sources and provided preliminary staff input for each of the assessments. MRP staff participated in the Stock Assessment Review (STAR) panel for lingcod during the summer of 2017. The lingcod assessment is available from the Pacific Fishery Management Council website: https://www.pcouncil.org/groundfish/stock-assessments/by-year/gf-2017/. Finally, MRP staff also participated in a stock assessment process review workshop in December 2017 to review the process and recommend improvements for the following assessment cycle.

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iii. Management

Lingcod are landed in both the commercial and recreational fisheries in Oregon. Commercial lingcod landings from both the open access and limited entry sectors are monitored weekly in conjunction with the nearshore commercial groundfish fishery. Commercial landings in 2017 increased to 72.7 metric tons, from 53.3 metric tons in 2016. In the recreational fishery, lingcod is currently managed under a two fish bag limit with a minimum size limit of 22 inches. Following the closure of the nearshore recreational groundfish fishery in mid-September 2017, lingcod was re-opened in late September for spearfishing gear only. Total recreational landings, including discard mortality, for lingcod are 176.9 metric tons in 2017.

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l. Atka mackerel

There were no research, assessment or management activities related to Atka mackerel by ODFW in 2017.

m. Pacific halibut & IPHC activities

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 coordination. Marine Resources Program staff continued to participate in the IPHC annual meeting, at which the results of the coastwide halibut stock assessment are presented and management for the coming year is determined. In 2017, the IPHC recommended an annual catch limit for Area 2A (Oregon, Washington, and California) of 1.33 million pounds, an increase of approximately 16% from the 2016 2A catch limit. The recreational fishery for Pacific halibut in Oregon is managed under three subareas with a combination of all-depth and nearshore quotas. In 2017, the Columbia River subarea quota was 12,709 pounds, the Central Coast Subarea quota was 240,812 pounds, and the Southern Oregon Subarea quota, was 10,039 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 2017 recreational landings in the Central Coast Subarea was 244,046 pounds. Four thousand pounds were transferred into this subarea's quota from the Southern Oregon Subarea inseason, and Central Coast subarea landings attainment was 99.7 percent of the adjusted quota. Landings in the Southern Oregon Subarea were 2,811 pounds (53.5% of the adjusted quota) and in the Columbia River Subarea, landings were 14,014 pounds (109 % of subarea quota).

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n. Other Groundfish species
   i. Kelp Greenling

Kelp greenling (*Hexagrammos decagrammus*) are a component of both the nearshore commercial and recreational fisheries. In 2017, commercial harvest guidelines changed from 2016 levels for kelp greenling. The commercial harvest guideline increased ~625% as a result of an increased federal annual catch limit and new management measures implemented based on the 2015 federal stock assessment of kelp greenling. Commercial fishermen only attained six percent of this new harvest guideline as few fishers targeted this species. However, commercial landings did increase by approximately 26% from 2016, totaling 11.5 metric tons in 2017. The majority of the commercial landings were from hook and line gear in the southern ports. Recreational landings, including estimated discard mortality, totaled 3.2 metric tons in 2017. In mid-September, the nearshore groundfish recreational fishery was closed due to attainment of several harvest guidelines of other groundfish species, and retention of kelp greenling was prohibited for the remainder of the year.

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   ii. Cabezon

Cabezon (*Scorpaenichthys marmoratus*) are landed in both the nearshore commercial and recreational fisheries. Commercial landings, including estimated discard mortality, totaled 29.8 metric tons in 2017, a 94.4% attainment of the annual commercial allocation. Approximately half of the commercial landings are from hook and line and half are from bottom longline gear, and most of the catch occurred in the southern ports.

In the recreational fishery, continuing from previous years, retention of cabezon was prohibited until July 1 to reduce the chances of inseason management action. 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. In mid-September, the nearshore groundfish recreational fishery was closed, despite inseason action to slow landings, and retention of cabezon was prohibited for the remainder of the year. Recreational landings and estimated discard mortality totaled 22.3 metric tons in 2017. This exceeded the 2017 Oregon recreational harvest guideline by approximately 33%.

Additionally, the federal Oregon annual catch limit for cabezon was exceeded by 5.1 metric tons (11%) and the federal overfishing limit was exceeded in 2017 by 3.1 metric tons (6.3%). This was primarily due to overages in the recreational sector and was compounded by an unprecedented surge in commercial landings in December, which were more than 12 times higher than average in 2017. This increase in the commercial sector was likely due to a combination of factors, including a delayed commercial crab season and favorable weather and ocean conditions.

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V) Ecosystem studies

a. Combined visual acoustic survey of semi-pelagic rockfish

The purpose of this project is to further the development of a nearshore fishery-independent survey to improve stock assessments and promote sustainable management of nearshore rocky reef fish stocks off of Oregon. The specific goals are to gather detailed data to inform the selection of the optimal combination of visual survey tools and hydroacoustic data collection for quantifying nearshore rocky reef fish abundance and biomass, with a focus on the semi-pelagic rockfish species that are most critical to Oregon's coastal communities. Determining the total abundance of nearshore rockfish species populations would be extremely helpful in developing more reliable stock assessments which routinely struggle with scaling the population size appropriately. This work is supported by a Saltonstall-Kennedy Grant to ODFW. There are two specific objectives for this project.

Objective 1: Assess the effectiveness of paired acoustic and pelagic drop-camera surveys for documenting semi-pelagic rockfish density and biomass.
A primary challenge for an acoustic-based rocky reef survey is identifying the species composition and size distribution of schools, as species identification of acoustic targets is currently not possible for mixed schools of morphologically-similar rockfish species. Identifying an efficient strategy for quantifying these variables using a suspended pelagic stereo drop-camera is a core goal of the proposed work. Acquiring drop-camera footage from as many different schools as possible, containing a diversity of species compositions and size distributions, will provide information on the range of school structures and allow for evaluation of the level of sampling effort that would be needed for future broad-scale surveys. Therefore for Objective 1, the focus is to sample as many schools of fish as possible in nearshore waters less than 50 m with high-speed echosounder surveys of subjectively selected reef features to find schools, using the sampling vessel's wide-beam sounder.

Schools of fish were acoustically sampled using a BioSonics DT-X split-beam scientific echosounder with a 200 kHz, 6.5° digital transducer, followed by sampling using a pelagic drop-camera system developed by ODFW. The pelagic drop-camera is an anchored suspended stereo video camera system capable of being deployed at various depths off bottom. In order to obtain adequate stereo video footage for length measurements it was designed to remain upright and orient into the current. In addition to two forward looking stereo cameras, the platform has a downward looking camera to provide fish counts within the acoustic dead zone adjacent to the bottom. The platform is outfitted with sensors to record depth, temperature, camera system tilt and optical back scattering. Tilt data can be used to improve hydroacoustic biomass estimates, and scattering data allows for quantification of fish detectability. Initial findings indicate that the combination of acoustic data and pelagic drop-camera are effective for determining species composition and abundance of semi-pelagic species in Oregon's rocky reefs. The height of the buoyant camera above the bottom is determined by an adjustable attachment to a weight that is lowered to the bottom, resulting in the camera system sampling a known, fixed height above the bottom.

A number of single day cruises have been conducted at different reefs to assess the validity of combining our suspended camera system with the hydroacoustic data to generate population estimates. Preliminary analyses suggests this combination of tools is ideally suited for this project. A preliminary survey of Seal Rock reef has also been completed to provide an extensive mini-survey that can be used as a trial. Based on previous pit tagging studies, there is an estimate of the abundance of black rockfish in this area. Therefore the results of the combined video-hydroacoustic survey can be compared to the pit tagging population estimates as a base calibration. Finally, a subset of videos are currently being analyzed to determine what video review methodologies will maximize efficiency while ensuring precise and accurate data. All of these data are being used to assess uncertainity and help in overall survey design and parameterization through the development of a survey simulation.

Objective 2: Assess the importance of near-bottom fish (including target species and non-target species) for interpretation of acoustic-based abundance estimates. Evaluate the ability of three visual survey tools (drop-camera, lander, ROV) to quantify the contribution of these fish to total abundance for target species.

While the pelagic drop-camera has been developed specifically for use with the acoustic system, there is the potential for bias in its sampling frame, as it is geared towards mid-water column data collection, and therefore may underestimate abundance and bias species compositions by not sampling near-bottom species that are acoustically detected. Additionally, an inherent feature of acoustic data collection is the presence of a near-bottom "dead zone" in high relief habitat. MRP has an ROV that is capable of capturing species composition and length distributions of benthic fish, including those adjacent to or within the acoustic dead zone. By evaluating each of these tools, in concert with the acoustic and pelagic drop-camera combination, a more complete picture of the species present will be provided and would quantify the importance of regularly sampling the benthos during a nearshore survey. To evaluate this objective, multiple reefs will be surveyed with all four sampling tools. Densities of near-bottom fish will be compared from all three tools or tool combinations, and sampling area population estimates will be produced. Field work for this objective is proposed for spring and fall 2018.

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b. Surveys of subtidal rocky areas with the video lander

Video lander survey data from an approximate 30.2 km2 area of subtidal nearshore rocky reefs in the marine waters from Cape Foulweather to Alsea Bay Oregon was analyzed in 2017. The focus of the work was to investigate the use of the video lander as a tool to characterize the fish community and habitat characteristics and evaluate the potential for a lander to provide density and abundance estimates for fish species. Sixteen fish species were observed on 145 lander drops, with the blue/deacon rockfish complex being counted as one. The frequency at which species were observed varied from 53.1 % for kelp greenling to 0.7 % for wolf-eel and tiger and yelloweye rockfish. Based on the sum of MaxN species counts, the maximum number visible in a single frame, ten species made up more than 99 % of the fish identified to species with the remaining six species combined making up less than 1 % of the total. Density and abundance estimates for species observed were calculated and compared the estimates for black rockfish, which had the highest density and abundance for the species observed, to abundance estimates derived from previous PIT tag work in the same area. Preliminary estimates from both the video lander and the PIT tag project were of a similar magnitude. Bedrock was the most frequently observed primary substrate, occurring in 82 (57%) of the samples. A diversity of substrate types were observed in the study area, with 29 distinct combinations of primary and secondary substrate types occurring in the samples.

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c. Aging Activities

During 2017, 5,204 age estimates were produced from recreational and commercial sampling for research and assessment purposes from three rockfish species, including black, blue and deacon rockfish. With the primary goal of preparing for the 2017 combined blue and deacon rockfish federal stock assessment, 2,409 commercial blue and deacon rockfish structures were aged. Additionally, MRP staff re-aged, or tested, samples from both the commercial and recreational fishery to provide estimates of aging error for blue and deacon rockfish. A total of 446 commercial structures (18.5%) and 64 structures from the recreational fishery (19.6%) were aged a second time. While the MRP aging lab did not age the lingcod fin rays needed for the 2017 federal lingcod stock assessment, staff cut and mounted onto slides 1,040 fin rays for aging by an outside lab.

Post stock assessment, work continued with aging black rockfish (recreation collection: 545 aged, 110 tested) and fulfilling aging requests for blue and deacon rockfish research (1081 aged, 223 tested).

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d. Habitat Studies
   i. ROV surveys of Cascade Head and Cape Perpetua Marine Reserves

Remotely operated vehicle video surveys were conducted in Cascade Head Marine Reserve and associated comparison areas in May 2017, contributing to ongoing monitoring efforts for this recently established reserve. Thirty-two dives were conducted, each targeting a 500 m transect. Cape Perpetua Marine Reserve was also surveyed, adding to a time series of observations originating in 2001. Stereo video was added to the standard Phantom ROV equipment, providing improved estimates of fish sizes and transect width.

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ii. Development of new approaches for stereo-video transects

A project was initiated to develop and test equipment and techniques for conducting stereo video transects from a small boat. The cost and logistical/vessel constraints of large ROV surveys, and the availability of affordable new technologies, spurred this effort to fill in gaps in MRP's survey capabilities, with the ultimate goal of conducting inexpensive single-day habitat, groundfish, or invertebrate surveys from ODFW boats to augment larger-scale multi-day ROV surveys. The design settled on a small hand-deployable and affordable ROV as the platform for carrying stereo GoPro cameras and additional lights. The platform was tested in the context of a study to investigate the use of stereo video for assessing red sea urchin populations at depths below those accessible by SCUBA divers. Despite substantial technological hurdles associated with the adoption of this low-cost ROV, built on open-source software, the project demonstrated a high potential for the approach. The ROV is configured to either fly freely in standard transects, or to be towed near the sea floor in suitably low-relief areas.

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iii. Pilot Study: Evaluation of acoustic-based habitat assessment

ODFW's acquisition of a BioSonics DTX split-beam scientific echosounder provided an opportunity to evaluate approaches to classifying substrates in unknown areas, particularly in the so-called "white zone", inshore of the shallow limit of existing multibeam bathymetry and backscatter survey data, and also in other distinct habitats of interest such as sand dollar beds. In conjunction with the development of towed stereo video techniques (described above), Habitat project staff tested deployment methodologies and data analysis approaches for acoustically classifying substrates, using groundtruth video data acquired synchronously with the acoustic data acquisition. Results demonstrated consistent ability to differentiate groups of substrates, but struggled with the consistency of low-relief type classifications across surveys conducted at different depths and on different days. The development of a data library representing known substrate classes, against which new survey data could be compared, shows promise for improving the ability to resolve substrate types.

Contact: Scott Marion (scott.r.marion@state.or.us)

VI) Publications

Dick, E., A. Berger, J. Bizzarro, K. Bosley, J. Cope, J. Field, L. Gilbert-Horvath, N. Grunloh, M. Ivens-Duran, R. Miller, K. Privitera-Johnson, & B. Rodomsky (2017) The Combined Status of Blue and Deacon Rockfishes in U.S. Waters off California and Oregon in 2017. https://www.pcouncil.org/groundfish/stock-assessments/by-year/gf-2017/. 413pp.

Huntington, B. & J. Watson (in prep) Comparing relative abundance and length of reef fishes using simultaneous angling, underwater visual census, and video sampling to refine long-term monitoring in a temperate marine reserve. Oregon Department of Fish and Wildlife.

Huntington, B. & J. Watson (2017) Tailoring Ecological Monitoring to Individual Marine Reserves: Comparing Longline to Hook-and-Line Gear to Monitor Fish Species, Marine and Coastal Fisheries, 9:1, 432-440.

Oregon Department of Fish and Wildlife (2017) Marine Reserves: Ecological Monitoring Plan. http://oregonmarinereserves.com/. 32 pp.

Oregon Department of Fish and Wildlife (2017) Marine Reserves: Human Dimensions Monitoring Plan. http://oregonmarinereserves.com/. 40 pp.

Rodomsky, B. & T. Calavan (2017) The Oregon Nearshore Commercial Fishery Summary: 2016. http://www.dfw.state.or.us/MRP/publications/. 63pp.

Washington Department of Fish and Wildlife Contribution to the 2018 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2017-April 2018

April 24th-25th, 2018

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Washington Department of Fish and Wildlife
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Contents

Agency Overview

The Washington Department of Fish and Wildlife is divided into three major resource management Programs (Fish, Habitat, and Wildlife) and three major administrative support programs (Enforcement, Technology & Fiscal Management, and Capital & Asset Management). Within the Fish Program, research and management of marine fishes is housed within the Fish Management Division, which also oversees research and management of shellfish, warmwater species, and aquatic invasive species. The Marine Fish Science (MFS) Unit, in turn, is broadly separated into two groups that deal with distinct geographic regions (Puget Sound and the Outer Coast), though there is some overlap of senior staff. The Unit is overseen by Dr. Theresa Tsou and supported by Phil Weyland (programming and data systems). In April of 2017 Phill Dionne was hired to assume authority for statewide marine forage fish research and management. Together with Phill, this Marine Forage Fish (MFF) Unit is composed of Dr. Todd Sandell, Adam Lindquist, and Patrick Biondo. During herring spawning season the unit receives staff support from members of the Intertidal Shellfish Unit as needed (i.e., the “loan” of four staff at approximately half time for four months).

Staff of the Puget Sound Marine Fish Science (PSMFS) Unit during the reporting period included Dr. Dayv Lowry (lead), Robert Pacunski, Larry LeClair, Jen Blaine, Lisa Hillier, Taylor Frierson (transferred at end of project), Andrea Hennings, Dr. Mike Burger (transferred at end of project), Mark Millard, and Amanda Philips. In addition, Courtney Adkins and Peter Sergeeff work as PSMFS employees during the annual spring bottom trawl survey (April through June). 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 Dr. Jim West (lead), Dr. Sandy O’Neill, Jennifer Lanksbury, 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 marine fish populations in Puget Sound, study of marine fish ecology and demography, evaluation of bottomfish in marine reserves and other fishery-restricted areas, and development of conservation plans for particular species (and species groups) of interest. Forage fish in Puget Sound are managed under the auspices of the Puget Sound Forage Fish Management Plan (Bargmann 1998) and managed by members of the statewide MFF Unit described above. 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.

Since December of 2016 Dr. Dayv Lowry has also served as the Washington State representative on the Scientific and Statistical Committee (SSC) of the North Pacific Fishery Management Council (NPFMC), and members of the PSMFS Unit are occasionally called upon to assist with evaluation of documents pertinent to fisheries in federal waters off Alaska. Bill Tweit, who reports straight to the Director of the WDFW, serves as a member of the NPFMC.

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Forage Fish Stock Assessment and Research – *Contact: Phill Dionne 360-902-2641, phillip.dionne@dfw.wa.gov; Dr. Todd Sandell 425- 379-2310, todd.sandell@dfw.wa.gov; Dr. Dayv Lowry 360-902-2558, dayv.lowry@dfw.wa.gov.*
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For complete staff contact information see section VIII of this report.

Staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Lorna Wargo (lead), Brad Speidel (resigned in 2017), Rob Davis, Donna Downs, Bob Le Goff, Kristen Hinton, Jamie Fuller, Hannah Grout, Michael Sinclair, and Tim Zepplin. In early 2018 a cohort of non-permanent survey staff were also hired to conduct nearshore hook-and-line surveys, including Annie Cavanaugh, Raymond Ramirez, Thomas Hargrove, Gordon Verbos, Mitchell Loman, Glen Beck, and Dan Wolfley. 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 the Washington coast, the monitoring of groundfish commercial and recreational landings, and the coastal rockfish tagging project. More recently, unit activity has expanded to include forage fish management and research, though this responsibility is shared and coordinated with the statewide MFF Unit.

The MFS Unit contributes technical support for West Coast groundfish and forage fish management via participation on the Coastal Pelagic Species Management Team (CPSMT, Lorna Wargo), the Scientific and Statistical Committee (SSC, Dr. Theresa Tsou), and the Habitat Steering Group (HSG) of the Pacific Fishery Management Council (PFMC). Landings and fishery management descriptions for PFMC-managed groundfish and coastal pelagic species are summarized annually by the GMT and the CPSMT in the Stock Assessment and Fishery Evaluation (SAFE) document. Additional West Coast fishery management support is provided by the Ocean Policy Unit, which consists of Michele Culver (lead), Corey Niles, Heather Reed, and Jessi Doerpinghaus. Both Heather and Jessi serve on the PFMC's Groundfish Management Team (GMT).

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Forage Fish Management, Monitoring, Research, and Assessment – *Contact: Lorna Wargo 360-249-1221 lorna.wargo@dfw.wa.gov; Phill Dionne 360-902-2641, phillip.dionne@dfw.wa.gov.*
For complete staff contact information see section VIII of this report.

Surveys

Puget Sound Bottom Trawl – Since 1987, 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 were moved slightly to accommodate concerns raised by fiber-optic cable companies.

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.

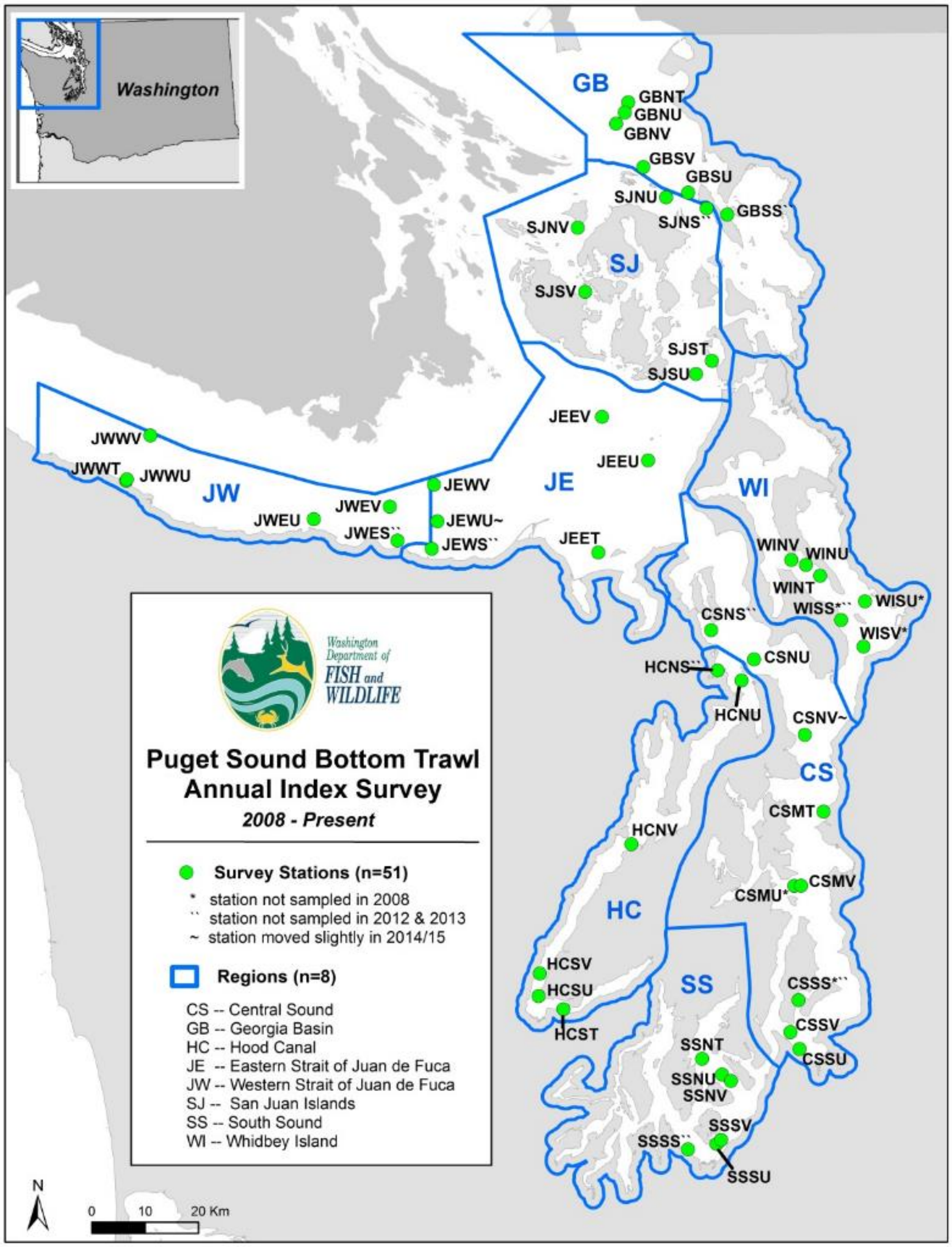


Figure 1. Trawl site locations for the Index survey, sampled 2008-2017

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' 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, 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 2017, the PSMFS Unit conducted the 10th Index trawl survey of Puget Sound from April 24 through June 1. Boat time was split between the PSMFS Unit and the TBiOS group, which conducts their bottom trawl survey biennially. During our 14 survey days, we occupied all 51 stations and conducted 53 bottom trawls, as 2 stations required a second tow. An estimated 55,183 individual fish among 76 species/taxa weighing 9.4 mt were collected (2016: 44,300 fish; 80 species; 7.9 mt). Similar to previous years, Spotted Ratfish constituted 60% of the total fish catch by weight and 27% of the total number of individual fish, followed by English Sole at 17% and 21%, respectively. The remaining fish species contributed 3% or less to the total fish catch weight and 14% or less to the total number of individual fish. For invertebrates, an estimated 65,500 individuals from 75 different species/taxa weighing 1.7 mt were caught in 2017, compared to 60,800 individuals from 73 species/taxa weighing 1.5 mt caught in 2016. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 47% and 22% of the total invertebrate catch weight. By number of individuals, Dock Shrimp and Alaskan Pink Shrimp comprised 42% and 32%, 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 2017 survey; 29 individuals were caught (34 in 2016) in regions JE, JW, and GB (Figure 1). Bocaccio were also encountered for the third time in the history of the bottom trawl survey (1st= 2012, 2nd=2016); all 7 individuals were found in JW, west (and outside) of the species' Puget Sound/Georgia Basin DPS boundary. All were juveniles/sub-adults, as lengths ranged from 73 to 264 mm. Fin clips were taken for genetic samples, and otoliths were taken for aging from two sacrificed individuals. No salmon or ESA-listed rockfish were caught within their respective DPSs during the 2017 survey.

Only 7 Pacific Cod, weighing a total of 20 kg, were caught in the 2017 survey in just two regions, resulting in an estimated population density of 1.4 ind/ha in JW and 0.3 ind/ha in GB. While the density in GB is similar to that from the 2016 estimates, the density in JW is 75% lower than in 2016. Based on the trawl survey results, P-cod populations have been declining for years. JW has consistently been the region with the highest catch rate of P-cod, but density estimates have decreased from 11 ind/ha in 2014, to 9.5 in 2015, 5.7 in 2016, and now 1.4 ind/ha in 2017. Pacific Hake biomass estimates increased 35% to 1,400 mt compared to 2016 while abundance estimates decreased 9% to 23.6 million individuals; these values are still significantly higher than the estimates in 2015 of 103 mt and 2.4 million individuals. Hake were found in each of the eight regions, including JW for the first time since 2011. Walleye Pollock were also found in each of the regions. Biomass and abundance estimates increased 30% and 38%, respectively, from 2016 to 1,400 mt and 23.7 million individuals.

North Pacific Spiny Dogfish catch was higher in 2017 with 123 individuals (131 kg) compared to 65 individuals (78 kg) in 2016, resulting in an 86% increase in the abundance estimate, bringing it to 1.3 million individuals. Dogfish were found in each of the regions, with the highest catch by both abundance and weight in SS. Big Skate biomass and abundance estimates increased 50% and 149%, respectively, to 4,380 mt and 2.3 million individuals. Encounter rates of Big Skates were highest in JE and SJ, which accounted for over 86% of the biomass and abundance. Longnose Skate biomass estimates increased 53% to 1,430 mt while abundance estimates decreased 22% to 1.3 million individuals; encounter rates were highest in CS, JE, and JW. Seven Sandpaper Skates were caught in 2017, compared to 8 in 2016; while most were caught in JW and JE per usual, 2 were caught in GB, which were the first encounters in that region since 2013.

Three additional fish finds are worth noting. Firstly, Sablefish (*Anoplopoma fimbria*; aka "Black cod") were caught in the survey for the first time since 2011 and in the highest numbers since 2009; 3 were found in JW, 2 in CS, and 1 each in GB, SJ, and JE. Individuals ranged in size from 31 cm to 39 cm, and fin clips were taken for genetic analysis; all individuals were released alive. While this species was historically more prevalent throughout the Sound, recent populations have been very low. Secondly, a Ragfish (*Icosteus aenigmaticus*) was caught for the first time in the history of the bottom trawl survey (Figure 2). This species is generally a deep-sea coastal fish, but this was not the first sighting of one in Puget Sound. The individual was caught in SS, measured 61 cm TL, exhibited adult morphology, and was preserved for genetic analysis and given to the Burke Museum/UW Fish Collection. Thirdly, a male albino Spotted Ratfish was caught near Apple Cove Point amidst a catch of 1,845 other 'normal' ratfish. There have only been two other documented instances of an albino chimaera in the world: one female caught by UW in 2007 and one female caught by the WDFW in the 2012 bottom trawl survey. All three specimens have been found near the same area. Fin clips were taken for genetic analysis, and the preserved specimen was delivered to the Burke Museum/UW Fish Collection after further examination.

The 2018 Index bottom trawl survey is scheduled to occur from April 30 – May 24 and, in addition to the normal Index stations, will incorporate 5 additional sampling sites in Hood Canal to expand coverage and validate the representativeness of existing index stations.

Figure 2. The Ragfish *Icosteus aenigmaticus* captured in South Sound during the 2017 bottom trawl survey. This was the first representative of this species ever captured in the 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 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. The combination of survey methods included ROV, scuba, beach seine, hydroacoustics, and lighted fish traps to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. A series of annual reports was submitted, including in 2017, with the ultimate conclusions that: no ESA-listed rockfish were observed; no deep-water critical habitat (>30m) for adult rockfish is present; and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish exist within the surveyed areas. Surveys in 2017 focused on these nearshore critical habitats using scuba transect and fish trap methods.

Underwater visual strip transects by divers, accompanied by trap deployments, were conducted monthly throughout 2017 and early 2018 at 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, were also being surveyed with the same methods to assess the relative success of the 2017/18 recruitment cohort. While several juvenile Copper/Quillback and Yellowtail Rockfish (from the 2016 cohort) were captured in traps when the dive surveys observe zero juvenile rockfish, no ESA-listed rockfishes were ever observed or captured. The PSMFS Unit has now published a final document giving the Navy a "no significant findings" assessment for these bases and further monitoring has been discontinued as the Navy focuses on assessing bird and marine mammal occurrence in the area.

Annual Pacific Herring Assessment in Puget Sound – Annual herring spawning biomass was estimated in Washington in 2017 using well established, decades old spawn deposition survey methods. The WDFW recognizes twenty-one different herring stocks in Puget Sound, and two coastal stocks, based primarily on timing and location of spawning activity. There are currently three recognized distinct genetic groupings (Cherry Point, Squaxin Pass, and the "other stocks" complex). WDFW staff based in the Olympia, Mill Creek, and Port Townsend offices attempt to conduct spawn deposition (aka vegetation rake) surveys of all herring populations in Washington annually from January through June (acoustic-trawl surveys were discontinued in 2009 due to a lack of funding). Stock assessment activities for the 2018 season are currently in progress.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2017 was 9,466 short tons, a 22% decrease from 2016 (12,192 tons) (Table 1, Figure 3). The 2017 cumulative total is an increase from the 2013 low point of 7,332 tons, but was 13% below the previous ten-year average (10,856 tons). The general trend was driven mainly by decreases in the Semiahmoo

Bay (North Puget Sound) and Quilcene Bay (Hood Canal) stocks, although both of these stocks remain healthy. The 2017 total for the Quilcene Bay stock is likely an underestimate because herring began spawning on the eastern shore of Hood Canal (a range expansion likely due to increases in stock abundance), but this activity was not immediately detected.

Table 1. Pacific Herring spawning biomass (short tons) in Puget Sound by stock and year.

Regional/Genetic grouping	**Stock**										
South-Central Puget Sound		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
	Purdy	496	125	500	711	135	260	84	32	0	22
	Wollochet Bay	45	359	50	21	31	10	39	0	0	6
	Quartermaster Harbor	491	843	143	96	108	157	44	55	0	0
	Elliot Bay					290	214	29	135	109	75
	Port Orchard-Port Madison	1,186	1,755	350	123	217	184	90	92	0	0
	South Hood Canal	223	156	150	156	264	199	112	282	249	99
	Quilcene Bay	2,531	3,064	2,012	4,443	2,626	2,072	3,097	4,097	7,160	4,941
	Port Gamble	208	1,064	433	1,464	404	273	170	345	179	181
	Kilisut Harbor	0	0	0	0	0	0	5	0	0	0
	Port Susan	345	251	152	138	61	29	68	70	61	114
	Holmes Harbor	686	1,045	673	3,003	678	585	459	456	494	77
	Skagit Bay	1,342	1,027	500	469	443	454	294	285	48	194
Squaxin Pass		1,025	817	750	565	589	554	394	324	260	299
South-Central Puget Sound Total exc. Quilcene (HC)		6,047	7,442	3,701	6,746	3,220	2,919	1,788	2,076	1,401	1,067
South-Central Puget Sound Total		8,578	10,506	5,713	11,189	5,846	4,991	4,885	6,173	8,561	6,008
North Puget Sound		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
	Fidalgo Bay	156	15	103	119	89	100	221	80	5	6
	Samish/Portage Bay	409	320	640	387	430	693	778	559	1,025	497
	Interior San Juan Islands	60	0	17	0	5	0	5	38	0	0
	NW San Juan Islands	0	0	0	0	0				0	0
	Semiahmoo Bay	662	990	1,000	1,605	879	569	2,828	5,852	1,798	2,311
Cherry Point		1,352	1,341	774	1,301	1,120	908	1,003	524	516	372
North Puget Sound Total		2,639	2,666	2,534	3,412	2,523	2,270	4,835	7,053	3,343	3,186
Strait of Juan de Fuca		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
	Discovery Bay	248	205	26	0	105	0	5	12	244	103
	Dungeness/Sequim Bay	69	46	75	104	43	71	72	8	44	169
Strait of Juan de Fuca Total		317	251	101	104	148	71	77	20	287	272
All stocks combined excluding Cherry Pt. and Squaxin		9,157	11,265	6,824	12,839	6,808	5,870	8,400	12,398	11,416	8,795
All Puget Sound Stocks combined		**11,534**	**13,423**	**8,348**	**14,705**	**8,517**	**7,332**	**9,797**	**13,246**	**12,192**	**9,466**

The combined spawning biomass of South/Central Puget Sound herring stocks in 2017 was 6,008 tons, a decrease from the 2016 total of 8,561 tons and 17% below the ten-year average (7,245 tons). The Quilcene Bay stock contributes 82% of the total for the region and accounted for over half of all spawning activity in Puget Sound in 2017 (Table 1). 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, and Kilisut Harbor stocks, which had no spawn recorded in 2016. Two of these sites - Wollochet Bay and Port Orchard-Port Madison - have now recorded zeros for two years in a row, and are again being closely monitored in 2018. Kilisut Harbor has not had spawn documented for several years and is considered to be locally extirpated.

The cumulative biomass of North Puget Sound stocks (3,186 tons) remained much lower than the recent peak in 2015 (7,053 tons), but remains close to the ten-year average for this region (3,446 tons). This was primarily the result of a more average year (2,311 in 2017) for the Semiahmoo Bay stock, which had a record year in 2015 (5,852 tons). However, the spawning biomass of the Cherry Point stock again declined in 2017 to 372 tons, a decrease of 27% from 2016 (516 tons) and only 40% of the ten year average for this site (921 tons) (Figure 3). 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 and has declined over 96% since the initial estimate in 1973 (14,998 tons).

Estimated herring spawning biomass for the Strait of Juan de Fuca region in 2017 remained higher (272 tons) than the ten year average (165 tons), but declined slightly from 2016 (287 tons). Spawning in Dungeness Bay (169 tons) increased almost four-fold over 2016 (44 tons), and was well above the ten-year average (70 tons) for this site.

No spawning activity was observed in 2017 for coastal stocks (Willapa Bay and Grays Harbor), although the number of surveys (6) was restricted by poor weather. In general, herring spawning biomass for these areas is relatively small compared to Puget Sound.

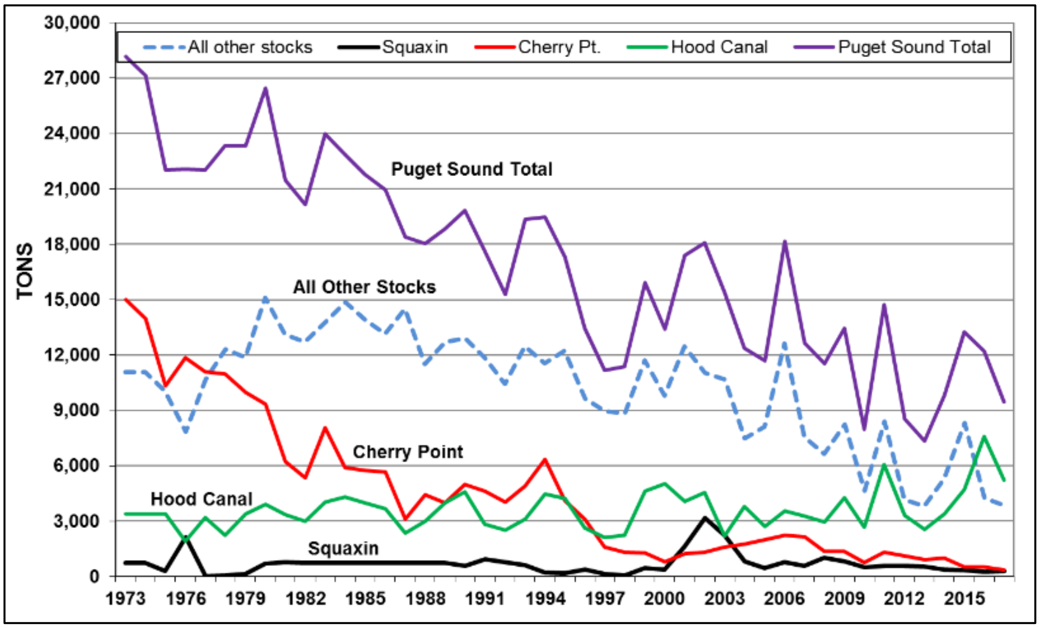


Figure 3. A comparison of Pacific Herring spawning biomass estimates for notable stocks/stock groupings in Puget Sound (note that only Squaxin Pass and Cherry Point are genetically distinct from the "Other stocks" complex)

Yelloweye Rockfish and Expanded Nearshore Rockfish Set Line Survey – The WDFW has been conducting longline surveys off the Washington coast to better understand population size, distribution, and life history of rockfish that inhabit rocky habitat. Initial research focused on Yelloweye Rockfish, which were designated as overfished in 2000 under provisions of the Magnuson Stevens Fishery Act. Beginning in 2007, a number of rockfish stations were added to the standardized, fixed-station, halibut stock assessment survey conducted annually by the International Pacific Halibut Commission (IPHC) in an effort to increase survey coverage in areas where rockfish occur. The addition of rockfish stations to the IPHC survey did improve the opportunity to collect biological data from these rockfish during the summer Halibut stock assessment surveys, however, the survey fishing effort is not concentrated on specific habitat, and Halibut monitoring is the primary focus. Using the IPHC survey design and data, the WDFW has been refining a survey strategy more specifically geared toward rockfish and 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 IPHC 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 do not seem to reside in the IPHC survey zone which is located in the 80-100 fathom depth range. Thus, additional areas need to be surveyed 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. Accordingly, in 2015, the WDFW expanded longline surveys, experimenting with longline gear in nearshore (inside 30 fathoms or 55 meters) rockfish habitat.

In addition, increasing concern regarding populations of China rockfish and other nearshore demersal rockfish species coupled with the need for a fishery-independent survey that can describe multiple nearshore rockfish species prompted the WDFW to examine nearshore survey options. Initially, the existing WDFW rod and reel survey for Black Rockfish was modified to collect information on other rockfish species that inhabit nearshore waters. Issues with fishing tackle selection and general concern about gear standardization with rod and reel surveys prompted experimentation with longline gear. Longline gear is used in nearshore commercial fisheries targeting demersal rockfish and has a strong potential for future nearshore multi-species rockfish surveys. Pilot use of this gear began in 2015 with further modifications to the gear and methods in 2016.

The focus of the fall 2017 cruise season was to describe seasonal differences of abundance of Yelloweye at new locations discovered in 2016 surveys, and to continue experimentation with longline gear targeting rockfish in nearshore waters. This report outlines activities and results from survey operations carried out in September of 2017 on the WDFW longline survey. Timing for this cruise was based on vessel availability and annual weather conditions. The survey was conducted aboard the chartered R/V Pacific Surveyor, a 56’ ex-crab vessel which conducts the annual IPHC Halibut survey in IPHC area 2A.

Seven general fishing areas along the Washington Coast surveyed in the spring of 2017 were re-visited for a seasonal comparison. Skipper knowledge indicated the rocky habitat in waters east of Grays Canyon (Figure 4) ranging from 70 to 90 fathoms was potential Yelloweye habitat. This general area was surveyed in the spring and each individual spring set was fished again in the fall. Fall sets were deployed as close as possible to the spring set locations using the anchor GPS coordinates. Before gear deployment each day, time was spent scouting the area immediately adjacent to each set location with the vessel’s onboard sounding equipment. Spring set locations determined to have ample surrounding rocky habitat were elongated in the fall by adding more skates per set to increase the survey area and effort. The longer fall sets were deployed so that either the north or south end of each set would cover the spring set location to allow for a skate-to-skate comparison.

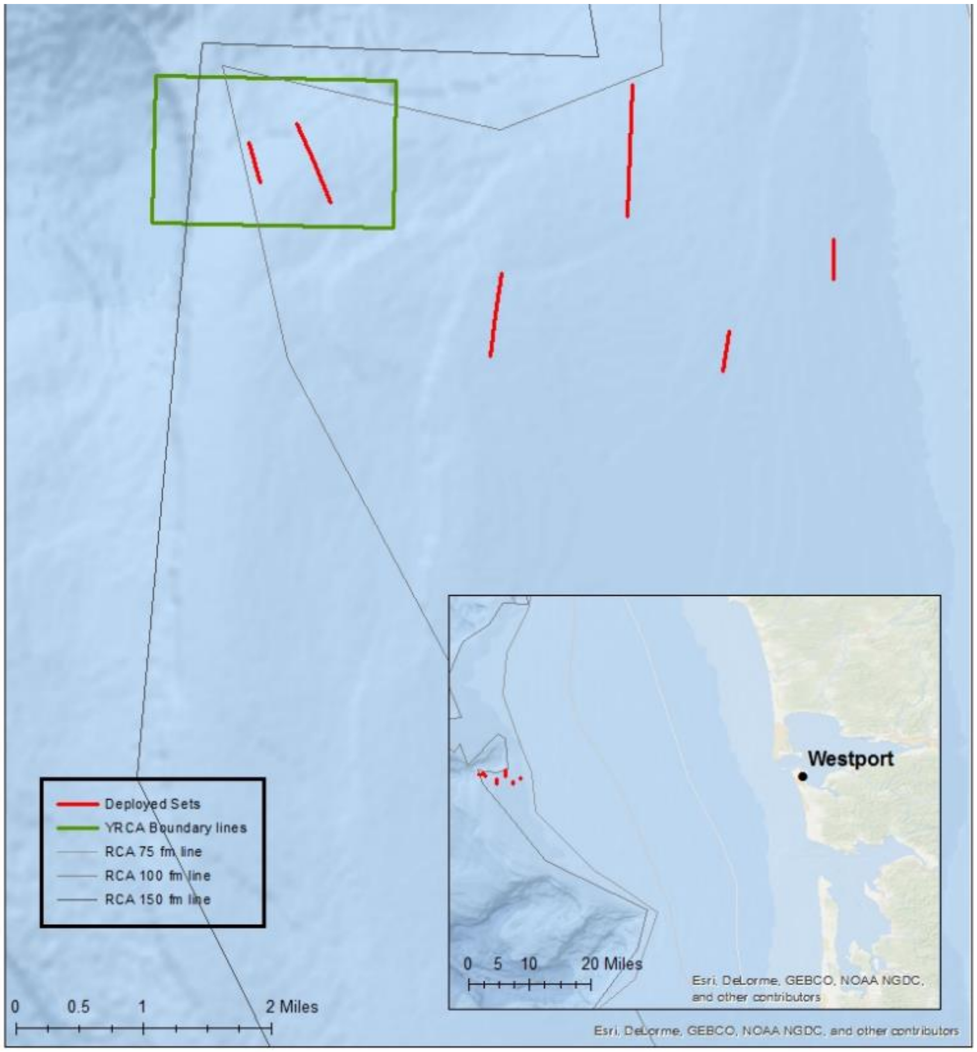


Figure 4. Grays Canyon set locations.

Nearshore sets were deployed on rocky substrate in less than 30 fathoms of water. Six general fishing areas along the Washington coast surveyed in the spring of 2017 were repeated for the fall nearshore operations: Pt. Grenville, Destruction Island, Toleak Point (south La Push), Cape Johnson, Ozette/Cape Alava, and Makah Bay/Pt. of Arches (Figures 5-7). In order to minimize gear loss, only spring sets that had minimal gear damage were fished in the fall. In general, where spring set locations were eliminated due to gear damage, additional sets were added to increase the total set number per general fishing area to six. These additional sets were deployed at locations that have produced high catch and diversity of nearshore rockfish species in previous longline surveys. Sets were deployed as close as possible to previous survey set locations.

Conventional fixed longline gear was used for all sets with slight differences in hook size, hook spacing, and gangion material between nearshore and Yelloweye sets. Gear used to target Yelloweye in this survey was consistent with gear used annually at IPHC rockfish stations as modified by WDFW. The configuration of nearshore gear was identical to the WDFW longline survey conducted in the spring of 2016. This gear was modified from IPHC standardized longline gear to increase catch and species diversity of nearshore rockfish species. All longline gear used was demersal and designed to keep all hooks on the bottom.

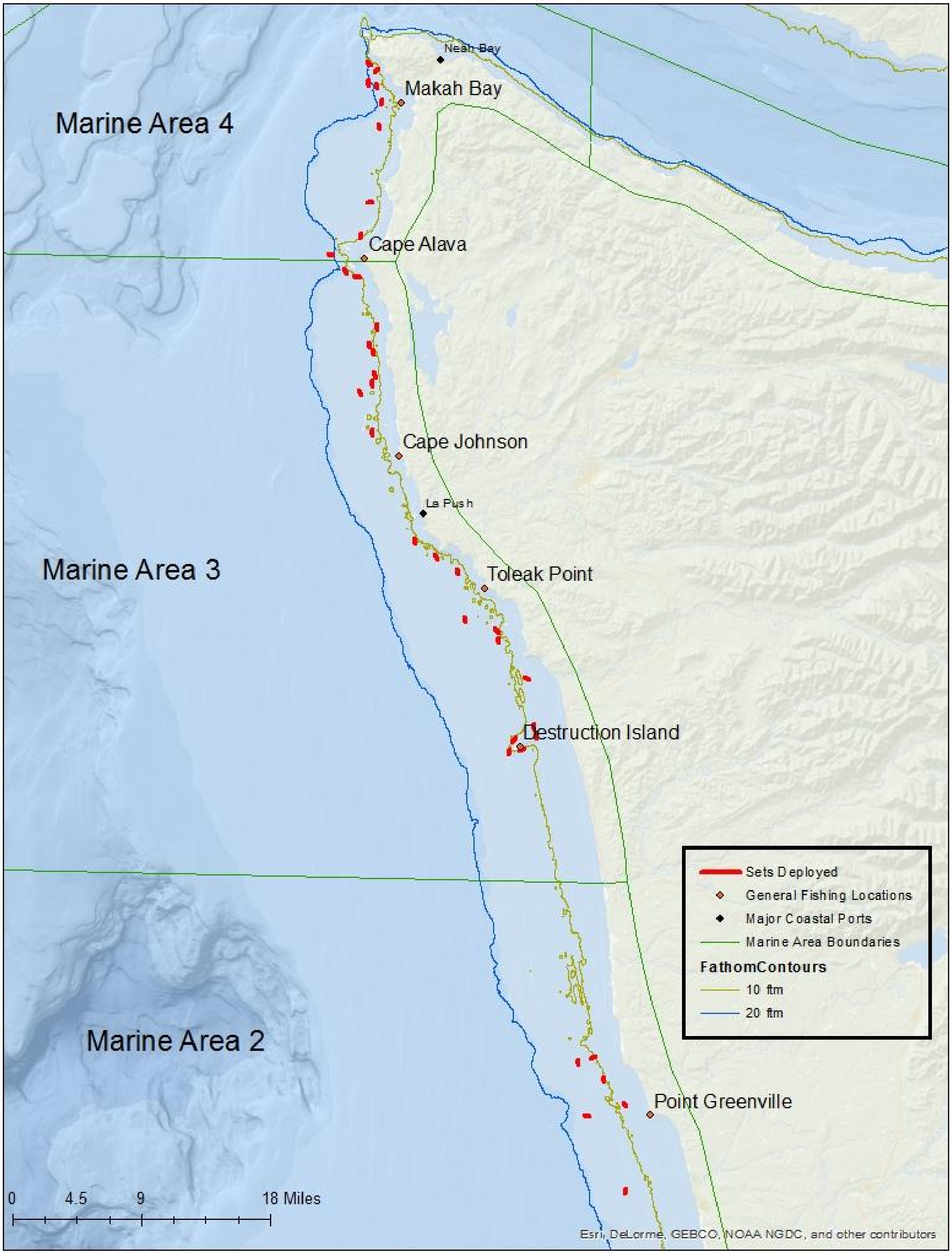
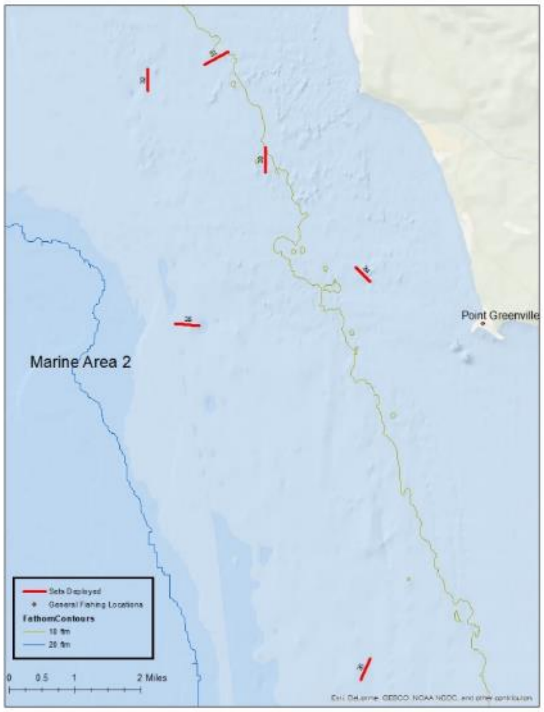
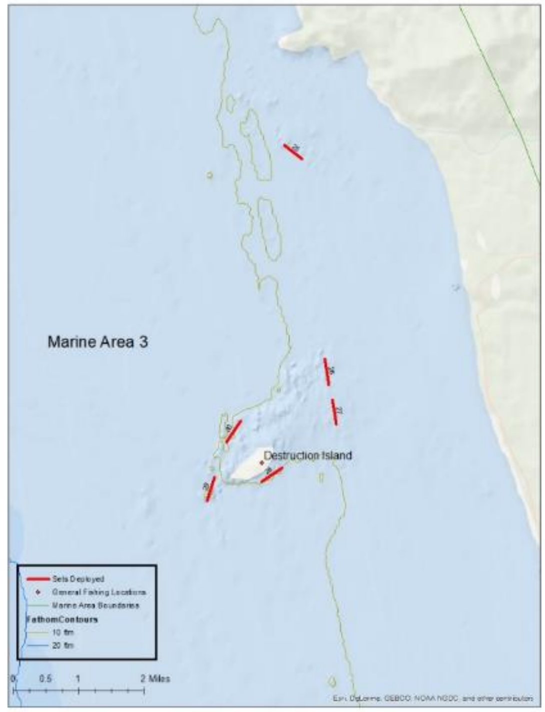


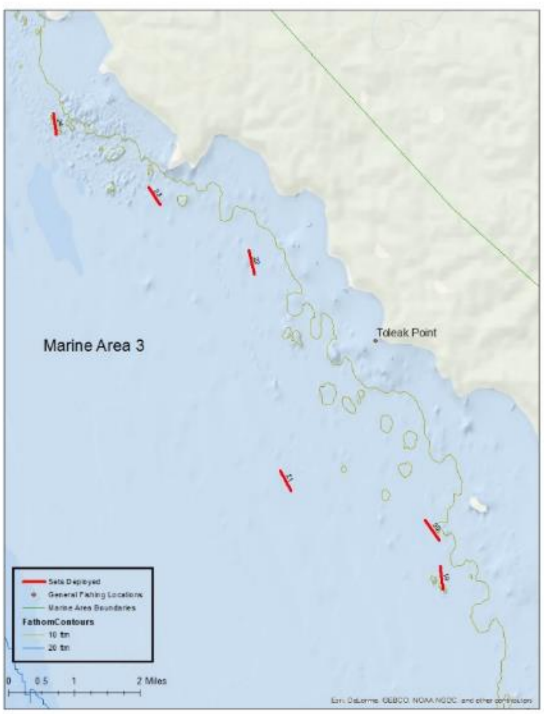
Figure 5. Nearshore set locations deployed coast wide.



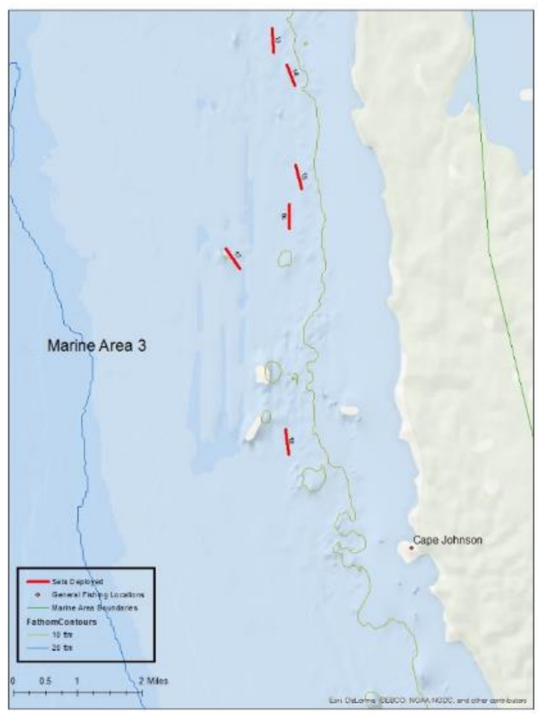
A) Point Grenville



B) Destruction Island

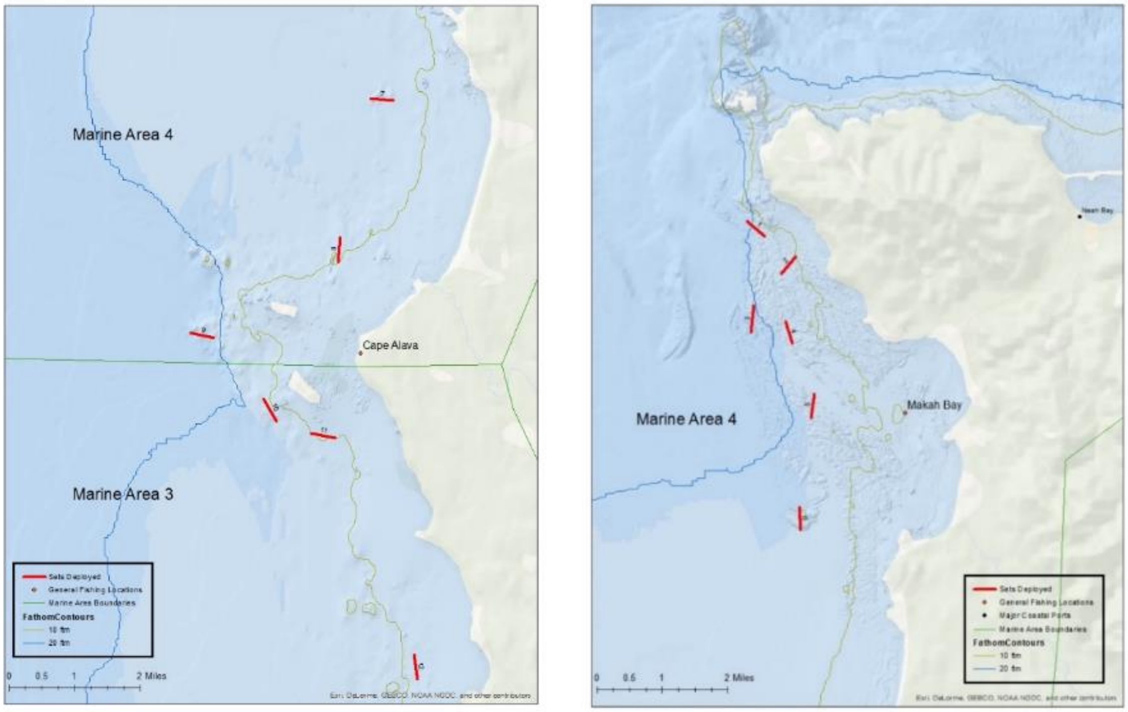


C) Toleak Point



D) Cape Johnson

Figure 6. Nearshore set locations at Point Grenville (A), Destruction Island (B), Toleak Point (C) and Cape Johnson (D).



A) Cape Alava B) Makah Bay

Figure 7. Nearshore set locations at Cape Alava (A) and Makah Bay (B).

Three hours was estimated as sufficient soak time to provide good catch rates, limit lingcod predation on hooked fish, and allow for logistical needs of travel and bottom familiarization while deploying gear each day. Soak time is defined as the elapsed time between deployment of the first anchor and the beginning of retrieval of the buoy line for any given set. From a practical standpoint, usually it takes at least three hours to deploy all of the sets in the morning before transiting back to the first set to begin retrieval.

With favorable weather conditions, a model SBE 19+ V2 water column profiler (CTD) was deployed immediately before each set was retrieved. The CTD was cast as close as possible to the set's retrieval start anchor location without risking entangling with the set's buoy line. For each cast, the entire water column was intended to be sampled with a descent rate of one to two meters per second

Cruise operations began out of Neah Bay, WA on 9/22/2017 and ended in Westport, WA on 9/28/2017. General fishing locations were surveyed from the north to south with the last day of the cruise focused on Grays Canyon. The seven planned fishing areas were covered over seven charter days with 42 individual locations (sets) fished at six sets per day. Gear deployment was successful for all sets and minimal gear damage noted. The CTD was deployed at each set location, but did not reach the bottom for the casts at Grays Canyon's set five and six.
Sets at Grays Canyon ranged from one skate to three skates of gear (100 to 300 hooks). Soak times varied from 180 to 372 minutes with an average soak time of 292 minutes. Sets spanned from 77 to 86 fathoms (Table 2). Benthic water quality parameters collected (Table 3) were within expected ranges with the exception of dissolved oxygen. Dissolved oxygen dipped below an anoxic level of 1.4 milliliters per liter at depths below around 50 fathoms (Figure 8).

Table 2. Grays Canyon set summary.

Set Date	Set	Marine Area	Survey Location	Soak Time (min)	Minimum Depth (ftm)	Maximum Depth (ftm)	Skates Set	Hooks Retrieved	Total Catch	Hook Occupancy
9/28/2017	1	2	Grays Canyon	180	77	81	1	103	62	60.19%
9/28/2017	2	2	Grays Canyon	250	80	81	2	200	74	37.00%
9/28/2017	3	2	Grays Canyon	295	83	86	2	202	26	12.87%
9/28/2017	4	2	Grays Canyon	316	83	86	3	306	39	12.75%
9/28/2017	5	2	Grays Canyon	339	81	83	1	99	5	5.05%
9/28/2017	6	2	Grays Canyon	372	83	83	1	102	12	11.76%

Table 3. Water quality measurements collected by the CTD at the maximum depth sampled for the Grays Canyon sets. Sets 5 and 6 did not reach the bottom. Readings at a descent rate of <0.9 m/s are not shown here.

Set	General Location	Maximum Depth (M)	Dissolved Oxygen (ml/l)	Temperature (C)	Salinity (PSU)	Chlorophyll a (ug/l)
1	Grays Canyon	146.858	1.0425	7.6785	33.9114	0.1778
2	Grays Canyon	150.799	1.1746	7.6138	33.9203	0.1755
3	Grays Canyon	155.564	0.8258	7.7547	33.8995	0.1785
4	Grays Canyon	148.633	1.1663	7.7076	33.9057	0.1778
5	Grays Canyon	117.594	1.1874	7.7775	33.9007	0.1801
6	Grays Canyon	79.129	1.9152	7.9831	33.8426	0.1778

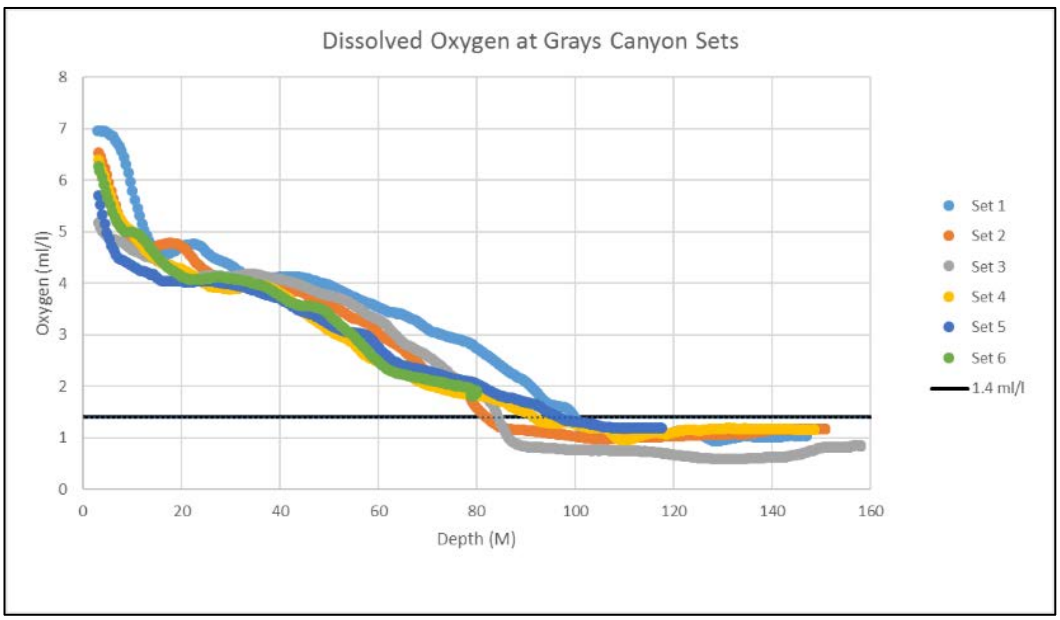


Figure 8. Dissolved oxygen readings per depth at the six Grays Canyon sets. The 1.4 ml/l line indicates an oxygen level below which is considered anoxic.

A total of 218 hooks were recorded with catch at the vessel rail upon retrieval for a total hook occupancy rate of 21.54 percent with Pacific Halibut, North Pacific Spiny Dogfish, and Canary Rockfish making up 29.8, 29.8, and 19.7% of the catch respectively (Table 4). Only 3 Yelloweye were captured at Grays Canyon producing a fairly low catch per unit effort (CPUE) of 0.003 fish per hook retrieved (Table 5). One of the Yelloweye was measured under 40cm (37cm) and two were found to be healthy and were tagged with passive integrated transponder (PIT) and external tags then released at the capture location (Table 6).

Table 4. Grays Canyon catch (number of individuals) summary.

Species	Number Caught
Canary rockfish	43
Flathead sole	1
Greenstriped rockfish	2
Inanimate Object	2
Lingcod	4
Longnose skate	21
Pacific halibut	65
Ratfish	3
Sablefish	3
Spiny dogfish	65
Yelloweye rockfish	3
Yellowtail rockfish	6
Grand Total	218

Table 5. Grays Canyon catch per unit effort. CPUE reported here is number of fish captured per hook retrieved.

Species	CPUE
Canary rockfish	0.0425
Flathead sole	0.0010
Greenstriped rockfish	0.0020
Inanimate Object	0.0020
Lingcod	0.0040
Longnose skate	0.0208
Pacific halibut	0.0642
Ratfish	0.0030
Sablefish	0.0030
Spiny dogfish	0.0642
Yelloweye rockfish	0.0030
Yellowtail rockfish	0.0059
Grand Total	0.2154

Table 6. Number of biological samples collected and tags released at Grays Canyon.

Species	Length	Sex	Weight	DNA	Age Structure	Tags Released
Canary rockfish	43	43	43		43	
Flathead sole	1					
Greenstriped rockfish	4	3	3		4	
Lingcod	3					
Longnose skate	21	19	7			
Pacific halibut	64					
Ratfish	3					
Sablefish	2					
Spiny dogfish	61	55				
Yelloweye rockfish	3	3	1	3	1	2
Yellowtail rockfish	5	5	5		5	
Totals	210	128	59	3	53	2

All nearshore locations were fished with one skate of gear (200 hooks). Nearshore soak times varied from 182-447 minutes with an average soak time of 290 minutes. Set depths ranged from 5-21 fathoms. A total of 1051 hooks were recorded with catch at the vessel rail upon retrieval for a total hook occupancy rate of 14.63% for all nearshore sets. Occupancy rates ranged from 1.5 to 39.3% for individual successful sets. Nearshore set data is summarized in Table 7. Coast-wide benthic temperatures averaged 12.3° Celsius with Point Grenville containing the coldest water (8.8°C) and Destruction Island the warmest (14.3°C). All other benthic water quality parameters collected were within expected ranges, with the exception of dissolved oxygen at Point Grenville which produced the lowest oxygen readings from the coast (Table 8). Point Grenville sets 35 and 36 dipped below an anoxic level of 1.4 milliliters per liter at depths below approximately 11 fathoms (Figure 9).

Twenty different nearshore species were encountered (excluding invertebrates) including 10 different species of rockfish. The full range of nearshore catch rates were seen coast wide. But, in general, higher catch rates were observed on the northern most parts of the coast, such as Makah Bay and Cape Alava, where higher species diversity and total number of focus species were caught (Table 9). Cabezon was the by far the most commonly encountered fish species at all general fishing areas except Point Grenville and made up 38.3% of the coast wide nearshore catch. Other predominant species encountered along the coast included China Rockfish and Lingcod making up 16.2 and 10.9% of the total nearshore catch, respectively. Abnormally large numbers of Buffalo Sculpin were encountered at the Point Grenville sets and made up 60.8% of the total catch there. Catch per unit effort rates by species correlate with these catch compositions and are summarized in Table 10. Biological data collected at the nearshore general fishing areas are summarized in Table 11.

A total of 3501 11/0 and 3685 12/0 hooks were set and retrieved in nearshore waters. The large difference in numbers of hooks by size retrieved is due to poor gear work on the first day. Set 3 at Makah Bay was set with only 12/0 hooks and the error was not caught until the gear was retrieved. Total catch rates were fairly similar between the two hook sizes (Table 12). The 12/0 hooks caught 71 more Cabezon while the 11/0 hooks caught 42 more Black Rockfish, 20 more

Table 7. Nearshore set summary.

Set Date	Set	Survey Location	Marine Area	Soak Time (min)	Minimum Depth (ftm)	Maximum Depth (ftm)	Hooks Retrieved	Total Catch	Hook Occupancy
9/22/2017	1	Makah Bay	4	186	16	18	199	43	21.61%
9/22/2017	2	Makah Bay	4	213	9	15	195	29	14.87%
9/22/2017	3	Makah Bay	4	247	16	21	203	69	33.99%
9/22/2017	4	Makah Bay	4	285	12	15	199	37	18.59%
9/22/2017	5	Makah Bay	4	311	12	15	201	37	18.41%
9/22/2017	6	Makah Bay	4	339	9	18	195	19	9.74%
9/23/2017	7	Cape Alava	4	252	9	16	207	23	11.11%
9/23/2017	8	Cape Alava	4	281	10	11	200	43	21.50%
9/23/2017	9	Cape Alava	4	316	14	21	204	56	27.45%
9/23/2017	10	Cape Alava	3	366	10	14	196	52	26.53%
9/23/2017	11	Cape Alava	3	422	6	10	198	38	19.19%
9/23/2017	12	Cape Alava	3	447	6	8	200	20	10.00%
9/24/2017	13	Cape Johnson	3	196	11	14	207	47	22.71%
9/24/2017	14	Cape Johnson	3	228	10	13	200	34	17.00%
9/24/2017	15	Cape Johnson	3	261	11	14	209	41	19.62%
9/24/2017	16	Cape Johnson	3	287	15	15	197	34	17.26%
9/24/2017	17	Cape Johnson	3	315	17	17	199	36	18.09%
9/24/2017	18	Cape Johnson	3	337	13	15	199	36	18.09%
9/25/2017	19	Toleak Point	3	186	8	11	196	10	5.10%
9/25/2017	20	Toleak Point	3	212	11	11	202	7	3.47%
9/25/2017	21	Toleak Point	3	237	9	14	194	5	2.58%
9/25/2017	22	Toleak Point	3	265	10	14	200	16	8.00%
9/25/2017	23	Toleak Point	3	292	11	14	196	14	7.14%
9/25/2017	24	Toleak Point	3	332	10	15	199	63	31.66%
9/26/2017	25	Destruction Island	3	182	5	9	198	6	3.03%
9/26/2017	26	Destruction Island	3	208	5	9	198	23	11.62%
9/26/2017	27	Destruction Island	3	222	5	6	199	33	16.58%
9/26/2017	28	Destruction Island	3	251	7	10	200	14	7.00%
9/26/2017	29	Destruction Island	3	272	9	13	197	17	8.63%
9/26/2017	30	Destruction Island	3	297	6	12	200	19	9.50%
9/27/2017	31	Point Grenville	2	309	10	11	201	79	39.30%
9/27/2017	32	Point Grenville	2	335	15	15	199	4	2.01%
9/27/2017	33	Point Grenville	2	354	9	11	201	24	11.94%
9/27/2017	34	Point Grenville	2	370	5	9	199	17	8.54%
9/27/2017	35	Point Grenville	2	397	15	18	200	3	1.50%
9/27/2017	36	Point Grenville	2	447	12	16	199	3	1.51%

China Rockfish and 15 more Lingcod than the 12/0 hooks. Length ranges of most species captured were fairly similar between the two hook sizes. However, smaller Black Rockfish and one small (24cm) China Rockfish were caught with the 11/0 hooks. Length frequencies by hook size of the most frequently encountered groundfish are summarized in Figure 10.

Table 8. Water quality measurements collected by the CTD at the maximum depth sampled for the Nearshore sets. Readings at a descent rate of <0.9 m/s are not shown here.

Set	General Location	Maximum Depth (M)	Dissolved Oxygen (ml/l)	Temperature (C)	Salinity (PSU)	Chlorophyll a (ug/l)
1	Makah Bay	24.939	5.4336	12.0633	32.8061	0.7401
2	Makah Bay	16.011	5.7277	12.2064	32.6979	1.0422
3	Makah Bay	38.383	4.3097	11.4744	33.0393	0.679
4	Makah Bay	31.634	5.5444	12.4249	32.8029	0.8553
5	Makah Bay	23.355	5.2417	12.1377	32.7834	0.9606
6	Makah Bay	25.961	5.4671	12.3523	32.8167	1.3344
7	Cape Alava	15.178	5.5699	11.929	32.7177	1.0353
8	Cape Alava	22.061	4.8514	11.8296	32.8308	0.8637
9	Cape Alava	35.002	4.4663	11.868	32.8934	1.0376
10	Cape Alava	21.302	6.0544	13.1205	32.811	0.9125
11	Cape Alava	20.896	6.1057	13.1327	32.8054	0.959
12	Cape Alava	17.367	6.1394	13.1335	32.7274	1.2627
13	Cape Johnson	26	6.0387	13.1636	32.7356	1.1414
14	Cape Johnson	23.285	5.4319	13.056	32.7973	1.0391
15	Cape Johnson	24.829	5.1651	12.9318	32.8399	1.2306
16	Cape Johnson	29.557	4.0301	12.1876	32.952	2.0859
17	Cape Johnson	33.433	4.3353	11.3483	33.016	1.7754
18	Cape Johnson	31.159	4.172	12.1215	32.9485	1.2879
19	Toleak Point	21.914	4.738	13.3724	32.6889	1.4199
20	Toleak Point	22.367	4.8543	13.3076	32.7475	2.047
21	Toleak Point	18.669	4.7801	12.7483	32.6682	0.3044
22	Toleak Point	26.397	3.7777	12.122	32.8433	0.6653
23	Toleak Point	27.612	3.3924	11.2582	32.7811	0.8812
24	Toleak Point	23.79	4.2787	12.3731	32.6089	0.5737
25	Destruction Island	16.04	5.6631	14.0985	32.08	0.6691
26	Destruction Island	16.939	5.9998	14.0677	32.1962	0.9308
27	Destruction Island	9.297	6.1849	14.3313	31.5021	0.3883
28	Destruction Island	20.163	5.8463	14.0684	31.7999	0.5409
29	Destruction Island	25.081	4.3096	10.8636	32.7807	0.8286
30	Destruction Island	12.322	6.0201	14.1878	31.7589	0.4631
31	Point Grenville	16.299	2.408	12.0705	32.5923	0.4288
32	Point Grenville	28.609	0.9791	9.7227	33.3425	0.322
33	Point Grenville	21.699	2.0717	10.88	33.0123	0.322
34	Point Grenville	17.238	4.6561	12.648	32.3698	0.415
35	Point Grenville	35.876	0.9091	8.7725	33.558	0.3861
36	Point Grenville	30.304	1.9819	9.2519	33.3234	0.3784

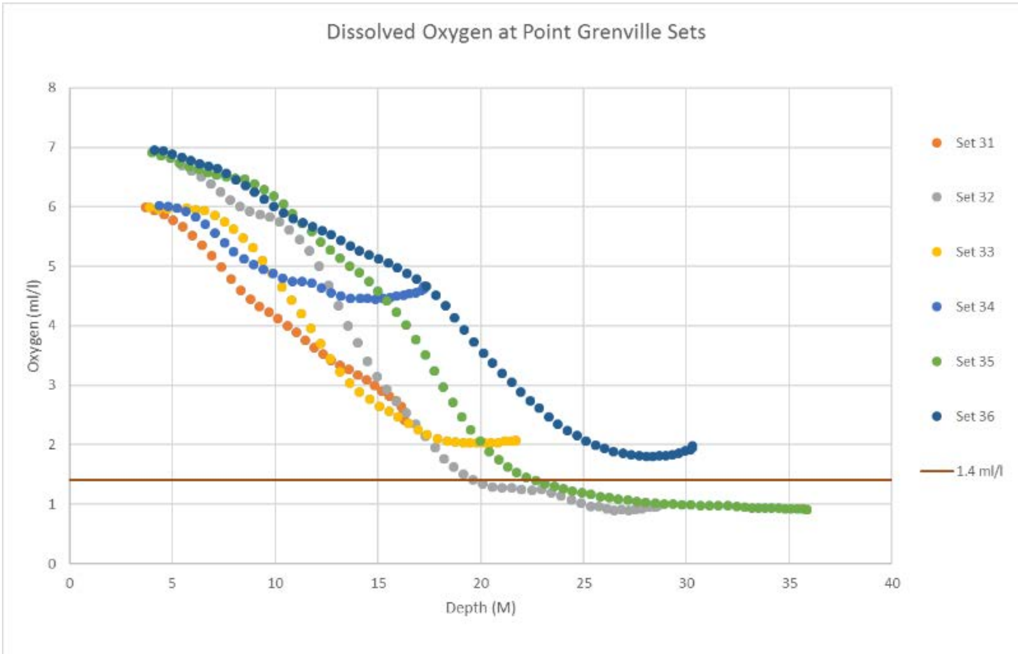


Figure 9. Dissolved oxygen readings per depth at the six Point Grenville sets. Readings at a descent rate of <0.9 m/s are not shown here. The 1.4ml/l line indicates an oxygen level below which is considered anoxic.

Table 9. Catch summary by number of individuals for nearshore sets. * denotes priority species.

Species	Point Grenville	Destruction Island	Toleak Point	Cape Johnson	Cape Alava	Makah Bay	Cruise Total
Anemone						1	1
Big skate		1				5	6
Black rockfish	7	1	33	25	15	3	84
Buffalo sculpin	79	8	8				95
Cabezon*	11	26	48	133	85	100	403
Canary rockfish				3	1	13	17
China rockfish*		7	11	34	70	48	170
Copper rockfish*	6	2		2	8	12	30
Coral						1	1
Deacon Rockfish*		4	2		4	2	12
Inanimate Object					1	2	3
Kelp greenling*			1	1	2	1	5
Lingcod	11	21	7	24	33	19	115
Pacific halibut				1	2	11	14
Quillback rockfish*	2			1		9	12
Red Irish lord			1				1
Sixgill shark			1				1
Spiny dogfish	2	1			1		4
Starfish	12	40	1	2			55
Starry flounder		1					1
Tiger rockfish*						1	1
Vermilion rockfish*				1	9	6	16
Yelloweye rockfish*			2		1		3
Yellowtail rockfish				1			1
Totals	**130**	**112**	**115**	**228**	**232**	**234**	**1051**

Table 10. Catch per unit effort of nearshore sets. CPUE reported here is number of fish captured per hook retrieved. * denotes priority species.

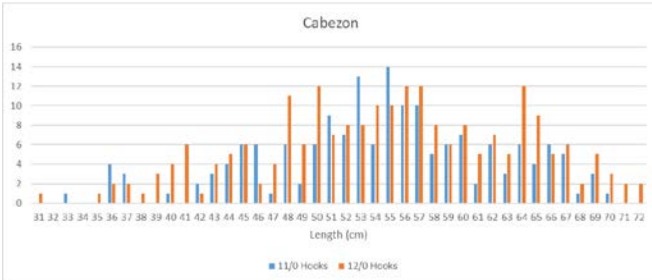
Species	Point Grenville	Destruction Island	Toleak Point	Cape Johnson	Cape Alava	Makah Bay
Anemone						0.0008
Big skate		0.0008				0.0042
Black rockfish	0.0058	0.0008	0.0278	0.0206	0.0124	0.0025
Buffalo sculpin	0.0659	0.0067	0.0067			
Cabezon*	0.0092	0.0218	0.0404	0.1098	0.0705	0.0839
Canary rockfish				0.0025	0.0008	0.0109
China rockfish*		0.0059	0.0093	0.0281	0.0581	0.0403
Copper rockfish*	0.0050	0.0017		0.0017	0.0066	0.0101
Coral						0.0008
Deacon Rockfish*		0.0034	0.0017		0.0033	0.0017
Inanimate Object					0.0008	0.0017
Kelp greenling*			0.0008	0.0008	0.0017	0.0008
Lingcod	0.0092	0.0176	0.0059	0.0198	0.0274	0.0159
Pacific halibut				0.0008	0.0017	0.0092
Quillback rockfish*	0.0017			0.0008		0.0076
Red Irish lord			0.0008			
Sixgill shark			0.0008			
Spiny dogfish	0.0017	0.0008			0.0008	
Starfish	0.0100	0.0336	0.0008	0.0017		
Starry flounder		0.0008				
Tiger rockfish*						0.0008
Vermilion rockfish*				0.0008	0.0075	0.0050
Yelloweye rockfish*			0.0017		0.0008	
Yellowtail rockfish				0.0008		
Totals	0.1084	0.0940	0.0969	0.1883	0.1925	0.1963

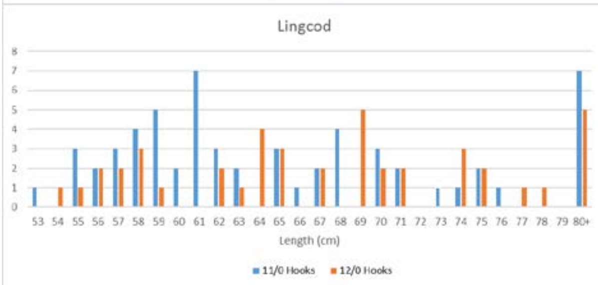
Table 11. Total number of biological samples collected and tags released at the nearshore fishing locations.

Species	Length	Sex	Weight	DNA	Age Structure	Tags Released	Tags Recovered
Big skate	6	6	4				
Black rockfish	73	72	72		58		1
Buffalo sculpin	95						
Cabezon	392	4	4				
Canary rockfish	18	18	17		18		
China rockfish	171	170	169	103	171		1
Copper rockfish	28	28	28		28		
Deacon Rockfish	14	14	14		7		
Kelp greenling	5	5	5		2		
Lingcod	102	6	6		6		
Pacific halibut	11						
Quillback rockfish	12	12	12		12		
Red Irish lord	1						
Sixgill shark	1	1					
Spiny dogfish	3	3					
Tiger rockfish	1	1	1				
Vermilion rockfish	16	16	16		16		
Yelloweye rockfish	3	2		2		3	
Yellowtail rockfish	1	1	1		1		
Grand Total	**953**	**359**	**349**	**105**	**319**	**3**	**2**

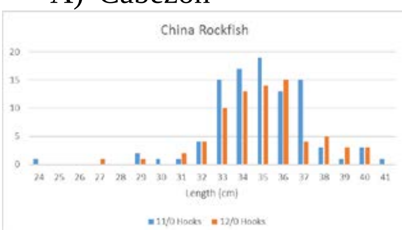
Table 12. Catch per hook size of nearshore sets CPUE reported here is number of fish captured per hook retrieved. * denotes priority species.

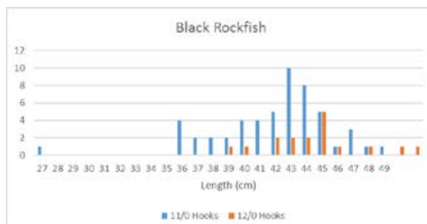
Species	Number of Fish Hook Size		CPUE Hook Size	
	11/0	12/0	11/0	12/0
Anemone		1		0.0003
Big skate	1	5	0.0003	0.0014
Black rockfish	63	21	0.0180	0.0057
Buffalo sculpin	44	51	0.0126	0.0138
Cabezon*	166	237	0.0474	0.0643
Canary rockfish	6	11	0.0017	0.0030
China rockfish*	95	75	0.0271	0.0204
Copper rockfish*	17	13	0.0049	0.0035
Coral		1		0.0003
Deacon Rockfish*	8	4	0.0023	0.0011
Inanimate Object		3		0.0008
Kelp greenling*	2	3	0.0006	0.0008
Lingcod	65	50	0.0186	0.0136
Pacific halibut	1	13	0.0003	0.0035
Quillback rockfish*	3	9	0.0009	0.0024
Red Irish lord	1		0.0003	
Sixgill shark		1		0.0003
Spiny dogfish	1	3	0.0003	0.0008
Starfish	24	31	0.0069	0.0084
Starry flounder	1		0.0003	
Tiger rockfish*		1		0.0003
Vermilion rockfish*	9	7	0.0026	0.0019
Yelloweye rockfish*	2	1	0.0006	0.0003
Yellowtail rockfish	1		0.0003	
Grand Total	510	541	0.1457	0.1468

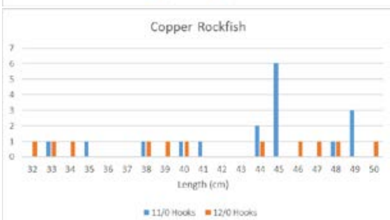




A) Cabezon B) Lingcod







C) China Rockfish D) Black Rockfish E) Copper Rockfish

Figure 10. Length frequencies of the most commonly encountered nearshore groundfish. Species include Cabezon (A), Lingcod (B), China Rockfish (C), Black Rockfish (D), and Copper Rockfish (E) and are summed by hook size of the gear they were captured with.

Yelloweye Rockfish Nearshore Rod and Reel Survey – The WDFW has been conducting longline surveys off the northern Washington coast for several years and recent research has focused on Yelloweye Rockfish. Fishery catch, a customary source of biological and population trend data, has been severely limited or completely lacking, since the designation of Yelloweye as overfished and, more than any other single groundfish species, this species now constrains both commercial and recreational groundfish fisheries. In addition, due to stringent catch restrictions on slope and shelf rockfish complexes, fishery-dependent data are very limited for species such as Rougheye, Shortraker, and Redbanded Rockfish.

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 collect data used to monitor Pacific Halibut abundance. These are standardized fixed-station surveys based on a 10 nautical mile grid. Beginning in 2007, several rockfish stations were added to the IPHC survey to enhance knowledge of rockfish population trends. The addition of rockfish stations to the IPHC survey offered the opportunity to collect biological data during the summer stock assessment surveys; however, the survey 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 certain rockfish species that inhabit rocky habitat. Using the IPHC survey design and data, the WDFW is refining a survey strategy more specifically for rockfish that inhabit rocky habitat. Such a survey is needed to collect species-specific data to inform population assessments and conservation efforts.

One issue apparent in IPHC longline surveys is the lack of Yelloweye Rockfish less than 40 cm in length. To understand why the survey captures only larger fish, gear and area experiments were conducted by the WDFW using smaller hooks in areas where Yelloweye were known to occur. We determined that it is likely an area issue – the smaller, younger fish do not seem to reside within the IPHC survey zone, which is located in the 80-100 fathom depth range. Thus, additional areas need to be surveyed in order to sample a representative portion of the population. Expanded areal coverage would also improve documented Yelloweye habitat, which would be valuable for future survey design. Previous WDFW surveys searched shallower areas in Marine Area 3 for Yelloweye with some success.

In the fall of 2017, Marine Areas 1 and 2 were surveyed from a vessel chartered at Westport, to document additional areas in waters less than 80 fathoms where Yelloweye might occur. These areas were searched with rod and reel gear to document location and evaluate size distribution of Yelloweye and other rockfish. This report documents these efforts.

After consultation with the skipper, several areas were identified in Marine Area 2 within a 20-50 fathom depth range for searching. For each trip, four to six volunteers fished with typical recreational rod and reel gear. Salmon mooching gear, consisting of a weight followed by a leader and hook baited with a combination of Herring and American squid, was used for terminal tackle. Depending on the conditions, the vessel either drifted or anchored over the fishing location. The amount of fishing effort expended per day was only constrained by daily weather conditions and logistics.

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 were 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 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 (fork length in cm), scanned for previously implanted tags, and 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 all Yelloweye Rockfish encountered. All priority rockfish (Table 13) were tagged with an internal passive integrated transponder (PIT) tag and an external Floy T-bar Anchor tag then released at their capture location unless they were to be kept for age structure collection (Table 14). Benthic habitat observations was documented for each of the WDFW survey grid cells visited.

Poor weather conditions allowed only one trip. Total rod hours fished were 9.284 and depths ranged from 135 feet to 258 feet with an average of 221 feet (Tables 15 and 16). A total of six fish were caught, including one Yelloweye Rockfish (Table 17). Of the six fish, one Yelloweye and two Quillback were successfully tagged with both PIT and Floy tags, and released at the point of capture.

Table 13. Priority species list for rod and reel survey.

Species
Blue Rockfish
China Rockfish
Copper Rockfish
Deacon Rockfish
Quillback Rockfish
Tiger Rockfish
Vermilion Rockfish
Yelloweye Rockfish
Cabezon
Kelp Greenling

Table 14. Fork lengths targeted for age structure collection by species. Individuals below the minimum length or above the maximum length were collected.

Species	Minimum Length (cm)	Maximum Length (cm)
Bocaccio Rockfish	All lengths	All lengths
Copper Rockfish	All lengths	All lengths
Cabezon	All lengths	All lengths
Silvergray Rockfish	All lengths	All lengths
Blue Rockfish	All lengths	All lengths
China Rockfish	32	36
Quillback Rockfish	42	43
Kelp greenling	36	38
Canary Rockfish	36	57
Widow Rockfish	31	51
Yellowtail Rockfish	31	54
Lingcod	55	90
Black Rockfish	32	50

Table 15. Summary of cruises.

Cruise Date	Sets	Average Depth (ft)	Total Rod Hours	Total Minutes Fished
4/3/2017	9	221	9.284	98

Table 16. Characteristics of each fishing set.

Cruise Date	Set Number	Anchor/Drift	Depth (ft)	Minutes Fished	Rods	Rod Hours
9/5/2017	1	D	173	2	5.00	0.167
9/5/2017	2	D	213	7	5.00	0.583
9/5/2017	3	D	199	15	6.00	1.5
9/5/2017	4	D	249	5	5.00	0.417
9/5/2017	5	D	256	11	5.00	0.917
9/5/2017	6	A	258	6	5.00	0.5
9/5/2017	7	A	255	14	6.00	1.4
9/5/2017	8	D	255	8	6.00	0.8
9/5/2017	9	D	135	30	6.00	3

Table 17. Catch and CPUE (fish/rod hour) for each cruise.

Species	Number Caught	CPUE
Black Rockfish	1	0.108
Canary Rockfish	1	0.108
Quillback Rockfish	2	0.215
Yelloweye Rockfish	1	0.108
Yellowtail Rockfish	1	0.108
Totals	**6**	**0.646**

Toward a Synoptic Approach to Reconstructing West Coast Groundfish Historical Removals – Understanding and quantifying the historic fishery removals from a stock is essential to generating a time series of these data, which is, in turn, a crucial input to a variety of stock assessment methods and catch-based management approaches. Estimating population-specific removals is exceptionally hard, though, especially for periods with limited record keeping, aggregation of species into market categories, and aggregation of catch by outdated or poorly described geographic area. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are significant additional complications that vary across time and space, and for which the level of reporting detail can vary widely.

Given that many 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 continue 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 are continuing to reconstruct flatfish catch histories. At least one report detailing data sources and analytical assumptions, and one report providing details on the history of fishery technology and prosecution, are expected to be completed in the next year. Additionally, significant progress has been made on a report documenting the history of the fishery, fishing technology, and harvest patterns for groundfish in Puget Sound. A definitive compendium on the topic is anticipated to be complete by 2020.

Port Sampling/Creel Surveys of Recreational Fisheries – Estimates are made for recreational harvest of bottomfish, Pacific Halibut, salmonids, and other fishes caught in marine waters on an annual basis in Washington waters. Catch composition is estimated in two-month "waves" throughout the year via angler intercept surveys (i.e., creel sampling). Effort is estimated via a phone survey, which also samples two-month waves. Staffing for angler intercept surveys, contracting of the phone surveys, and all estimation procedures are the responsibility of the Fish Management Division's Coastal and Puget Sound Sampling Units, respectively. Details on the methods and results can be obtained by contacting Wendy Beeghley (coastal; Wendy.beeghley@dfw.wa.gov), Anne Stephenson (Puget Sound; Ann.stephenson@dfw.wa.gov), or Eric Kraig (estimation; Eric.kraig@dfw.wa.gov).

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 several 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 2017. A systematic evaluation of data from SCUBA-based surveys collected between 1995 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-year evaluation period simply does not 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 several scoping and site exploration dives at select sites occurred in 2017. These dives validated presence/absence of previously placed transect markers, qualitatively assessed habitat condition (including presence of kelp and other macrovegetation), and allowed collection of initial fish abundance and distribution data. 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 sparser. This report is undergoing final formatting and will be available by June 30, 2018.

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 fishery 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. Efforts have been undertaken to refine and improve these programs, including improving systematic sampling, developing species composition protocols, and shifting to use the maturity scale developed by Martini (2013). The time series using this scale now supports evaluation. Interest remains in conducting a study similar to research conducted in California to evaluate escapement relative to barrel dewatering-hole size but funding sources have not been identified.

The Washington hagfish fishery operates by rule only in offshore waters deeper than 50 fathoms and is open access. Figure 11 presents annual landings since 2000. Landings do not necessarily represent where fishing occurred. Washington licensed fishers can fish federal waters off Oregon and land catch into Washington. Live hagfish vessels typically fish grounds closer to their home ports, while at-sea freezing allows some vessels to fish further afield. The fishery catches predominantly Pacific Hagfish. Occasionally, Black Hagfish are landed incidentally. A few trips attempting to target Black Hagfish were successful but the market was not receptive. Landings data cannot distinguish between species as only one code exists. Hagfish are caught in long-lined barrels constructed from olive oil or pickle barrels modified with an entrance tunnel and dewatering holes (Figure 12).

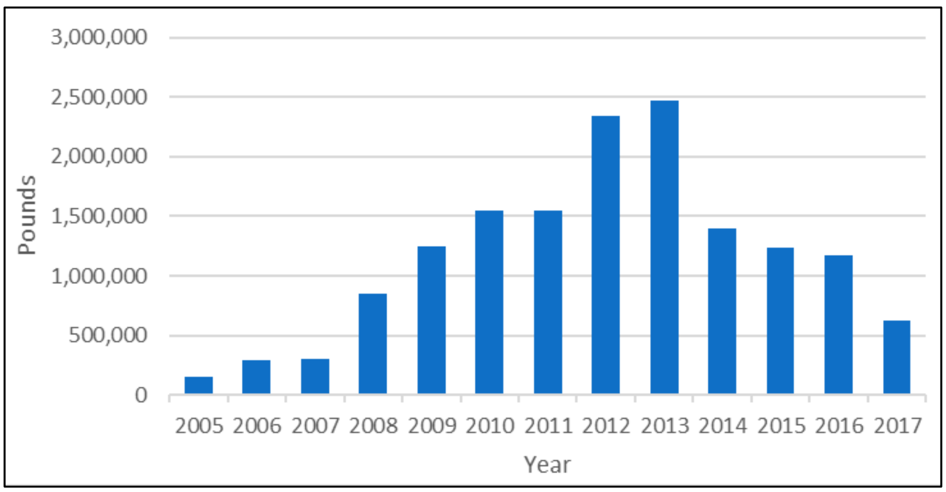


Figure 11. Hagfish Landings in pounds by Washington 2005-2017

Fishing occurs on soft, muddy habitat along the entire outer coast of Washington and northern Oregon (Figure 13). Pacific Hagfish predominate from 50-80 fa. Deeper sets, up to 300 fa, 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, as evidenced by reports of “plugged” barrels.

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 (Figure 14). The in-sample largest specimen was a 72 cm male, the smallest 19 cm of unknown sex. An evaluation of maturity suggests year-round spawning. Fecundity is low, with the number of mature eggs rarely exceeding 12. Few females with developed eggs have been sampled.

Figure 12. Barrels used in the WA commercial hagfish fishery.

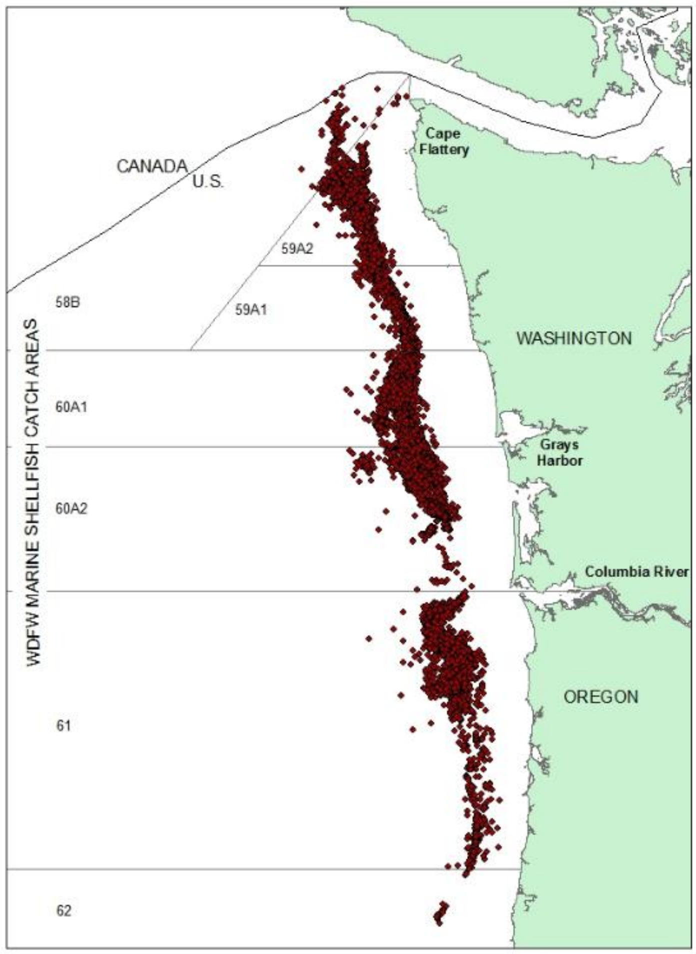


Figure 13. Distribution of Hagfish fishing trips off WA and OR, from Washington logbooks, 2005-2017.

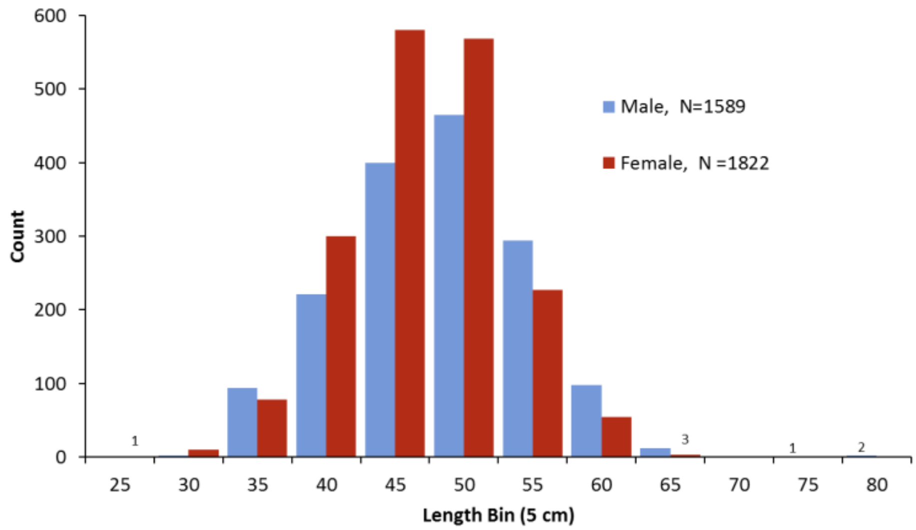


Figure 14. Length (cm), male and female Pacific Hagfish only, 2005-2014.

North Pacific Spiny Dogfish and other sharks

Lummi Nation Dogfish Fishery in Northern Puget Sound – Directed commercial fishing for North Pacific Spiny Dogfish 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 (predominantly Birch Bay and Lummi Bay). The harvest quota for this fishery was set at 250k lbs, and has remained at this level since. Harvest occurs predominantly from May-August, involves little to no reported bycatch, and tails off as fishers transition to targeting salmon in the fall.

Landings since 2014 are shown below (Table 18) and are typical of a short-term, opportunistic fishery. Only two permitted vessels fished in 2014, and they made 342 total landings. As a result of their success, five vessels fished in 2015 and 2016 and landings average 503 annually. In 2017 enthusiasm for the fishery began to wane as catch per unit effort decreased and participation dropped back to the original two vessels, which made only 260 landings. Harvest levels in 2018 are anticipated to be well below the 250k lb quota.

Table 18. Landings of Spiny Dogfish by the Lummi Nation since 2014.

Year	Landings (thousands of lbs)
2014	160
2015	219
2016	263

2017	87

In August of 2015, 2016, and 2017 Lummi Nation natural resource management 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 in all three years was female, and their average size was 91.7 cm. Many contained full-term embryos. Lummi biologist Breena Apgar-Kurtz confirmed this was a representative sub-sample years and that the "vast majority" of the harvest consisted of relatively large female sharks. Though harvest effort is localized, WDFW researchers remain concerned about potential population-level impacts of this harvest.

Publishing of Books Entitled North Pacific Shark Biology, Research, and Conservation – Together with Dr. Shawn Larson of The Seattle Aquarium, Dayv Lowry co-edited a pair of books entitled Northeast Pacific Shark Biology, Research, and Conservation, Part A and Part B (Figure 15). The concept for the books grew out of a biennial meeting on cowshark research and management that began in 2004 and eventually morphed into the Northeast Pacific Shark Symposium (NEPSS). This two-day conference, the third of which was held in Seattle in March of 2018, is now the second largest international gathering of elasmophiles in North America, behind only the American Elasmobranch Society's annual meeting. As the conference grew over the years it became apparent that much of the new research being shared was unavailable for citation because it was either not yet published, amounted to "side projects" for many researchers that might never be published, and/or was being published in largely inaccessible government "grey literature." At the second NEPSS on Catalina Island in 2016 Shawn and Dayv solicited potential authors to lead chapters, having already received a commitment from Elsevier to publish a book if suitable material could be generated.

Figure 15. Covers of the two shark books co-edited by Shawn Larson and Dayv Lowry.

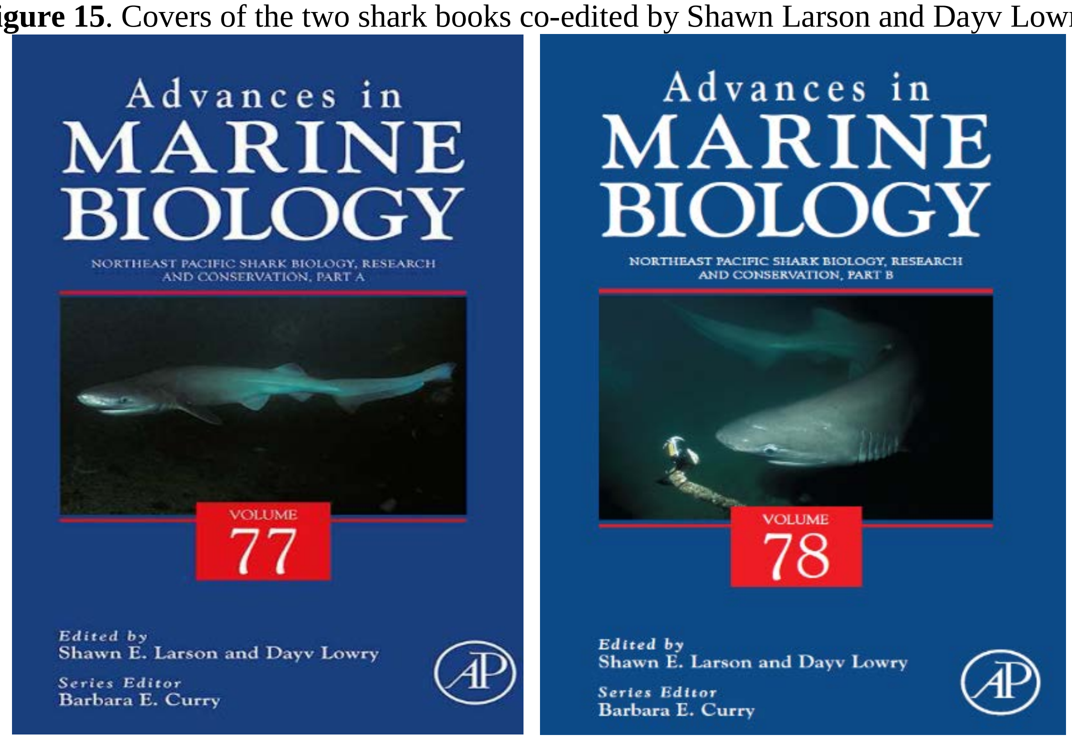


Table 19. Details for chapters in both volumes of Northeast Pacific Shark Biology, Research, and Conservation.

Authors	Title (abbreviated)	Volume	Citations	Downloads
Lowry+Larson	Introduction to Volume 77	77		38
Ebert, et al.	Biodiversity, Life History, and Conservation	77	1	83
Bizzarro, et al.	Diet Composition and Trophic Ecology	77	2	96
Reum, et al.	Stable Isotope Applications for Understanding Sharks	77	1	128
Matta, et al.	Age and Growth of Elasmobranchs	77	2	85
Larson, et al.	Review of Current Conservation Genetic Analyses	77	1	147
Larson+Lowry	Introduction to Volume 78	78		42
Kacev et al.	Modeling Abundance and Life History Parameters	78		40
Grassman et al.	Sharks is Captivity: Husbandry, Breeding, Education	78		137
King, et al.	Shark Interactions With Directed and Incidental Fisheries	78	1	84
Mieras et al.	Economy of Shark Tourism: Ecotourism and Citizen Science	78		141
Lowry	Conclusion: Future of Management and Conservation	78		63

Volume 77 was published in October of 2017 and Volume 78 followed in December. Volume 77 contains chapters pertinent to fundamental biology and ecology of sharks in the NE Pacific, such as current taxonomy and population trends, food web ecology, advances in aging techniques, and geographic breaks in populations (Table 19). Volume 78 deals largely with how humans interact with sharks in the region, and addresses population modeling, fisheries impacts/interactions, the role of captive husbandry programs in conservation, and the economy of ecotourism (Table 19). In addition to co-editing the books Dayv also co-authored the introduction to each volume and was the sole author of the conclusions chapter in Volume 78. To date, chapters in the two volumes have been cited 8 times and downloaded over 1,000 times. This citation rate is roughly average, but the download rate is well above normal given the elapsed time since publication.

At the third NEPSS in March of 2018 an agreement was reached with several researchers and resource managers in Mexico to produce a third volume that will deal specifically with the biology, research, and conservation of sharks in waters of the Pacific Ocean off Mexico, and possibly extending as far south as Panama. Additional arrangements and negotiations are currently underway to bring this volume to fruition by 2020.

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, 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 laid the groundwork for future genetic stock identification and genetics-based management of Pacific Cod from Puget Sound.

At the World Aquaculture Society's annual meeting in Las Vegas, NV in 2016 Co-PI Kristen Gruenthal presented a talk detailing the potential value of genetic variation at identified 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. The results of this research, including hypotheses about cod aquaculture, is now in press in the journal *Evolutionary Applications* (see Publications section below).

Ageing of Pacific Cod from Puget Sound – Pacific Cod in Puget Sound are a genetically distinct population characterized by an unusually high thermal tolerance. In order to evaluate cohort-specific survival rates during a period of unusually high marine water temperatures from 2014-16 the MFS Unit undertook a dedicated ageing effort in 2018. All otoliths from bottom trawls and hook-and-line surveys conducted over the past 10 years in Washington waters were aged. This meant coordinating with staff at the AFSC and elsewhere to deal with idiosyncrasies associated with ageing of Pacific Cod otoliths. Results of the analysis are pending, but in total over 330 fish were aged and analysis of growth and survival patterns is currently underway.

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 20). 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 16). 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).

Table 20. Number of fin clip samples successfully sequenced from each region and used in subsequent analyses for each ESA-listed rockfish species (from Andrews et al., 2018).

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.

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 17). No changes were made to the listing status of Bocaccio due to low sample size. A manuscript of the study was recently published in the journal *Conservation Genetics* (see Publications section below).

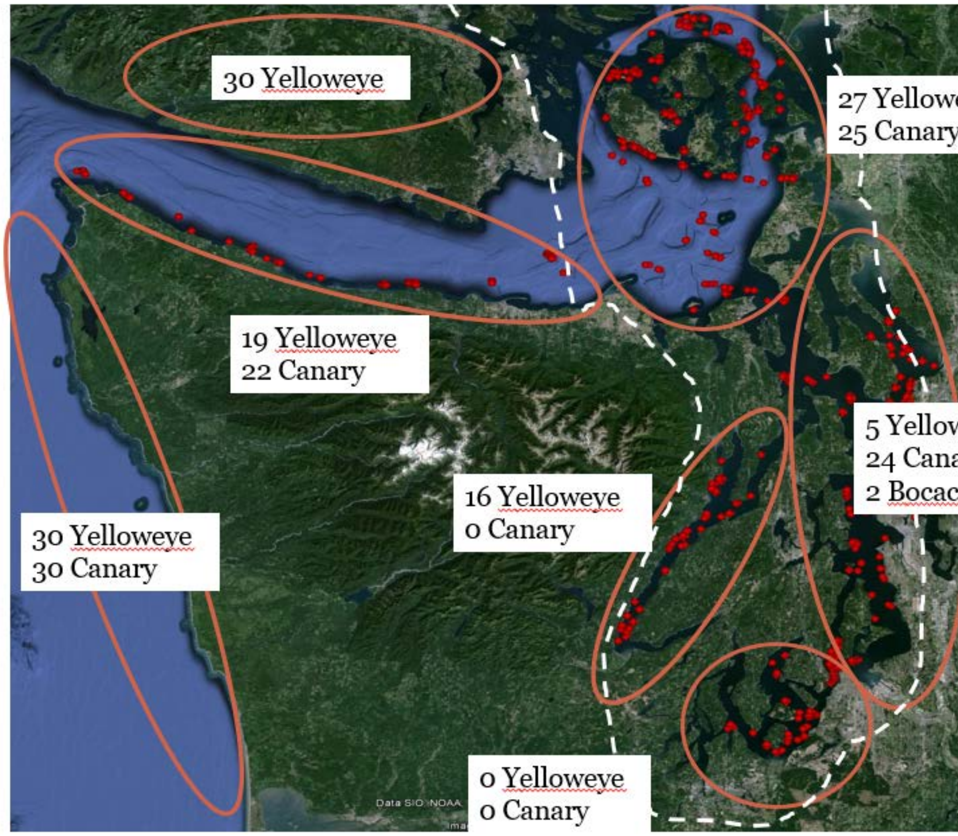


Figure 16. Total sample numbers for ESA-listed rockfish by region as of December 2016 for the Sound-wide genetic study. The 30 Yelloweye Rockfish samples shown on Vancouver Island were provided by DFO from fish collected throughout the inside waters.

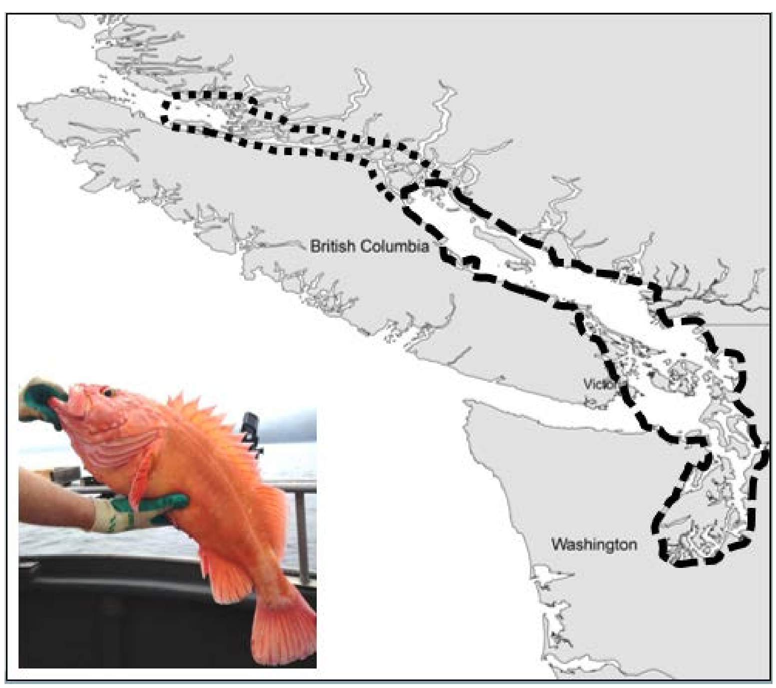


Figure 17. Depiction of the initial (long dashes) and revised (short dashes) DPS boundaries for Yelloweye Rockfish. The revised boundary was proposed based on the results of a collaborative genetic study.

Developing an Index of Abundance for Yelloweye Rockfish Off the Washington Coast – Yelloweye Rockfish 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 2017 as noted above in the Surveys section (due to captures of more than just Yelloweye Rockfish).

ROV Studies of Yelloweye Rockfish in the greater Puget Sound/Georgia Basin DPS – The PSMFS Unit completed a two-year survey of the U.S. portion of the Yelloweye Rockfish and Bocaccio DPSs in January 2017 (see previous TSC reports for preliminary results). Video review from this survey is ongoing and is currently ~50% complete (as of March 2018). Survey stations where Yelloweye Rockfish were found have been prioritized to enable a population estimate for the species to be made as soon as possible. No Bocaccio were encountered as part of the survey, though four fish were noted during "exploratory" side surveys.

In the spring of 2017, Dan Tonnes at NOAA's NWFSC was able to secure supplemental funding to conduct a three-week survey of a portion of the Yelloweye Rockfish and Bocaccio DPSs lying in Canadian waters of the Gulf Islands, within southern Strait of Georgia. The goals of this survey were to: 1) estimate the population size of Yelloweye Rockfish (and Bocaccio as possible) within the survey area; and 2) utilize a stereo-camera system to collect accurate length information of Yelloweye Rockfish, which is needed for the length-based spawner-per-recruit (SPR) model that will be used as a basis for tracking recovery of the species per the conditions of the federal Recovery Plan. The survey was designed using the same MaxEnt modelling approach as the 2015-16 Puget Sound survey. The model was developed by Bob Pacunski with data provided by Dana Haggarty (DFO Canada). The survey was originally scheduled for the period between October-December 2017, however, the paperwork necessary to conduct research in Canadian waters was delayed and the survey was not conducted until February/March 2018.

In preparation for the survey, the ROV was completely rebuilt during the summer of 2017. This process included a complete cleaning of the vehicle, repair and replacement of worn thrusters, replacement of the navigation pod and frame components, and modifications to the light system mounting bracket. Also, the WDFW acquired and mounted a stereo-camera system from staff at the NOAA NWFSC (Susanne McDermott and David Bryan). The camera system was tested extensively during the fall and winter of 2017 to ensure it would perform as required for the survey. Testing included several deployments in areas of known rockfish habitat to collect imagery in order to optimize the camera exposure and gain settings. Additionally, the camera was calibrated at the NOAA NWFSC (Bryan and Pacunski) and then tested by driving the ROV along a transect line populated with fish decoys of known size. Review of videos collected during the three-week survey are currently under way.

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 three 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 2002-17. 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 2004-17 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.

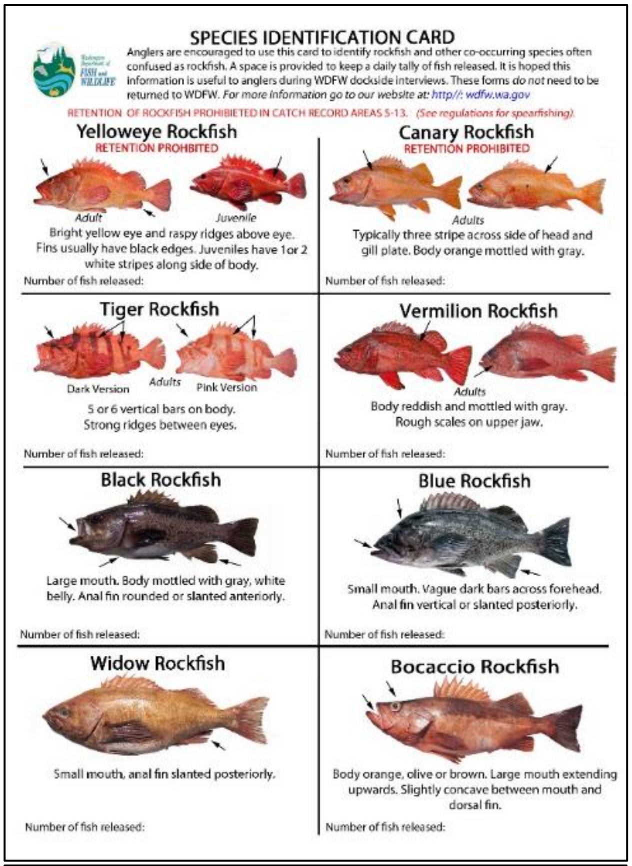
Current collaborators and contributors who have helped with this project include: Melissa Head (NWFSC, project lead), Neosha Kashef & David Stafford (SWFSC), Kari Fenske (previously WDFW), Donna Downs (WDFW), and Sheryl Flores (ODFW)

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 one conference call 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 then dedicated itself 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 was revised to recognize these significant changes. The final recovery plan was released by NOAA's Office of Protected Resources on October 13th, 2017 and implementation is now underway.

Education, Outreach, and Rule Changes Pertinent to Use of Descending Devices – For the last several years the WDFW has been advocating the voluntary use of descending devices to return rockfish and other groundfish to the depth of capture, thus reducing deleterious effects of barotrauma. The Puget Sound Anglers and staff from NOAA's Northwest Fishery Science Center have been strong partners in this effort – providing funding to purchase devices, engaging in promotional/educational efforts to inform the public about their use, and offering up manpower to distribute thousands of descenders and educational pamphlets over the past 5 years. In total, over 6,500 descending devices (Shelton Fish Descenders and SeaQualizers), 21,000 laminated rockfish species identification cards (Figure 18), and 9,000 pocket rockfish identification keychain card sets (Figure 19) have been distributed to charter boat captains and members of the public. Members of the MFS have also presented at over two dozen meeting of regional fishing and conservation clubs regarding the fundamentals of rockfish management and the roll that descending devices and other conservative fishing tools/practices can play.



SPECIES IDENTIFICATION CARD

Anglers are encouraged to use this card to identify rockfish and other co-occurring species often confused as rockfish. A space is provided to keep a daily tally of fish released. It is hoped this information is useful to anglers during WDFW dockside interviews. These forms *do not* need to be returned to WDFW. *For more information go to our website at: http//: wdfw.wa.gov*

RETENTION OF ROCKFISH PROHIBIETED IN CATCH RECORD AREAS 5-13. *(See regulations for spearfishing).*

Yelloweye Rockfish
RETENTION PROHIBITED
Adult *Juvenile*
Bright yellow eye and raspy ridges above eye. Fins usually have black edges. Juveniles have 1or 2 white stripes along side of body.
Number of fish released:

Canary Rockfish
RETENTION PROHIBITED
Adults
Typically three stripe across side of head and gill plate. Body orange mottled with gray.
Number of fish released:

Tiger Rockfish
Dark Version *Adults* Pink Version
5 or 6 vertical bars on body. Strong ridges between eyes.
Number of fish released:

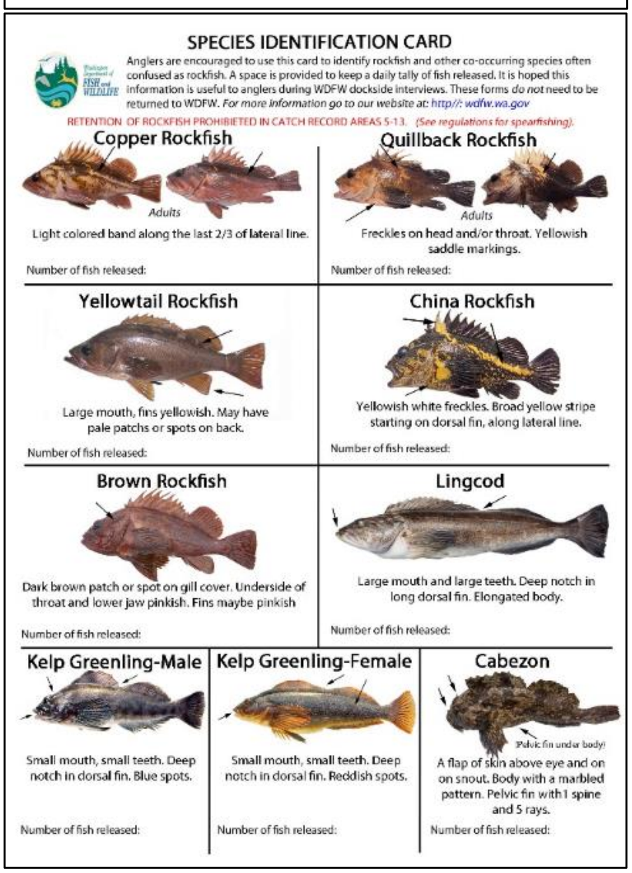
Vermilion Rockfish
Adults
Body reddish and mottled with gray. Rough scales on upper jaw.
Number of fish released:

Black Rockfish
Large mouth. Body mottled with gray, white belly. Anal fin rounded or slanted anteriorly.
Number of fish released:

Blue Rockfish
Small mouth. Vague dark bars across forehead. Anal fin vertical or slanted posteriorly.
Number of fish released:

Widow Rockfish
Small mouth, anal fin slanted posteriorly.
Number of fish released:

Bocaccio Rockfish
Body orange, olive or brown. Large mouth extending upwards. Slightly concave between mouth and dorsal fin.
Number of fish released:



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RETENTION OF ROCKFISH PROHIBIETED IN CATCH RECORD AREAS 5-13. *(See regulations for spearfishing).*

Copper Rockfish
Adults
Light colored band along the last 2/3 of lateral line.
Number of fish released:

Quillback Rockfish
Adults
Freckles on head and/or throat. Yellowish saddle markings.
Number of fish released:

Yellowtail Rockfish
Large mouth, fins yellowish. May have pale patchs or spots on back.
Number of fish released:

China Rockfish
Yellowish white freckles. Broad yellow stripe starting on dorsal fin, along lateral line.
Number of fish released:

Brown Rockfish
Dark brown patch or spot on gill cover. Underside of throat and lower jaw pinkish. Fins maybe pinkish
Number of fish released:

Lingcod
Large mouth and large teeth. Deep notch in long dorsal fin. Elongated body.
Number of fish released:

Kelp Greenling-Male
Small mouth, small teeth. Deep notch in dorsal fin. Blue spots.
Number of fish released:

Kelp Greenling-Female
Small mouth, small teeth. Deep notch in dorsal fin. Reddish spots.
Number of fish released:

Cabezon
(Pelvic fin under body)
A flap of skin above eye and on on snout. Body with a marbled pattern. Pelvic fin with 1 spine and 5 rays.
Number of fish released:

Figure 18. Front (left) and back (right) of species identification guide distributed to recreational anglers. A digital version is available on the WDFW's webpage and thousands of laminated versions have been handed out at boat launches, piers, and sportsman's shows.

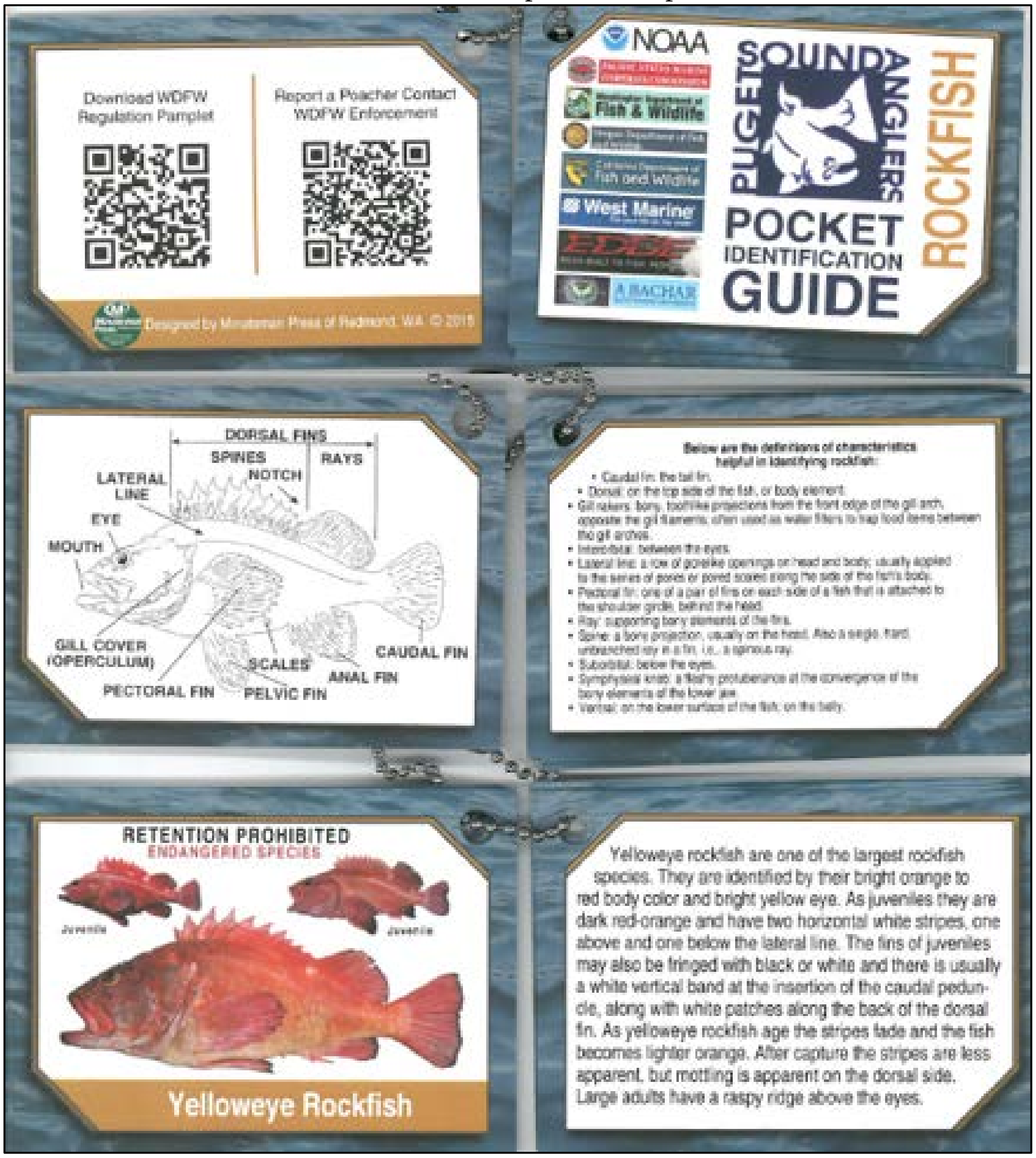

Figure 19. Example cards from keychain rockfish species identification guides distributed to recreational anglers. Thousands of sets have been handed out at boat launches, piers, and sportsman's shows in the past two years.

In 2016-17 the PSMFS Unit collaborated with NOAA fisheries, the Seattle Aquarium, and the PSMFC to develop large, colorful signs to help educate the public about Washington's rockfish (Figure 20). The signs provide information on how to identify several species of rockfish, how important it is to accurately identify and report catch, and the benefits of using descending devices to return rockfish to the depth of capture. The sign also instructs recreational scuba divers on how to report sightings of ESA-listed juvenile rockfish. Sixteen, 4'x3' aluminum signs with anti-graffiti coating were created and installed by crews at marinas and ports throughout Puget Sound and on the outer coast where high average incidence of groundfish encounters was well documented (via creel surveys). Installation was coordinated with the monofilament line recycling program and line collection receptacles were installed near, or on the posts of, each sign.

Figure 20. Final rockfish conservation sign designed by the WDFW, NOAA Fisheries, the Seattle Aquarium, and the PSMFC (left), and a representative example of an installed sign in Port Townsend (right).

As a result of proposals solicited during the triennial fishing rule modification cycle in March 2016, the WDFW instituted a regulation that became effective on July 1, 2017 requiring that anglers fishing for bottomfish (and Pacific Halibut) from a vessel in Washington waters have a descending device onboard, rigged, and ready for use. In the latter part of 2017 WDFW Enforcement elected to approach violations with warnings and education, but as of early 2018 they began systematically ticketing non-compliant anglers.

Creation of Relational Database for Scientific Collection Permits (SCPs) – Under Washington State law any time an individual or entity seeks to take specimens of fish or wildlife species for scientific or educational purposes they must apply for, and be granted, an SCP *prior* to initiating collection. The current record keeping system associated with SCPs is antiquated and deals solely with the application and issuance process. While annual reports detailing the species actually collected are submitted by permittees, these records are static PDFs, Excel spreadsheets, or tables in Word that are labor intensive and time consuming to search using existing technologies. Recent pressure has been placed on all State-level government agencies to respond to Public Data Disclosure Requests in an efficient and timely manner, and existing SCP records are woeful inadequate with regard to this need.

In 2015 a plan was developed for creation of a relational database that would allow not only tracking of the permitting process but also provide the ability to search, aggregate, and summarize proposed and realized species-specific take across multiple permits, years, and clearly defined geographic scales. Funding shortages stopped the plan from coming to completion in late 2015. In February of 2017 this plan was resurrected based on a new funding source and a beta version of the database was created, as well as a web-enabled data entry front end. Of particular interest to marine fish managers, who have been actively involved in the planning and development process, is that this tool has the ability to quickly summarize recent take data such that managers can evaluate impacts on rockfish and other bottomfish populations in regions where fisheries are currently closed.

In February of 2018 a beta version of the front-end application tool was sent to ten applicants who: 1) submit permit requests annually; 2) request take of twenty or more species; and 3) tend to communicate well with application reviewers. Most of these were representatives of local aquaria or academic entities. Initial feedback was largely positive, though several small bugs were discovered. Final polishing of the tool is now occurring and full release to the general public is anticipated by June of this year.

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, 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. 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. Otoliths (surface aged) took only minutes per sample to prepare and age, but had below average readability, the least precision between readers, 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 have enlisted 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.

Lingcod Instructional Videos for Fin Collection and Prepping Fins for Age Reading – The CMFS Unit is producing instructional videos describing Lingcod fin ray collection and preparation for ageing. The videos present step-by-step procedures to ensure the preferred rays are selected and properly prepared, e.g., dried, cut, and mounted on slides, to standards that produce high quality specimens. Each video is short and structured so the viewer can select subtitled sections, allowing quick reference to specific steps. A PDF transcript with photos will accompany the instructional video. Currently, the WDFW processes and ages Lingcod fins from Washington, Oregon and California commercial and recreational fisheries and research surveys. Providing adequate training is difficult across the span of agencies and programs. The hope is that the videos will aid in training field staff that collect Lingcod fins and/or facilitate efforts to begin fin processing in the lab.

Atka mackerel

No specific, directed research or management to report.

Flatfishes

No specific, directed research or management to report.

Pacific halibut & IPHC activities

Disagreement Regarding Permitted Activities – In 2010 the Puget Sound/Georgia Basin distinct population segments of three species of rockfish were listed under the federal Endangered Species Act. As a result, action immediately began to: 1) close several commercial fisheries with the potential to bycatch these species; and 2) ensure all remaining State-level fishery activities in the region were appropriately permitted. In 2012 a five-year Section 10(a)1(A) permit was issued to cover recreational bottomfish hook-and-line and shrimp beam trawl fisheries in Washington waters affected by the listing. In 2017 this permit was up for reassessment and renewal. After consultation with NOAA Fisheries, Marine Fish Science Unit staff revised the Incidental Take Permit Application and Fishery Conservation Plan associated with this permit to include recreational and commercial shrimp pot fisheries, for which recent research had demonstrated a very small risk of bycatch for listed rockfish species. All documentation for permit renewal was submitted to NOAA well in advance of the October 2017 renewal deadline.

Unfortunately, during the term of the initial permit, a regulation change had been made regarding the prosecution of recreational Pacific Halibut fisheries in Puget Sound. Specifically, on halibut fishing days in Marine Catch Area 6 (the eastern Strait of Juan de Fuca, from Low Point to Port Townsend) it was made permissible to retain Lingcod and Pacific Cod from waters deeper than 120 ft. The 120-foot depth restriction was put in place for all bottomfish fisheries in 2010 (Pacific Halibut are not bottomfish as defined by Washington Administrative Code), and was a conservation measure considered when evaluating bycatch levels associated with recreational fishing for the original Section 10 permit. NOAA Fisheries viewed any and all harvest of Lingcod and Pacific Cod during this fishery as a potential violation of the Section 10 permit, while the WDFW contended that such harvest was being duly reported on the permit covering Pacific Halibut fisheries, thus all potential risks to ESA-listed rockfish were being adequately accounted for. As of this report, a final decision regarding renewal of the Section 10 permit has not been reached, but recreational bottomfish fisheries, shrimp beam trawl fisheries, and recreational/commercial shrimp pot fisheries are moving ahead as scheduled for 2018.

Other groundfish (and forage fish) species

Liver to Whole Fish Weight Conversion: Improving Historical Catch Data in Stock Assessments – Prior to the synthetic manufacture of vitamin A, this valuable nutrient was derived from fish livers for human consumption. Fish livers were also highly desired sources of oil for lighting and lubrication. World War II spurred the demand for aircraft lubricants and “liver fisheries” developed to meet this need. Livers from North Pacific Spiny Dogfish were prized as a rich source of Vitamin A and oil, and other groundfish species such as Lingcod, Sablefish, flatfishes, and rockfishes were utilized for their oils as well. Demand declined in the 1950’s and largely ceased when synthetic vitamin A became available. Nowadays, there is a high demand for squalene oil present in certain shark livers for use in cosmetics, machine oil, and pharmaceuticals. The challenge for stock assessors in constructing historical catch series is that given this particular “liver fishery” focus, in the decades prior and through the mid-1960s, it was typical to record only liver weight on fish landings receipts (Figure 21). To complicate matters, it is not always clear whether whole or liver weight was recorded.

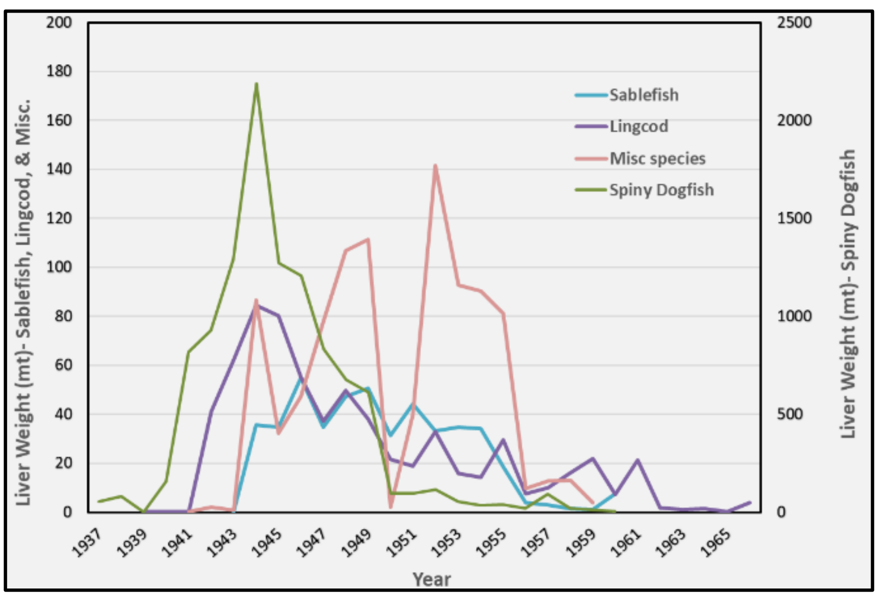

Figure 21. Washington “liver fishery” landing weights from 1937-1966 from Sablefish, Lingcod, North Pacific Spiny Dogfish, and “misc species.” Composition of the “misc species” category is unknown.

For some species, historical liver to body weight conversion factors were documented. To confirm these historical conversion factors and fill the gap for other species, we collected whole fish from commercial groundfish landings. For each fish, the ratio of liver weight to body weight for each fish was calculated. The median of the ratios for each species or species group (Lingcod, North Pacific Spiny Dogfish, flatfishes, rockfishes, and Sablefish) was used to determine the conversion from liver weight to round weight (Table 21; Figure 22). Finally, we applied these conversion factors to estimate round weights for Sablefish, North Pacific Spiny Dogfish, and Lingcod (Table 22).

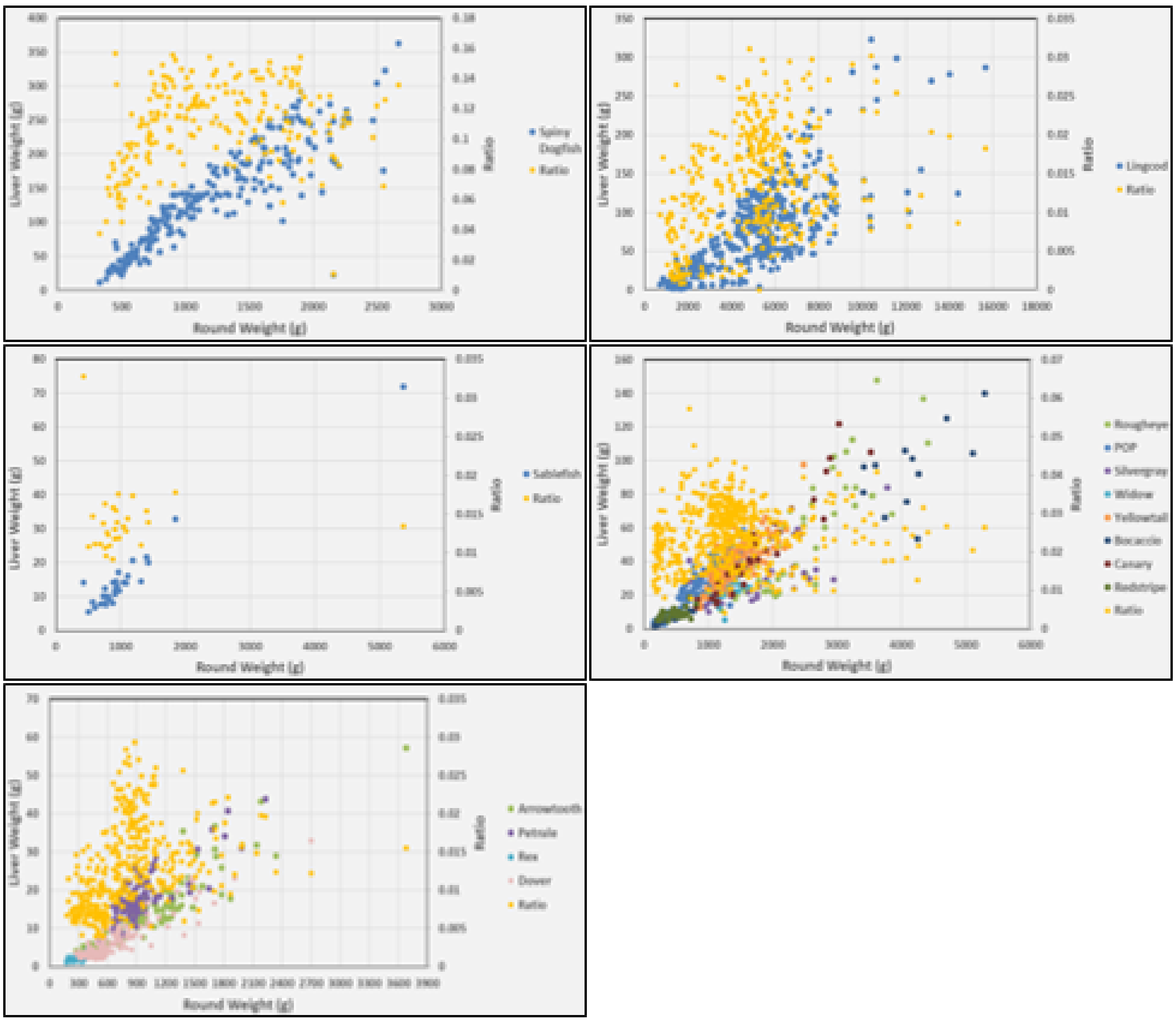

Figure 22. Liver weight, round weight, and liver:round weight ratios for sampled species.

Based on our review of historical landings and study results we identify several implications for historical catch reconstructions. First, assume the whole fish weight for species with high market values (i.e., Lingcod) are already accounted for on fish tickets. Second, for species with low to no market value (i.e., North Pacific Spiny Dogfish) the assumption is the whole weight of the fish is not included on fish tickets. Thus, converted liver weights for low market value fish need to be added to the catch estimates. Finally, for this unknown group, based on our estimated conversions, the catch estimates would be higher if the composition of rockfish was greater, but lower if the composition of flatfish was greater. An accurate composition of this group will need to be determined before catch estimates can be calculated.

Table 21. Study and historical conversion factors.

Percentage of Round Weight				
Species	**Current Conversions**	**Historical Conversions**		
		1944 WDF Bulletin	1947 landing data	Pugsley, 1940[1]
Lingcod	1.39%		2%	1.46%
Spiny Dogfish	11.29%	12%	10%	
Flatfish	1.19%			
Rockfish	2.43%			1.50%
Sablefish	1.33%			2.20%

Table 22. Historical liver weights converted to round weight applying current conversion factors from Table 1.

Historical Liver Weights Converted to Round Weight						
Year	Sablefish		Spiny Dogfish		Lingcod	
	Liver Weight (mt)	Round Weight (mt)	Liver Weight (mt)	Round Weight (mt)	Liver Weight (mt)	Round Weight (mt)
1937			54.38	60.52		
1938			79.61	88.60		
1939			1.22	1.36	0.02	0.02
1940			157.32	175.08	0.10	0.10
1941			817.67	909.99	0.01	0.01
1942			927.87	1032.63	41.08	41.65
1943	0.08	0.08	1290.76	1436.49	62.03	62.89
1944	35.49	35.96	2186.90	2433.80	84.33	85.50
1945	34.66	35.12	1272.33	1415.98	80.08	81.19
1946	54.83	55.56	1204.64	1340.64	55.11	55.88
1947	34.81	35.27	831.81	925.72	37.14	37.66
1948	47.17	47.79	676.58	752.96	49.55	50.24
1949	50.54	51.22	611.58	680.62	38.06	38.59
1950	31.23	31.65	97.06	108.01	21.46	21.76
1951	44.09	44.68	96.37	107.25	18.69	18.95
1952	33.15	33.59	114.11	126.99	32.69	33.14
1953	34.56	35.02	55.29	61.54	15.84	16.06
1954	34.15	34.61	35.93	39.98	14.35	14.55
1955	18.56	18.81	39.93	44.44	29.33	29.73
1956	3.80	3.85	20.38	22.68	7.38	7.48
1957	2.78	2.81	92.78	103.26	10.01	10.15
1958	1.32	1.33	17.78	19.78	15.99	16.21
1959	0.96	0.98	12.50	13.91	21.71	22.01
1960	7.52	7.62	5.68	6.32	7.13	7.23
1961					21.21	21.51
1962					1.82	1.84
1963	0.07	0.07			0.93	0.95
1964					1.52	1.55
1965					0.27	0.27
1966					3.86	3.91
Total	469.76	476.01	10,700.48	11,908.57	671.70	681.04

Future work includes continued liver weights and whole weights collection for other species (skates, Pacific Cod, and other sharks), and evaluation of the misc. liver weight group to determine species composition.

Pacific Herring Assessment and Conservation Plan for the Salish Sea – Pacific herring is a critical species in the Salish Sea ecosystem, with broad connections throughout the food web. Evidence from historic tagging studies suggests that some herring are resident in the southern Salish Sea, though an oceanic component to the life cycle exists for at least some stocks. As a result, herring represent a significant annual influx of energy to the Salish Sea. Herring are also a culturally important species for native Tribes and First Nations in the region, and are economically valuable to commercial fisheries in British Columbia and a limited fishery in Puget Sound that provides bait to recreational salmon fisheries. While herring populations in BC are near record highs, many of the stocks in Puget Sound have declined substantially. Despite their importance, herring have received relatively little research emphasis compared to salmon and other high profile species, and coordination among the various stakeholders and across international boundaries has flagged in recent years, preventing development of a coherent and comprehensive management strategy.

Using funding from the SeaDoc Society, MFF Unit and PSMFS Unit staff (Lowry, Sandell, and Dionne) collaborated with the University of Washington, Tacoma to convene an expert working group; compile Pacific Herring demographic and biological data; compile habitat condition and distribution data; compile stressor data; and produce an assessment and conservation plan for herring in the entirety of the Salish Sea. Working group members included representatives from WDFW, DFO Canada, NOAA Fisheries, several First Nation and Treaty Indian Tribes, conservation groups, academia, and representatives from the fishing industry. Data were also used to develop a conceptual model of factors influencing herring status, then this model was converted to a qualitative network model (QNM) to simulate future potential states resulting from proposed management actions. The recovery and conservation plan is in final review and a planned peer-review publication is in the works to describe application of the QNM.

Other species – 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 – The Toxics-focused Biological Observation System for the Salish Sea (TBiOS) 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, Spot Prawn, and Blue Mussels, as well as a field experiment testing the effects of chemicals leaching from creosote-treated wooden pilings on the health of developing Pacific Herring 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.

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 23). (Note: South Cypress Island was only surveyed in February of 2016, at which time it was determined that tidal currents in the area would preclude future sampling.)

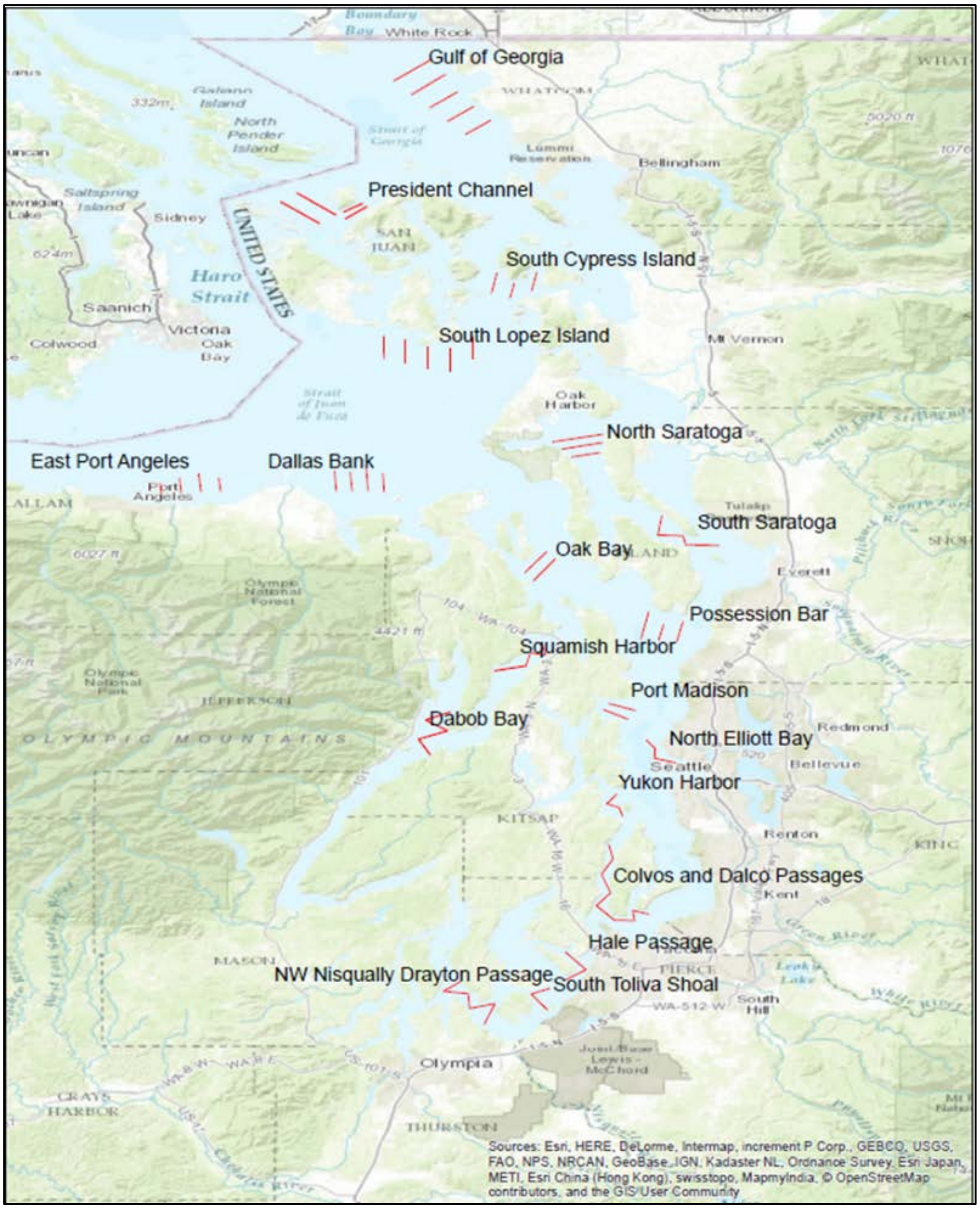

Figure 23. Map of station locations for the Puget Sound Mid-water acoustic trawl survey, Southern Salish Sea, WA.

Trawl catch was normalized by the length of tow and adjusted for currents as transects differed in length and, rarely, tows had to be ended early due to vessel traffic or sudden changes in bathymetry. A total of 96 different species were collected throughout the survey area, including 64 vertebrate species and 32 invertebrate species. Of these, nine species made up 96% of the overall catch (Figure 24). Trawl catches were dominated by Pacific herring, which constituted 70% of the total vertebrate catch (Figure 24). Pacific hake were the second most commonly encountered vertebrate, at 17% of overall catch. No other species of invertebrate or vertebrate exceeded 10% of the catch.

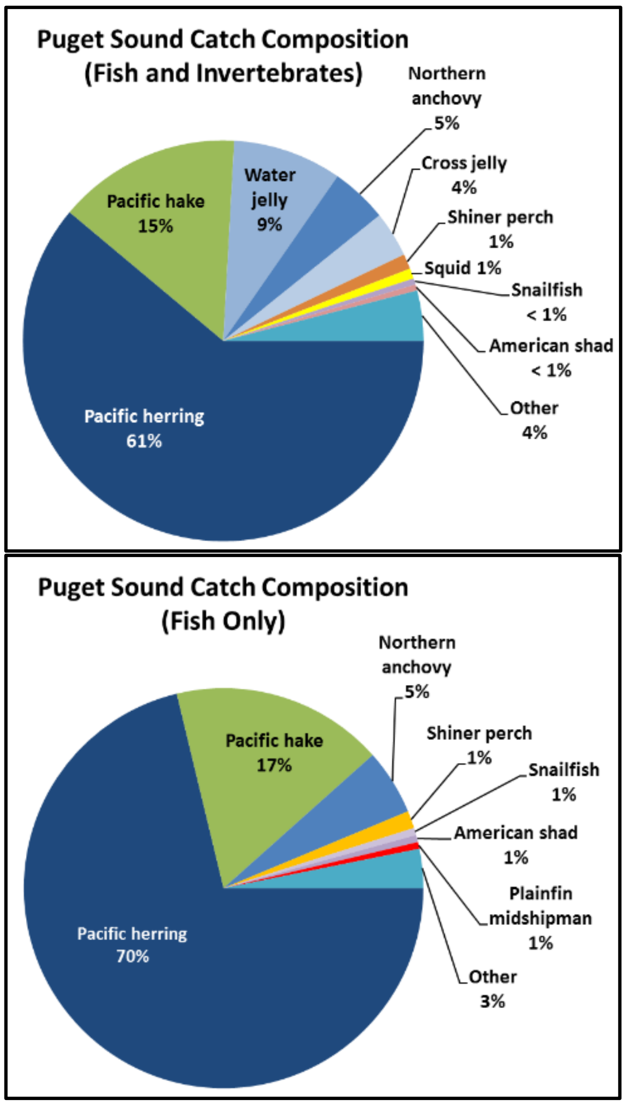

Figure 24. Total catch composition of fish and invertebrate species (left) and finfishes (right) collected during the 2016-17 Mid-Water Trawl Survey.

It should be noted that trawl catches in this survey were not random samples but, rather, directed based on real-time observations of the acoustics boat. Additionally, due to the mesh size of the net (1 cm^2), it is unclear how effective the net was at collecting and quantifying certain species of invertebrates (especially gelatinous zooplankton) and narrow-bodied fish (i.e., Pacific Sand Lance). As a result, the discussion here will concentrate on the vertebrate species captured and will include California Market Squid due to their potential as forage for culturally and economically important finfish species in Puget Sound.

In all, 11 of the 64 vertebrate species were collected in all six basins. California Market Squid, Fried Egg Jellyfish, and Moon Jellyfish were also captured in all basins (Table 23). Pacific Herring was the dominate species in all basins, constituting 50% (Whidbey Basin) to 91% (Hood Canal) of the total catch (Figure 25). Pacific Hake/Whiting was common in the Main and Whidbey Basins, making up 20 and 44% of the catch, respectively. Northern Anchovy was captured in all basins and constituted 26% of the catch south of the Tacoma Narrows. Aside from Pacific Herring, no other species was captured in high numbers in all basins. For example, Pacific Hake was a significant component of the catch in the Main and Whidbey Basins, as noted above, but did not exceed 4% of the catch at any other basin. American Shad were only significant contributors to the catch in Hood Canal. Monthly total catches from the mid-water trawl (independent of basin) are shown in Figure 26 for total catch (left panel) and for fish only (right panel).

Table 23. Numerical catch of the most abundant species by basin. Together these nine species made up 96% of overall catch.

	Basin						
Common Name	**Frasier Plume**	**Hood Canal**	**Juan de Fuca**	**Main Basin**	**South of Narrows**	**Whidbey Basin**	**Grand total**
Pacific herring	7,752	17,324	4,665	23,182	9,835	14,202	76, 960
Pacific hake	103	1,053	8	6,501	628	12,377	20,670
Northern anchovy	153	304	25	854	4,073	987	6,396
Shiner perch	8	2	7	1,362	244	68	1,691
CA market squid	31	142	305	349	326	7	1,160
American shad	3	514	28	49	3	89	686
Spiny dogfish	74	19	2	58	42	289	484
Northern lanternfish	157	17	80	6	1	1	262
Pacific pompano	16	11	1	29	25	170	252

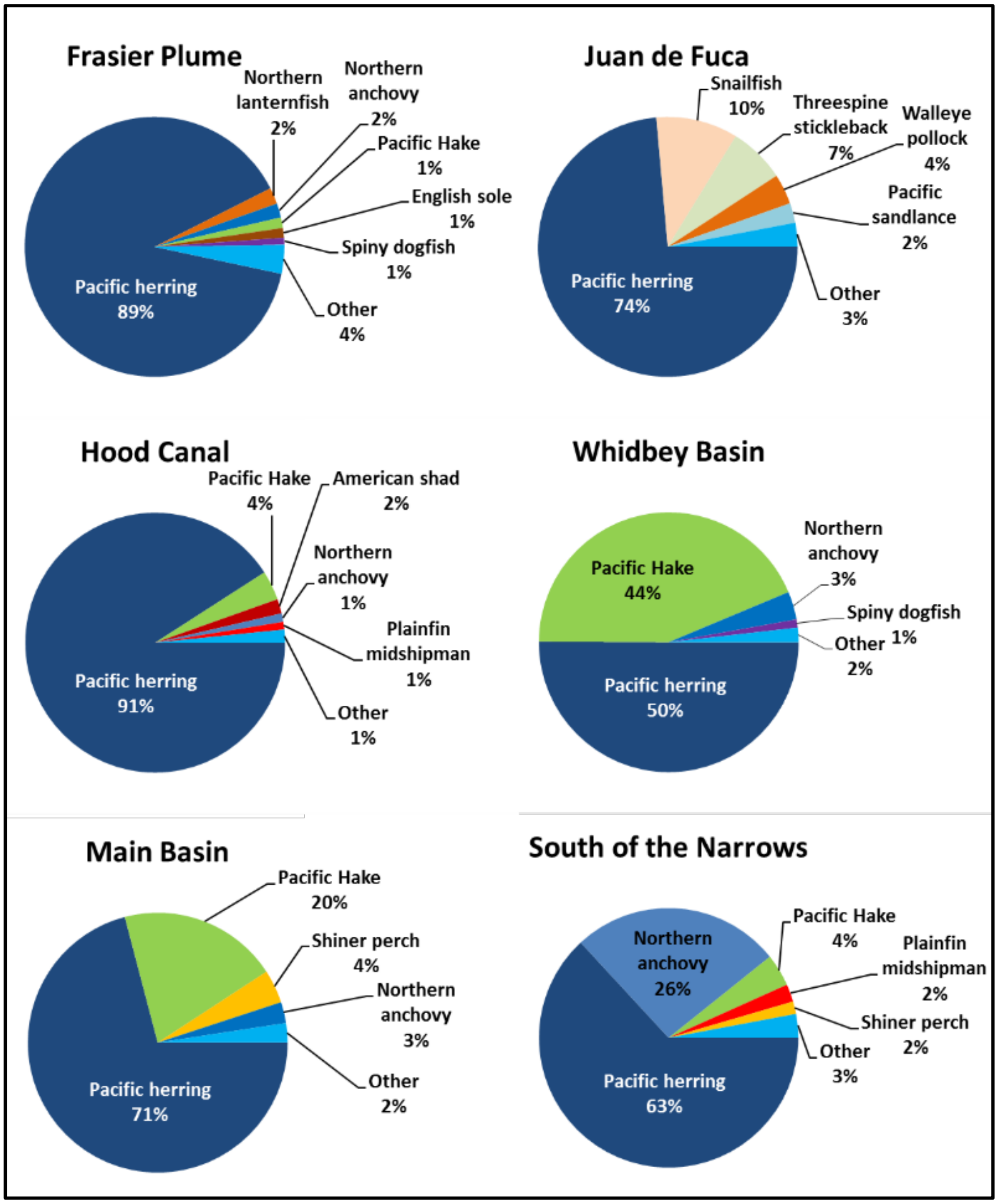

Figure 25. Realtive abundance of fish in the mid-water trawl catch, by species, by basin.

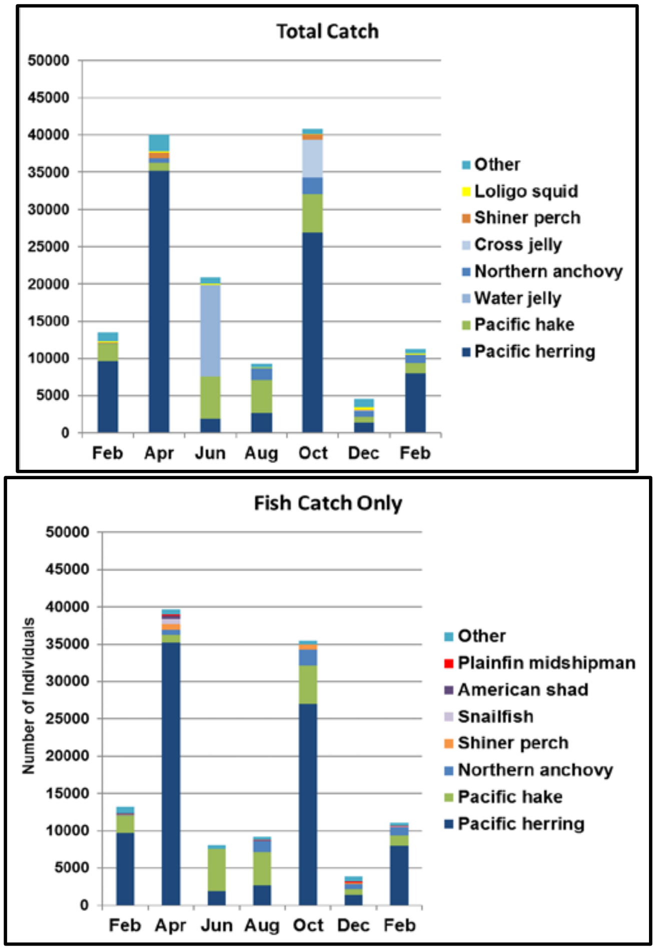

Figure 26. Total catch (left panel) and most abundant fish catch (right panel) by month, February 2016-February 2017.

Total mid-water trawl catches were greatest in the spring and fall sampling periods, and lowest in the winter and summer surveys. Pacific Herring was the most abundant fish caught in all survey months except during the summer, when Pacific Hake/Whiting became dominant. The spike in hake abundance during the summer was driven primarily by large catches in the Whidbey and Main Basins and decreases in the overall abundance of herring and other fish species (Figure 27).

Acoustic biomass estimates were generated for each of the six basins, in total, by species, and by month. Pacific Herring were also the dominate contributor to biomass overall, with an estimated biomass of 115,834 kg for the entire survey (Table 24). North Pacific Spiny Dogfish, due to their large size relative to other fish species captured in the trawl, were also large contributors to the estimated overall biomass.

Biomass Estimate for each Basin							
Common Name	**Frasier Plume**	**Hood Canal**	**Juan de Fuca**	**Main Basin**	**South of Narrows**	**Whidbey Basin**	**Total Biomass**
Pacific herring	20,500	22,937	4,198	39,706	5,655	22,837	115,834
Spiny dogfish	74,373		203	4,721	9,337	21,542	110,176
Pacific hake	3,917	2,524		25,008	1,392	7,951	40,792
Chinook salmon		48	4,698	18,742	4,672		28,159
Walleye pollock	13,924		497	1,033			15,454
Northern anchovy	2,234	462	36	1,448	4,486	131	8,797
Market squid	50	51	172		1,027		1,299
Other	2,681	2,478	287	5,139	6,481	438	17,503

Table 24. Acoustic biomass estimates (kg) for the dominate species. “Other” is a grouping of all fish species that did not exceed 5% of the catch in any individual trawl sample.

The acoustic estimate of Chinook Salmon biomass is likely an overestimate and is an artifact of low overall trawl catch at some sampling locations. When acoustic biomass estimates are produced for each species, the estimate is based on each species’ proportion of the total catch. If the trawl catches few fish, the proportion of any one species increases. For example, fish tended to congregate tightly along the bottom at some sampling stations (Port Madison and North Elliott Bay), making them inaccessible to the mid-water trawl, and catch at these locations tended to be low. When the acoustic biomass estimate generated from the fish along the bottom is applied to the low overall catch, the species biomass estimates can become artificially inflated, as appears to have happened with Chinook salmon in the Main Basin (due mainly to catches at North Elliot Bay; Table 4).

Figure 27. Catch of the most abundant species by basin and month.

Fish density estimates for the dominant species of interest were produced for each basin. Both Pacific Herring and Pacific Hake/Whiting had the greatest density in the Whidbey Basin and lowest in the Strait of Juan de Fuca (Figure 28). South Sound ("South of Narrows" Basin) had the highest density of Northern Anchovy.

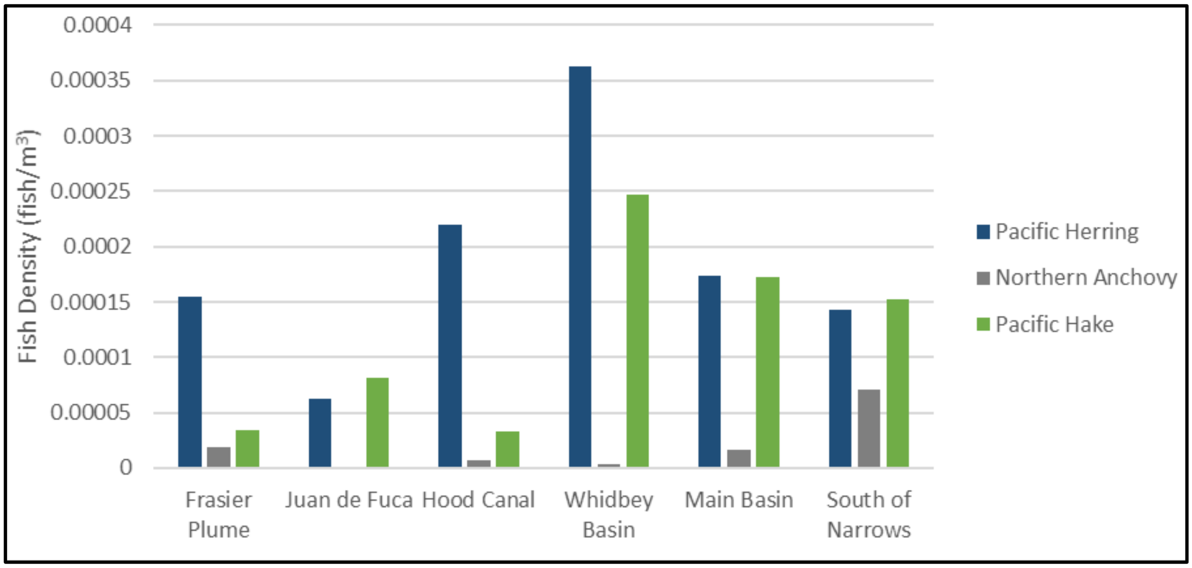

Figure 28. Acoustic fish density (fish/m3) for Pacific Herring, Northern Anchovy, and Pacific Hake/Whiting.

Pacific Herring densities were generally consistent throughout the survey with moderate increases during the spring and fall as the fish moved to and from the spawning locations in the Sound. Note, however, that low catches in February of 2016 likely underestimated the mid-water fish community because of delays in obtaining the Marport net sounding unit (installed for the April 2016 survey and all others); as a result our trawl depths were less precise and likely resulted in reduced catches.

This survey was the first by the WDFW to target forage fish, and particularly Pacific Herring, when they were *not* aggregating prior to spawning or on their spawning grounds. Instead, it investigated pelagic fish community composition over the course of the year in a broader, offshore-focused manner. Overall, the study captured a "snapshot" of Puget Sound after an extended period (late 2013 through 2016) of anomalously warm surface waters in the northeastern Pacific Ocean and will serve as a baseline for future comparisons. The value of this study will be amplified by future efforts to emulate this work, building a time series that will be an invaluable reference as the human population around the southern Salish Sea increases and the climate shifts over coming decades. Data reported here are preliminary and WDFW staff continue to finalize evaluations of biodiversity and abundance patterns (using PRIMER-E), work through the backlog of frozen samples that were captured to age fish and analyze samples for genetics, toxics, etc., and generate a technical report to make this information publicly available. These data will be further investigated to enhance understanding of the physical and biological determinants of forage fish abundance and aggregation in the southern Salish Sea and the dynamics between forage fish and the other trophic levels in the ecosystem. The final report detailing acoustic results and biodiversity patterns is expected to be complete by the end of May, with the biodata report to follow late in 2018.

High-Resolution Modeling of Fish Habitat Associations, and Predictive Models -- In collaboration with the SeaDoc Society and Tombolo Laboratories (now part of the SeaDoc Society), PSMFS Unit staff worked to integrate high-resolution multibeam bathymetry data from the San Juan Islands and Puget Sound "proper" (roughly inland of Port Townsend and

Deception Pass) with fish occurrence data obtained from ROV and drop camera surveys over seven years. H. Gary Greene, a geologist, has spent several years mapping and typing benthic habitats in the San Juans and extrapolating these assessments, as possible, to other areas of the Sound. 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 expanded 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 Rockfish section) was used to create a Sound-wide model that can be used to evaluate rockfish critical habitat designations made by NOAA in 2015. The final report for this project is available upon request from Dayv Lowry or Dan Tonnes (NOAA).

Location information for Yelloweye rockfish collected during the 2015-16 ROV survey of Puget Sound are being used to update the MaxEnt species distribution model used to design that survey. The original modelling work was developed by Chris Rooper at the NOAA NWFSC, but has subsequently been taken over by Bob Pacunski.

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, followed by a one-year grant from the Puget Sound Restoration Fund to continue the work through 2018. Combined with the legislative grant money mentioned above, these funding sources allow 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 21 free-floating nets, 19 sunken/entangled nets, and ample opportunity for public outreach regarding when nets are derelict and when they are legally 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 June of 2019. Funding beyond that date is uncertain.

Coastal Ocean Pink Shrimp Trawl Bycatch Reduction – Addressing bycatch in Washington's coastal pink shrimp fishery has been a primary focus of management since 2000 when several rockfish species were declared over-fished. Historically, shrimpers commonly caught and sold rockfish and other groundfish as "gas money." WDFW actions to reduce bycatch in the shrimp trawl fishery include the mandatory use of finfish excluder panels or grates in trawl nets (2003) to protect rockfish species, and narrowing excluder grate bar spacing to ¾ inch (2012) to further protect eulachon smelt following its 2010 listing as an ESA threatened species by NMFS. In addition, the WDFW conducted a two-year observer program (2011-2012) to collect bycatch data from Washington licensed pink shrimp trawl vessels. Recent research conducted by the Oregon Department of Fish and Wildlife and Pacific States Marine Fisheries Commission has demonstrated further, significant bycatch reductions when LED fishing-lights are placed on shrimp trawl net footropes. Estimated reductions were about a 90% for eulachon smelt, and from 56% to 86% for certain juvenile rockfish and flatfish. Based on this research, the National Marine Fisheries Service lists utilization of LED fishing-lights among its five-year priority actions in its eulachon recovery plan issued September 2017. Accordingly, WDFW managers pursued new rules requiring Washington licensed shrimp trawl vessels to use LED-fishing lights. The Oregon Department of Fish and Wildlife is adopting similar rules. The new regulation will be in effect beginning the 2018 pink shrimp fishery season (April 1).

In February 2018, the Marine Stewardship Council re-certified the coastal pink shrimp trawl fishery as sustainable. The coastal pink shrimp fishery is the only Washington state-managed fishery to achieve such a designation. WDFW is implementing improved fishery landings monitoring to better inform management, and will continue to pursue strategies to reduce bycatch.

Publications

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- Lowry, D. and S.E. Larson. (2017). Introduction to Northeast Pacific shark biology, ecology, and conservation. In: Larson, SE, and D Lowry (eds). *Northeast Pacific Shark Biology, Research and Conservation Part A*. Advances in Marine Biology. Academic Press. Volume 77: 1-8.

Larson, S.E., and D. Lowry (eds.) (2017). *Northeast Pacific Shark Biology, Research and Conservation Part B*. Advances in Marine Biology. Academic Press. Volume 78. 318 pp. ISBN: 9780128123942.

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- D. Lowry. (2017). Conclusions: the future of the management and conservation of sharks in the Northeast Pacific Ocean (NEP). In: Larson, SE, and D Lowry (eds). *Northeast Pacific Shark Biology, Research and Conservation Part B*. Advances in Marine Biology. Academic Press. Volume 78: 155-164.

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WDFW Marine Fish Science Unit. (2017). BN 2013-2015 Report to the Legislature: Status of Rockfish Research and Stock Assessment Programs. Washington Department of Fish and Wildlife. 14 pp.

Conferences and Workshops

In 2017-18 staff of the MFS Unit presented at, participated in research presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events, as indicated below.

American Society of Ichthyologist and Herpetologist annual meeting. Austin, TX, 2017. Dayv Lowry was a co-author on two talks.

Western Fish Disease Workshop. Suquamish, WA, 2017. Dayv Lowry and Todd Sandell were co-authors on a talk.

American Fisheries Society national annual meeting. Tampa, FL, 2017. Dayv Lowry and Bob Pacunski were co-authors on two talks.

Seattle Aquarium Discover Science Days. Seattle, WA, 2017. Bob Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Patrick Biondo, Adam Lindquist, Taylor Frierson, Dayv Lowry, Phil Campbell, and Amanda Phillips attended and presented.

Western Groundfish Conference. Seaside, CA, 2018. Dayv Lowry, Bob Pacunski, Jen Blaine, Theresa Tsou, Lorna Wargo, Jamie Fuller, Donna Downs, and Rob Davis were co-authors on a total of three talks and two posters.

- Dayv Lowry also co-organized session on descending device research and management on behalf of the TSC.

Alaska Marine Science Symposium. Anchorage, AK, 2018. Dayv Lowry was a co-author on a talk.

Salish Sea Ecosystem Conference. Seattle, WA, 2018. Dayv Lowry, Bob Pacunski, Todd Sandell, Adam Lindquist, and Phill Dionne were co-authors on a total of five talks and two posters. Phill Dionne and Todd Sandell also co-organized a session.

The Fisheries Society of the British Isles Symposium. Norwich, UK, 2018. Dayv Lowry was a co-author on a talk.

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Committee of Age Reading Experts

2017 Committee Report

and

Executive Summary of the

Nineteenth Biennial Meeting April 4-6, 2017

Prepared for the Fifty-Ninth Annual Meeting of the

Technical Subcommittee of the Canada-USA Groundfish Committee

April 24 – 25, 2018

Prepared by
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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, 2017. This reporting period includes information from the 2014 Committee Report and Executive Summary prepared by outgoing CARE Chair Chris Gburski. CARE Officers through June 30, 2017 (elected at the April 2015 meeting) are:

- Chair – Chris Gburski (AFSC)
- Vice-Chair - Lance Sullivan (NWFSC)
- Secretary – Kevin McNeel (ADF&G)

The 2017 CARE Conference Minutes have been prepared and are waiting CARE member approval. The Chair prepared an executive summary and the Secretary prepared the first draft of the minutes, which were edited and reviewed by the Chair prior to final distribution to the members for review and approval. After the minutes are approved by CARE members, they will be uploaded to the CARE website.

3. CARE Conference

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 2018. 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 (Hippoglossus stenolepis) 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 Pacific 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.

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, University of Washington-Seattle) and lighting conditions (Morgan, Chris, Beth, and Tyler Johnson-NWFSC. There were 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) were discussed. Attendees viewed annotated rougheye rockfish break and burn otoliths on dissecting microscopes at imaging workstations. Samples were provided by the AFSC and ADF&G. 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. Kevin McNeel brought young rougheye otoliths from North Gulf of Alaska with fish length and otolith length, height, and weight. From Harris's measures, the group identified identifiable first annulus with 1-1.5 mm dorsal-ventral width. They also discussed plus growth, clarified potential differences, and discussed differences in processing (i.e. braking or cutting otoliths and using water dishes to clear whole otoliths). Betty Goetz (AFSC) and McNeel suggested the port samplers should collect young rougheye released during adult female sampling to get a better idea on the size of otolith between 0 and 1-year-old. There were 13 participants from AFSC, ADF&G, CDFO, and NWFSC.

Betty Goetz suggested that agencies talk about the research they were involved with rougheye, blackspotted, and shortraker rockfish. Harris and

Charles Hutchinson (AFSC) are involved in research working on blackspotted, rougheye, and shortraker genetically identifies specimens. Lance Sullivan commented that the NWFSC is also going to work on a collection of potential blackspotted and rougheye rockfish. The workshop went back to the Traynor Room to go over shape analysis using shapeR. McNeel walked through an analysis of rougheye, blackspotted, and shortraker rockfish that he ran on previously tested specimens. Harris and Hutchinson commented that rougheye/blackspotted rockfish could impact results and that they had 19 out of 700 rougheye/blackspotted hybrids in their sample. McNeel commented that there was no indication of hybridization within the samples he tested. During the analysis, Joanne Groot (CDFO) commented that readers at CDFO noted two distinct rougheye rockfish otolith patterns and felt that these might be related to rougheye and blackspotted. Harris commented that individuals at AFSC likely couldn't distinguished between the two species based on the shape of the whole otolith without analysis. After McNeel's demonstration, he told the group that the R script would be uploaded to the CARE forum.

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 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 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 sizes 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:

a. **Website:** Jon Short (AFSC) CARE Webmaster 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 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 take time as well. In the previous meeting, other agencies had suggested using ASP.NET 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.NET windows.

b. **Forum:** Nikki Atkins (NWFSC) gave an update on the CARE website forum. Atkins remarked that the forum has users from 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.

   Tom Helser (AFSC) commented that the current Age and Growth Lab's webpage may change. Jon Short elaborated that current information may be combined with other centers to group similar information.

c. **Website Publication Portal:** Kevin McNeel (ADF&G) CARE Secretary 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.

2. **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.

3. **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.

4. **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 the end of 2018);
   3. Update agency production numbers annually (update website with current production numbers by the end of 2018), 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 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 2015/2016/2017

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.

E. In 2017 TSC asked CARE to again review yelloweye rockfish aging.

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 and 2017.

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
16-003	Arrowtooth Flounder	NWFSC-PSMFC	Lance Sullivan	AFSC
16-004	Blue/Deacon Rockfish	ODFW	Lisa Kautzi	SWFSC (Don Pearson)
17-001	Yelloweye Rockfish	CDFO	Barbara Campbell	NWFSC
17-002	Rougheye Rockfish	ADF&G - Juneau	Kevin McNeel	
17-003	Rougheye Rockfish	ADF&G - Juneau	Kevin McNeel	
17-004	Blue/Deacon Rockfish	ODFW	Lisa Kautzi	SWFSC (Don Pearson)
17-005	Yelloweye Rockfish	ADF&G - Juneau	Kevin McNeel	WDFW, NWFSC, and ADF&G- Juneau
17-006	Lingcod	WDFW	Jennifer Topping	ADF&G - Juneau
17-007	Yelloweye Rockfish	NWFSC	Patrick McDonald	WDFW, NWFSC, and ADF&G
17-008	Yelloweye Rockfish	NWFSC	Patrick McDonald	WDFW
17-009	Yelloweye Rockfish	WDFW	Andrew Claiborne	ADF&G
17-010	Pacific Cod	WDFW	Sandy Rosenfield	AFSC
17-011	Petrale Sole	NWFSC	Patrick McDonald	WDFW
17-012	Lingcod	MLML (moss landing)	Laurel Lam	PSMFC
17-013	Pacific Cod		Sandy Rosenfield	AFSC

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)

- **C.** TSC Meeting 2016 (Chris Gburski)
- **D.** Age Structure exchanges (Lance Sullivan)
- **E.** CARE Website and publication database (Jon Short, Kevin McNeel)
- **F.** CARE Forum (Nikki Atkins)
- **G.** CARE Manual (Elisa Russ)
- **H.** Charter Committee (Elisa Russ)
- **I.** 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) add time if needed.
2. Working Groups (Traynor Room and Room 2079)
3. Hands-on microscope work and calibration (Traynor Room)

Wednesday, April 5

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)

Thursday, April 6

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

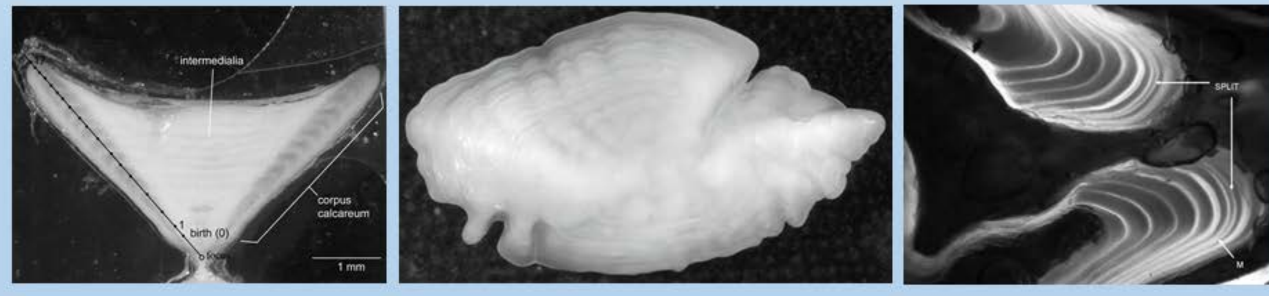
4. Group photo

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 Meeting2017

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.