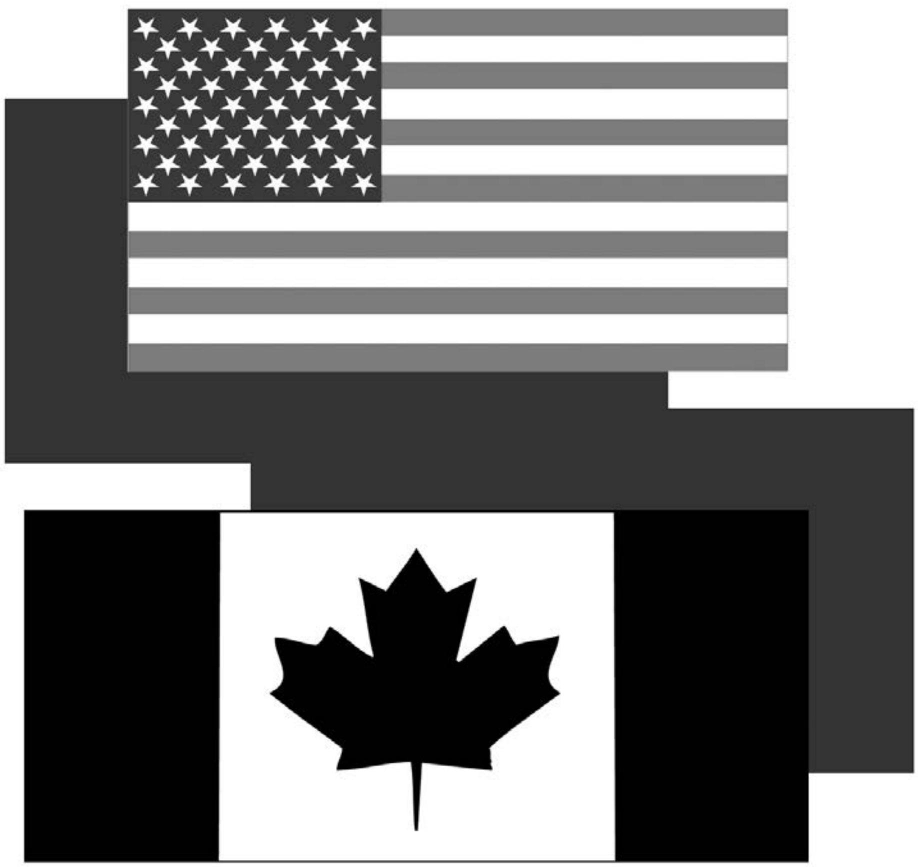
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

60th Annual Meeting of the TSC

April 23 – 24, 2019
Olympia, Washington



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
2019	April 23-24	Olympia, WA	Lowry	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 **DoubleTree Hotel, Olympia, Washington,** April 23-24, 2019.

This year's meeting was hosted by the Washington Department of Fish and Wildlife (list of attendees is included in the minutes). Dayv Lowry, Washington Department of Fish and Wildlife once again chaired the meeting. As is done each year at the meeting, participants reviewed previous year (2018) research achievements and projected current year (2019) 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 consider ageing lingcod otoliths from fish for which spines have also been collected using NI-spec. If results coincide well, this could allow samplers to avoid the need to collected fin spines, which can be problematic in some jurisdictions. The TSC also recommended to CARE that they preserve a record of ageing methods for use as teaching tools. Specifically, a library of video instructions that include microscope footage and detailed verbal methods could be housed on the CARE webpage.

There were several suggestions for TSC workshops at the 2020 Western Groundfish Conference (WGC) in the future, perhaps as part of the 2020 Western Groundfish Conference including review of maturity schedules; ageing tools and concerns; and management of cryptic species as complexes or as separate species.

The TSC noted in its discussions that many of the groundfish populations occurring along the west coast of North America and managed by TSC member agencies may span the entire north Pacific Ocean, including the waters of Russia, Korea, Japan, and others. Therefore the TSC urges member agencies to try to obtain data from these other countries, and suggest that individuals from TSC-member agencies could make contact with individuals from management entities in these countries at the PICES meeting October 16-27, 2019 in Victoria, BC.

The TSC discussed how the long delays among the holding annual meeting, finalizing the meeting minutes, finalizing the combined agency TSC report, and sending summary letter to the groundfish supervisors make the TSC advice and report less relevant. If the finalization of the annual report was more timely, the relevance of the report could serve a broader scientific community and interest to managers. Therefore, the TSC committed members to review the meeting minutes and finalizing their reports within 2 months of the meeting. Additionally, the Chair will be asking for recommendations as to additional regional and management entities that would benefit from the annual TSC Report. In this way the annual TSC Report can be made available to a wider audience in a timelier manner than in previous years.

Dayv Lowry, WDFW, will continue as Chair of the TSC for 2020. The next TSC meeting will be held in British Columbia, either April 14-15 or 21-22, 2020 and hosted by Fisheries and Oceans, Canada.

Meeting Notes

Sixtieth Annual Meeting of the Technical Subcommittee (TSC) of the Canada - U.S. Groundfish Committee
April 23 - 24, 2019
DoubleTree Hotel Olympia
415 Capitol Way N
Olympia, WA 98501
Phone: (360) 570-0555

Host: Dayv Lowry and WDFW
Chair: Dayv Lowry

I. Call to order (8:30 am Tuesday April 23rd)

II. Appointment of Rapporteurs

Bob Pacunski and Lisa Hillier of WDFW

III. Housekeeping

No specific housekeeping items identified

IV. Introductions/List of Attendees

Cara Rodgveller; NMFS AFSC, Auke Bay Lab
Maria Surry, Dana Haggarty, Greg Workman; DFO Canada
Wayne Palsson, Olav Ormseth; NMFS AFSC
Josep Planas, Lara Erikson; IPHC
Dayv Lowry, Bob Pacunski, Lisa Hillier, Corey Niles; WDFW
Andrew Claiborne; WDFW (CARE)
Stephen Phillips; PSMFC
Alison Whitman; ODFW
Traci Larinto; CDFW

Annual reports were submitted by the ADF&G, NMFS NWFSC, and NMFS SWFSC but representatives did not attend the meeting due to scheduling conflicts and budget limitations.

V. Approval of Agenda

Agenda approved as submitted. Will need to ensure we deal with old business prior to recommendations.

VI. Approval of 2018 Report

Final report approved by all attendees. Post to web page.

VII. Agency Overviews

The AFSC has had some staff changes at the Auke Bay Lab – Jon Heifetz retired and Chris Lunsford was promoted to replace him as groundfish program manager. Cara Rodgveller will replace Jon for the ABL-AFSC role on the TSC. Tom Wilderbuer also retired from the AFSC. Olav Ormseth will replace Tom for the REFM-AFSC role on the TSC. There have been few other substantive staffing changes in the past year. NOAA is revamping their entire website for ADA compliance. They are also re-structuring the webpage to enhance their ability to get specific messages out to the public. The page is now organized by major topic, rather than by region, making it easier to find comprehensive details on specific areas of concern, fisheries, etc., although some information remains hard to find.

DFO Pacific groundfish research and assessment section is down to 14 personnel, from 24. Staff reductions are largely due to a reorganization of DFO Pacific Science branch two years ago and unstaffed retirements. There are five staff in the DFO Pacific Region Groundfish Management Unit (GMU) tasked with managing all groundfish fisheries in the region. Despite reductions, Groundfish Science still produces 3-4 stock assessments annually. There have been several recent changes at the section head level, Chris Rooper replaced Robyn Forrest as section head of Quantitative Assessment, Lynne Yamanaka, former TSC co-chair and inshore rockfish assessment program lead and most recently the section head for the Marine Invertebrates section retired in January of this year but has come back to assist with abalone. All Groundfish Fisheries in BC are monitored with at sea observers, EM camera systems, and Fisher log books, fishers pay the full cost of all monitoring activities. The Groundfish Science section leads or participates in 11-12 fishing surveys annually, including trawl, trap, and longline gears. Acoustic-trawl Pacific Hake surveys are conducted in collaboration with NOAA partners.

Recommendation: send Lynne, Jon, and Tom a letter of thanks for their service to the TSC.

At the IPHC, Lara Erikson is now in Jamie Goen's position as manager of the Fisheries Statistics and Services branch. There has been quite a bit of staff shuffling in the past two years as a result of several retirements, promotion, etc. They also have two new programmers/IT staff, which has made possible a massive webpage revamp. Survey data are now interactive and all meeting notes are online within a week. Getting praise from constituents and collaborators alike.

The WDFW has a new Director as of early 2019, who was previously with the WA State Department of Ecology. He is changing the culture of the Department, for the better. There have been no major staffing changes within the Marine Fish Science Unit this year, and approximately 35 staff perform all marine fish research, conservation, and management activities. A substantially redesigned version of the Department's webpage launched a little over a month ago. While the page serves certain constituents very well (e.g., those seeking to buy a license) hundreds of pages have been deactivated until they can be updated to match the new page templates. These include the groundfish identification pages, staff profiles, and other key tools for education, outreach, and collaboration.

The ODFW has approximately 60 staff researching and managing marine fishes and habitats, plus temporary survey staff on a seasonal basis. There have been no substantial structural changes to the organization this year. In 2018 electronic licensing was introduced for recreational anglers. It hasn't rolled out without problems, but it has been largely well received. The department has been revamping their webpage for about 3 yrs and the process is ongoing but they have no internal website staff at the Marine program. Only about a third of links available prior to the remodel are now available.

The CDFW has approximately 140 permanent and 100 seasonal staff to cover marine fish research and management needs and staffing for groundfish program is fairly stable. Most seasonal staff are involved with collection of recreational fishery survey data. July 1, 2019 electronic reporting via E-TIX, PSMFC's electronic fish ticket system, will be mandatory for commercial fisheries – it is currently voluntary. The department has been focusing on pushing more data to the web to increase transparency and stakeholder involvement and to provide data in real-time. They have also been engaged in an extensive task-based budgeting exercise to justify costs and benefits of various activities. There have been some management changes, but nothing terribly substantive with groundfish this year. Groundfish staff support management and stock assessment for the PFMC but don't do much of the survey or modeling work themselves.

For those new to the TSC meeting, Wayne provided a brief overview of what we do. The TSC is an advisory body that shares methods and data on a coast-wide basis to further collaboration. Sixty years ago the TSC was created because U.S. and Canadian vessels were fishing all over the NE Pacific Ocean. With the Magnuson-Stevens Act and Pacific Salmon Treaty the main committee went away, but the technical *sub*-committee kept meeting. Our recommendations, which derive from the annual meeting, are our real power. The letter from the chair to agency "higher ups" includes these recommendations each year. We also host periodic workshops on issues of intense management concern, and coordination in recent years with the organizing committee of the Western Groundfish Conference has allowed for sponsored sessions on similar issues. Cara is on the planning committee for WGC in Juneau next year, so she can carry forward our ideas about session topics this go 'round. Our annual report is a great tool and getting it out sooner would be great for media. Stephen says its minutes driven, so we must commit to getting minutes reviewed and finalized quickly.

Recommendation: work to finish final version of meeting minutes by June. Greg also recommended including an executive summary to the TSC report to "boil things down." Stephen wants to see a research priorities list in the Exec Summary.

VIII. CARE Report

Andrew is the vice-chair of CARE and is presenting here on behalf of this group of state and federal representatives from ageing labs along the entire west coast. Their major goal is to standardize methods and approaches to ageing groundfish (and other species) across management entities, and to share new data and results. Working collaboratively with us on research needs and priorities is critical for CARE because we are the users of the data. Kevin McNeel (ADFG) is chair for 2017-19 but Andrew is here because Kevin couldn't travel. Full details on the CARE meeting are available in their report, but highlights include:

- 10 sample exchanges in 2018 – 1 big skate, 1 longnose skate, 2 canary rockfish, 1 Pacific cod, 4 sablefish, 1 yelloweye. Four so far in 2019. Only 4 outstanding right now, most have been completed.
- The CARE website has been updated substantially. It is now in Word Press. Porting of content is ongoing. It now shows agency production numbers so people can track in "real time" what's being aged, and by whom. The CARE manual is there too, and it's a great tool. The manual was updated substantially and new sections are coming soon. The CARE charter has also been updated and posted.
- Many CARE members met for an international ageing meeting April 9-12, 2019 at the AFSC. Focused on near-infrared spectroscopy aging techniques. NOAA is leading the charge on getting everyone to use this tool, which has the potential for massive efficiencies. The meeting was joined by folks from Korea, Australia, etc. Some issues with software for shifting from consideration of food stuffs to fish otoliths. Method looks sound for medium-lived species, but may be less useful

for long-lived species. Currently gives precision comparable to age readers. Some samples were run at the meeting, from various sources, to show economy of scale and speed of turnover. A tech memo based on this on-site work might be produced.

- 36 people from 7 agencies attended the CARE meeting. Results were shared and some hands-on otolith reading activities were done under a scope.
- Yelloweye exchanges were reviewed. Several exchanges over the last few years, but only one this year. There appears to be substantial bias at some labs once fish are older than 30 years. Details to follow during later presentation.
- There are still issues with storing otoliths in glycerin thymol. Some break down, and it appears to be linked to chemical preparation methods. Some labs (such as the WDFW) are now storing them dry, in envelopes. Some labs (ODFW) are now systematically transferring them out of glycerin.
- CARE has no recommendations for the TSC this year. The 2021 meeting will be in Newport with date and time to be set in 2020.

Recommendation: The TSC should support their next steps, including making video documentation on how to process and age samples in an effort to fight the brain drain of retirements.

IX. Surveys

CDFW – No specific groundfish surveys are being conducted, but they are doing ROV surveys for MPAs. Very collaborative, with government and academic partners. Baseline monitoring of MPAs has been completed, so now it's ongoing monitoring. There is a post-doc working on using ROV data to do spatial monitoring with the intent to incorporate the data into NMFS stock assessment work. A workshop designed to determine how best to incorporate these data has been delayed from February to the fall, or even the spring 2020. ODFW is doing similar work on incorporating MPAs into stock assessments.

ODFW –Several large-scale recreational fishery sampling surveys are being conducted in addition to fish sampling from anglers. Systematic dockside creel data has been collected since 2001, with all major ports sampled since 2003. Researchers are also conducting ride-alongs on commercial vessels to get encounter and capture rates for groundfish. Carla Sowell retired as the lead of commercial monitoring and Cameron Sharpe is now in charge. The research arm of MRP is also working on a coastwide hydroacoustics survey for midwater rockfish (details below).

WDFW – Recreational fisheries monitoring is done by the Puget Sound Sampling Unit and includes creel and phone surveys. Scientific surveys include the Puget Sound bottom trawl, which has been systematic since 2009. The majority of this catch has been flatfish and ratfish. Bocaccio were first encountered in 2018 inside the DPS. Pacific cod have been rare for several years but recent data show continued declines in abundance. There was an increase in sandpaper skates from 8-14 individuals, but this is insignificant. Few rockfish are typically encountered in most years but 2018 showed increased catches of Copper, Quillback, and Yellowtail rockfish. Several extra stations were sampled in Hood Canal in 2018 to evaluate representativeness of current index stations. Results indicated current stations are reasonable for this sub-basin.

Herring rake surveys are continuing, as they have for 35 years, and a couple of new spawning locations were reported. There has been zero spawning for some stocks for the last several years. Genetic work is ongoing to look at possible changes in spatial distribution. Efforts were also made, and are ongoing, to test some of the assumptions used to estimate spawner abundance (e.g., spawnable vegetated area, sex ratio in schools).

Outer coast rockfish rod/reel surveys also target lingcod and cabezon. This work has been ongoing for the past several years. Black rockfish are typically encountered midwater, Copper, China, and Quillback are captured closer to the bottom.

Monitoring at Navy bases, which have been included in the last several reports, is now complete. However, the WDFW has been asked to submit a proposal to sample the Bremerton drydocks. Work continues on a historical reconstruction of Puget Sound groundfish removals; current documentation is now several hundred pages long.

IPHC – The annual coast-wide longline survey occurred again this year, as scheduled. Only a small proportion (3%) of fished sites had to be excluded from use in the stock assessment as a result of whale depredation, etc. Several collaborative projects were incorporated into the survey, leveraging the platform to obtain various occurrence data and biosamples. Many vessels have transitioned to snap gear and a study will be conducted this year to compare snap vs. fixed gear. If results are good this could open up a new suite of vessels to bid on the survey.

All survey data are now available in an interactive, queryable map view on the IPHC website. This includes information on all encountered species, not just halibut, and is a great data visualization tool. AFSC – Pollock and Pacific cod have been moving/missing for the last several years in the trawl surveys conducted in the Eastern Bering Sea Shelf (EBS) and Gulf of Alaska. The northern Bering Sea (NBS) was completely sampled in 2010 and again in 2017 and showed shocking increase in cod and pollock in recent surveys. Only half of the NBS was sampled in 2018, also continued abundance of cod and pollock in the the NBS but lower abundance in the annually sampled EBS. Sea surface temperatures are trending higher; last 2 years with almost a complete lack of sea ice in the EBS. Cod are shifting from the edge of the shelf to the NBS with a similar pattern for pollock. This signal is also present in hydroacoustic surveys. There is considerable concern among native populations that fisheries developed in traditional cod and pollock ranges may shift to areas in the NBS where subsistence fishing occurs. NOAA is engaging more with native communities due to climate change in the high latitudes. Pollock are doing well in Shelikof Strait, and a winter survey near Bogoslov Island indicated a strong increase in pollock density. Note that Anne Hollowed is heading up an effort to stitch together coast-wide survey data and do selectivity evaluations on various assessment methods. Considerable work is still needed. There is a recently published paper on the “blob” using NOAA trawl data and second paper is in press. NOAA is trying to develop and oceanographic/productivity model for the entire west coast.

Recommendation: having comparable occurrence, density, and abundance data along the coast would allow for a comprehensive analysis of groundfish populations for the NE Pacific. This could then be put in a regional ocean modeling system (ROMS) framework to truly get at ecosystem management. We should promote such an effort, to include direct sampling method calibrations/comparisons.

An ICES workshop focused on unavoidable reductions in survey effort was scheduled for February but was delayed due to the government shutdown. It is now scheduled for February of 2020. Loss of support for surveys is a big issue we are all facing and understanding how sampling changes affect long-term data series, models, and assessments will be key to future management.

Fishery monitoring and analysis rooted in the use of on-board observers is ongoing. In recent years reliance on electronic monitoring has increased in Alaska. In 2018, a new multi-spectrum camera was used to identify Blackspotted and Rougheye rockfish. It works 91% of the time, making it more accurate than observer species differentiation.

The Auke Bay Lab conducted their typical longline survey this year and tagged thousands of Sablefish, Shortspine Thornyhead, rockfish, and some dogfish. Whale depredation is a continuing issue that requires novel methods to account for. Cindy Tribuzio did some Dogfish tagging with pop-off archival tags. An ADF&G employee, Kevin McNeel, is investigating Yelloweye Rockfish spawning frequency by using laser ablation of operculae (which store signals of hormone cycles). Their pelagic trawl survey does some midwater tows for age-0 pollock. In 2018, they observed warm water and few large copepods.

DFO - For trawl survey purposes, the B.C. coast is divided into four regions, two of which are surveyed each year. In 2018 the west coasts of Vancouver Island (WCVI) and Haida Gwaii (WCHG) were surveyed. There were also two longline surveys, one which focused on the south half of the outside waters of the BC coast and one that focused on the southern half of the Strait of Georgia. DFO conducts annual sablefish trap surveys of entire BC coast using pot gear, one advantage of using pot gear for surveys is that they do not have whale depredation issues. All fishing surveys share in common a random, depth-stratified design intended to cover all habitats coastwide available to a particular gear type, and all species. In 2018 dogfish, which have been conspicuously missing the last four years, were back off the WCVI, Bocaccio were also more plentiful than in previous years, though small. Three years ago there were reports of a major rockfish recruitment event, juvenile yellowtail, bocaccio, black and other rockfish species were reported in large numbers coastwide, we are now seeing the results in our surveys with increased survey indices for several rockfish species. Juvenile Sablefish were abundant in all surveys and are becoming a pinch point species for trawlers. Petrale Sole has also been increasing in abundance for roughly a decade. In aggregate WCVI biomass indices for most species have been trending up for several years. The WCHG is still a very fishy area with high abundance of Pacific Ocean Perch, shortspine thornyhead, redstripe rockfish, and yellowmouth rockfish. The southern half of the WCHG is untrawlable.

The inside waters longline survey was reduced in scope due to the lack of skipper for the research vessel, a portion of the survey are was completed. The northern portion of 2018 survey will be conducted in 2019. Dogfish and Lingcod indices were up in the inside waters, but rockfish were down. The Outside waters longline survey showed increasing indices for Yelloweye rockfish stocks in the northern portion of the WCVI. Inside and outside longline survey surveys both incorporate a hook competition model in generating their biomass indices to account for Dogfish competition (and other species).

All commercial fishing vessels are monitored, either by on-board observers or with cameras. On-board biosampling and some port sampling are conducted by a third party. Reporting of First Nations catch is very sparse. First Nations can fish a single trip, offload some as “Food, Social, and Ceremonial” (FSC),” and then sell the rest. This complicates reporting and record keeping immensely. There is a major trust building reconciliation effort going on right now in Canadian government, and it will directly affect fisheries. Hope is that new, better data will be available in the future.

ADFG, NWFSC, SWFSC – see reports for this, and all other, agenda items. Corey noted that NWFSC bottom trawl survey data was discussed last week at the Pacific Fishery Management Council. They are going from four to two contracted trawl vessels next year, which will affect data availability for assessments.

The broad issue arose of being unable to sample some areas that have been closed for conservation purposes (i.e., reserves and MPAs). Upper management, permit authorizers, and co-managers need to understand the importance of having data from these areas to: 1) evaluate their efficacy; 2) assess the abundance of fish protected within these areas; and 3) allow models to be adjusted to account for the biomass no longer available to fisheries. Visual surveys can fill some needs, but biodata from otoliths, gonads, and other structures need to be obtained at some level.

Recommendation: formulate a statement to those who authorize permits, and others managers, to highlight the need for sampling inside closed areas.

X. Reserves

AFSC – nothing to report. Stellar Sea Lion closures are still in effect and monitoring of some groundfish species has been done within them. In 2018 there was EIS work associated with the closures. Work is ongoing on a large-scale essential fish habitat review, but it is not a reserve.

DFO – work continues toward achieving the Aichi Targets for reserve coverage. New protected areas have been created and there are extensive plans for other areas. In 2018 a draft MPA network plan for the Northern Shelf Bioregion was drafted and new protected areas in southern Haida Gwaii (Gwaii Hannas National Marine Conservation Area) were established. The goal is to have protection for 10% of all marine waters by 2020, but the distribution of these reserves the Pacific, Atlantic, and Arctic Oceans is uneven. Some of the currently identified closure areas are in Dixon Entrance between B.C. and AK where the international border is “a bit gray.” The potential closure of a large area off North Vancouver Island (northern shelf bioregion) could impact up to 20% of DFO survey locations. Dana Haggarty noted the need for research in regards to closed areas, such as survey-type calibrations (e.g., hook-and-line vs. visual) and sedimentation studies.

WDFW - A tech memo was published last year on the long-term study of MPAs in Puget Sound. Obvious signals of rockfish recruitment was noted in several of the survey years. Some data showed evidence of increased rockfish and Lingcod sizes in some reserves but the data was not overwhelming. WDFW is evaluating the advantages of restarting monitoring studies after nearly a decade lapse.

ODFW – Reserves have been in place for about a decade and they have specific monitoring plans. ive, drop camera, and ROV surveys continue to cover their bases, but each site is not sampled annually. Juvenile fish are sampled via SMRFs. Ocean acidification and seastar wasting disease work continues. Additional research projects that are being done within the reserves include looking at microplastics, growth and reproduction of Canary Rockfish, invertebrate biodiversity with ROVs, and Dungeness Crab movement associated with environmental cues. A project evaluating how humans are impacted by reserves is also being done. This study evaluates how fishing effort has shifted in response to reserves and includes a coastal resident “life satisfaction” survey. In 18 months they will be doing a programmatic reserve evaluation. This year, reserve data has been incorporated into the stock assessments for cabezon. The reserves webpage is maintained by an outside contractor and has data, outreach materials, etc.
The recreational fishing regulations app also incorporates details on MPAs to help anglers identify and avoid them. The app isn’t updated regularly enough to be “the definitive view” on regulations, but it largely works. ODFW allows anglers to enter caught fish into their app, which links to their license. WDFW and CDFW do not have this, but are trying to move toward it.

CDFW – Baseline monitoring of reserves was completed last year, and they are now on to long-term monitoring. (2016 was first year of long-term monitoring for early reserves). The Department has an action plan that was released for state-wide MPAs.

A brief discussion was had about eDNA and how it can or cannot be used. While the technique may have promise in marine environments, there is still concern about cell shedding rate, DNA residual residence time, and other factors that affect detectability rates.

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

A. Hagfish

CDFW – The fishery still going. Landings have been up a bit at 976 mt. Product is primarily sold to South Korea for eating. They are still taking samples at the dock and there does not appear to be any big changes in size, species composition, etc. There has been a slight change in how barrel-traps were designed and authorized.

ODFW – The commercial fishery is ongoing, with a 1.6 M lb harvest guideline. 91% was taken in 2018. Slight uptick in the fishery. Managers tried some stock assessment methods (delta GLM) but they were not terribly successful, so this fishery is managed under existing harvest limits.
WDFW – 230 mt (510,000 lb) caught in 2018. Reported landing were at the lowest in 10 years. The fishery is ongoing.

DFO – An experimental fishery was permitted some years ago, but the proponent didn't comply with the data collection protocol, consequently the permit was not renewed.

ADFG/AFSC – The state is working on gathering data. A small, directed fishery was allowed in the southeast within state waters only. Contact Aaron Baldwin for more information

B. Dogfish and other sharks

AFSC – Cindy Tribuzio has tagged 186 dogfish with satellite tags since 2009. Data shows they migrate long distances and don't always stay close to the coast. There is a paper pending for this study. She also tagged 6 dogfish with acoustic and satellite tags to ground truth satellite tag data. Publication pending. There is work being done on sleeper shark genetics and tagging. Samples from 200 sharks have been collected so far, with evidence that there are two groups that co-occur that might have been separated in the past. Work is being done on ageing sleeper shark eye lenses, similar to the study recently done for Greenland sharks. Shark stock assessment is complex because species differ in life history and behavior, but are assessed as a group. Work is being done to improve this by collecting enough data to separate species out in the assessments.

DFO – There is nothing new to report. The most recent assessments are a bit out of date – the last one was done in 2010. They are caught by almost all fisheries but nobody really targets them anymore; 0% of the total allowable catch taken in 2018. COSEWIC will re-review the status Tope Sharks soon. Status should stay as Special Concern. A directed Dogfish survey in the Strait of Georgia is coming up this year. Options for collaboration with the WDFW exist, and will be pursued.

WDFW – The Lummi Nation dogfish fishery in northern Puget Sound did not occur this year due to a lack of interest and markets. The shark books co-edited by Dayv in 2017 are being widely distributed and cited. A third book on sharks of Pacific Mexico is currently being written and will be released in 2019.
ODFW and CDFW – No directed research or management to report.

C. Skates

AFSC – Chris Rooper et al. published a paper on skate nursery ground modeling. A graduate student (Dan Michwrowski) at UAF Juneau is looking at discard mortality rates for skates. The NPFMC currently assumes 100% discard mortality, so may be able to improve management a bit based on results. Note that

DFO uses a DMR for skates – it is admittedly inexact, but it is better than a blanket assumption. Skates are assessed biennially in both the Bering and Gulf of Alaska, to coincide with data availability from surveys. Having data from the Bering Sea slope is critical, more diversity of skates here, but the last survey here was in 2014. Most of the skate biomass in Alaska is from Alaska skate, though, and they are everywhere. Assessment is focused on Alaska skate with other species (12 spp.) "factored in." One quota for the whole complex. Species identification in longline surveys is poor due to drop-off prior to handling. Big skate appear to be moving from SE Alaska into the Bering. They don't appear to be reproducing, but are feeding up there at least. Longnose skate ageing and life history work being done by a graduate student. Note that skate liver oil might become a sought after fishery product – it is on the east coast.

IPHC – Note: the new web tool includes bycatch data too, so there is a lot of skate data.

DFO – Nothing new to report. Assessments are 5 yrs old now for longnose and big. There will be an updated assessment in the not too distant future but they are not a major conservation or fishery concern at this time.

WDFW, ODFW, and CDFW – supporting NPFMC and PFMC work, but no directed research in state waters. Catch reconstruction has been difficult, but they have made progress. CDFW only allows whole fish landings, not dressed, so they are getting better data now (this began in 2009). In Oregon, people don't wing skates and the market is so sporadic that skates are usually discarded.

D. Pacific Cod

CDFW, ODFW, WDFW – No directed research or management to report.

DFO – A full assessment was done in 2018, and new data were collected. The assessment includes new harvest advice: TAC is 1,450 tonnes overall. There are four stocks in B.C. waters and catch recommendations went down for all of them. Normally they are assessed separately, but Queen Charlotte and Hecate Strait stocks were combined this time. Cod are rare in the Strait of Georgia. All stocks are in the cautious zone and need active management to promote rebuilding. Low-level fisheries will continue; fisheries are a tenth of what they once were. It is essentially a bycatch fishery now, and ships catch them when fishing for Flatfish and Pacific Ocean perch.

AFSC – Pacific cod in the Gulf of Alaska have been disappearing for several years and biomass has dropped at least 75% since 2017. The blob is thought to be the cause. There is a cod working group now at the AFSC and they are tagging, etc. in 2019. Lots of money and attention are being focused on research and fishery concerns. Dan Cooper et al. have been looking for cod juveniles in the Chukchi Sea and found them at 11 of 59 stations. This indicates fish are moving north out of the current range of the fishery. Pacific Cod aren't the only fish redistributing, there is a lot of concern about codfishes in general moving north. Cod work funded by Sea Grant is looking at juveniles in other areas down the west coast (Hauser et al. and work from Auke Bay). At Auke Bay there are lab studies on temp tolerance, growth rates, etc. to see how cod perform in marine heat wave (aka Blob) conditions. Alan Hayne et al. are working on economic impacts of fish moving north and the fleet having to spend more to pursue them. There are also satellite tagging projects, larval and juvenile abundance estimation work, etc. Details are provided in the report.

In 2018 Pacific Cod assessments were conducted for both the Bering Sea and Gulf of Alaska. Lots of iterations, review, and revamping over the last several decades, so the models are sound (though their strength under marine heat wave conditions is questionable). The Bering and the Aleutian Islands have now been split. Cod in western AI are noticeably larger. Biomass is down a bit, but not that much, and big fish are well represented. Changes in the survey have affected the integrity of data used in the assessment in several ways, and staff are working out how best to address this. Cod movement in BS is causing problems with the assessments because they are not consistent and it was decided to lump the EBS survey dataset with the NBS data set assuming that fish in both areas are the same stock (which they seem to be with a few caveats). Not sampling the northern Bering is a big deal – how long have fish been going up there? Ingrid Spies did genetics to show the Bering and N Bering fish are the same stock.

The Gulf of Alaska is a different story – Pacific Cod are doing very poorly in response to the heat wave. There were big 2012 and 2013 year classes, but they all died because of ecological and physiological effects of the warm water. There was no survey in 2018, but longline data are available. These data suggest that biomass declines were not as bad as anticipated in 2018. As a result of the Gulf of Alaska cod issues there is now a decision matrix being used by the NPMFC to reduce ABC below maxABC, when appropriate. It's about being risk averse and at least semi-quantitative.

E. Walleye Pollock

CDFW, ODFW, WDFW, IPHC – no directed research or management to report.

DFO – Data on trawl surveys only, otherwise nothing to report this year. A full assessment was done in 2017 for both the north and south stocks. Report is available on the web.

AFSC – In 2018 there were several projects relating environmental parameters to recruitment success/failure. There was also work examining the energy content of juvenile pollock relative to copepods and such in the diet. In warm years the age-0 pollock predict age-1 recruitment well. In cold years, there is more variation in growth rate and diet due to food availability, and thus the relationship is weaker. Staff also did research looking at the depth distribution of age-0 pollock and how it relates to water temperature. In theory, they should shift deeper in warm years to stay in cold water, but they don't. There was also some economic work performed to assess how to adapt fisheries implementation to climate change. There will be monetary loses, but how severe will depend on our adaptability. Protein noodles are a new product that utilizes pollock, but it's too soon to say just how much of a market share they will eventually take from traditional noodles. NOAA economists have also been looking at size-based targeting (filets vs. surimi).

In 2018, assessments were done for both the Bering Sea and the Gulf of Alaska. There are three stocks in Bering: Eastern Bering Sea (EBS), Aleutian Islands, and Bogoslof Island. Only the EBS really gets fished hard. Assessment shows that the EBS stock has been very strong for several years. It was down at bit in 2018, but not to a degree that causes any concern. The Bering Sea ABC for all groundfish species in aggregate is capped at 2M tons, and there are often 3M+ tons of pollock. TSC members asked if this cap makes sense, given the available biomass, and it was explained that a hard cap rather than a limit sensitive to fluctuating biomass was established years ago as a conservative and stable approach. Wayne noted that bycatch of Pacific Ocean perch has increasing in both the Gulf of Alaska and Aleutian Islands. The Gulf of Alaska pollock fishery is much smaller, and the assessment shows the stock is not in good shape. The 2012 year class is carrying the fishery, but is starting to decrease in proportional abundance due to both the fishery and natural mortality. Another strong year class isn't present in the data yet to carry the fishery. In 2017 and 2018 they had contradictory survey information (trawl vs. longline) and split the difference on the assessment.

F. Pacific Whiting (Hake)

CDFW, ODFW, WDFW, IPHC, AFSC – no directed research or management to report.

DFO – An assessment was done this year, but not a survey. There are two stocks in B.C. waters, one in the Strait of Georgia and one offshore (managed with US). The inside stock hasn't been assessed in 20 yrs but a request has been made to do this. Largest cohorts in the outside stock were age 8 and 4 (2010 and 2014). 2016 fish were also plentiful. TAC for 2018 is same as 2017: 597,500 mt coast-wide, with Canada getting 27%. Hake break into stocks pretty readily, based on life history, genetics, etc. There is interest in a coast-wide assessment of this. There were joint venture fisheries in 2017 and 2018, but prior to 2017 the last one was in 2011. May be one in 2019.

Acoustic target strength studies were done this year for hake and other species, but nothing detailed here. Did some sail drone acoustic work for the outer coast this year. The drones have two frequencies, while ships have five. Data collected were clean and could be used, however, so these might help to supplement future ship-based surveys. Still need to catch fish to get biodata, though, so drones don't fill the whole need.

G. Grenadiers

DFO – Episodic interest, but nothing serious that has developed into a fishery.

IHPC – Catch grenadier now and then, and all bycatch data is now available on the webpage in the mapping tool.

AFSC – Cara does unofficial assessment every 4 yrs. Nothing this year. The biomass of grenadiers in Alaska is huge. They catch as many grenadiers as bycatch as they do sablefish, in a directed fishery. Not of resale interest though, so they get ignored.

WDFW, ODFW, CDFW – no directed research or management to report.

H. Rockfish – nearshore, shelf, and slope

CDFW – No directed studies to report, but rockfish are included in catch monitoring, carcass recovery from recreational boats, etc. They have also been getting carcasses from commercial sources to compare biodata. Several species are no longer overfished so opportunity is opening up on all fronts. For nearshore fishery permits, fishers used to have to buy two permits, retire one, then fish. It is now down to 1-to-1, which is promoting new participants to get into the fishery.

ODFW – Three notable studies on Deacon Rockfish: 1) Investigated depth-associated variation in age, growth, and maturity. Fish in offshore schools are bigger, older, and males grow faster. Models have been run with various growth parameters from different population segments. All were within initial range of uncertainty for the stock assessment, so there is no need to assess independently; 2) Compared inshore and offshore otolith shape and genetics, which differ statistically, if not in a biologically meaningful way; and 3) Investigated habitat use and activity patterns in the nearshore using acoustic tags. Note this was one of Polly Rankin's last projects. Also observed a hypoxic event, opportunistically, in which fish moved around more. Generally found high site fidelity, as well as clear diurnal behavior that lessened in winter.

Now looking at ageing error in Black Rockfish in preparation for a full assessment. Also working on getting video lander data into VAST to model yelloweye habitat. Working on post-release mortality of yelloweye after venting by commercial harvesters. The live fish fishery is still going, and focuses mostly on rockfish. Now that overfished stocks have recovered, there is a mid-water trawl fishery for rockfish again. Black Rockfish have become a constraining species. In 2018 there were several mid-season changes to keep things going. 109K angler trips reported in 2018 - highest on record. They have been promoting long-leader fishery to push fleet offshore (to avoid yelloweye). Descenders have been required since 2017. Monitoring usage rates and handing out free devices. Usage rates are in the mid-90s, but these are angler-reported so may need to be taken with a grain of salt.

WDFW – Staff are continuing to develop an index of abundance for yelloweye on the coast, and are now working with Jason Cope to figure out the best index for a stock assessment. There are also hook and line (mentioned in Surveys above) and longline surveys on the coast that provide biodata and contribute information to stock assessments. In the Salish Sea considerable ROV work was done in 2018, including surveys in the San Juans, Canadian Gulf Islands, and Canadian RCAs throughout the inside waters. Data from these surveys will go straight into recovery planning efforts for ESA-listed rockfish. An ESA rockfish recovery plan was finished in late 2017, with a spinoff Kelp Recovery plan. The WDFW has required descending devices to be onboard, rigged, and ready for use since 2017 and continues to work on education and outreach. The newest marketing tool is Li'l Sucker drinkware stabilizers with a message about descending device use printed on them.

Corey stated that the yelloweye index work is still "not quite there," but it's getting close. Projections, with new data, are that recovery for yelloweye will occur by 2024! Note that Pacific Ocean Perch were the original overfished stock on the West Coast, but new assessments say it was never overfished. New model interpretations are largely due to differences in steepness and other parameters that we have a better understanding of now.

DFO – Yelloweye are a pinch-point species constraining other fisheries, especially halibut and require a rebuilding plan as they are in the "critical" zone. Separate studies being conducted for inside and outside yelloweye stocks to model management strategies. They conducted an ROV survey on CCGS Vector in collaboration with WDFW and NWFSC. A passive acoustic monitoring project is also being done because many rockfish make noise and researchers want to know if ship noise is impacting fish populations in protected areas, where it may mask mating calls. Modelling of the community structure on Bowie Seamount aboard R/V Nautilus is being done with the ROV dives being streamed worldwide. Modelling for Yelloweye and Quillback rockfish habitats is also being done.

Descending devices are required as of April 2019. During 2018 Yelloweye retention was prohibited on outside populations but allowed for the inside stock, this has since been amended to prohibit retention of either stock. Both stocks are being reassessed by COSEWIC this November (2019).

Several stock assessments for shelf and slope rockfish were completed in 2018. See the agency report for details. The most recent assessment, for Redstripe, shows they are doing well.

AFSC – Christina Conrath has been working on rockfish habitat use under an NPRB project that just concluded. The team used stereocams to estimate fish density and found no seasonal differences, but habitat-specific and regional differences. High relief and biotically complex is prime real estate.

Recent work with fecundity and maturity schedule of Shortraker, Rougheye, Blackspotted, Dusky, and Northern rockfish showed presence of skip spawning and incomplete fertilization was observed.

Multiple rockfish assessments completed this year – see report for fine details. Pacific Ocean perch are increasing in the Aleutian Islands, but it was not an assessment year in the Gulf of Alaska. Dusky in the

Gulf of Alaska do not have a high ABC, but are not subject to overfishing. It was an off year in both the Bering Sea and Aleutian Islands for Northern rockfish. The exploitation rate is pretty low, so no concerns. Bering Sea/Aleutian Islands Shortraker are a low tier species and exploitation is well below ABC. The stock structure of the Bering Sea/Aleutian Islands blackspotted/rougheye complex poses problems with apportionment and there is some concern about local depletion. Gulf of Alaska "other rockfish" stock includes 25 species, all different tiers, and is a "super pain" to assess.

I. Thornyheads

AFSC – Cara is going to catch Shortspine Thornyhead and bring them into the lab to monitor survival. They have been tagging since 1992 but never evaluated the effects of capture. Working with OSU on this. The annual assessment puts them in Tier 5 (reliable estimates of biomass and natural mortality). Data from the longline survey was incorporated for the first time in 2018, in addition to the trawl survey biomass estimates.

DFO – Nothing new to report in 2018. Last assessed in 2017 (published in 2018). Longspine thornyhead (LST) are two years past due for COSEWIC assessment, so are likely to be assessed in 2019. The fishery for LST took off in the 90s and went about 10 years before the CPUE showed declines, quota was reduced, and fuel price went up. The fishery became unprofitable and markets failed. Industry reports there are still plenty of Thornyhead out there but there is no incentive to fish them.

Shortspine Thornyhead are still harvested along with Pacific Ocean Perch, Blackspotted/Rougheye rockfish complex, etc. Dana noted that there were lots of thornyhead on the seamounts they did ROV work on. There were especially prevalent at Bowie Seamount and one or two other locations. Plan is to go back to a few of these locations again in 2019. Found Longspine Thornyhead down to 2000m or so and then they petered out. DFO Fisheries is doing some habitat modeling, but no details provided in the report.

CDFW, ODFW, WDFW, IPHC – no directed research or management to report

J. Sablefish

CDFW, ODFW, and WDFW – Contributing to coming assessment for west coast, but no directed research of management to report.

IPHC – Setline survey catch is online, as with all other species. Logbook data on sablefish is collected for the Auke Bay Lab. Added some additional columns to the log in 2017 for the US, and are now using them in Canada too. New questions are about marine mammal presence, marine mammal numbers, and whether damage was noted to gear.

DFO – Brendan Connors is now the lead on Sablefish. In 2018 there was a large-scale compilation of data for assessment, as well as the normal survey. A full assessment and accompanying management strategy evaluation was completed. Over the last 4-5 years a harvest floor was added, the quota was raised, and the fishers have self-imposed a maximum harvest rate. The model was updated in 2017 but management practices were reviewed in 2018. Most of the fleet fishes with pots, when they target Sablefish, but use longline when fishing halibut on the same trip. Pots are very clean, and don't have whale depredation issues, so are the preferred method. Fleet mostly fish the deep slope off the west of Vancouver Island and Haida Gwaii. Juveniles have been plentiful and occur as bycatch in all other fisheries. Working on a tagging data compilation study with AFSC and Auke Bay to look at movement patterns.

AFSC – The current tagging program releases about 2,000 fish annually during the longline survey but 3,600 were released in 2018. These are reward tags used to obtain movement data, but are not part of a mark-recapture study. The longest a tag was at liberty and recovered this year was 40 years and the longest distance was 2000 miles. They have been placing pop-up archival tags on juvenile fish each year; 3-5 individuals age-2 or age-3. Development of an interactive website that allows people access to tag data is ongoing. This page will go public soon. Many fish are tagged during the survey, including 14 satellite tagged Sablefish this year.

Work is being done on diet in St. John the Baptist Bay for age-0 fish. A 10-day cruise around Kodiak this year found no small Sablefish. Usually this is the only place they are found. Effort is being made to use maturity data from the summer longline survey, but data show that it is best evaluated late in the season and only data from late August should be used. Age, length, and body condition need to be considered rather than just looking at the gonad because macroscopic determinations of maturity are not always accurate.

Stock assessment for Sablefish is done annually. There was a huge 2014 year class, so small fish are swamping the fishery – full retention is required. Quotas are not increasing because they don't want to exploit small fish before they have a chance to grow to the market-preferred size. In 2017, within the population model, recruitment was set at the previous highest recruitment, because there is concern that the the 2014 estimate could drop in the future. In 2018, the Council rolled over the same numbers (1% increase for whale depredation). A study evaluating discard mortality rates is being considered because so many small fish are now being caught in the fishery and are not as valuable. Signs indicate that the 2016 year class may also be very large. Work is being done on a coast-wide Sablefish project funded through an NSF grant. A doctoral student, post doc, etc. are working on a "coast wide operating model" for Sablefish. There are many subgroups working on growth, maturity, movement, etc. of Sablefish.

K. Lingcod

AFSC and IPHC – no directed research or management to report

DFO – Researchers have started collecting length, weight, sex, and fin spines (for ageing) on IPHC survey, as well as on the inside and outside longline surveys, in 2018, and intend to collect these samples again this year. The assessment was initially scheduled for 2019 but it is being delayed to allow fins to be read. The outside stock seems to be trending down and catches have been lower for the last few years. There is a large recreational fishery, with no size limit on northern fisheries. The southern region has a 65-cm size limit and harvest concerns (e.g., declining CPUE) are mostly there, where the effort is highest.

WDFW – This year saw the beginning of the first ever effort to conduct a full stock assessment (SS3) for Lingcod inside Puget Sound. Fishery and survey data were compiled, historical management actions reviewed, and an initial model built. Final results are anticipated later this year in preparation for the recreational rule change proposal cycle in late 2019. The request for the stock assessment came from recreational anglers, who have been seeing declining CPUE at several locations in central and southern Puget Sound for the last few years. The fishery is only 6 weeks long, the bag limit is one fish daily, and anglers cannot fish below 120 ft deep, but a substantial increase in effort since 2010 means that CPUE drops off quickly early in the season. A pre- and post-season test fishery to look at CPUE, size distribution, sex ratio, etc. will occur in 2019.

Staff are also contributing to the coast-wise assessment for Lingcod in federal waters.

ODFW – Lingcod are very popular on both the commercial and recreational side of the fisheries. With relaxed regulations on yelloweye and other historically overfished stocks retention may go up soon, as bycatch concerns lessen. They are also contributing to the coast-wide assessment of Lingcod in federal waters.

CDFW – Carcasses are being recovered from both the recreational and commercial fisheries for age and other life history parameters. Staff can't take spines from commercially caught fish because it "compromises the quality of the fish," according to the buyers. DFO noted that in BC they modified the method to remove the spine, using a very shallow cut, and didn't disrupt the buyers. A question was raised regarding whether near-infrared spectrometry might be able to be applied to otoliths to age Lingcod, eliminating the need to collect spines, but it sounds like it's still early to discuss using this as ageing method. Dayv volunteered to follow up with Andrew and other CARE members on this.

L. Atka Mackerel

AFSC – Susanne McDermott just finished 5-yr NPRB project on sea lion prey in the western Aleutians. The main focus was on Atka Mackerel, which are a key prey for ESA-listed Steller Sea Lions. There are trawl exclusion zones, and the TAC is controlled to prevent overutilization and competition with ecosystem needs. Tagging and recovery work occurred in four regions within the Aleutians and determined that 1M metric tonnes of Atka Mackerel are available in the whole of the area. Exploitation rates are location specific, and range from 10% down to 1% (in the far west). Density and abundance between the fished and unfished zones didn't differ. Also looked at maturity data, growth, etc. and details are available in the full report. They have been using a towed stereo camera to look at fine-scale distribution of fish with associated habitat data. They are also looking at Pacific Cod, some rockfish, etc.

Gulf of Alaska Atka Mackerel stock is small, data quality is low, and few details are available about population status. The western Aleutian Islands stock has been declining in recent years. There is an issue here with catchability though, because fish spend some time up in the water column and in untrawlable habitats. As a result, the trawl survey gives a highly variable index of abundance. Only a few catcher-processor boats (4-5) fish them, but there is good money to be had. Additional details are available in the report.

CDFW, ODFW, WDFW, IPHC, DFO – no directed research or management to report

M. Flatfish

AFSC – Recently completed several tagging studies. Turbot prefer the cold pool and have shifted north a bit to stay in waters of their preferred temperature range. Males tend to chase females up and down the slope but the females only make one rise up the slope – presumably for spawning.

A catchability study was started in 2017, and continued in 2018, on Northern and Southern Rock Sole, and other flatfish species. The big question is whether fish in the path of the net actually get caught. Auxiliary catch nets have been added to the trawls above and below the head and foot ropes, respectively. Southern Rock Sole escaped 30% of the time and northern 60% of the time. Assessments will have to start taking this variable catchability into account. Using a catchability of one is not accurate.

Full assessments are done for many flatfish species in Alaska, see the details in the report. In the Bering Sea and Gulf of Alaska flatfish are one of the big groups exploited. Yellowfin Sole is a large fishery. Fish are more active when it's warmer, so there is a temperature-dependent catchability included in Bering Sea assessment. The stock is currently in fine shape, partially due to a 2M metric tonne annual cap on aggregate groundfish harvest. Greenland Turbot is down a bit, as is Yellowfin Sole, but Bering slope survey data is needed to really assess population status and the last survey was done in 2014. Arrowtooth Flounder is assessed and fished. The stock is increasing dramatically but nobody really wants to fish them too hard. Kamchatka Flounder used to be in a complex with Arrowtooth Flounder until 2011, but they are now broken out. They are doing well. Rock Sole is also doing well. Alaska Plaice is only in the Bering Sea, but Rex Sole is big in the Gulf of Alaska. Both are stable and relatively lightly exploited. There are "other flatfish" complexes in each area, which are based on depth and co-occurrence in the catch. Light exploitation and limited data available, but seem to be doing well.

DFO – Not much to report. No current flatfish research. Assessments are getting stale. Last one was Arrowtooth Flounder in 2016 (pub 2017). Found that ATF are impervious to harvest, due to size selectivity of gear. Seems unlikely, but CPUE and biomass haven't changed appreciably as a result of harvest. Still working on maturity schedule for Arrowtooth Flounder. Have a 10k tonne TAC on coastwide basis. Most flatfish are lightly exploited (leave 70% of TAC in the water). All stocks are healthy. Industry has been consolidating to fish from bigger, more specialized vessels. Two or three boats specializing in Arrowtooth flounder harvest, which they freeze and ship to China. Fillets are mushy, but the "fin frills" get dried and nibbled on. There is an English Sole market in the Strait of Georgia, but it's small. Bigger than any other except ATF, but still small. Processing plant in Prince Rupert went away (burned down), so no more flatfish fishing in Hecate Strait. Small boats can't compete. SFU student working on simultaneous assessment of all flatfish at once using a "Robin Hood" approach by stealing data from data rich species and using them for data poor species. The first publication is out, but work is still under way. Dana noted that deep sea sole were all over the seamounts in the ROV survey. They will likely produce a short note on this.

CDFW, ODFW, WDFW, IPHC – no directed research or management to report

N. Pacific Halibut & IPHC activities

IPHC – Josep shared a presentation on research projects and Lara shared a presentation on fisheries, both of which were recently given at the IPHC annual meeting. Integration of biological research, stock assessment, and policy is a key effort. Three are several projects happening right now working to align research with stock assessment needs: 1) Larval and early juvenile dispersals, to understand the spawning grounds vs settlement grounds in the Gulf of Alaska and Bering Sea; 2) Late juvenile dispersal using tagged fish to look at distribution, growth, and thermal history; 3) Using tail pattern recognition as an individual identification mark; 4) Identification of sex in the commercial landings via genetics; 5) A full characterization of the annual reproductive cycle for use in revising the maturity estimates for males and females; 6) Identification and validation of physiological markers for growth and variation in growth patterns; 7) Examination of growth patterns in the population in conjunction with the effects of environmental variability; 8) Establishing handling practices by looking at injury levels and physiological conditions of released halibut in the directed longline fishery. This final project looks at careful shake vs. gangion cutting vs. hook stripping. This evaluates the physiological conditions post-capture and survival post-release as assessed by tagging (tagged with accelerometer tags n=79). Mortality of 4%. Also wire tags (n=1,048) includes all handling practices and release conditions. Also looking at guided recreational fishery estimate of DMR in 2019.

New projects for 2019: 1) discard mortality rates of P. Halibut in the recreational fishery; 2) Up to date genetic analysis of population structure; 3) Whale detection techniques (using acoustic towed arrays); 4) Bycatch reduction techniques; 5) Incidence of chalky halibut in commercial landings and understanding possible causes.

On fisheries, 2018 total mortality was 17,590 thousand tons. Primarily taken from the commercial fleet but the report includes a table of landings for each area and each type of fishery. In general the allocations were slightly under or over. In Canada bycatch rates were higher and it is a concern because it is in excess of their predetermined level. There are concerns with mortality estimates in the Alaska commercial fishery. Also in the Canadian and US recreational fisheries because of self-reporting and no discard mortality reported for Washington and California. Problems in the Canadian and US subsistence (roll over) and in the bycatch in the other fisheries in the US. All commercial license applications must be submitted online. There is a head-on requirement for landed fish.

Adding collection of marine mammal details to logbooks and FLOAT logs collected in field via Bluetooth from skipper's advice. Tissue sampling is being done coast-wide. In the US, Seward had the greatest amount of landings (weight).

Working with NOAA and state agencies on moving management of domestic fisheries to their purview (staff). Includes licensing and trip limits. Concerns with safety and discards, and fish wastage.

The annual full stock assessment was completed by Ian Stewart, as in past years. There is no explicit exploitation limit set, which complicates management but also allows considerable flexibility in setting regional and total catch levels. Female spawning biomass is healthy and TAC seems to be working. The stock is not subject to overfishing and is not overfished. A decision table has been used for several years rather than recommending a straight up TAC, which allows Commissioners and others to assess various potential levels of risk during TAC setting. The stock is projected to decrease slowly until 2022.

AFSC – Though details are not currently included in the report, center staff are working on Marine Stewardship Council certification and abundance-based management for halibut in the Bering Sea. Also, the economics group has been doing a lot of work looking at elements of the halibut fishery, including rationalization.

DFO – Robyn Forrest has been doing work on spatial changes in the fishery as a result of rockfish avoidance. The analysis is ongoing and will likely be included in the 2019 report. Preliminary results suggest interesting patterns in depth and spatial distribution of fishing effort, and overall benefits to rockfish.

CDFW, ODFW, and WDFW – In-season management is tightly regulated, but details were largely included in the IPHC fisheries presentation from Lara, and the report. CDFW autoconforms their regulations with federal rules after they are finalized in order to simplify management and reduce confusion.

O. Other groundfish (and forage fish) species

CDFW – no directed research or management to report. Catch of many species is recorded/estimated as part of regular recreational and commercial monitoring.

ODFW – Kelp greenling have been exceptionally abundant in recent years in Oregon. Harvest is up a bit, but no specific large-scale changes to harvest have occurred.

Have been working on compiling data for, and otherwise contributing to, a coast-wide cabezon assessment. Work has included otolith processing method comparison and generation of new growth curves. Cabezon otoliths are best read by a specialized break and burn technique developed by ODFW staff. Aging cabezon is “not fun”; high CVs and strong evidence of both between and within reader bias.

See ODFW informational report for more info. Will continue trying to age cabezon but will explore other structures. The recreational fishery reaches attainment in about 7 weeks but is open 6 months. The commercial fishery is open all year and the regulate themselves to spread attainment out through the season

WDFW – Together with partners at the AFSC, Shoreline Community College, UW's Friday Harbor Labs, and NPRB staff are currently evaluating Pacific Sand Lance genetics to explore patterns of regional diversity. Students at Shoreline Community College are processing and collecting microsatellite data from sample collected from throughout the Salish Sea. Over 200 samples have been read thus far and initial results suggest interannually consistent patterns of variation between sites in South Puget Sound and the San Juan Islands. Additional results will be shared in the 2019 report.

AFSC – The report includes numerous studies focused on a variety of species that range from fundamental biology and physiology, to ecology and stock assessment. Projects on several "non groundfish" critters like octopuses and forage species are also included. See the report for details (in the interest of time).

Wayne noted a long-standing project with Korea to improve fishery-independent survey designs in Korean waters. This has benefitted the AFSC from a collaborative aspects and has also provided access to data from Korean waters.

Noelle Yochum is doing work on salmon bycatch reduction in the pollock fishery, etc. She is also doing a lot of camera and fish eye physiology work with Lyle Britt.

Mark Zimmerman has been working on using various types of bathymetric data to map habitat. Has been filling in gaps with depth data recorded from the trawl survey and is getting close to a full map extending down to SE Alaska

.

Jay Orr continues to work on fish identification projects and will soon release the final version of Fishes of the Salish Sea. The plates of fish in the book are phenomenal artistic renderings.

Essential fish habitat work continues at a rapid pace. Three publication have recently been finalized (see report for details).

The Center is making a concerted effort to make data entry all digital on the back decks of all survey ships. They have come a long way in the last five years or so, but are not yet 100% digital.

Several analyses occurred in 2018 to evaluate effects of trawl survey reductions on long-term monitoring data series, stock assessments, etc. Were meant for inclusion in the ICES workshop but the federal shutdown delayed the workshop a full year.

DFO – All at-sea survey data acquisition is digital. Data are uploaded into a corporate database, which has become a template for other non-groundfish groups.

XII. Ecosystem Studies

CDFW – no directed research or management actions to report, but see notes on MPA monitoring above.

ODFW – Working to operationalize a broad coastal hydroacoustic survey for semi-pelagic rockfishes and other species. Have a Saltonstall-Kennedy grant for development of the survey and have done pilot work with hydroacoustics and tow cameras. Will be on the water August to October this year. They are also comparing stereo lander drops for species composition comparisons between the day and night, and looking at detectability. Big video lander report coming soon, combining all drops over all time. Over 5,000 structures were aged in 2018, mostly Cabezon and Black Rockfish.

WDFW – The TBiOS program continues to monitor accumulation, and evaluate the biological effects, of various toxins in marine ecosystems. They have large-scale projects focused on mussels, juvenile Chinook Salmon, herring, and English Sole. They publish regular reports and have a detailed website (unless the recent renovation broke the links). See the report for links and a short list of publications.

Removal of derelict fishing nets continues to be a priority in Puget Sound. Historical "legacy" nets have largely been dealt with over the last decade – with over 5k nets recovered. Newly lost nets are dealt with via a reporting, response, and retrieval network that has been operating for several years. Funding for the program was tenuous past 2019 but recently secured funding will ensure the program operates at least through 2021.

DFO – Development of a Management Procedure (MP) framework for data deficient groundfish stocks continued in 2018. Had been working toward a tiered approach to stock assessment, as is used in Alaska and Australia however when a workshop on tiered approaches was held Dr. Tom Caruthers came to talk about his Data Limited Tools (DLMTool) software. DFO is now pursuing a more "simulation based" approach using DLMTool to generating advice for data poor and data moderate species. A steering committee and working group have been formed to provide oversight in development of the framework. The first step in developing the MP Framework was to build GFSynopsis, a software tool for extracting, summarizing, and displaying all of DFOs data holdings for a given species. They now have "R" code that pulls all available data from all available systems and displays it in a two-page format. GFSynopsis is being used it to evaluate assessment options and priorities. A report based on this data compilation tool was reviewed in November. Examples are provided in the report, as is a link to the full draft document. This is an excellent data exploration and decision support tool.

AFSC – Kalei Shotwell has been working on ecosystem-socioeconomic profiles (ESP) for stock assessments. These are two-page overviews that cover all relevant data series, much like DFO's effort noted above. They are attached to the end of the stock assessment and fishery evaluation documents to fill in details of *why* things are happening the way they are. First workshop on ESPs is this May.

The Alaska Climate Integrated Modeling Project (ACLIM) is an interdisciplinary collaboration that is tying multiple models together to address climate change projections. Several papers published in the last year and considerable progress has been made toward operationalizing the products. See details in the report.

The Center also has Integrated Ecosystem Research Programs (IERP) for both the Bering Sea and the Gulf of Alaska. These programs generate ecosystem report cards that contain biological and economic data (https://access.afsc.noaa.gov/reem/ecoweb/index.php?ID=3). See details in report.

Also conducting: genetics work on capelin population structure; sand lance morphology and genetic work; age-0 pollock, age-0 cod, and sand lance abundance estimation relative to sea surface temperature in the Bering Sea; and project associating trawl data with the blob.

IPHC – Deploy SeaCAT devices at all stations, so have coast-wide oceanographic data available to use as modeling covariates, etc.

XIII. Progress on Previous Year's Recommendations

A. From TSC to CARE

i. A review assessing variation in Yelloweye Rockfish ages assigned by various laboratories was completed. The results are crucial to management and are applicable to other groundfish species. The TSC recommends publishing this work.

ii. Some progress was made on using otolith morphometrics to discriminate otherwise cryptic species. Work is ongoing, and the TSC looks forward to seeing results in future CARE reports.

iii. The TSC applauds CARE's efforts to read otoliths from easy-, moderate-, and difficult-to-age species using near infrared spectrometry in a continued effort to apply this technique to production ageing. CARE should continue to carefully consider validation studies associated with machine reading of otoliths via this method.

B. From TSC to Itself

i. Dayv and Stephen reached out to PFMC and NPFMC representatives regarding attendance of the 2018 TSC meeting. Due to staffing changes and scheduling conflicts neither Council was able to send a representative this year. Dayv and Stephen will reach out again, then ask for them to attend the meeting in April of 2020.

ii. The rockfish descending device research and policy session at the 2018 Western Groundfish Conference was very well received. Dayv will work with Cara and other members of the organizing committee to identify topics for a session at the 2020 meeting in Juneau. Once potential topics are identified Dayv will consult with the full TSC.

iii. Neither the PFMC nor NPFMC submitted a report for the 2018 TSC meeting. Dayv and Stephen will reach out to request these reports again for next year.

iv. A representative from DFO's Fishery Management group was not able to attend the 2018 meeting. Dayv will reach out, with help from DFO Science representatives, to ensure participation at the meeting in April of 2020.

v. The US-Canada border issue in Dixon Entrance still exists where the same marine waters are claimed by the two countries. The AFSC bottom trawl survey has conducted stations in the disputed area and DFO has also conducted studies in the same area. The issue has been elevated to the US Department of State through NOAA but this is not a hot button issue. The main problem is transiting the area being managed by the Canadian Coast Guard when the US chartered fishing vessels still have active fishing gear aboard. This gear is usually being cleaned and stowed at the time. The TSC recommends that international research permits or similar recognitions be obtained by either country when conducting surveys or studies in the disputed waters.

vi. A standardized TSC report format was provided to member entities several years ago, but clear guidance on report length and complexity is still missing. Members should make efforts to keep reports concise and focused.

vii. Again this year a representative from the NWFSC was not able to attend the meeting. A report was submitted, but scheduling conflicts prevented attendance. Dayv and Stephen will continue to work with the NWFSC to facilitate attendance.

C. From TSC to Parent Committee

i. None

XIV. Current Year Recommendations

A. From TSC to CARE

a. The TSC recommends that CARE consider ageing lingcod otoliths from fish for which spines have also been collected using NI-spec. If results coincide well, this could allow samplers to avoid the need to collected fin spines, which can be problematic in some jurisdictions.

b. The TSC recommends to CARE that they preserve a record of ageing methods for use as teaching tools. Specifically, a library of video instructions that include microscope footage and detailed verbal methods could be housed on the CARE webpage. In addition, the TSC recommends that agencies provide overlap in new hires and retiring age readers, as practicable, to maintain continuity and avoid loss of crucial technical knowledge.

B. From TSC to Itself

a. The TSC recognizes the importance of member attendance at the annual meeting to facilitate communication and collaboration. Agency reports are a wonderful tool for communicating current research efforts; however, discussion at the meeting really highlights the work being done and provides valuable opportunities to pursue collaboration amongst the member agencies. The TSC recommends that all members pursue approval to attend the meeting well in advance and leverage travel funds provided by the PFMC (to non-federal members) as possible.

b. The TSC recognizes the valuable opportunity to highlight the TSC's work at the Western Groundfish Conference (WGC) and that sponsored sessions and workshops at the WGC are excellent ways to showcase the TSC. Potential sponsored session topics for the 2020 WGC in Alaska include: review of maturity schedules; ageing tools and concerns; and management of cryptic species as complexes, or independently. The TSC recommends that the Chair and/or Cara Rodgveller, NMFS-AFSC and WGC organizing committee member, engage with the WGC Organizing Committee to develop a topic for a sponsored session.

c. The TSC recognizes that the annual combined TSC report contains substantial useful information about groundfish research efforts off the west coast of North America, but that its length may make it difficult for individuals to find information on species or research of interest. Therefore, the TSC recommends that additional guidance be drafted (by the Chair) for agencies in advance of preparing next years' reports. This guidance should include the option to highlight research projects using extended abstracts rather than cutting and pasting the entire research report. Additionally, it would be useful for each agency to provide links to agency reports in their TSC report. Finally, the TSC proposes that it would be beneficial to have a clickable Table of Contents in the combined report, including the subsections of each agency's report.

d. The TSC recognizes that recent retirees Lynne Yamanaka-DFO Canada, Jon Heifetz-NMFS-AFSC, and Tom Wilderbuer-NMFS-AFSC have made substantial contributions to the TSC and towards groundfish research at large over many years. Therefore, the TSC recommends that the Chair draft thank you letters to the individuals for their years of service. These drafts will be circulated to TSC members for review prior to sending them to the past members.

f. The TSC recognizes that the long delay between the annual meeting and finalization of the minutes, the combined agency TSC report, and the letter to Supervisors summarizing the meeting is sub-optimal, and that the distribution of the annual TSC Report could be broader. Therefore, the TSC recommends that the members review the meeting minutes and finalize their reports within 2 months of the meeting. To facilitate this the Chair has agreed to review and distribute the meeting minutes within 2 weeks via Google Docs, and request that agencies finalize their reports by the end of June. Additionally, the Chair may ask for suggestions as to additional regional and management entities that would benefit from the annual TSC Report. In this way the annual TSC Report can be made available to a wider audience in a more timely manner than in previous years.

g. The TSC notes that many of the groundfish populations occurring along the west coast of North America and managed by TSC member agencies may span the entire north Pacific Ocean, including the waters of Russia, Korea, Japan, and others. Therefore the TSC urges member agencies to try to obtain data from these other countries, and suggest that individuals from TSC-member agencies could make contact with individuals from management entities in these countries at the PICES meeting October 16-27, 2019 in Victoria, BC.

C. From TSC to Parent Committee

a. The TSC recognizes that ecological conditions in the northwest Pacific Ocean are currently unlike anything on record. To properly understand these new conditions, additional survey effort is needed to document changing conditions, yet repeated actions to reduce survey effort have instead occurred. The TSC requests that the Parent Committee advocate for continued or increased survey efforts by member agencies, and that there are no further reductions in survey effort.

b. Various areas in the north Pacific have been closed to fisheries due to conservation concerns. In the most extreme cases, these no take areas have also been closed to ecological sampling and monitoring efforts. The Parent Committee should reach out to member agencies to make clear the management disadvantages of this policy decision, which compromises the ability to evaluate efficacy of the closed areas.

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

Wayne agreed to update. Should just involve adding the 2019 meeting.

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

April 21+22, 2020 in Canada. Victoria, Vancouver, or Nanaimo? (WGC is April 27 to May 1 in Juneau). Maybe April 14+15? Final dates and location to be determined by local host and chair. Dayv was re-elected to serve as chair for the 2020 meeting.

XVII. Adjourn (~12:00 PM Wednesday April 24th)

XIX. Parent Committee Minutes

Minutes of the 60th 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 11:30am, April 24, 2018.

B The Agenda

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

C The 2018 Parent Committee meeting minutes

The 2018 Parent Committee meeting minutes were adopted as presented

D Progress on 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.

   No Action Needed

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.

   *Todd Phillips, PFMC replaced Kelly Ames at the PFMC. Todd was contacted and invited the TSC annual meeting. Todd was unable to attend the 2019 meeting because of a prior commitmen*t. DFO, Pacific Region, Groundfish Fisheries Management Unit (GMU) lead, Mr. Adam Keizer was invited to the meeting but due to pre-existing commitments unable to attend, Mr. Keizer has committed to attending the 2020 TSC meeting or send an alternate to represent the GMU.

E. 2019 Parent Committee Recommendations

1. The Parent Committee concurs with the TSC the importance of member attendance at the annual meeting to facilitate communication and collaboration, that Agency reports are a wonderful tool for communicating current research efforts; and that all members should pursue approval to attend the meeting well in advance and leverage travel funds provided by the PFMC (to non-federal members) as possible.

2. The Parent committee agree on the concern that various areas in the north Pacific have been closed to fisheries due to conservation concerns. In the most extreme cases, these no take areas have also been closed to ecological sampling and monitoring efforts. The Parent Committee will follow-up member agencies to make clear the management disadvantages of this policy decision, which compromises the ability to evaluate efficacy of the closed areas.

3. **The Parent Committee thanks recent retirees Lynne Yamanaka-DFO Canada, Jon Heifetz-NMFS-AFSC, and Tom Wilderbuer-NMFS-AFSC for their decades of outstanding service and contributions to the TSC and towards groundfish research at large over many, many years.**

XX. Other Business

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

2. The Parent Committee thanks Bob Pacunski and Lisa Hillier of WDFW for acting as rapporteurs for the TSC meeting and expresses its deep appreciation to Dayv Lowry for chairing and hosting the 2019 meeting.

XXI. Selection of the next Chair, Schedule and Location of 2020 Meeting

Dayv Lowry of the WDFW will continue as Chair for the 2020 meeting to be held April 21-22, 2020 or April 14-15, 2020 in Canada. Victoria, Vancouver, or Nanaimo. (WGC is April 27 to May 3 in Seward). Final dates and location to be determined by local host and chair.

XXII. The Parent Committee meeting was adjourned at 12:00 pm, Wednesday April 24, 2019.

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

AGENCY REPORTS

1. ALASKA FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERES SERVICE
2. CANADA, BRITISH COLUMBIA GROUNDFISH FISHERIES
3. INTERNATIONAL PACIFIC HALIBUT COMMISSION (IPHC)
4. NORTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE
5. SOUTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE
6. STATE OF ALASKA – ALASKA DEPARTMENT OF FISH AND GAME

8\. STATE OF CALIFORNIA – DEPARTMENT OF FISH AND GAME

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

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

Alaska Fisheries Science Center of the National Marine Fisheries Service

2018 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

April 2019

Compiled by Wayne Palsson, Olav Ormseth, and Cara Rodgveller

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2018

I. Agency Overview

Groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the following Divisions: Resource Assessment and Conservation Engineering (RACE) Resource Ecology and Fisheries Management (REFM), Fisheries Monitoring and Analysis (FMA), and the Auke Bay Laboratories (ABL). All Divisions work closely together to accomplish the mission of the Alaska Fisheries Science Center. In 2018 our activities were guided by our Strategic Science Plan (www.afsc.noaa.gov/GeneralInfo/FY17StrategicSciencePlan.pdf) with annual priorities specified in the FY18 Annual Guidance Memo (https://www.afsc.noaa.gov/program_reviews/2017/2017_Core_Documents/FY18%20AFSC%20AGM.pdf). A review of pertinent work by these groups during the past year is presented below. A list of publications relevant to groundfish and groundfish issues is included in Appendix I. Annual 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. **Note that NOAA-Fisheries Science Center web materials can be found on the national NOAA-Fisheries web site after April 30, 2019 (https://www.fisheries.noaa.gov); they may no longer be available on the afsc.noaa.gov web site. Users should be able to find the same materials on the new national site.**

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). Our surveys often cover the entire life history of the focal species, from egg to adult. All surveys provide a rich suite of environmental data that are key to practicing an ecosystem approach to fisheries management (EBFM: https://www.fisheries.noaa.gov/insight/understanding-ecosystem-based-fisheries-management) . In addition, the Division works collaboratively with Industry to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat.

RACE 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 and species-specific ecosystem and socioeconomic 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 (FBE), Groundfish Assessment (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes (RPP), Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations: 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 summer 2018, RACE Groundfish Assessment Program (GAP) and Shellfish Assessment Program (SAP) scientists conducted bottom trawl survey of Alaskan groundfish and invertebrate resources during the annual eastern Bering Sea Shelf Bottom Trawl Survey, including a rapid response extension into the northern Bering Sea shelf to investigate how a record low in sea ice and cold water temperatures affected fish and crab distributions and biomass. GAP also carried out the biennial Aleutian Island 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 the eastern Bering Sea (summer). Track lines for the summer survey were extended northward to examine climate-mediated effects of loss of sea ice and the cold pool on fish distribution. A collaborative cruise to test the efficacy of different types of trawl excluders to minimize salmon bycatch was accomplished, as well. MACE and GAP continue to collaboratively design an acoustical-optical survey for fish in grounds that are inaccessible to fisheries research trawls (e.g Gulf of Alaska or Aleutian Islands). Once implemented, the survey will reduce bias in our survey assessments of particular taxa such as rockfish.

The Recruitment Processes Alliance (RPA: RACE RP and ABL EMA Programs) conducted Bering Sea surveys on the early life history stages of groundfish species in the spring and summer, as well as the environmental conditions necessary to explain growth and mortality of fish. Spring surveys focus on winter and early spring spawners such as Walleye Pollock, Pacific cod, Arrowthooth and Kamchatka Flounder and Northern & Southern Rock Sole, Alaska Plaice, Greenland Turbot. Summer surveys concentrate on the age-0 and age-1 juvenile stages of the winter/spring spawners as well as summer spawners (e.g. Yellow-Fin Sole). This survey also estimates whether or not age-0 fish have sufficient energy reserves to survive their first winter. In 2018 the summer RPA surveys were cut short due to NOAA ship electrical issues.

Research on environmental effects on groundfish species such as the impacts of ocean acidification on early life history growth and survival continue at our Newport, Oregon facility. Similarly the lab is engaged in a novel line of research to examine oil toxicity for arctic groundfish (e.g. arctic cod) This effort is to understand risks associated with oil and natural gas extraction as well as increased maritime traffic across the arctic ocean.

In 2018 RACE scientists continued research on essential habitats of groundfish including: identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, 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.

Groundfish surveys by the RACE Division have been increasingly challenged by climate-mediated ocean warming and loss of sea ice. These phenomena are likely directly related to changes in fish distribution, particularly the northern summer expansion of pollock and cod stocks. Movement of fish outside of our historical survey boundaries challenges the assumption that our surveys capture an invariant fraction of the population from one year to the next. These distributional changes are occurring at exactly the same time as our survey and science resources are declining. The RACE Division is currently collaborating with an international team of scientists to examine the impacts of reduced survey effort on the accuracy and precision of survey biomass estimates and stock assessments. AFSC will host an ICES workshop on the impacts of unavoidable survey effort reduction (ICES WKUSER) in the winter 2019/2020. Similarly, current research by RACE and other Center scientists will examine the efficacy of model-based survey estimates to supplement our current design-based surveys.

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. The activities of REFM are organized under several programs that have specific responsibilities but also interact:

- The Age and Growth Studies program performs production ageing of thousands of otoliths each year and performs research regarding new technologies, reproductive biology, and enhancing age and growth data for less well known species.
- Economics and Social Sciences Research (ESSR) performs analyses of fisheries economics as well as sociological studies of Alaska fishing communities, and produces an annual economic report on federal fisheries in Alaska.
- The Resource Ecology and Ecosystem Modeling (REEM) program maintains an ever-growing database of groundfish diets, constructs ecosystem models, and produces an extensive annual report

on the status of Alaska marine ecosystems.

- Status of Stocks and Multispecies Assessment (SSMA), in collaboration with the Auke Bay Laboratories, prepares annual stock assessment documents for groundfish and crab stocks in Alaska and conducts related research. Members of REFM provide management support through membership on regional fishery management teams.

For more information on overall REFM Division programs, contact Division Director Ron Felthoven (ron.felthoven@noaa.gov). For more information on REFM assessment reports contact Olav Ormseth (olav.ormseth@noaa.gov).

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. A major focus of the MESA Program is on research and assessment of sablefish, rockfish, and sharks in Alaska. Presently, the program is staffed by 10 scientists. ABL's Ecosystem Monitoring and Assessment Program (EMA), Recruitment Energetics and Coastal Assessment Program (RECA), and Genetics Program also conduct groundfish-related research and surveys and all programs have contributed to this report.

In 2018 the ABL Division conducted the following surveys that sample groundfish: 1) the AFSC's annual longline survey in Alaska, 2) surface trawl surveys in the northern and southeastern Bering Sea, and 3) nearshore juvenile sablefish tagging surveys in southeast and central Alaska.

Projects at ABL included: 1) tagging and analyses of sablefish, sharks, and Greenland turbot movement, 2) ageing and genetic studies of sharks, 3) maturity of sablefish, 4) predicting survival and recruitment of Walleye pollock from energetics, temperature, or copepod abundance, 5) population structure and distribution of forage fish and Arctic cod, 6) a lab study on the effects of temperature and diet on juvenile Pacific cod condition, 7) the creation of nation-wide Ecosystem and Socioeconomic reports for use in stock assessment, and 8) the formation of a sablefish coast-wide assessment and research group (CA, OR, WA, BC, AK).

In 2018 ABL continued to prepare eleven stock assessment and fishery evaluation reports for Alaska groundfish: Alaska sablefish, Gulf of Alaska (GOA) Pacific ocean perch (POP), GOA northern rockfish, GOA dusky rockfish, GOA rougheye/blackspotted rockfish, GOA shortraker rockfish, GOA "Other Rockfish", GOA thornyheads, and GOA and Bering Sea/Aleutian Islands sharks.

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. For more information on the ABL reports contact Cara Rodgveller (cara.rodgveller@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

2018 Eastern Bering Sea Continental Shelf and "Rapid-Response" Northern Bering Sea Bottom Trawl Surveys – RACE GAP

The thirty-seventh in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 31 July 2018 aboard the AFSC chartered fishing vessels *Vesteraalen* and *Alaska Knight*, which together bottom trawled at 376 stations over a survey area of 492,898 km^2. Researchers processed and recorded the data from each trawl catch by identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. Supplementary biological and oceanographic data collected during the bottom trawl survey was also collected to improve the understanding of groundfish and crab life histories and the ecological and physical factors affecting distribution and abundance.

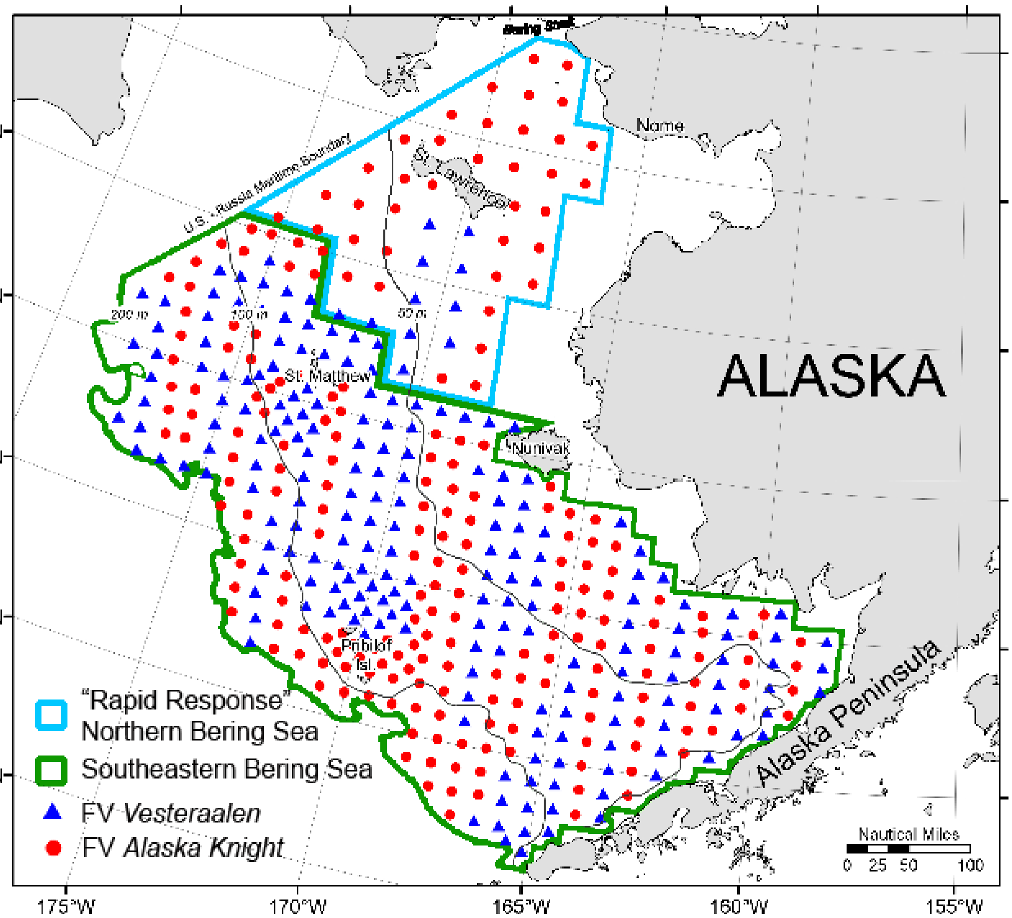

Fig. 1.
Map showing survey stations sampled during the 2018 eastern and northern Bering Sea shelf bottom trawl survey.

Survey estimates of total biomass on the eastern Bering Sea shelf for 2018 were 3.1 million metric tons (t) for walleye pollock, 506.1thousand t for Pacific cod, 1.89 million t for yellowfin sole, 1.05 million t for northern rock sole, 18.0 thousand t for Greenland turbot, and 125.7 thousand t for Pacific halibut. There were decreases in estimated survey biomass for most major fish taxa compared to 2017 levels. Walleye pollock biomass decreased 35%, Pacific cod 21%, yellowfin sole 32%, northern rock sole 21%, for Alaska plaice 15%, Greenland turbot 16%, and Pacific halibut 0.78 %. Arrowtooth flounder biomass increased 21%.

The summer 2018 survey period was warmer than the long-term average for the fifth consecutive year. The overall mean bottom temperature was 4.16°C in 2018, which was warmer than 2017 (2.83 °C); however, the mean surface temperature was 7.58C in 2018, which was slightly lower than 2017 (7.83°C).

After the completion of the EBS shelf survey, which started for both vessels in Dutch Harbor on 3 June 2018, 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 31 July to 3 August, and the F/V *Alaska*

Knight from 01 August to 14 August. A total of 49 30 x 30 nautical mile sampling grid stations in the combined EBS and NBS were successfully sampled in 2018.

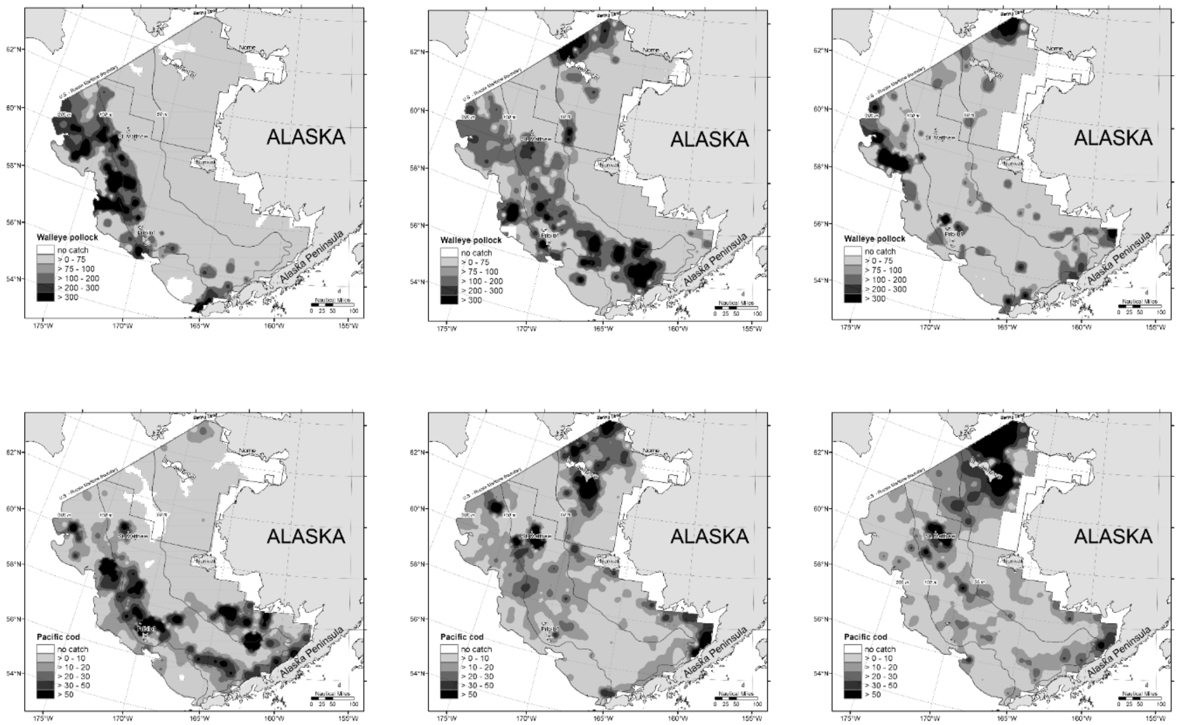

Fig. 2.

Spatial distribution of large gadids, in terms of mean CPUE (kg/ha), observed during the 2010, 2017, and 2018 bottom trawl surveys of the EBS and NBS: Top left is walleye pollock in 2010, top middle is walleye Pollock in 2017, and top right is walleye pollock in 2018; bottom left is Pacific cod in 2010, bottom middle is Pacific cod in 2017, and bottom right is Pacific cod in 2017.

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 left). 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 middle). 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 2018, again pollock distributions were quite different than in 2010 or 2017. In the EBS, pollock were densest in the south east corner of Bristol Bay and in small clusters along the Aleutian chain, and near the shelf break between 59°N and 60°N. In the NBS, pollock were most concentrated in the most northwestern corner of the NBS survey grid, along the U.S. – Russia Maritime Boundary (Figure. 2, top right). The total pollock biomass from EBS was 3.1 million mt, while pollock biomass from the NBS was 1.1 million mt in 2018.

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. middle). 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 2018, Pacific cod biomass was again concentrated in only a few areas of the EBS, but the majority of the biomass was concentrated to the north, east, and south of St. Lawrence Island in the NBS (Fig. 2, bottom. right). Total estimated cod biomass from the EBS was 507 thousand mt, while biomass from the NBS was 565 thousand mt in 2018. In all 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 2018 were 1.89 million mt for yellowfin sole, 1.05 million mt for northern rock sole, 511 thousand mt for arrowtooth flounder, and 125.7 thousand mt for Pacific halibut. Compared to 2017 levels, there was an overall general decrease in survey biomass for the major species: walleye pollock biomass decreased 35%, Pacific cod 21%, yellowfin sole 32%, northern rock sole 21%, and Pacific halibut 0.78%. Arrowtooth flounder biomass increased 21%.

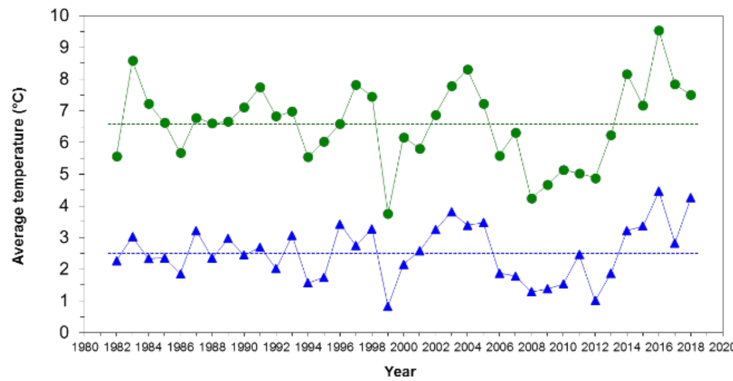

Fig. 3. Graph of mean annual surface and bottom temperatures for the eastern Bering Sea shelf bottom trawl survey.

The surface temperature mean for 2018 eastern Bering Sea shelf decreased from 2017 estimates, while the bottom temperature mean increased from 2017 estimates, but both were still warmer than the long-term time-series mean (Fig. 3). The 2018 mean surface temperature was 7.6°C, which was 0.2°C lower than 2017 and 1°C above the time-series mean (6.6°C). The mean bottom temperature was 4.2°C, which was 1.4°C above the mean bottom temperature in than 2017, but 1.7°C above the time-series mean (2.5°C). The 'cold pool', defined as the area where temperatures <2°C, only appeared in a few stations just to the west of St. Lawrence Island at a latitudes between 62° N and 64° N and between 50 and 100 m bottom depth. This extent was significantly less developed than in 2017, when the cold pool extended south-east to latitude 54° N.

2018 Aleutian Islands Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources – RACE GAP

The ninth biennial groundfish assessment survey of the Aleutian Islands region was conducted during the summer of 2018 by the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering Division's Groundfish Assessment Program (RACE-GAP). This effort constitutes the fifteenth in the full series dating from 1980. The survey area covered the continental shelf and upper continental slope to 500 m in the Aleutian Archipelago from Islands of Four Mountains (170° W long.) to Stalemate Bank (170° E long.), including Petrel Bank and Petrel Spur (180° long.), and the northern side of the Aleutian Islands between Unimak Pass (165° W long.) and the Islands of Four Mountains. The survey was conducted aboard two chartered trawlers, the *FV Ocean Explorer* and *FV Sea Storm*. Samples were collected successfully at 420 survey stations using standard RACE Division Poly Nor'Eastern high-opening bottom trawl nets with rubber bobbin roller gear.

The primary survey objectives were to define the distribution and estimate the relative abundance commercially or ecologically important principal groundfish and invertebrate species that inhabit the Aleutian marine habitat and to collect additional data to define biological parameters useful to fisheries researchers and managers such as growth rates; length-weight relationships; feeding habits; and size, sex, and age compositions. During these surveys, we also measure a variety of physical, oceanographic, and environmental parameters. 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 of successfully trawls stations stratified into 45 combinations of depth and regions and applied to a grid of 5x5 km2 cells. 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.

A validated data set was finalized on 30 September, and final estimates of abundance and size composition of managed species and species groups were delivered to Groundfish Plan Team of the NPFMC. Pacific ocean perch or POP (*Sebastes alutus*) was the most abundant species with an estimated biomass of 1,016,309 metric tons (t). Atka mackerel (*Pleurogrammus monopterygius*), northern rockfish (*Sebastes polyspinis*), and walleye pollock (*Gadus chalcogrammus*) were also abundant with estimated biomasses of 354,871, 212,536 t, and 197,079 t, respectively. Catches of POP were large throughout the survey area at intermediate depths. Arrowtooth flounder (*Atheresthes stomias*) and northern rock sole (*Lepidopsetta polyxystra*) were the most abundant flatfish species. The skate assemblage was primarily comprised of three skate species, whiteblotched (*Bathyraja maculata*), Aleutian (*B. aleutica*), and leopard (*B. panthera*) skates, with a wide diversity of species captured in the eastern portion of the survey area. Survey results are presented as estimates of catch per unit of effort and biomass, species distribution and relative abundance, population size composition, and length-weight relationships for commercially important species and for others of biological interest. The survey data are available at https://www.afsc.noaa.gov/RACE/groundfish/survey_data/data.htm and can also be obtained through the AKFIN system (www.psmfc.org). The Plan Team incorporated these survey results directly into Aleutian Island stock assessment and ecosystem forecast models that form the basis for groundfish harvest advice for ABCs and TAC for 2019.

The data report for the 2017 Gulf of Alaska Bottom Trawl Survey can be found at https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-374.pdf

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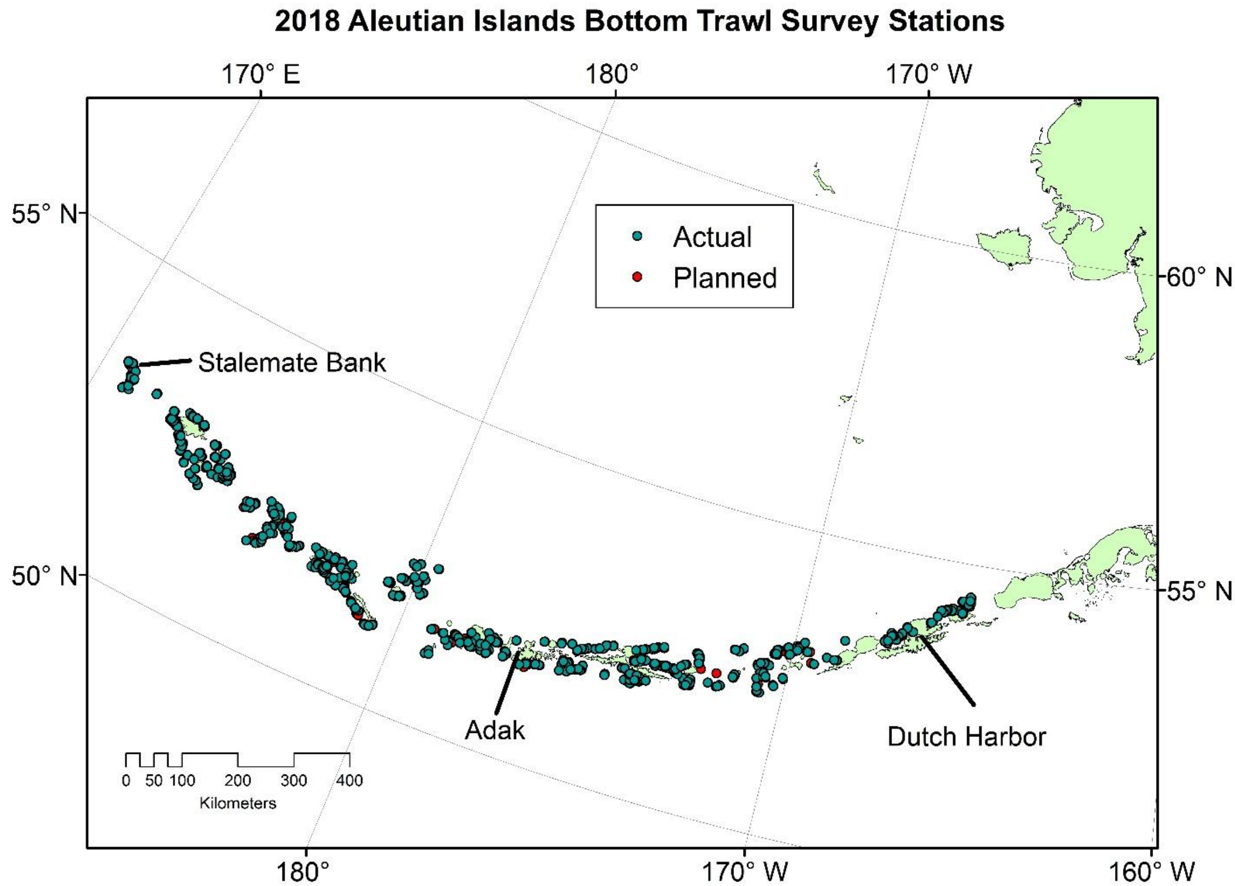

Figure 1. Planned and occupied stations during the 2017 Gulf of Alaska Biennial Bottom Trawl Survey.

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

Two cruises were conducted to survey several GOA walleye pollock (Gadus chalcogrammus) spawning areas in the winter of 2018. The first cruise (DY2018-01) surveyed the Shumagin Islands area (i.e., Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait; 7-10 February), Sanak Trough (11 February), Morzhovoi Bay (11 February), and Pavlof Bay (12 February). The second cruise (DY2018-03) covered Shelikof Strait (15-21 March) and Marmot Bay (21-22 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 sampled using an Aleutian Wing 30/26 Trawl (AWT) and a poly Nor'eastern (PNE) bottom trawl was used to estimate the abundance of walleye pollock. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques. The trawl hauls conducted in the GOA winter surveys included a CamTrawl stereo camera attached to the net forward of the codend. The CamTrawl was used to capture stereo images for species identification and fish length measurements as fishes passed through the net toward the codend, primarily as a comparison with lengths measured from fish caught in the net in support of research on automated image analysis.

In the Shumagin Islands, acoustic backscatter was measured along 872 km (471 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 in 2018 were between 9-14 cm fork length (FL). This size range is characteristic of age-1 pollock. This size range accounted for 99.1% of the numbers and 55.7% of the biomass. Larger pollock between 40-60 cm FL accounted for 43.8% of the biomass of all pollock observed in this area. This larger size range is likely dominated by age-6 walleye pollock, and suggests the continued success of the 2012 year class. Walleye pollock between 9 and 14 cm FL were present mainly in Shumagin Trough. Pollock between 40 and 60 cm FL were present mainly off Renshaw Point, where they have historically been detected (but were absent in 2017), and near the mouth of Stepovak Bay. The majority of the pollock were scattered throughout the water column between 50-200 m depth, within approximately 50 m of the bottom, and occasionally formed small, very dense (i.e., "cherry ball") schools. The maturity composition of males > 40 cm FL (n = 100) was 0% immature, 4% developing, 93% pre-spawning, 3% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 128) was 3% immature, 9% developing, 88% pre-spawning, 0% spawning, and 0% spent, based on data from specimens collected from seven AWT hauls. The estimated amounts of pollock for the Shumagin area were 1,247 million pollock weighing 17,390 t (with a relative estimation error of 8.3%), which is 42% lower than last year's estimate (29,621 t) and 24% of the historical mean of 73,330 t for this survey.

In Sanak Trough, acoustic backscatter was measured along 165km (89 nmi) of transects spaced 3.7 km (2 nmi) apart. A few walleye pollock with FL between 11 and 12 cm FL were present (2% by numbers), but the vast majority of the pollock were between 37 and 56 cm FL. This mode accounted for 99.9% of the biomass of all pollock observed in Sanak Trough and likely represents age-6 fish. The majority of walleye pollock biomass was located in the middle of the surveyed trough and distributed throughout the water column below 50 m, concentrated around 140 m. The maturity composition for males > 40 cm FL (n = 18) was 0% immature, 0% developing, 89% pre-spawning, 11% spawning, and 0% spent. The maturity composition for females > 40 cm FL (n = 31) was 0% immature, 10% developing, 90% pre-spawning, 0% spawning, and 0% spent, based on data from specimens collected from one AWT haul. The biomass estimate of 1,317 t (with a relative estimation error of 12.2%) is 38% higher than last year's estimate of 957 t, but represents only 3.5% of the historic mean of 36,823 t for this survey.

In Morzhovoi Bay, acoustic backscatter was measured along 68.5 km (37 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 10 and 59 cm FL in Morzhovoi Bay. Walleye pollock between 10-14 cm FL, indicative of age-1 pollock, accounted for 24% of the numbers but only 0.4% of the biomass of all pollock observed in this area. Larger pollock between 39-59 cm FL accounted for 75% and 99.6% of the numbers and biomass, respectively. Walleye pollock were located throughout the surveyed area and were concentrated between 50-100 m depth from the surface. The maturity composition for males > 40 cm FL (n = 9) was 0% immature, 0% developing, 56% pre-spawning, 44% spawning, and 0% spent. The maturity composition for females longer than 40 cm FL (n = 21) was 0% immature, 19% developing, 67% pre-spawning, 14% spawning, and 0% spent, based on data from specimens collected from one AWT haul. The biomass estimate of 3,722 t (with a relative estimation error of 23.0%), is comparable to the biomass estimates generated between 2007 and 2013 and in 2017 (mean = 2,667 t; standard deviation = 897 t), and approximately a third of the estimate from either 2006 (11,700 t) or 2016 (11,412 t).

In Pavlof Bay, acoustic backscatter was measured along 75 km (40.5 nmi) of transects spaced 3.7 km (2 nmi) apart. Walleye pollock ranged between 10 and 60 cm FL. Walleye pollock between 10-14 cm fork length (FL), indicative of age-1 pollock, accounted for 77% of the numbers but only 4.7% of the biomass of all pollock observed in this area. Larger pollock between 25-60 cm FL accounted for 23% and 95.3% of the numbers and biomass, respectively. 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 25-150 m from the surface. The maturity composition for males > 40 cm FL (n = 29) was 0% immature, 24% developing, 41% pre-spawning, 34% spawning, and 0% spent. The maturity composition for females > 40 cm FL (n =

38) was 0% immature, 11% developing, 87% pre-spawning, 3% spawning, and 0% spent, based on data from specimens collected from two AWT hauls. The biomass estimate of 4,619 t (with a relative estimation error of 19.9%) is roughly double either the 2016 or 2017 estimates of 2,130 t and 2,228 t, respectively. Surveys of Pavlof Bay were also conducted in 2002 and 2010, but an equipment malfunction and inclement weather, respectively, prevented trawling.

In the Shelikof Strait sea valley, acoustic backscatter was measured along 1613 km (871 nmi) of transects spaced 13.9 km (7.5 nmi) apart. The majority of walleye pollock in Shelikof Strait were between 9 and 62 cm FL with two length modes centered around 12 and 44 cm FL (Fig. 41). Age-1 walleye Pollock, between 10-14 cm FL, accounted for 53% of the numbers but only 1.6% of the biomass of all pollock observed in this area. Larger pollock between 39-62 cm FL accounted for 44% and 97.5% of the numbers and biomass, respectively. Walleye pollock were observed throughout the surveyed area and were most abundant in the central part of the surveyed area. They were detected as a thick, uniform layer between 150m to 300 m from the surface. Dense midwater pollock aggregations of pollock ≥ 39 cm FL were encountered higher in the water column, generally above 100 m. Spawning aggregations historically observed in the northwestern part of the Strait were not observed in 2018 (or in 2016-2017), which contrasts with previous years. The maturity composition in the Shelikof Strait area for males > 40 cm FL (n = 324) was 0% immature, 2% developing, 5% pre-spawning, 69% spawning, and 24% spent. The maturity composition of females > 40 cm FL (n = 383) was 0% immature, 2% developing, 30% pre-spawning, 24% spawning, and 44% spent, based on data from specimens collected from 14 AWT hauls and 3 PNE hauls. The biomass estimate of 1,320,867 t (with a relative estimation error of 3.9%) is 88% of that observed in 2017 (1,489,723 t) and almost twice the historic mean of 690,451 t. Survey biomass estimates in 2017 and 2018 are the largest since the mid-1980s.

In Marmot Bay, acoustic backscatter was measured along137.5 km (74 nmi) of transects spaced 1.75 km (1.0 nmi) apart in inner Marmot Bay, and 43.5 km (23.5 nmi) of a zig-zag transect in outer Marmot Bay. Walleye pollock ranged between 8 and 56 cm FL with two clear modes at 10 and 45 cm FL. Age-1 walleye pollock between 10-14 cm FL accounted for 74% of the numbers but only 4% of the biomass of all pollock observed in this area. Walleye pollock that ranged from 39 to 56 cm FL accounted for 94.6% of the biomass. The majority of walleye pollock biomass occurred in aggregations in Spruce Gully, just NE of Spruce Island. These aggregations were typically within 100 m of the seafloor. A diffuse acoustic scattering layer present near the seafloor in the inner Bay was composed of age-1 pollock. The maturity composition in Marmot Bay for males > 40 cm FL (n = 60) was 0% immature, 2% developing, 8% pre-spawning, 58% spawning, and 32% spent. The maturity composition of females > 40 cm FL (n = 40) was 0% immature, 10% developing, 25% pre-spawning, 3% spawning, and 63% spent, based on data from specimens collected from three AWT hauls. The biomass estimate of 13,531 t was slightly less than both last year's estimate of 14,259 and the historic mean of 15,576 t.

Summer 2018 acoustic vessel of opportunity (AVO) index for midwater Bering Sea walleye pollock--MACE

An acoustic-trawl survey of walleye pollock (*Gadus chalcogrammus*) in the southeastern Aleutian Basin near Bogoslof Island was conducted 3-7 March, 2018 aboard the NOAA Ship *Oscar Dyson*. The survey covered 1,500 nmi^2 of the Central Bering Sea Convention Specific Area.

Acoustic backscatter was measured at 38 kHz along 35 north-south parallel transects, which were spaced 3-nmi apart. Backscatter in the eastern, Umnak region was sampled with five trawl hauls to identify the species composition of the acoustic scattering layers and to provide biological samples. Mechanical problems with the trawl-winch system unfortunately prevented any trawling in the western Samalga region, where the densest backscatter was distributed.

For the five trawl samples in the Umnak region, pollock was the dominant species by weight, and represented 98.5% of the total catch. Northern smoothtongue dominated the catch by number (48.6%), with pollock second most numerous at 37.5% of the total catch. Pollock lengths ranged from 37 to 63 cm fork length (FL), with a primary mode at 49 cm.

Pollock specimens from the Umnak region were examined for maturity stages. Of the 183 males, 7% were in the pre-spawning stage, 56% were spawning, and 37% were in the post-spawning stage. Of the 223 females, 18% were in the pre-spawning stage, 3% were spawning, and 79% were in the post-spawning stage. The average gonado-somatic-index for pre-spawning mature (i.e., FL≥ 39.9) female pollock in the Umnak region was 0.17.

Pollock biomass was distributed on all transects with minor concentrations in the Umnak region and the bulk of the biomass located in a relatively small area of the Samalga region. The densest concentration was located on transect 26, in the Samalga region, which represented 66% of the total estimated pollock biomass. This layer extended horizontally for about 9 nmi with a vertical extent from 150 m down to 650 m below the surface.

The pollock abundance estimate in 2018 was 964 million fish weighing 663 thousand metric tons for the entire surveyed area. The overall size-composition for the pollock was unimodal at 49 cm FL, with an average length at 48.2 cm. The estimates represent an increase of 11% in abundance and 31% in biomass from the 2016 survey estimates of 866 million fish weighing 507 thousand metric tons. Based on the 1D geostatistical analysis, the relative estimation error for the biomass estimate was 42.5%. This error rate was the largest estimated to date and likely reflects the high-density biomass estimate on transect 26, in the Samalga region.

The estimated age-composition for pollock ranged from 5 to 12 years of age. Sixty-eight percent of the estimated biomass were 8-9-year old fish (2010-2009 year classes), and another 14% were 6-year-old fish (2012 year class).

A major assumption underlying the survey results for 2018 was that the backscatter observed in the Samalga region was primarily from pollock. Backscatter observed on transect 26 in this region was particularly important because it contributed 66% of the estimated pollock biomass in 2018. Because no trawl samples occurred in the Samalga region, we relied on prior pollock surveys to support this assumption. Similar backscatter confirmed by trawling was observed in this region during the 2014 and 2016 surveys.

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

The MACE Program conducted an acoustic-trawl survey of Eastern Bering Sea shelf walleye pollock (Gadus chalcogrammus) between 6 June and 26 August 2018. Midwater abundance and distribution were assessed from Bristol Bay to the U.S.-Russia Convention Line using acoustic-trawl survey methods aboard the NOAA ship Oscar Dyson. This survey has been conducted since 1979; triennially through 1994, and biennially or annually since then. The survey design covered the EBS shelf between roughly the 50 m and 200 m isobaths, from 162° W to the U.S.–Russian Convention line. The adjoining Russian portion of the EBS shelf was not surveyed as permission to survey that region was not granted in 2018. A northern extension beyond the traditional (core) survey area was added in 2018 based on observations of pollock extending north of the core survey area in 2016 (Honkalehto et al. 2018), saildrone observations (Mordy et al. 2017), and analysis of fish backscatter data collected in this northern region from the NOAA summer EBS bottom trawl survey in 2017. The survey design initially consisted of 28 north-south oriented parallel transects spaced 20 nmi apart over the Bering Sea shelf from 162° W (west of Port Moller, Alaska) to about 178° 20 E, excluding Russian waters and a northern extension, with similar spacing. The initial plan was amended with the following three changes: 1) Due to Oscar Dyson engine malfunction during leg 2, the remaining northern extension transect spacing was increased, and 2) an additional leg (3b) was added to the survey. Finally, 3) A second Oscar Dyson engine malfunction during leg 3b forced us to drop the final three transects, and the survey ultimately consisted of 25 transects.

The primary survey objective was to collect daytime 38 kHz acoustic backscatter and trawl data to estimate the abundance of walleye pollock. Additional survey sampling included conductivity-temperature-depth (CTD) measurements to characterize the Bering Sea shelf temperature conditions, and supplemental nighttime trawls to improve acoustic species classification and to obtain an index of euphausiid abundance using multiple frequency techniques. In addition to these nighttime trawls, AFSC scientists from the Recruitment Processes Alliance (RPA) participated on leg 3b to collect data on groundfish recruitment, including Methot and Bongo tows. Two drifters were also deployed for Pacific Marine Environmental Laboratory (PMEL) researchers during the survey. Sampling devices used during the survey include an Aleutian Wing Trawl (AWT) rigged with pocket nets to estimate fish escapement and a trawl-mounted stereo camera (CamTrawl) designed to identify species and determine size and density of animals as they pass by the camera during a haul; an 83-112 Eastern bottom trawl without roller gear; a Methot trawl, and Bongo nets.

Biological data and specimens were collected from 119 AT trawl hauls. The majority of these hauls (100) targeted backscatter during daytime for species classification: 97 with an AWT, 3 with a bottom trawl, and 7 with a Methot trawl. The remaining 12 hauls were either nighttime bongo net tows (6) targeting larval fish or nighttime Methot tows (6) targeting euphausiids. Catch data for some of these hauls assisted with backscatter classification. CamTrawl image data were successfully collected for 83 AWT hauls. Among midwater hauls used to classify backscatter for the survey, walleye pollock was the most abundant species by weight (83.6%) and by number (90.2%), followed by northern sea nettle jellyfish (Chrysaora melanaster; 12.4% by weight and 4.5% by number). Among bottom trawls, pollock was the most abundant species by weight (31.3%) and snow crab (Chionoecetes opilio) the most abundant by number, followed by Pacific cod (Gadus macrocephalus; 16.5% by weight and 1.4% by number). Methot hauls were dominated by weight by northern sea nettles (57.4%) and euphausiids (37.8%), and numerically by euphausiids (98%).

Temperature measurements during the 2018 survey produced an estimated mean SST of 8.48 °C (range 5.2°-10.6°C; Fig. 3, upper panel). The estimate was cooler than 2016 (mean SST 11.4°C , range 7.4°-14.0°C), and 2014 (mean SST 9.6°C, range 6.4°- 12.4°C), but still much warmer than relatively cold survey years 2006-2012 (means between 4.9° - 6.8°C). About 35% of the summed acoustic backscatter observed in the core survey area between 16 m below the surface and 3 m off bottom (the midwater layer) during the 2018 survey was attributed to age 1+ walleye pollock. This was lower than the percentage of pollock observed in 2016 (52%), 2014 (45%) and 2012 (56%), and much less than that observed in 2010 (82%). In the northern extension area, about 38% of the backscatter was attributed to pollock. Pollock were observed in a variety of aggregations including near-bottom layers, small dense schools (cherry balls) in midwater, and diffuse aggregations of individual fish. The remaining non-pollock midwater backscatter was attributed to an undifferentiated plankton-fishes mixture (60%), or in a few isolated areas, to rockfishes (Sebastes spp.) or other fishes (2%). The near-bottom analysis (Lauffenburger et al. 2017) attributed ~ 60.5% of the backscatter in the near-bottom zone in the core survey area to pollock, and 93.7% of the backscatter in the near-bottom of the northern extension area to pollock. The northern extension area contributed about 8.7% additional pollock backscatter to the survey over the amount in the core survey area.

Estimated numbers and biomass of walleye pollock in midwater to within 0.5 m of the bottom along the U.S. Bering Sea shelf in the core survey area were 5.57 billion fish weighing 2.5 million t. This 2018 biomass estimate represents ~40% decrease compared to 2016 (4.06 million t), and a 30% decrease from the 2014 biomass estimate (3.44 million t). It is on par with the biomass estimates in 2010 and 2012 (2.64 million t and 2.30 million t, respectively. The relative estimation error for the U.S. EEZ walleye pollock biomass estimate for the entire water column was 0.039, indicating a patchier distribution of pollock than observed in 2016 (0.019). Pollock were observed throughout the EEZ area between the 100- and 200-m isobaths. East of 170° W, pollock abundance was 1.28 billion fish, weighing 0.74 million t (27% of total midwater biomass, Fig. 8). This was less than half of the pollock biomass observed east of the Pribilof Islands in the AT survey in 2016 (1.80 million t). In the U.S. EEZ core survey area west of 170° W, pollock numbered 4.29 billion and weighed 1.75 million t, which was 64% of total midwater biomass. The majority of the pollock biomass in the survey was found in the region to the south and west of St. Matthew Island (e.g., transects 20-25). Pollock biomass decreased inside the SCA from 0.54 million t in 2016 to 0.23 million t in 2018. Estimates for the entire survey and the SCA correlate well ($r2 = 0.79$ $p < 0.001$) throughout the 1994-2018 time series. The pollock estimate in the northern extension area was 492 million fish weighing 0.24 million metric tons, contributing an additional 9% by number and weight compared with the amount of pollock estimated within the core survey area. In the northern extension, fish were sparsely but evenly distributed between the 50- and 100-m isobaths.

Pollock length compositions differed between midwater and near bottom layers, and modal lengths tended to decline to the west. East of 170° W, pollock ranged between 8 and 72 cm FL with a mode of 43 cm. Very few fish smaller than 30 cm were observed east of 170° W. In the U.S. EEZ core survey area west of 170° W, pollock ranged from 8 to 75 cm FL with multiple modes observed at 17, 26 and 42 cm FL. Within the northern extension of the survey area fish were slightly longer than in the core survey area (mode of 42 cm with a long right tail), and a few much smaller fish were also seen (mode of 14 cm). Near-bottom pollock were both smaller (mode of 15 cm) and larger (mode of 45 cm) in comparison to midwater fish throughout the survey area in 2018. Age data are not yet available for this survey.

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Summer 2018 acoustic vessel of opportunity (AVO) index for midwater Bering Sea walleye pollock

Acoustic backscatter data (Simrad ES60, 38 kHz) were collected aboard two fishing vessels chartered for the AFSC summer 2018 bottom trawl surveys (F/V *Alaska Knight*, F/V *Vesteraalen*). These Acoustic Vessels of Opportunity (AVO) data were processed according to Honkalehto et al. (2011) to provide an index of age-1+ midwater pollock abundance for summer 2018. The 2018 AVO index of midwater pollock abundance on the eastern Bering Sea shelf decreased 13.5% from 2016 and decreased 8.0% from 2017. However, the AFSC biennial acoustic-trawl (AT) survey conducted using NOAA Ship *Oscar Dyson* in summer 2018 decreased 48.2% from 2016. Even so, the correlation between the AVO index and the AT survey biomass only decreased minimally (r^2= 0.74, n= 9 surveys, Figure 2, vs. r^2= 0.76, n=8 surveys for the period 2006-2016). The percentage of pollock backscatter east of the Pribilof Islands was 14% (Figures 3, 4). Although this is larger than the percentages in summers 2010-2012 (range 4-9%), it is the lowest percentage observed east of the Pribilof Islands since 2013.

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

Longline Survey – ABL

The AFSC has conducted an annual longline survey for sablefish and other groundfish in Alaska since 1987. 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 2018, the 41st annual longline survey sampled the upper continental slope of the Gulf of Alaska and the eastern and central Aleutian Islands region. One hundred and forty-eight longline hauls (sets) were completed during June 1 – August 28 by the chartered fishing vessel *Alaskan Leader*. Total groundline set each day was 16 km (8.6 nmi) long and contained 160 skates and 7,200 hooks.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), shortspine thornyhead (*Sebastolobus alascanus*), Pacific cod (*Gadus macrocephalus*), and rougheye/blackspotted rockfish (*Sebastes aleutianus/S. melanostictus*). A total of 80,865 sablefish, with an estimated total round weight of 175,088 kg (386,003 lb), were caught during the survey. This represents a decrease of 3,552 sablefish over the 2017 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 2,248 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at two stations in the western Gulf of Alaska and two stations in the Aleutian Islands. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 18 stations in 2017. Sperm whales were observed depredating on the gear at four stations in the central Gulf of Alaska, seven stations in the West Yakutat region, and ten stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2018 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. Throughout the survey, stereo cameras were installed outboard of the hauling station to collect imagery that will be used for the refinement of electronic monitoring. The imagery will be used as a training dataset to develop machine learning for length measurements and species identification. Additionally, a multispectral camera was used on the 2-day experimental leg to take detailed images of rougheye and blackspotted rockfish. These images will be used, along with DNA samples taken from the fish, to develop and verify algorithm-based species identifications for potential use during electronic monitoring. Yelloweye rockfish (*Sebastes ruberrimus*) samples were collected for a study examining reproductive life history. Hormone concentrations, extracted from growth increments within their opercula, will be used to reconstruct individual reproductive life histories (e.g., age at maturity and spawning frequency). This information may be used to refine the parameters and results of the Southeast Alaska yelloweye rockfish stock assessment. Additionally, samples were collected for a genetics study aimed at examining yelloweye population structure from California up to Alaska.

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 a password word protected website through the Alaska Fisheries Information Network (AKFIN).

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. For more information on data access, contact Cara Rodgveller, cara.rodgveller@noaa.gov

Northern Bering Sea Integrated Ecosystem Survey – ABL

The Auke Bay Laboratory (ABL) Division of the Alaska Fisheries Science Center (AFSC) has conducted surface trawling and biological and physical oceanography sampling in the Northern Bering Sea annually since 2002. The ABL 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 Program, conducted a survey August 27 to September 20, 2018 aboard a chartered fishing vessel, which included the collection of data on pelagic fish species and oceanographic conditions in the Northern Bering Sea shelf from 60°N to 65.5°N (Fig. 1). Overall objectives of the survey 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, and 3) sample collections within Region 2 of the Distributed Biological Observatory.

Physical and biological data are typically collected from 50 stations and oceanographic and fish 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.

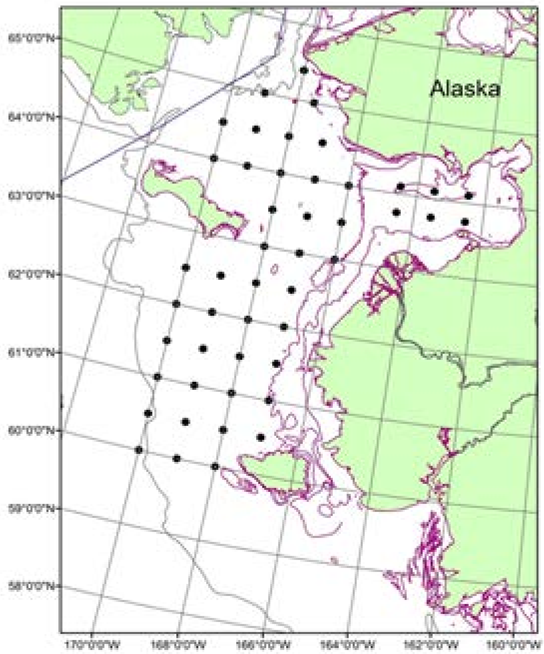


Figure 1. Stations sampled during the August 27 to September 20, 2018 surface trawl survey in the northern Bering Sea.

For more information, contact Jim Murphy 907-789-6651, Jim.Murphy@noaa.gov or Kristin Cieciel at (907) 789-6089, Kristin.Cieciel@noaa.gov.

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

BASIS fisheries-oceanographic surveys in the SEBS have been conducted annually since 2002 (with the exception of 2013) and biennially since 2016. Scientists from the Alaska Fisheries Science Center (AFSC), Recruitment Processes Alliance (RPA) conducted a fisheries-oceanographic survey in the southeastern Bering Sea (SEBS) aboard the chartered FV *Northwest Explorer* from September 20 to 3 October, 2018. Note: This survey was originally scheduled to be conducted aboard the NOAA Vessel *Oscar Dyson* with more days at sea from August to September, but due to mechanical issues the vessel was not available. In 2018, the reduced survey covered the SEBS shelf between roughly the 50 m and 100 m isobaths, from 161° W to 171° W (Figure 1). A surface trawl (top 20 m), CTD cast, and zooplankton bongo net tow were performed at each core trawl station (18 stations total); a CTD cast and bongo net tow were performed at each oceanography station (8 stations total). In addition, six targeted midwater tows were performed to collect data on the vertical distribution of age-0 Walleye pollock.

During this survey, trawl catch and ecosystem data were collected with a priority to provide information on commercially important species (e.g., pollock, Pacific cod), ecologically important forage species (e.g., Capelin, Pacific herring), and all salmon species. In 2018, we observed warmer surface and bottom temperatures, lower large copepod abundances (an important prey item for age-0 pollock), and average age-0 pollock abundances. Findings from additional research associated with this survey have been included separately in this report.

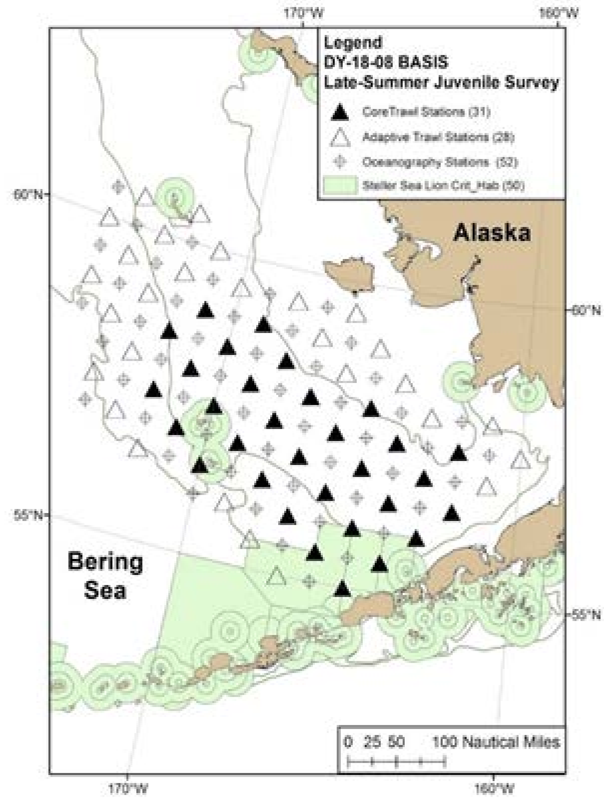


Figure 1. Station locations for the 2018 BASIS cruise in the southeastern Bering Sea (not all locations were sampled due to fewer sea days).

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 Fisheries Monitoring and Analysis (FMA) Division administers the North Pacific Observer Program (Observer Program) and Electronic Monitoring (EM) Program which play a vital role in the conservation and management of the Bering Sea, Aleutian Islands, and Gulf of Alaska groundfish and halibut fisheries.

FMA observers and EM systems collect fishery-dependent data onboard fishing vessels and at onshore processing plants that is used for in-season management, to characterize interactions with protected resources, and to contribute to assessments of fish stocks, provide data for fisheries and ecosystem research and fishing fleet behavior, and characterize fishing impacts on habitat. The Division ensures that the data collected by observers and through EM systems are of the highest quality possible by implementing rigorous quality control and quality assurance processes.

In 2018, FMA continued the development and testing of new and innovative EM technologies by deploying stereo and chute camera systems on fixed gear and trawl catcher-processor vessels, as well as on surveys conducted by NOAA Fisheries and the International Pacific Halibut Commission. Electronic monitoring systems were also tested for the first time at shoreside processors to investigate alternative methods to account for incidentally caught Salmon. Considerable headway was made testing hardware and developing the necessary applications to automate species identification and length estimation. This year, FMA also made remarkable progress identifying fish within the Rockfish complex. Using a multi-spectrum chute system, the Blackspotted, Shortraker, and Rougheye Rockfish were able to be distinguish from one another with a 91.7% accuracy. Within the Salmon complex, Chinook, Chum, Pink, and Coho salmon were able to be distinguished from one another to an accuracy level 97.7%.

III. Reserves

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

Note: Management of federal groundfish fisheries in Alaska is performed by the North Pacific Fishery Management Council (NPFMC) with scientific guidance (research and stock assessments) from the Alaska Fisheries Science Center and other institutions. Assessments are conducted annually for major commercial groundfish stocks, with biennial assessments for most of the other stocks. Groundfish populations are typically divided into two geographic stocks: Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA). Some BSAI stocks are further divided into Eastern Bering Sea (EBS) and Aleutian Islands (AI). In the GOA, assessment and management for many stocks is structured around large-scale spatial divisions (western, central, and eastern GOA) although the application of these divisions varies by stock. Current and past stock assessment reports can be found by following the "historical groundfish SAFE" link on the NPFMC website (https://www.npfmc.org/safe-stock-assessment-and-fishery-evaluation-reports/). Additional useful information (e.g. fishery management plans) can be found elsewhere at the NPFMC site.

A. Hagfish

There are currently no state or federal commercial fisheries for hagfish in Alaska waters. However since 2017 the Alaska Department of Fish & Game has been conducting research to explore the potential for small-scale hagfish fisheries.

B. Dogfish and other sharks

1. Research

Spiny Dogfish Ecology and Migration - ABL
A tagging program for spiny dogfish began in 2009, with 186 pop-off satellite archival tags (PSATs) deployed between 2009 - 2018. Data were recovered from 157 of those tags (nine tags are still at liberty), 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 nine 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 (HMM) model based on these tag data and incorporating environmental variables (e.g.

temperature/depth profiles and sea-surface temperature). The HMM model will provide daily locations in the form of probability surfaces as well as total residence probabilities for the duration of deployment for each tag. The results will be used to define habitat utilization distributions, and eventually inform Essential Fish Habitat.

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, and those data are being used in a simulation environment to test the Hidden Markov Movement model.

In 2016 staff at ABL began a collaboration with the University of Florida to examine stress physiology in spiny dogfish. In 2017 and 2018 a total of 13 PSATs were deployed on fish and blood samples were collected to correlate longer-term survival (i.e., > 3 months) with stress physiology and injuries.

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.

Ageing of Pacific Sleeper Sharks – ABL

A pilot study is underway by staff at ABL, REFM, and the Pacific Islands Fishery Science Center to investigate potential ageing methods for Pacific sleeper sharks. A recent study suggested extreme longevity in a closely related species by examining the levels of bomb-derived radiocarbon (14C) in the eye lens. The eye lens is believed to be a metabolically inert structure and therefore the levels of 14C could reflect the environment during gestation, which may be used to compare to existing known age 14C reference curves to estimate either a rough age, or a “at least this old” age estimate. The goal of the pilot study, which consisted of four animals, was to determining if 14C is detectable in the eye lens and staff are working with experts in the field of eye lens forensics and ageing via 14C to determine if the method is informative for this species. Previous studies in a closely related species have suggested extreme longevity, but a number of concerns exist for the results from this species. The eye lens forms during gestation, which is likely at least 2 years and all of the nourishment is likely supplied by a yolk sac, derived from ovum that took an unknown number of years to develop. Further, the 14C is a reflection of the diet of the female, which could be an accumulation of 14C from variously aged prey. Results of the pilot study are expected by spring 2019 and will guide how the study is planned for the remainder of the samples.

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 in even years. 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 2018 assessments, catch estimates from 2003-2018 were updated from the NMFS Alaska Regional Office’s Catch Accounting System. In the GOA, total shark catch in 2018 was 2,141 t, which was up from the 2017 catch of 1,632 t. The GOA assessment also reports catch of sharks occurring in federally managed fisheries in NMFS areas 649 (Prince William Sound) and 659 (Southeast Alaska inside waters), 719 t in 2017 and 95 t in 2018, however these do not accrue against the TAC. The assessment authors have been tasked with working with Council staff to explore options for incorporating these catches into the assessment.

The most recent trawl survey was in 2017, with the next planned for 2019. The trawl survey biomass estimates are used for ABC and OFL calculations for spiny dogfish and are not used for other shark species. 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 2015, the biomass was nearly three times greater; such variability in annual estimates is expected due to the patchy distribution of this species. The random effects model for survey averaging was used to estimate the 2017 (and thus 2018 because there was no survey that year) GOA biomass for spiny dogfish (54,301 t), which was used for Tier 5 calculations of spiny dogfish ABC and OFL.

The GOA shark assessment is a complex of both Tier 5 and 6 species. In the 2018 assessment, spiny dogfish were recommended to move to Tier 5 and the method for spiny dogfish changed over previous assessments where a trawl survey catchability value was estimated based on tag data and the survey biomass adjusted accordingly (258,577 t) and the $F_{OFL} = F_{max}$ from a demographic analysis. The Tier 6 species in the complex remained consistent, using the historical mean catch to calculate ABC and OFLs. 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 = 8,184 t and OFL = 10,913 t for 2019 and 2020.Because the survey biomass estimates on the BSAI are highly uncertain and not informative, all shark species are considered Tier 6. The Tier 6 calculations in the BSAI are based on the maximum catch of all sharks from the years 2003-2015. The resultant recommended values for 2019 and 2020 were ABC = 517 t and OFL =

689 t. In the BSAI, estimates of total shark catch from the Catch Accounting System from 2018 were 94 t, which is not close to the ABC or OFL. Pacific sleeper shark are usually the primary species caught, however catches of salmon shark have been greater for the last two years (71 and 51t salmon shark in 2017 and 2018, respectively and 59 and 38 t of Pacific sleeper sharks).

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

C. Skates

1. Research

2. Assessment

Bering Sea and Aleutian Islands (REFM)
The Bering Sea and Aleutian Islands (BSAI) skate complex includes at least 13 skate species, which are highly diverse in their spatial distribution. The complex is managed in aggregate, with a single set of harvest specifications applied to the entire complex. However, to generate the harvest recommendations the stock is divided into two units. Harvest recommendations for Alaska skate *Bathyraja parmifera*, the most abundant skate species in the BSAI, are made using the results of an age structured model (Stock Synthesis). The remaining species ("other skates") are managed under Tier 5 (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). The individual recommendations are combined to generate recommendations for the complex as a whole.

No changes were made to the model but a new method was used to estimate catches of Alaska skate and the other species in the skate complex was created (official catch estimates at the species level are unavailable due to problems with species identification in the fisheries) . Estimates from this method were used in the Alaska skate model and to produce exploitation rates for the skates in the "other skates" group.

The Alaska skate model produced similar results to the 2016 model run, and harvest recommendations are changed only slightly from last year. Spawning biomass of Alaska skate increased continuously from 2006 (194,515 t) through 2018 (268,836 t), and is currently at an all-time high. Recruitment of Alaska skate was above average for all cohorts spawned
between 2003 and 2010, but has been below average for all cohorts spawned since 2011. The remaining species of skates have relatively flat or increasing biomass, except for whiteblotched and leopard skates in the Aleutian Islands. Both of these species have been declining (since 2006 [whiteblotched] and 2010 [leopard]). For the skate complex as a whole, ABCs for 2019 and 2020 total 42,714 t and 40,813 t, respectively, and OFLs for 2019 and 2020 total 51,152 t and 48,944 t, respectively.

Big skate biomass has increased substantially in the southeastern Bering Sea and it is likely these skates are part of the Gulf of Alaska population. Exploitation rates of Bering and big skates exceed 0.1. While this is a concern, there are several reasons why these rates are likely acceptable. Alaska skate is common in the northern Bering Sea survey area, and increased abundance there matches the overall increase in the Alaska skate population

Gulf of Alaska (REFM)
The skate complex in the GOA is assessed biennially and there was no assessment in 2018, so harvest recommendations are the same as last year. Big skate and longnose skate are the primary skate species in the

GOA, and they have separate harvest recommendations from the remaining species ("other skates"). Big skate OFL and ABC in 2019 are 3,797 t and 2,848 t, respectively; longnose skate OFL and ABC in 2019 are 4,763 t and 3, 572 t. The ABCs for these two stocks are apportioned among GOA regulatory areas. The other skates group has a gulfwide OFL and ABC: in 2019 these are 1,845 and 1,384.

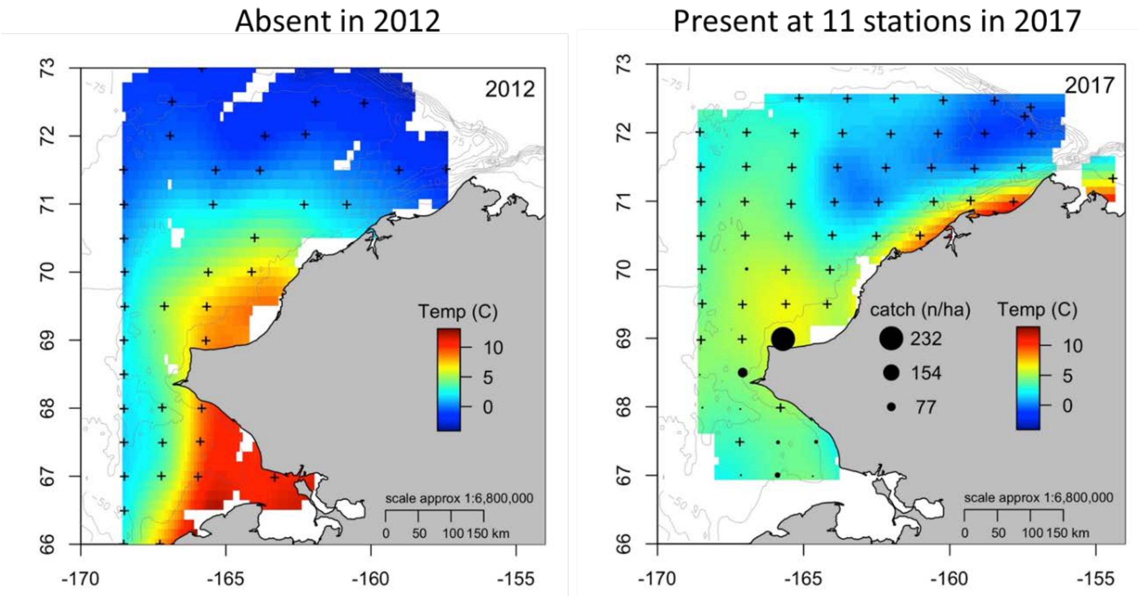
For more information contact Olav Ormseth (206) 526-4242 or olav.ormseth@noaa.gov.

D. Pacific Cod

1. Research

Pacific cod juveniles in the Chukchi Sea-RPP
Dan Cooper, Libby Logerwell, Nissa Ferm, Robert Lauth, Lyle Britt, and Lorenzo Ciannelli.

In recent warm years, catchable-sized Pacific cod have expanded their range from the southeastern Bering Sea into the northern Bering Sea, and possibly into the Chukchi Sea. One question is whether this expansion represents a temporary range shift, or a colonization of northern areas; early life stage abundance and distribution data may offer evidence of local spawning and therefore colonization. Pacific cod juveniles were surveyed in the Chukchi Sea using a small-mesh demersal beam trawl during August and September of two years: 2012 (Arctic EIS) and 2017 (Arctic IERP; Figure 1). Pacific cod juveniles (59-83mm TL) were present at 11 of 59 stations in 2017 (Figure 1). Similarly-sized fish in the eastern Bering Sea would be young-of-the-year. Pacific cod juveniles were absent from all 40 stations in 2012, including at 7 stations where Pacific cod were present in 2017 (Figure 1). Although summer bottom temperatures in the Chukchi Sea were generally warmer in 2017 than in in 2012, the southern and shallow sites with Pacific cod presence in 2017 were not uniformly warmer in 2017, and in fact some were cooler in 2017 (Figure 1). If warmer temperatures allowed Pacific cod to survive in 2017 and not in 2012, the temperature effect was likely at an earlier life history stage than the observed benthic juveniles. Pacific cod are able to survive to the transformed juvenile stage in the Chukchi Sea in some years, although this is not the first report of juvenile Pacific cod in the Chukchi Sea, and catch rates were lower than in nursery areas of the southeastern Bering Sea. Juvenile Pacific cod were also caught in surface and midwater trawls during the 2018 Arctic IERP Survey, and we are currently collaborating with Kristin Cieciel (EMA), Robert Levine (MACE), Louise Copeman (OSU), and Johanna Vollenweider (EMA) to describe habitat specific abundance, diet, and trophic markers for juvenile Pacific cod.



Genetic evidence for a northward range expansion of the eastern Bering Sea Pacific cod stock - REFM
Poleward species range shifts have been predicted to result from climate change, and many observations have confirmed such movement. The abundant center hypothesis predicts that range shifts will take place by movement of individuals from core habitat to marginal habitat. However, poleward shifts may represent a homogeneous shift in distribution, northward movement of specific populations, or colonization processes at the poleward edge of the distribution. The ecosystem of the Bering Sea has been changing along with the climate, moving from an arctic to a subarctic system. Several fish species have been observed further north than previously, replacing marine mammals and benthic prey. We examined Pacific cod in the northern Bering Sea to assess whether they migrated from another stock in the Eastern Bering Sea, Gulf of Alaska, Aleutian Islands, or whether they represent recently established separate populations. Genetic analysis using 3,457 SNP markers indicated that cod collected in August 2017 in the northern Bering Sea were most similar to spawning stocks of cod in the eastern Bering Sea. This result suggests northward movement of the large eastern Bering Sea stock of Pacific cod, and is consistent with the abundant center hypothesis.
Contact Ingrid Spies (Ingrid.Spies@noaa.gov) for more information.

Cod species and population structure in the Arctic - ABL
Cod samples collected during the 2012-2013 Bering Arctic Subarctic Integrated Survey (BASIS) (adults) and the 2017 Arctic Integrated Ecosystem Research Program (Arctic IERP) survey (juveniles) were genetically analyzed with 15 microsatellite markers and mtDNA sequences. Little population structure was evident for Arctic cod in the Chukchi Sea. Some of those morphologically identified as age-0 Arctic cod were genetically identified as pollock, and were found further north than previously observed (to latitude 70°), or a different stock of Arctic cod, which were all found north of latitude 72°. Due to the difficulty of visual identification of cod species at this early life history stage, all age-0 cod samples collected in the upcoming 2019 Arctic IERP survey will be genetically identified to species prior to other research project analyses.

For more information contact: Sharon.Wildes@noaa.gov

Warm Blob Effects on Juvenile Pacific Cod – ABL

To understand how environmental conditions during the "Warm Blob" may have influenced age-0 Pacific Cod survival, we conducted a laboratory study comparing diets and temperatures before and during the 'blob' to quantify its effects on fish growth and body condition. In July and August of their first year of life, we fed fish high fat and low fat diets at three temperatures: 9, 12, and 15 C. Chemical analysis of fish condition indices is underway, including total fat, protein, and caloric content, as well as RNA/DNA, which is an index of instantaneous growth rate. A replicate study will be conducted in 2019 using smaller fish collected two months earlier.

This laboratory study is one component of a broader study that seeks to validate a model constructed under the GOAIERP (Gulf of Alaska Integrated Research Program) to predict where larval juvenile Pacific Cod will drift after spawning and settle to the benthos for their first year of life. The Individual Based Model (IBM) predicted rates of dispersal and settlement around the shoreline of the Gulf of Alaska. In the fall of 2020 and 2021, we will be sampling areas the IBM predicts to be habitats with high, medium, and low abundance of juvenile Pacific Cod using video footage. This study is funded by the North Pacific Research Board.

For more information, contact Johanna Vollenweider (907) 789-6612 or Katharine Miller, (907) 789-6410.

Climate change and location choice in the Pacific cod longline fishery
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. For further information, contact Alan.Haynie@noaa.gov.

2. Stock Assessment

Eastern Bering Sea (REFM)
The EBS Pacific cod model has undergone numerous model changes and refinements over the last decade. Preliminary models are reviewed in the spring of each year. The model uses the Stock Synthesis 3

framework. A major issue in recent years has been an apparent shift in the distribution of EBS Pacific cod into the northern Bering Sea (NBS), an area which historically has not been surveyed. Surveys in the NBS were conducted in 2010, 2017, and 2018 and regular NBS surveys are likely to be conducted into the future as EBS groundfish stocks experience changes in distribution. The lack of survey data in the NBS has caused assessment difficulties for Pacific cod and other stocks.

Many changes to the stock assessment model have been considered since the 2017 assessment. Sixteen models were considered in the preliminary assessment, which included last year's model, models with updated treatment of the NBS survey data, and complex models that included time-varying parameters and/or multiple areas with movement between them. Eight models were presented in the final assessment. None of the final assessment models considered multiple areas, but some did treat the EBS and NBS surveyed areas as separate time-series. Updated data for the 2018 assessment included abundance and size composition from the EBS bottom trawl survey through 2018, total catch through 2018, and fishery and survey age compositions through 2017.

Four different survey abundance time-series were calculated using three different areas: the standard EBS shelf survey area, the expanded EBS shelf survey area which includes strata 82 and 90, and the NBS area with the truncated survey stations used in 2018. The expanded EBS survey area was preferred over the standard area and showed a 32% decline in abundance (numbers of fish) from 2017 to 2018. The NBS survey showed a 78% increase in abundance from 2017 to 2018, and summing the expanded EBS survey and the NBS survey results in a 1.8% decrease in abundance from 2017. Estimated spawning biomass (from the preferred model) increased from 2009 through 2017 to 303,676 t, and is predicted to decrease to 290,205 t in 2019, which is still above B40%. Recruitment is estimated to have been below average since the 2014 year class.

The maximum permissible ABC for 2019 as calculated using the present model fit is 181,000 t. However, risk matrix analysis for this stock resulted in "concern" levels of 3 for all categories (assessment, population dynamics, and environmental/ecosystem). This conclusion was based on the uncertainty in the distribution of Pacific cod, dramatic declines in the EBS shelf survey index, recent poor environmental conditions, lack of incoming recruitment, and structural uncertainty across presented assessment models. As a result, the recommended 2019 ABC was reduced to 144,800 t. The 2019 OFL from the new model is 216,000 t, which is greater than the projected OFL from the previous assessment. The 2019 projected OFL, given a 2019 ABC of 144,800 t is 183,000 t, and would be164,000 t with a 2019 ABC of 181,000 t. The stock would drop well into Tier 3b in 2020 if the full ABC of 181,000 t were taken in 2019, but would almost remain in Tier 3a in 2020 with the recommended 2019 ABC of 144,800 t.

Aleutian Islands (REFM)

This stock has been assessed separately from Eastern Bering Sea Pacific cod since 2013, and managed separately since 2014. The stock has been managed under Tier 5 (OFL = F * biomass, where F = M) since it was first assessed separately. No changes were made to assessment methodology, but data were updated with recent observations. Catch data from 1991-2018
were updated by including updated catch for 2017 and preliminary catch data for 2018, and the 2018 biomass point estimate and standard error were added to the survey time series. A random effects model using Aleutian Islands trawl survey biomass observations from 1991 to 2018 was used to estimate the biomass and provide management advice.

After declining by more than 50% between 1991 and 2002, survey biomass has since stayed in the range of 50-90 kilotons. The 2018 Aleutians survey biomass estimate (81,272 t) was down about 4% from the 2016 estimate (84,409 t). The estimate of the natural mortality rate is 0.34, which was taken from the 2018 EBS Pacific cod assessment model. The recommended ABC is 20,600 t, and OFL is 27,400 t.

Gulf of Alaska (REFM)
In 2017, survey biomass estimates for GOA Pacific cod plummeted. This was attributed to an increase in natural mortality resulting from increased metabolic costs (due to anomalously high water temperatures) and reduced prey availability. In 2017 this event was modeled by allowing natural mortality (M) during 2015-2016 to vary from the rest of the time series. For 2018, a similar model was used with the following changes: the M "block" was widened to include 2014-2016, age composition data before 2007 were omitted, and length-based rather than age-based maturity was applied due to a bias discovered in age readings prior to 2007. Data updated from the 2017 assessment included catch for 2017 and 2018 (preliminary catch projected through the end of 2018), fishery size composition for 2017 and 2018, 2018 AFSC longline survey abundance index (Relative Population Numbers, RPN) and size composition, and age data from the 2017 AFSC bottom trawl survey and 2012-2017 fisheries. The longline survey RPN for 2018 dropped 40% from 2017 to 2018 and was 73% lower than the 2015 RPN estimate.

The B40% estimate was 68,896 t, with projected 2019 spawning biomass of 34,701 t. The 2012 year-class remains the strongest in the recent period, followed closely by the 2013 year-class. Recruitment since 2013 is below the 1977-2015 average. Spawning biomass was projected to decline through 2020. The 2018 spawning biomass is estimated to be at 20.4% of B100%. The F35% and F40% values are 0.76 and 0.62, respectively. The maximum permissible ABC is 19,665 t but the authors recommended that it be reduced so that the projected biomass is above 20% of B100% in 2019 (if the stock is below B20%, directed fishing is prohibited due to Steller sea lion regulations). The recommended ABC is 17,000 t for 2019 which is a 6% decrease from the 2018 ABC of 18,000 t. Since the 2014 assessment, the random effects model has been used for Pacific cod apportionment.

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

E. <u>Walleye Pollock</u>

1. Research

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

Age-0 Walleye pollock were collected during the late summer BASIS survey in the southeastern Bering Sea (SEBS) from 2003-2017, except for 2015. The Average Energy Content (AEC; kJ/fish) was calculated as the product of the average individual mass, for all age-0 pollock in the tow, and the average energy density. The product of the two averages represents the average energy content for an individual age-0 pollock in a given year.

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 as well as prey conditions during the age-0 period. Late summer represents a critical period for energy allocation in age-0 pollock and their ability to store energy depends on water temperatures, prey quality, and foraging costs. 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. Zooplankton taxa available in cold years are generally higher in lipid content and the ability of age-0 pollock to store limit is maximized in cold water.

Energy density was at a minimum in 2003 (3.63 kJ/g), a warm year, and at a maximum in 2010 (5.26 kJ/g), a cold year (Figure 1). In contrast, the size (mass or length) of the fish has been less influenced by thermal regime. We relate AEC of the age-0 pollock to the number of age-1 recruits per spawner (R/S) using estimates of adult female spawning biomass as the number of spawners. Relating the AEC of age-0 pollock to recruitment from the age-structured stock assessment indicates the energetic condition of pollock prior to their first winter predicts their survival to age-1. The AEC of age-0 pollock in warm years between 2003-2017 accounts for 74% of the variation in age-1 recruits per spawner, but only 9% in cold years between 2003-2017.

The model fit under cold years suggests survival and recruitment success are more variable and likely the result of a suite of processes, including bottom-up and top-down pathways. 2017 was a moderate year in the southeastern Bering Sea in terms of thermal conditions, with an extensive, yet narrow cold pool. As such, it is difficult to predict the success of the 2017 year-class.

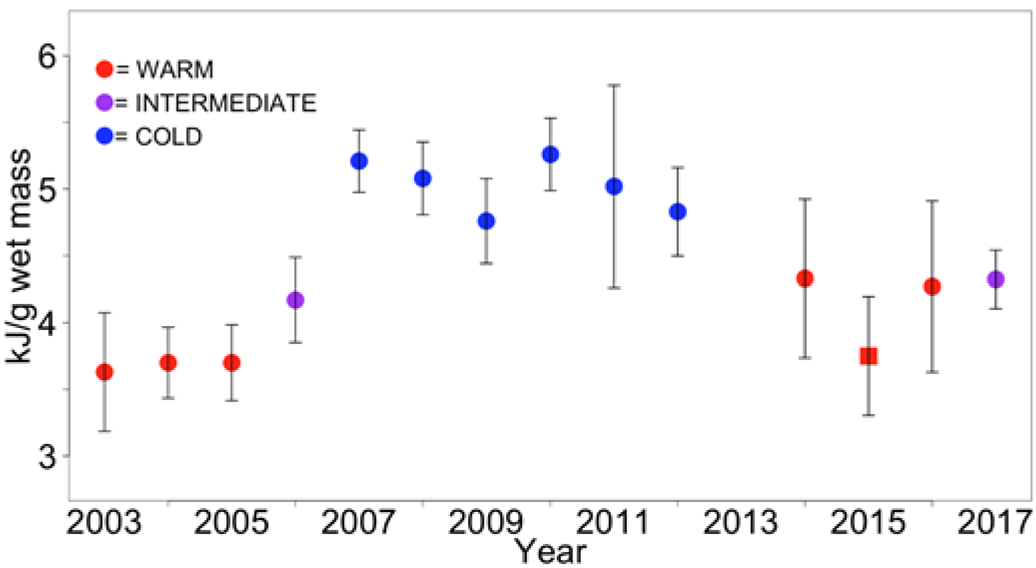


Figure 1: Average energy density (kJ/g) of age-0 Walleye pollock (*Gadus chalcogrammus*) collected during the late-summer BASIS survey in the eastern Bering Sea 2003-2017. Fish were collected with a surface trawl in all years except in 2015, when an oblique trawl was used.

For more information contact Elizabeth Siddon (Elizabeth.Siddon@noaa.gov).

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

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. 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. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-4 from 1964 to 2018, but not significantly correlated for the shorter period (1997-2018) (Table 1).

The 2018 TC index value of -4.06 was slightly above the long-term average of -4.61. Therefore, we expect average recruitment of pollock to age-3 in 2020 from the 2017 year class (Figure 2). However, both the late summer sea surface temperature (10.67 °C) in 2017 and spring sea temperatures (6.61 °C) in 2018 were warmer than the long-term average of 9.8 °C in late summer and 5.2 °C in spring since 1949. 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.

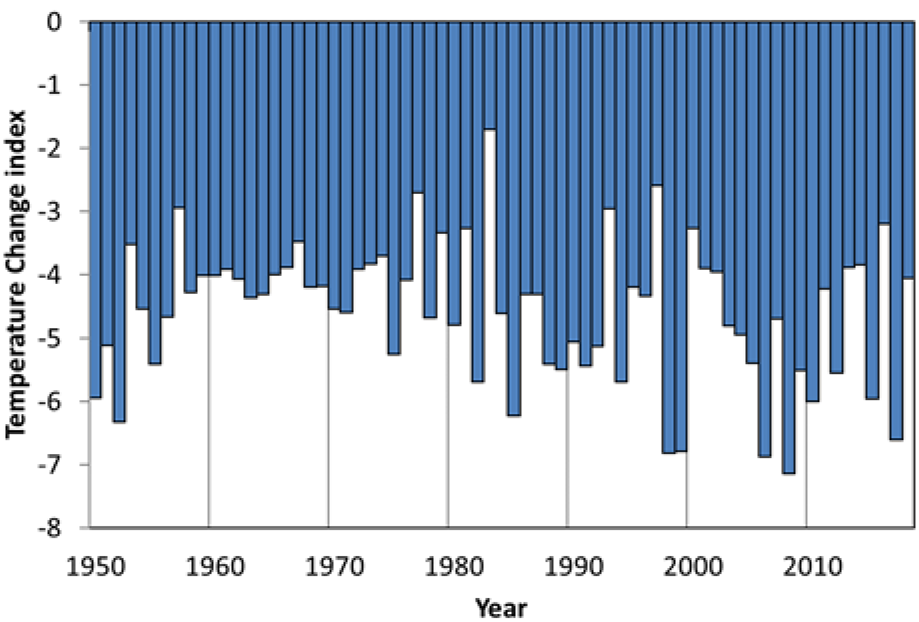


Figure 1: The Temperature Change index values from 1949 to 2018. Values represent the differences in sea temperatures on the south eastern Bering Sea shelf experienced by the 1948-2017 year classes of pollock. Less favorable conditions (more negative values) represent a warm summer during the age-0 life stage followed by a relatively cool spring during the age-1 life stage. More favorable conditions (less negative values) represent a cool summer during the age-0 life stage followed by a relatively warm spring during the age-1 life stage.

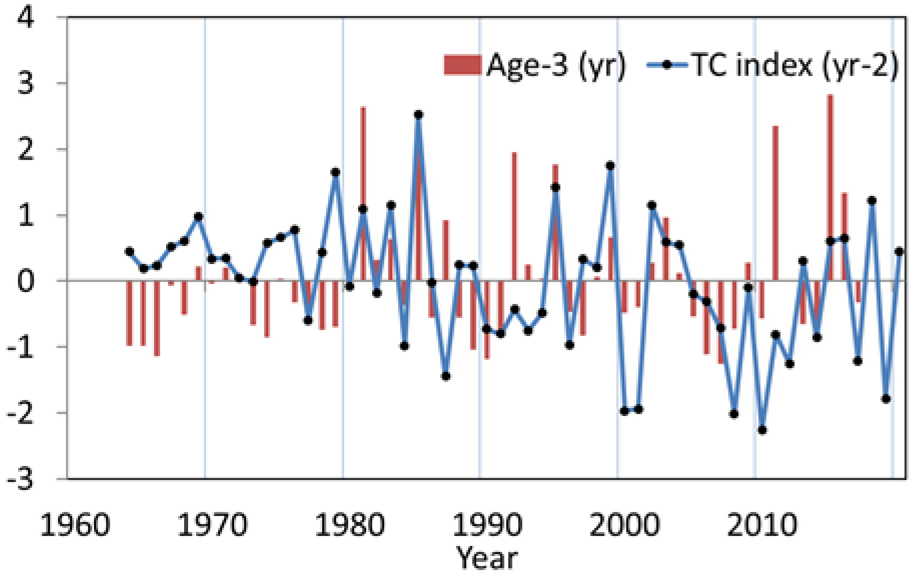


Figure 2: Normalized time series values of the temperature change index (t-2) from 1964-2020, showing conditions experienced by the 1961-2017 year classes of pollock during the summer age-0 and spring age-1 life stages. Normalized values of the estimated abundance of age-3 walleye pollock in the eastern Bering Sea from 1964-2017 (t) for the 1961-2014 year classes. Age-3 walleye pollock estimates are from Table 28 in Ianelli et al. 2017. The TC index indicate above average conditions for the 2015 and 2017 year class and below average conditions for the 2016 year class.

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
1964-2017	**0.35**	**0.35**	**0.33**	0.27	0.23	0.21
1996-2017	0.38	0.40	**0.44**	0.39	0.36	0.41

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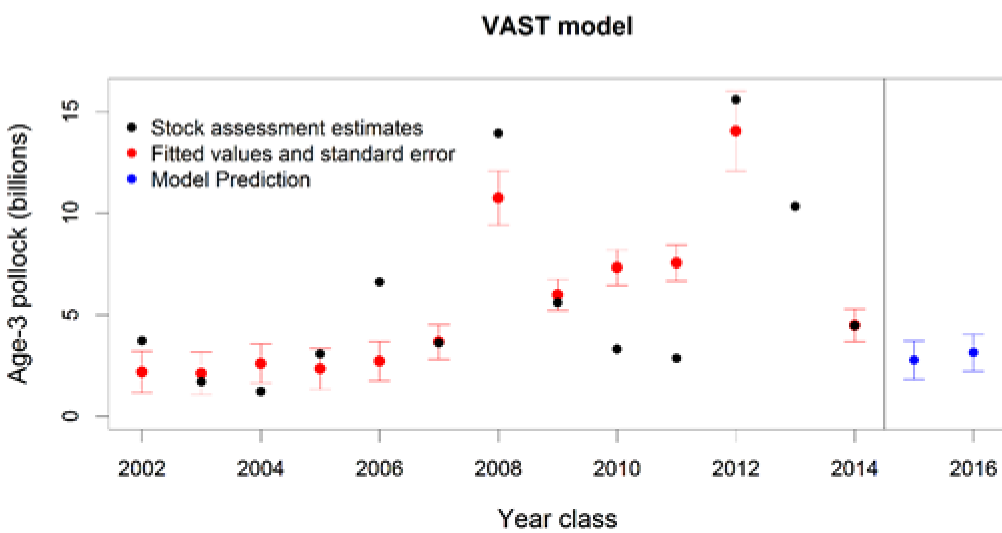
Large copepod abundance (observed and modeled) as an indicator of pollock recruitment to age-3 in the southeastern Bering Sea - ABL

Interannual variations in large copepod abundance were compared to age-3 walleye pollock (*Gadus chalcogrammus*) abundance (billions of fish) for the 2002-2016 year classes on the southeastern Bering Sea shelf, south of 60°N, < 200 m bathymetry. The large copepod index sums the abundances of *Calanus* *marshallae/glacialis* (copepodite stage 3 (C3)-adult), *Neocalanus* spp. (C3-adult), and *Metridia pacifica* (C4-adult), taxa typically important in age-0 pollock diets. Zooplankton samples were collected with oblique bongo tows over the water column using 60 cm, 505 µm mesh nets for 2002-2011, and 20 cm, 153 µm mesh and 60 cm, 505 µm nets, depending on taxa and stage for 2012-2016. Over the time period there were four warm years (2002-2005), followed by one average (2006), six cold (2007-2012), and three warm years (2014-2016). Zooplankton data was not available for 2013. Age-3 pollock abundance was obtained from the stock assessment report for the 2002-2014 year classes (Ianelli et al., 2017). Two estimates of a time series of large copepod abundances were calculated: the first used observed survey means of abundance data (number m^{-2}) and the second used the means estimated from the geostatistical model, Vector Autoregressive Spatial Temporal (VAST) package version 4_2_0 (Thorson et al. 2015). We specified 50 knots, a log normal distribution, and the delta link function between probability or encounter and positive catch rate in VAST.

Positive, significant, linear relationships were found between observed and VAST modeled mean abundances of large copepods collected during the age-0 stage of pollock and stock assessment estimates of age-3 pollock for the 2002-2014 year classes (Figure 1). Our regression models predict an abundance of 2.83 and 3.39 billion age-3 pollock for the 2015 and 2016 year classes, respectively. Likewise, estimates using VAST predict an abundance of 2.77 and 3.15 billion age-3 pollock for the 2015 and 2016 year classes, respectively. Our results suggest that decreases in the availability of large copepod prey, which are high in lipid content, in 2015 and 2016 were not favorable for age-0 pollock overwinter survival and recruitment to age-3. If the relationship between large copepods and age-3 pollock remains significant in our analysis, the index can be used to predict the recruitment of pollock three years in advance of recruiting to age-3.



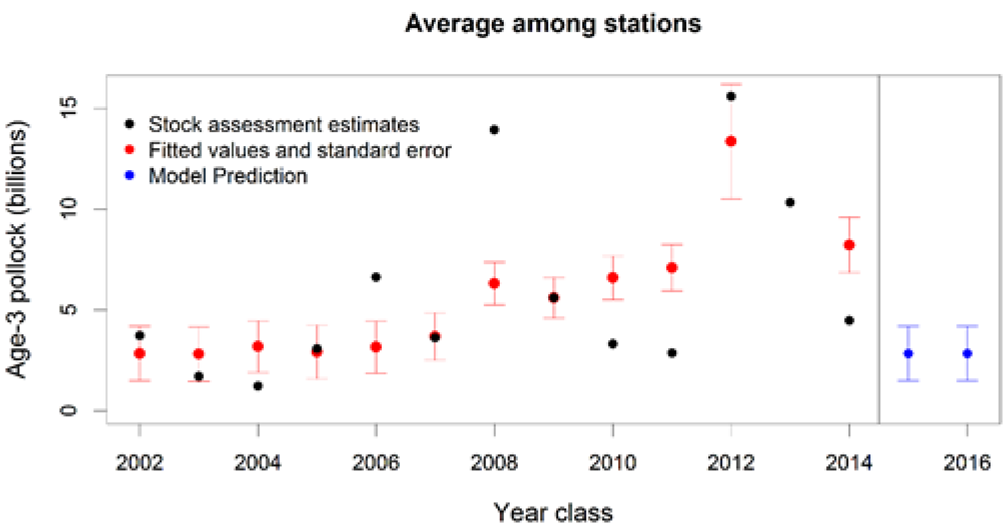


Figure 1. Fitted means and standard errors (red) of the age 3 pollock abundance estimated from the linear regression models using means of large copepods from observed data (top) and VAST model (bottom), and pollock stock assessment estimates (black) from Ianelli et al. (2017). Predicted estimates of age 3 pollock for 2015 and 2016 year classes (recruited into fishery as age 3's in 2018 and 2019, respectively) are shown in blue.

Literature cited:

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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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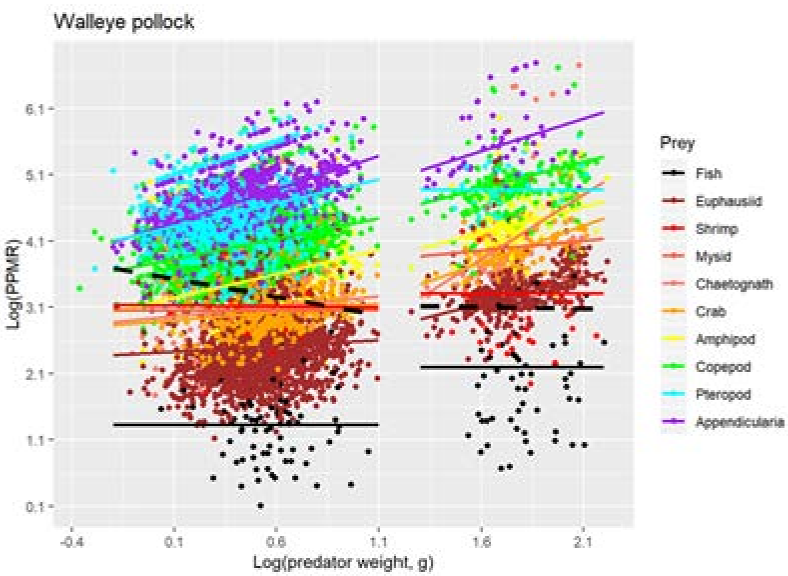
Gulf of Alaska

Taxonomy, Body Size, and the Predator-Prey Mass Ratio: Three Fish Species in the Gulf of Alaska - RPP
Matthew T. Wilson, David G. Kimmel, Kathryn L. Mier

The predator-prey mass ratio (PPMR), a parameter of size-structured food web models, has received much scrutiny about whether it varies with predator body size. PPMR relates theoretically to trophic efficiency and determines feeding kernel dynamics. We demonstrate that taxonomy and ontogeny affect the outcome of PPMR size-independence hypothesis tests by governing predator diet. We focused on the trophic link between zooplankton and 3 species of small neritic forage fishes: capelin *Mallotus catervarius*, eulachon *Thaleichthys pacificus*, and walleye pollock *Gadus chalcogrammus*, which were subdivided into age-0 and older (age-1) groups. These fishes support the piscivore-dominated, fishery-rich coastal ecosystem of the Gulf of Alaska (GOA). Body weight data were from 3615 individual predators that contained 163845 prey. The size-independence hypothesis was most commonly rejected because predators outgrew specific prey taxa, as indicated by a positive slope (Fig. 1). Predators that transitioned from small- to larger-sized taxa were able to maintain (slope = 0) or decrease (negative slope) PPMR. We hypothesized that maximum trophic efficiency from zooplankton to nektonic forage fishes occurs when the community is dominated by predators able to fully exploit euphausiids. We concluded that taxonomic and ontogenetic variation in predator diets were fundamental to whether the realized PPMR was independent of predator body size and this related to trophic transfer efficiency. Development of detailed, realistic size-structured food web models should consider taxonomic and inter-annual effects on the size-independence of realized PPMR to more realistically estimate fish production.



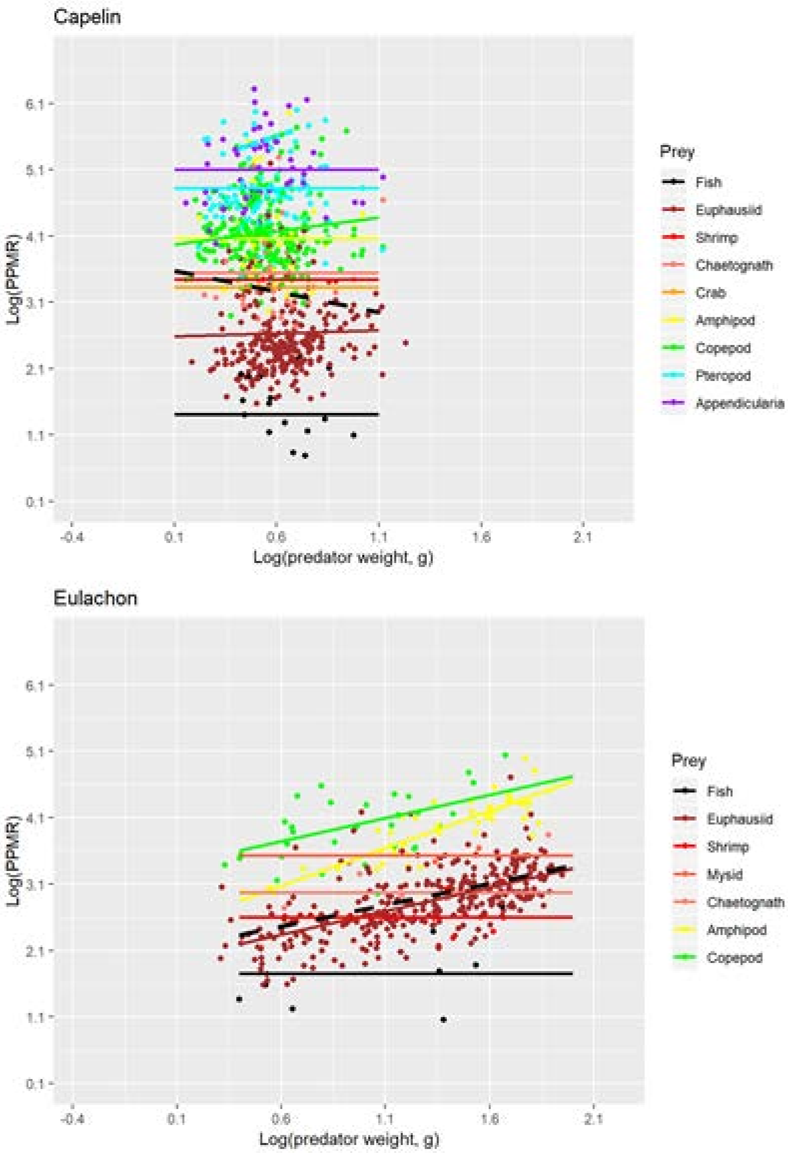


Figure 1. Log_{10} predator-prey body mass ratios (PPMR) by log_{10} body weight for individual predators and prey group. Mean functional relationships based on modified individual-predator prey weights (i.e., by prey group) are represented by thin solid lines; prey groups are sorted by mean individual weight. For comparison, mean functional relationships based on prey weights pooled across taxa are represented by thick dashed black lines.

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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 walleye pollock (n=503) were found southwest of Kodiak Island (Region A) and larger, less numerous walleye 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 walleye 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.

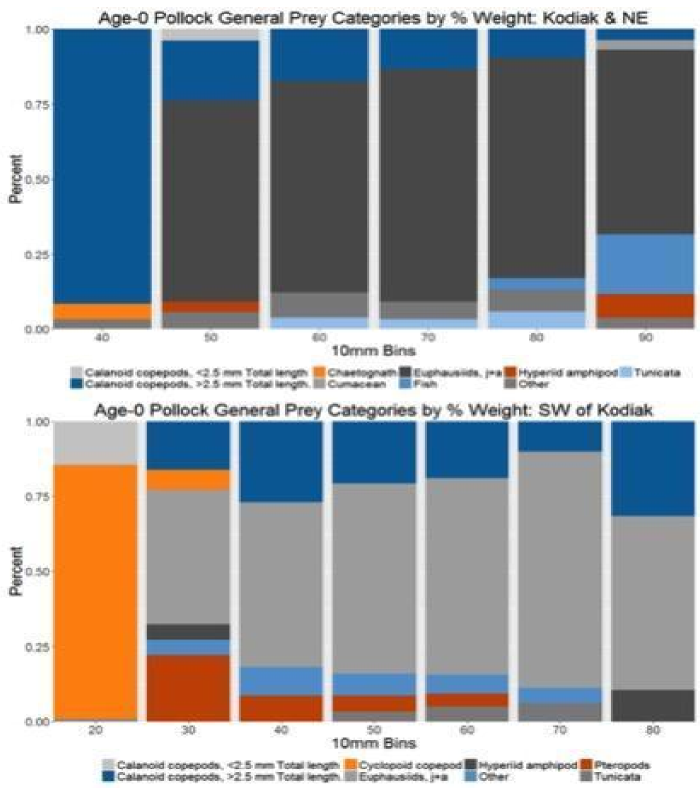

Figure 1. Age-0 pollock diet composition (percent weight) by 10mm length bins. The “Other” prey category was the sum total of prey categories that comprised less than 3% of the total prey weight in both regions.

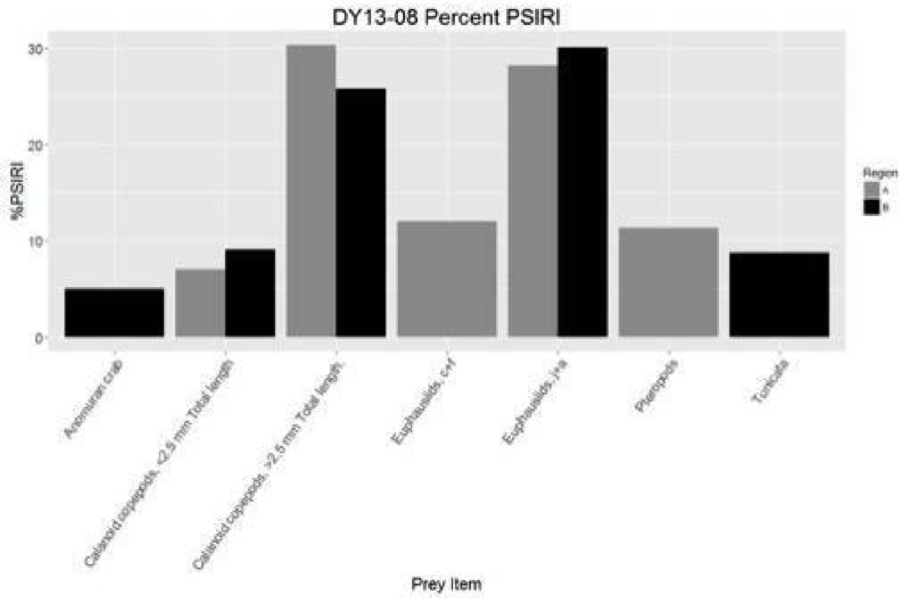

Figure 2. The top five selected prey taxa as determined by the PSIRI for stations southwest of Kodiak Isl. (Region A) and stations surrounding and to the northeast of Kodiak Isl. (Region B).

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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.

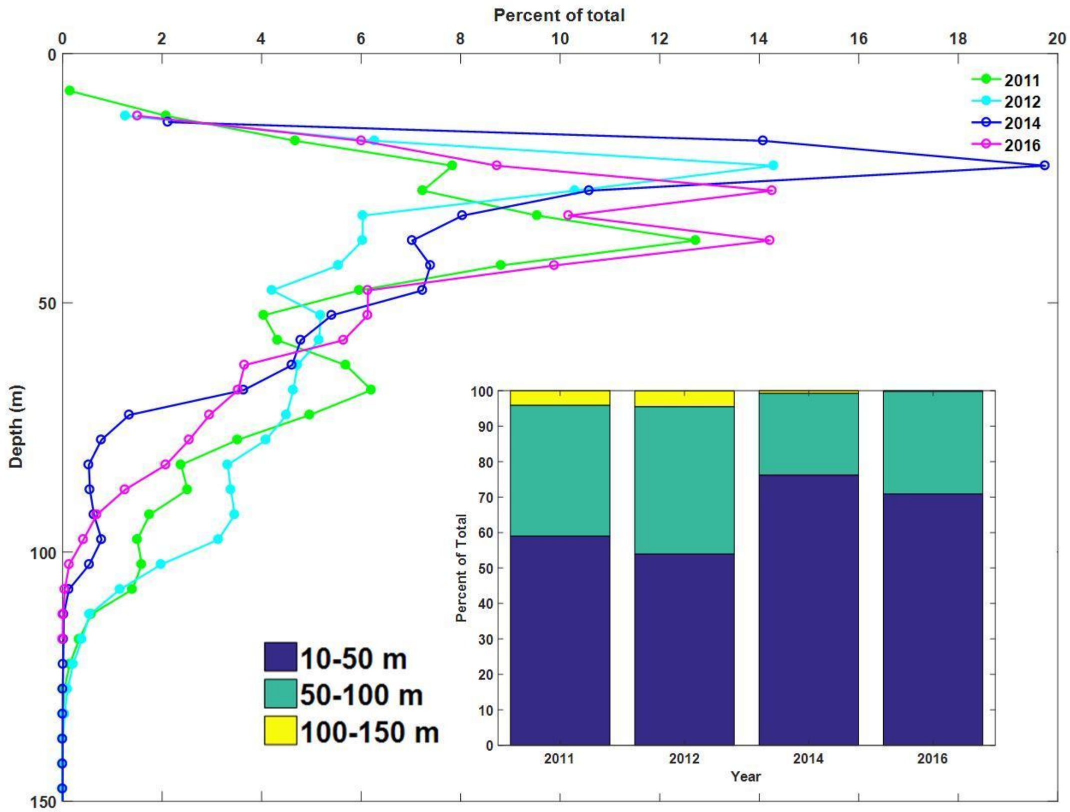

Figure 1. Depth distribution as percent of total abundance (fish nmi^{-2}) of age-0 pollock estimated by acoustic-trawl methods in 2011,2012, 2014,2016. Both plots show a shift in distribution towards the surface during warm years (2014, 2016). Colder years show a shift towards deeper waters.

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Management strategies for the eastern Bering Sea pollock fishery with climate change -- ESSR
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 ICES J Mar Sci 68: 1297–1304*) 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. The results of this project are summarized in Seung and Ianelli (2017), which is currently under review / revision at a peer-reviewed journal. For further information, contact Chang.Seung@noaa.gov

An examination of size-targeting in the Bering Sea pollock catcher processor fishery -- ESSR
Weight-based harvest quota regulations do not restrict the size of individual fish that fill that quota, although fish of different sizes may present varying fishery profit opportunities and have different impacts on the stock's growth potential. This paper empirically links revenue per unit of quota and fish size by investigating the catcher-processor fleet of the U.S. Bering Sea pollock fishery, where larger fish can be made into higher-value fillets, instead of surimi that is lower value on average. We then use a dynamic age-structured model to illustrate how some harvesters target smaller fish to decrease their own harvesting costs, which imposes a stock externality on the fleet. This is a working paper that is being revised for submission to a peer-reviewed journal. We estimate the potential increase in profit if a manager hypothetically controls for the size of fish caught in the pollock fishery. Fishers benefit due to higher prices coming from higher-value products, and greater catches because of a larger biomass. For further information contact Alan.Haynie@noaa.gov.

2. Stock Assessment

Eastern Bering Sea (REFM)
This is a mature assessment done annually with new catch, survey, and composition information. For the 2018 assessment this included data from the 2018 NMFS bottom-trawl (BTS) and acoustic-trawl (ATS) surveys as well as total catch through 2018. In addition, opportunistic acoustic data from vessels (AVO) conducting the 2018 BTS was used as an added index of pollock biomass in mid- water. Observer data for catch-at-age and average weight-at-age from the 2016 fishery were finalized and included.

Spawning biomass in 2008 was at the lowest level since 1981 but had increased by a factor of 2.52 by 2017, and has now started trending downward again. 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 (above average by factors of 2.19, 2.43, and 1.80 for the post-1976 time series, respectively), along with spawning exploitation rates below 20% since 2008. Spawning biomass is projected to be above BMSY in 2019 by a factor of 1.36.

The updated estimate of BMSY from the present assessment is 2.280 million t, 12% above last year's estimate of 2.043 million t. Projected spawning biomass for 2019 is 3.107 million t. 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 0.510, 9% above last year's value of 0.466. The harvest ratio of .510 is multiplied by the geometric mean of the projected fishable biomass for 2019 (6.073 million t) to obtain the maximum permissible ABC for 2019, which is 3.096 million t, down 10% from the maximum permissible ABCs for 2019 projected in last year's assessment. However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. Their reasons for doing so are listed in the "risk matrix" contained in the SAFE chapter, where assessment concerns are categorized as

Level 1 ("normal"), and population dynamic and environmental/ecosystem concerns are both categorized as Level 2 ("substantially increased concern"). The authors conclude that these levels of concern warrant setting the 2019 and 2020 ABCs at 2,163,000 t and 1,792,000 t (reductions of 30% and 26% from the corresponding maxABCs).

The OFL harvest ratio under Tier 1a is 0.645, 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 2019 determines the OFL for 2019, which is 3.914 million t. The current projection for OFL in 2020 given a projected 2019 catch of 1.350 million t is 3.082 million t.

In addition to the ecosystem considerations listed in the SAFE chapter, an 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, when CEATTLE is run in single-species mode, the 2019 "target" ABC value is within 5% of the authors' and Team's recommended 2019 ABC value. When CEATTLE is run in multi-species mode, the 2019 "target" ABC is 37% higher than the author's and Team's 2019 ABC value. The CEATTLE estimates of age 1 natural mortality are trending towards average after a peak in 2016. The climate-enhanced recruitment projections from CEATTLE model indicates the increase in 2018 age 1 recruitment may have been due to favorable environmental conditions in 2017. The model projects a decrease in 2019 age 1 recruitment to levels below 2017 age 1 recruitment due to poor environmental conditions in the spring-fall of 2018.

Aleutian Islands (REFM)
In 2018 there was a full assessment for AI pollock. The model accepted in 2015 was used again for this year's assessment. New data included catches through 2018, biomass data from the 2018 AI bottom trawl survey, and 2016 AI bottom trawl survey age composition data. In 2018, for the first time in eight years, there was a directed pollock fishery although it was small at 188 t. As of October 2018 there had been only 1,590 t of incidental catch, primarily in the Atka mackerel and rockfish fisheries.

This year's assessment estimates that spawning biomass reached a minimum level of about B35% in 2003 and then generally increased during the period with no directed fishery (1999-2017), with a projected value of B47% for 2019. The increase in spawning biomass since 1999 has resulted more from a dramatic decrease in harvest than from good recruitment, as the 2015 year class is the first since 1989 to exceed the 1977-2015 average (the 2015 year class is about 2% above average). The model estimates 2019 spawning biomass at 95,253 t which is above the B40% value of 81,312 t, and estimates the values of F40% as 0.331 and F35% as 0.415. The 2019 maximum permissible ABC and OFL are 52,887 t and 66,981 t, respectively.

Bogoslof Island (REFM)
Harvest recommendations for Bogoslof-area pollock are made by multiplying the biomass estimate from the NMFS acoustic-trawl survey by an estimate of natural mortality. The biomass estimate is made using a random effects model used widely in AFSC assessments. Natural mortality was re-evaluated using the age-structured model presented in previous assessments (unchanged except for new survey, fishery, and age composition data from the survey).

Between 1997 and 2016, biomass estimates varied between 508,051 t and 67,063 t. The most recent acoustic-trawl survey of the Bogoslof spawning stock was conducted in March of 2018 and estimated a biomass estimate of 663,070 t, resulting in a random-effects survey average of 610,267 t. Assuming FOFL =

M = 0.3 and FABC = 0.75 x M = 0.225, OFL for 2019 is 183,080 t and the maximum permissible ABC for 2019 is 137,310 t. The OFL and ABC for 2020 is the same.

Gulf of Alaska (REFM)
The 2018 GOA pollock assessment used a new model similar to the one used in 2017. The main difference in the 2018 suite of models is that the winter acoustic survey time series includes a net-selectivity correction, which results in increased estimates of abundance of age-1 and to a lesser degree age-2 fish, while the estimates for adult (3+) fish are slightly reduced. The effects on overall survey biomass are small. The abundance estimates for age-1 and age-2 pollock from the Shelikof Strait survey were used as separate indices in the model. The 2018 model also removed a power term on the age-1 pollock index, which was thought to no longer be structurally appropriate given the net- selectivity corrected data which greatly increased age-1 abundance estimates. Data were updated to include 2017 total catch and catch-at-age from, 2018 biomass and age composition from the Shelikof Strait acoustic survey, 2017 age composition from the NMFS bottom trawl survey, 2018 biomass from the ADFG trawl survey, and 2017 age composition from the summer GOA-wide acoustic survey.

In 1998, the stock dropped below B40% 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 decline in 2019 as the 2012 year class starts to decline in size. Survey data in 2018 are contradictory, similar to 2017, with acoustic surveys indicating the 2nd largest biomass in 30 years and the ADF&G bottom trawl survey showing a slight increase but still remaining near historic lows. These divergent trends are likely due to changes in the availability of pollock to different surveying methods. The model estimate of female spawning biomass in 2019 is 345,352 t, which is 62% of unfished spawning biomass (based on average post-1977 recruitment) and above the B40% estimate of 221,000 t.

This year's pollock assessment also incorporated a risk assessment matrix for evaluating whether a reduction from the maximum permissible ABC is warranted. This represents a trial approach in assessing additional risks to the stock that may be missed within the stock assessment model. The author scored the current risk conditions as Level 2 across all categories indicating a substantially increased level of concern, with the details of the scoring rationale provided in the document. Reduction from maximum ABC was calculated by averaging the projection of the current maxABC from last year's assessment with the maxABC for 2019. This alternative produced a 14.3% reduction over the maxABC for 2019 which the Team noted was quite similar to the author's recommended reduction.

Harvest specifications for GOA pollock are set on an area basis. For pollock in the Gulf of Alaska west of 140° W longitude , the model estimated 2019 age-3+ biomass is 1,126,750 t, the 2019 OFL is 194,230 t, and the 2019 ABC is 135,850 t (a decrease of 16% from the 2018 ABC). The 2019 Prince William Sound guideline harvest level (managed by the Alaska Department of Fish & Game) is 3,396 t (2.5% of the ABC). For pollock in southeast Alaska the ABC is 8,773 t for 2019 and 2020. 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.

For further information regarding BSAI pollock contact Dr. James Ianelli (jim.ianelli@noaa.gov); for further information regarding GOA pollock contact Dr. Martin Dorn (martin.dorn@noaa.gov).

F. Pacific Whiting (hake)

There are no hake fisheries in Alaska waters.

G. Rockfish

1. Research

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 review) Seasonal habitat use and community structure of rockfishes in the Gulf of Alaska.

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

Rockfish Reproductive Studies - RACE GAP Kodiak
RACE groundfish scientists initiated a multi-species rockfish reproductive study in the Gulf of Alaska with the objective of providing more accurate life history parameters to be utilized in stock assessment models. There is a need for more detailed assessment of the reproductive biology of 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 2019 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 2022.

Northern and Dusky Rockfishes

The reproductive potential of northern rockfish (*Sebastes polyspinis*) and dusky rockfish (*S. variabilis*) in the Gulf of Alaska was examined by measuring the success of oocyte and embryo development. The potential annual fecundity, annual failure rates, and relationships of these parameters to maternal size were examined. Both species have a seasonally synchronous reproductive cycle with parturition occurring in the late spring to early summer. Northern rockfish had a mean relative fecundity of 165.1 oocytes/g for samples captured in December and 109.6 embryos/g for samples captured in May. Dusky rockfish had a mean relative fecundity of 152.1 oocytes/g for samples collected in December and 108.1 embryos/g for samples captured in May. Reproductive failure was easiest to discern for the May samples with both partial and total failure primarily occurring due to lack of oocyte development or fertilization failure. Northern rockfish had a total reproductive failure or skipped spawning rate of 16.3% and dusky rockfish had total reproductive failure rate of 15.6% during this period. Larger dusky and northern rockfish had higher relative fecundities and lower rates of reproductive failure.

Conrath, C. (in press) Reproductive Potential of Dusky and Northern Rockfish within the Gulf of Alaska. Fishery Bulletin.

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.

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

Shortraker rockfish

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

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

2. Assessment

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

In the BSAI, POP are assessed using an age-structured population dynamics model implemented in the software program AD Model Builder. For 2018, new data included updated catch data through 2017, projected 2018-2020 catch estimates, fishery age data from 2015 and 2017, fishery length data from 2016, biomass estimate and length data from the 2018 Aleutian Islands (AI) bottom trawl survey, age data from the 2016 AI and eastern Bering Sea (EBS) bottom trawl surveys, updated length-at-age, weight-at-age, and age-to-length conversion matrices, and reweighted age and length data using the iterative reweighting procedure. The only change to the assessment methodology was an increase in the number of year nodes for the fishery selectivity spline (from 4 nodes to 5).

The 2018 survey biomass estimates in the Aleutian Islands increased by 3% from 2016, continuing the high survey biomass trend over the last three surveys. The 2018 estimates in the AI regions were within 6% of the 2016 estimates; however, there was a large increase (30%) in the EBS area between 2016 and 2018. These continued high survey biomass estimates have contributed to a substantial increase in estimated stock size in recent years; however, there remains a poor residual pattern in the fit to this survey index.

Spawning biomass is projected to be 399,024 t in 2019 and decline to 386,835 t in 2020. The 2000, 2005, and 2008 year classes are estimated to be 198%, 99%, and 104% above average, respectively.
The maximum permissible value of FABC (F40%) under Tier 3a is 0.079, which results in a recommended 2019 ABC of 50,594 t and 2020 ABC of 49,211 t. The OFL fishing mortality rate (F35%) is 0.095. which results in a 2019 OFL of 61,067 t and 2020 OFL of 59,396 t.

The ABC was apportioned regionally based on the proportions in combined survey biomass as follows (values are for 2019): EBS = 14,675 t, Eastern Aleutians (Area 541) = 11,459 t, Central Aleutians (Area 542) = 8,435 t, and Western Aleutians (Area 543) = 16,025 t. The recommended OFLs for 2019 and 2020 are not regionally apportioned.

For more information contact Paul Spencer,(206) 526-4248 or paul.spencer@noaa.gov.

Pacific Ocean Perch -- Gulf of Alaska - ABL
In 2018 the Pacific ocean perch assessment was presented in an executive summary format as a scheduled “off-year” assessment. Full assessments are scheduled to coincide with years when a Gulf of Alaska trawl survey is conducted. Therefore, only the projection model was run, with updated catches. New data in the 2018 assessment included updated 2017 catch and estimated 2018 catch. No changes were made to the assessment model.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 176,934 t in 2019 and to decrease to 172,345 t in 2020. The SSC has determined that 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 117,448 t, 0.094, and 0.113, respectively. Spawning biomass for 2019 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier “a” of Tier 3. The 2019 and 2020 catches associated with the $F_{40\%}$ level of 0.094 are 28,555 t and 27,652 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2019 and 2020 OFLs are 33,951 t and 32,876 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2019: Western GOA = 3,227 t, Central GOA = 19,646 t, and Eastern GOA = 5,682 t. The Eastern GOA is further subdivided into west (called the West Yakutat subarea) and east (called the East Yakutat/Southeast subarea, where trawling is prohibited) of 140° W longitude using a weighting method of the upper 95% confidence of the ratio in biomass between these two areas. For W. Yakutat the ABC in 2019 is 3,296 t and for E. Yakutat/Southeast the ABC in 2019 is 2,386 t. The recommended OFL for 2019 is apportioned between the Western/Central/W. Yakutat area (31,113 t) and the E. Yakutat/Southeast area (2,838 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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Dusky Rockfish-- Gulf of Alaska -- ABL
In 2018, an age-structured stock assessment was conducted for Gulf of Alaska dusky rockfish. Model data were updated to include survey age compositions for 2015 and 2017, final catch for 2015, 2016, and 2017 and preliminary catch for 2018, fishery age compositions from 2014 and 2016, and fishery size compositions for 2015 and 2017. Additionally, geostatistical model-based trawl survey biomass estimates for 2017 were updated and included. There were no changes in the assessment methods. The stock assessment is posted here https://www.afsc.noaa.gov/REFM/Docs/2017/GOAdusky.pdf.

Estimates of female spawning biomass for 2019 and 2020 from the current year (2018) assessment model are 20,342 t and 20,106 t, respectively. Both estimates are above the $B_{40\%}$ estimate of 18,535 t. The dusky rockfish stock is in Tier 3a and the recommended maximum permissible 2019 ABC of 3,700 t was from the updated projection model. This ABC is 6.5% lower than the 2018 ABC of 3,957 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 (t) for 2018 and 2019.

	Western	Central	Eastern	[Eastern sub-areas]		Total
Area Apportionment	21.1%	74.7%	4.2%	W.Yak	EY/SE	100%
2019 ABC (t)	781	2,764	155	95	60	3,700
2020 ABC (t)	774	2,742	154	94	60	3,670

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 stock assessment prioritization guidelines. Therefore, only the projection model was run, with updated catches. New data in the 2018 assessment included updated 2017 catch and estimated 2018-2020 catches.

Exploitation rates (i.e., catch/biomass) have averaged 0.015 from 2004-2018, which is below the exploitation rate associated with fishing at F40%. 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 104,201 t in 2019 and to decline to 102,480 t in 2020. Exploitation rates by area since 2004 appeared to be low in all areas in most years with some increase in all areas except the eastern AI in 2018.

The current estimates of B40%, F40%, and F35% are 65,870 t, 0.065, and 0.080, respectively. The maximum permissible value of FABC under Tier 3a is 0.065, which results a recommended 2019 ABC of 12,664 t and 2020 ABC of 12,396 t. The OFL fishing mortality rate is 0.080, which results in a 2019 OFL of 15,507 t and 2020 OFL of 15,180 t.

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

Northern Rockfish – Gulf of Alaska-ABL

In 2018, an assessment was conducted for Gulf of Alaska northern rockfish. Model data were updated to include survey biomass estimates for 2017, survey age compositions for 2015 and 2017, final catch for 2015, 2016, and 2017, preliminary catch for 2018, fishery age compositions from 2014 and 2016, and fishery size compositions for 2015 and 2017. The assessment model was changed for this year to include use of the Vector Autoregressive Spatio-Temporal (VAST) model for the biomass estimate of survey biomass and the survey index likelihood weights were rescaled.

Estimates of female spawning biomass for 2019 and 2020 from the 2018 model are 36,365 t and 34,046 t, respectively. Both estimates are above the $B_{40\%}$ estimate of 30,480 t.The northern rockfish stock is in Tier 3a and the recommended maximum permissible 2019 ABC of 4,529 t was from the updated projection model. This stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. The following table shows the recommended ABC apportionment (t) for 2018 and 2019.

Area	Western 26.28%	Central 73.70%	Eastern 0.02%	Total 100%
2019 Area ABC (t)	1,190	3,338	1	4,529
2019 OFL (t)				5,402
2020 Area ABC (t)	1,122	3,147	1	4,270
2020 OFL (t)				5,093

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

Shortraker Rockfish - - Bering Sea and Aleutian Islands - REFM
Harvest recommendations for shortraker rockfish in the BSAI are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). New data included updated catch data through 2018, and biomass estimates from the 2018 AI bottom trawl survey.

Estimated shortraker rockfish biomass in the BSAI has been relatively stable since 2002. Increases in the 2018 AI survey biomass estimates occurred in the western and eastern AI with a decrease in the central AI. According to the random effects model, total biomass (AI and EBS slope combined) from 2002-2018 has been very stable, with a slight increase in the estimate of 2019 biomass since the 2016 assessment, from 22,191 t in the 2016 assessment to 24,055 t in the current assessment. 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. Exploitation rates have generally been well below the ABC levels in all areas, except for the western area, where exploitation rates exceeded the ABC levels rom 2011-2013. The accepted value of M for this stock is 0.03 for shortraker rockfish, resulting in a maxFABC value of 0.0225. The resulting OFL and ABC for 2019 are 722 t and 541 t, respectively.

Shortraker Rockfish – Gulf of Alaska – ABL
Rockfish in the Gulf of Alaska (GOA) 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) Tiers 4, 5, and 6 rockfish remain on a biennial stock assessment schedule with a full stock assessment produced in even years and no stock assessment produced in odd years. Because 2018 was an "off year," the values for the 2018 fishery were rolled over for the 2019 fishery.

Estimated shortraker rockfish biomass is 38,361 t. The NPFMC's Tier 5 ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 863 t for the 2019 fishery. Gulfwide catch of shortraker rockfish was 751 t in 2018. This is up from 553 t in 2017.

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Other Rockfish – Gulf of Alaska – ABL

Like for shortraker rockfish (see above), 2018 was an "off year," and the 2018 values are rolled over for the 2019 fishery. The Other rockfish (OR) stock complex consists of up to 25 species in Tiers 4, 5, and 6 (depending on the management area). Biomass estimates and ABC/OFL values for the OR complex are the sum of the recommendations for each species. The total estimated OR complex biomass is 96,107 t. The recommended ABC for the 2019 fishery is 5,590 t. Gulfwide catch of OR was 1,225 t in 2018. This is up from 1,078 t in 2017.

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

Fish previously referred to as rougheye rockfish are now recognized as consisting of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*). The current information on these two species is not sufficient to support species-specific assessments, so they are combined as a complex in one assessment.

The 2016 assessment used an age-structured model applied to the entire BSAI area, using data from both the EBS slope survey and AI survey. In the 2018 assessment, this approach was altered so that an age-structured model was applied only to the AI portion of the population, while the EBS portion of the population was assessed with Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). Updated data included 2018 AI survey biomass estimate and length composition, total catch through 2018 (2018 total catch projected), 2016 AI survey age composition, survey and fishery age date through 2017, and revised growth parameters. New methods were used for weighting (Francis) and for estimating selectivity (two-parameter logistic curve). The Plan Team recommended combining the results of two alternative models by model averaging.

Spawning biomass for AI blackspotted/rougheye rockfish in 2019 is projected to be 6,858 t and is projected to continue increasing (based on averaging Models 18.1 and 18.2). There is some evidence of several large recruitments in the 2000s, but there is also evidence of relatively high mortality and declining abundance of larger/order fish. The most recent survey in the AI (2018) was nearly identical to the previous survey in 2016. The BSAI was separated into AI and BS components for this assessment year, returning to the practice that had been used prior to the 2016 assessment. For the AI, the projected female spawning biomass for 2019 of 6,858 t is less than B40%, (8,611 t). The adjusted FABC =F40% values for 2019 and 2020 are 0.027 and 0.0295, respectively. For the BS, recommended 2019 ABC is 451 t and 2019 OFL is 547 t. The apportionment of the 2019 ABC to subareas is 163 t for the Western and Central Aleutian Islands and 288 t for the Eastern Aleutian Islands and Eastern Bering Sea.

For more information contact Paul Spencer,(206) 526-4248 or paul.spencer@noaa.gov.

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 partial assessment was conducted for RE/BS in 2018. This consists of an executive summary with recent fishery catch and survey trends as well as recommend harvest levels for the next two years. There were no changes made to the assessment model inputs since this was an off-cycle year. However, new data added to the projection model included an updated 2017 catch estimate and new catch estimates for 2018-2020. Please refer to last year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Shotwell et al., 2017, available online at https://www.fisheries.noaa.gov/resource/data/2018-assessment-rougheye-and-blackspotted-rockfish-stock-complex-gulf-alaska).

This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels. The data sets used in this assessment include total catch biomass, fishery age and size compositions, trawl and longline survey abundance estimates, trawl survey age compositions, and longline survey size compositions. For an off-cycle year, we do not re-run the assessment model, but do update the projection model with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points. As with last year, we use the full assessment base model from 2015.

The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. The tests for evaluating these three statements on status determination require examining the official total catch from the most recent complete year and the current model projections of spawning biomass relative to $B_{35\%}$ for 2018 and 2020. The official total catch for 2017 is 523 t, which is less than the 2017 OFL of 1,594 t; therefore, the stock is not being subjected to overfishing. The estimates of spawning biomass for 2018 and 2020 from the current year (2018) projection model are 15,057 t and 14,926 t, respectively. Both estimates are well above the estimate of $B_{35\%}$ at 7,873 t and, therefore, the stock is not currently overfished nor approaching an overfished condition.

Catch of rougheye and blackspotted rockfish increased in all areas in 2018 compared to 2017, but remains within the range of the time series. The increase is consistent across gear types with one-third taken in longline fisheries and two-thirds taken in trawl fisheries. The majority of the RE/BS rockfish catch remains in the rockfish and sablefish fisheries, with some increase in the flatfish fisheries. The 2018 longline survey abundance estimate (relative population number or RPN) decreased about 31% from the 2017 estimate and is slightly below the long-term mean. The decrease was consistent across areas with the exception of the West Yakutat region, which had a 20% decrease. This information was not used for updating the 2018 projection model for RE/BS rockfish as this was an off-cycle year.

For the 2019 fishery, the Plan Team accepted the authors' recommended maximum permissible ABC of 1,428 t ($F_{ABC} = F_{40\%} = 0.04$) and OFL of 1,715 t ($F_{OFL}=F_{35\%} = 0.048$).
The apportionment percentages are the same as in the 2017 full assessment using the three-survey weighted average method and providing the random effects method as reference. Please refer to the last full stock assessment for information regarding the apportionment rationale for RE/BS rockfish. Area apportionments based on the three-survey weighted average method are as follows for 2019: Western GOA = 174 t, Central GOA = 550 t, and Eastern GOA = 704 t.

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H. Thornyheads

1. Research
None at present.

2. Stock Assessment

Gulf of Alaska - ABL

The Gulf of Alaska (GOA) thornyhead complex are assessed on a biennial stock assessment schedule with a full stock assessment produced in even years and no stock assessment produced in odd years. For this on-cycle year, we incorporated Relative Population Weights (RPWs) from the 1992-2018 AFSC longline surveys and updated catch. Estimated thornyhead rockfish biomass is 89,609 t, which is a decrease of 1% from the previous estimate in the 2017 assessment.

Gulf of Alaska thornyheads (*Sebastolobus*) 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 to use a random effects (RE) model fit to survey data to estimate exploitable biomass and determine the recommended ABC. In 2018 a new method of combining the AFSC longline survey Relative Population Weight (RPW) index (1992 - 2018) with the AFSC bottom trawl survey biomass index (1984 – 2017) within the RE model was used to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2019 fishery. Estimated thornyhead biomass is 89,609 t, which is a decrease of 1% from the 2017 estimate. This is the first decline in thornyhead biomass in the GOA after seeing an increasing pattern since 2011. The NPFMC's Tier 5 ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 the recommended ABC is 2,016 t for the 2019 fishery. Gulfwide catch of thornyhead rockfish was 1,021 t in 2017 and 1,109 t in 2018. 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

Groundfish 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 2018. Total sablefish tag recoveries for the year were approximately 700. Twenty four percent of the recovered tags in 2018 were at liberty for over 10 years. About 37 percent of the total 2018 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 33 percent within 100 – 500 nm, 20 percent within 500 – 1,000 nm, and 10 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 40 years, and the greatest distance traveled of a tag recovered in 2018 was 2,013 nm. Six adult sablefish and 3 juvenile sablefish tagged with archival tags were recovered in 2018. First reports describing the vertical movement (using collected depth data) of adult sablefish from these electronic tags has recently been published (Sigler and Echave 2019).

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye rockfish are also maintained in the Groundfish Tag Database. Twenty nine thornyhead and 1 spiny dogfish were recovered in 2018. Releases in 2018 on the AFSC groundfish longline survey totaled 3,604 adult sablefish, 740 shortspine thornyheads, 5 Greenland turbot, and 32 spiny dogfish. Pop-up satellite tags (PSAT) were implanted on 10 spiny dogfish and 14 sablefish. An additional 287 juvenile sablefish were tagged during two juvenile sablefish cruises in 2018.

Sigler MF, Echave KB. 2019. Diel vertical migration of sablefish (*Anoplopoma fimbria).* Fish Oceanogr. 2019:00:1-15. https://doi.org/10.1111/fog.12428

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Juvenile Sablefish Studies – ABL
Juvenile sablefish tagging studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2018. ABL staff coordinated with a University of Alaska Fairbanks (UAF) graduate project to collect stomach contents and tag juvenile sablefish in St. John Baptist Bay near Sitka, AK over 4 days (July 17 – July 20). A total of 36 juvenile sablefish were caught and tagged and released. Average length of fish during July sampling was 35 cm. Calculating CPUE was not possible due to the inconsistent sampling, but the total catch was down from the 164 individuals tagged in 2017. UAF returned in October for further sampling and experienced much higher catch rates, tagging an additional 251 juvenile fish over 4 days (October 20 – 23). Of note, the October sampling appears to have only captured young of the year (YOY) sablefish, whereas the July sampling caught age-1 fish. The average length of tagged fish was 25 cm, with total length range of 21 – 28 cm.

While juvenile sablefish have consistently been tagged in St. John Baptist Bay, a shallow bay with soft bottom nearby Sitka in Southeast Alaska, no other locations have been found to consistently hold juvenile sablefish. Therefore, movement of juvenile fish from areas other than the eastern GOA is relatively unknown. In 2018 ten days (9/22 – 9/31) were spent sampling various bays in the Central Gulf of Alaska (CGOA) from Whittier, the Kenai Peninsula, the Alaska Peninsula (Katmai), and around the southern half of Kodiak Island (Figure 1). This sampling cruise in the CGOA was conducted using NOAA National Cooperative Research Funds as a follow-up to compare with the highly successful 2015 CGOA juvenile tagging and unsuccessful 2016 CGOA sampling. A broad spatial distribution, including various habitat types and depths, were fished (Figure 1), but all were nearshore at between depths of 30 and 175 ft. Locations fished were chosen based on historical NMFS bottom trawl survey data, NMFS/ADFG mesh survey data, and anecdotal information provided by sport fishermen via an online outdoor forum. Methods included rod and reel jigging with squid (*Illex*) as bait. No sablefish were caught during the research cruise, and bycatch was minimal.

Several reasons for not catching sablefish in the CGOA are possible. Juvenile sablefish have historically been very difficult to find. In addition, the late season may have played a role in their absence. Juvenile sablefish generally spend their first one to two years of life in nearshore habitats before emigrating to offshore habitats, however, tag recovery and NMFS longline survey data from the Central and Western GOA have shown age-1 and age-2 sablefish to be in deeper shelf and slope waters at an earlier age than sablefish in the Eastern GOA. Near the end of the trip we spoke with a vessel returning from a halibut longlining trip in southern Shelikof Strait at an average depth of 275 ft. They reported that every other hook on the set had a 35-38 cm sablefish (age-1). Therefore, the fish may already be in deeper water and not available to our sampling in nearshore waters.

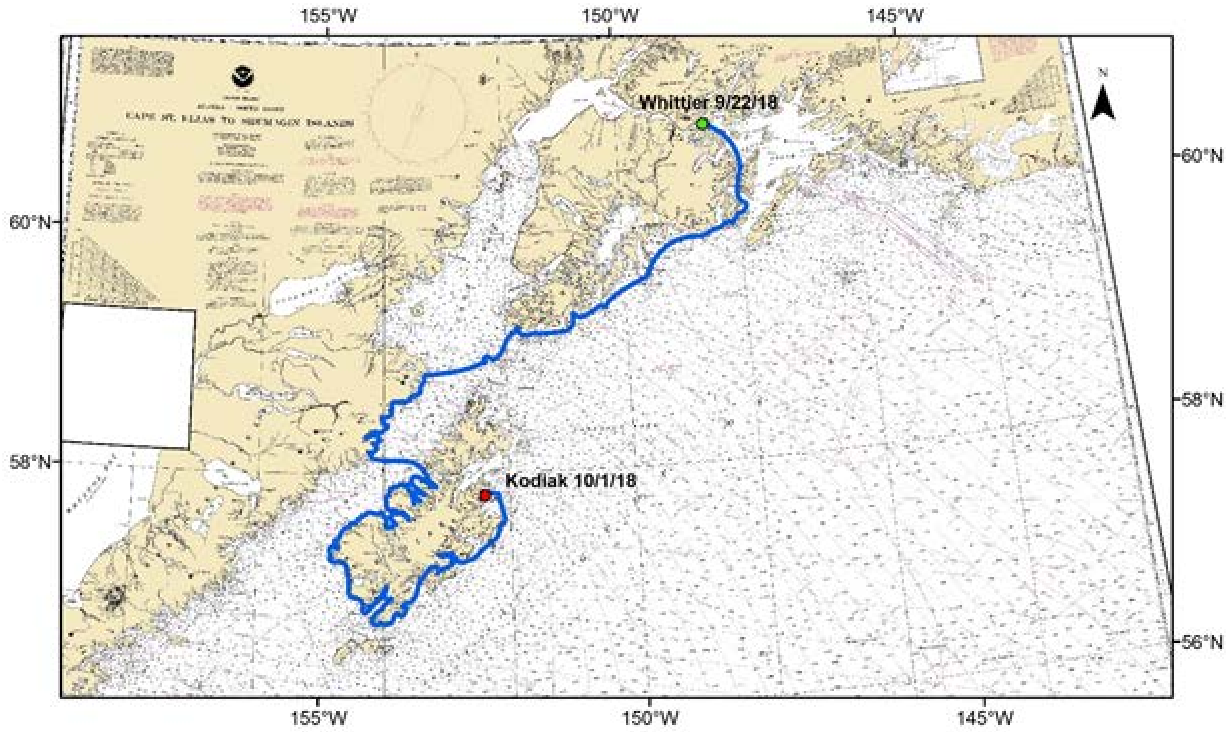


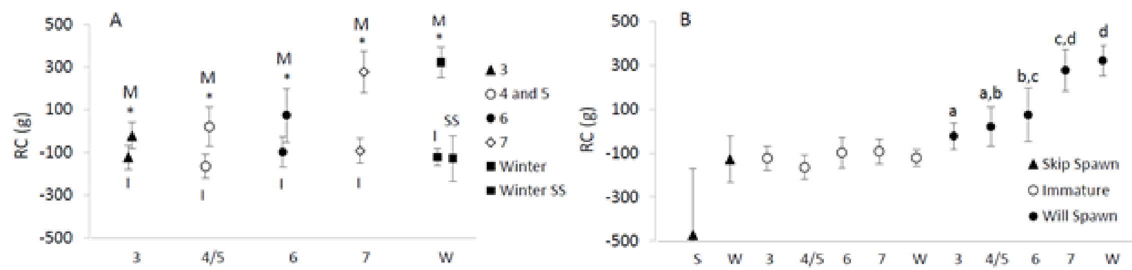
Figure 1. Rough track line of a tagging cruise beginning in Whittier on September 22, 2018 and ending in Kodiak on October 1, 2018.

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

Relative liver size and body condition topredicting maturity and fecundity of sablefish – ABL
The objectives of this study were to determine if relative body condition and relative liver size (hepatosomatic index, HSI) could be utilized to predict maturity 6–8 months prior to spawning, when samples are readily available, and if these condition measures were related to fecundity. Female sablefish were sampled on the annual AFSC summer longline survey in July and August 2015 and during a winter survey in December 2015, which is 1 to 3 months prior to the spawning season in the Gulf of Alaska. The relative body condition and relative liver weight (hepatosomatic index, HSI) of fish increased throughout the summer survey, reaching measurements similar to those observed during the winter (relative condition; Figure 1). There were significant differences between immature and mature fish HSI and relative body condition and these differences increased throughout the summer, making these factors useful for predicting maturity on the last legs of the survey. On these later legs, models that utilized relative body condition and HSI, as well as length and age, to predict whether a fish was immature or would spawn produced maturity curves that best matched models based on histological maturity classifications. However, models without HSI may be the best choice for future work because liver weight is not regularly collected on annual surveys.

Utilizing the winter data set when fecundity could be enumerated, fecundity was significantly related to relative condition and HSI. Increasing or decreasing these measures of condition by one standard deviation in a model of fecundity, which also included length, resulted in an estimated decrease in fecundity of 32% or an increase of 47% for an average size fish (78 cm). These results show the importance of incorporating fish condition into measures of population productivity.

Figure 1. Relative condition (RC) for sablefish collected on Legs 3 through 7 of the summer longline survey (S) or in the winter (W). Immature (I), mature (M), and skip spawning (SS) fish are labeled for the winter so that skip spawning fish can be differentiated from the other two groups. In Panel A, 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 within each maturity category 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). The 95% confidence intervals (CI) are marked with whiskers and the lower portion of the CI for summer skip spawning fish is truncated to maintain the same scale as Panel A.



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

2. Stock Assessment

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

A full sablefish stock assessment was produced for the 2019 fishery. New data included in the assessment model were relative abundance and length data from the 2018 longline survey, relative abundance and length data from the 2017 fixed gear fishery, length data from the 2017 trawl fisheries, age data from the 2017 longline survey and 2017 fixed gear fishery, updated catch for 2017, and projected 2018 - 2020 catches. Estimates of killer and sperm whale depredation in the fishery were updated and projected for 2018 - 2020.

The longline survey abundance index increased 9% from 2017 to 2018 following a 14% increase in 2017 from 2016. The lowest point of the time series was 2015. The fishery catch-rate/abundance index stayed level from 2016 to 2017 and is at the time series low (the 2018 data are not available yet). The maximum permissible ABC for 2019 is 10% higher than the 2018 maximum permissible ABC of 25,583 t. The 2017 assessment projected a 41% increase in ABC for 2019 from 2018. Instead of maximum permissible ABC, we recommended that the 2019 ABC to be equal to the 2018 ABC, which translates to a 45% downward adjustment from max ABC. The final 2019 ABC of 15,068 t is 1% higher than the 2018 ABC because of updated whale depredation adjustments that are slightly smaller. The author recommended ABCs for 2019 and 2020 are lower than the maximum permissible ABC for several important reasons.

First, the 2014 year class is estimated to be 2 times higher than any other year class observed in the current recruitment regime (1977 – 2014). Tier 3 stocks have no explicit method to incorporate the uncertainty of this extremely large 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 in the future. These concerns warrant additional caution when recommending the 2019 and 2020 ABCs. It is unlikely that the 2014 year class will be average or below average, but projecting catches under the assumption that it is 7.5x average introduces risk given the uncertainty associated with this estimate. Only one large year class since 1999 has been observed, and there are only two observations of age compositions to support the magnitude of the 2014 year class. Our caution seems justified as the estimate of the 2014 year class has decreased 30% since last year's estimate. The cause of this decrease could be simply imprecision in the age compositions for the first year it was seen, or something real, like an increase in natural mortality. Future surveys will help determine the magnitude of the 2014 year class and will help detect additional incoming large year classes other than the 2014 year class; there are indications that subsequent year classes may also be above average.

Recommending an ABC lower than the maximum should result in more of the 2014 year class entering into the spawning biomass. This more precautionary ABC recommendation buffers 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 composition in 2019 and allow this extremely young population to further mature so they can fully contribute to future spawning biomass.

The following additional bullets summarize the evidence for a lower ABC than maximum permissible:

- The estimate of the 2014 year class strength declined 30% from 2017 to 2018.
- Despite projected increases in spawning biomass in 2017, the 2018 spawning biomass and stock status is lower than in 2017.
- Despite conservative fishing mortality rates, the stock has been in Tier 3b for many years.
- Fits to survey abundance indices are poor for recent years.
- The AFSC longline survey Relative Population Weight index, though no longer used in the model, has strongly diverged from the Relative Population Number index, indicating few large fish in the population.
- The retrospective bias has increased in the last two years, and the bias is positive (i.e., historical estimates of spawning biomass increase as data is removed).
- The amount of older fish comprising the spawning biomass has been declining rapidly since 2011.
- The very large estimated year class for 2014 is expected to comprise about 10% of the 2019 spawning biomass, despite being less than 20% mature.
- The projected increase in future spawning biomass is highly dependent on young fish maturing in the next few years; results are very sensitive to the assumed maturity rates.
- The body condition of maturing sablefish in the recent years of high recruitment is lower than average, and much lower than during the last period of strong recruitments.
- Another potential marine heat wave is forming in 2018, which may have been beneficial for sablefish recruitment in 2014, but it is unknown how it will affect current fish in the population or future recruitments.
- Small sablefish are being caught incidentally at unusually high levels shifting fishing mortality spatially and demographically, which requires more analysis to fully understand these effects.

Finally, as is now standard practice, we also recommend a lower ABC than maximum permissible based on estimates of whale depredation occurring in the fishery in the same way as recommended and accepted starting in 2016. 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. The methods and calculations are described in the "Accounting for whale depredation section" of the sablefish stock assessment report.

Survey trends support keeping ABC level relative to last year. Although there was a modest increase in the domestic longline survey index time series in the last two years, and a large increase in the GOA bottom trawl survey in 2017, these increases are offset by the very low status of the fishery abundance index seen in 2016 and 2017. The fishery abundance index has been trending down since 2007. The IPHC GOA sablefish index was not used in the model, but was similar to the 2015 and 2016 estimates in 2017, about 50% below average abundance. 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 average. The 2014 year class appears to be very strong, but year classes have sometimes failed to materialize later and the estimate of this year class is still uncertain and has declined by 30% since the 2017 assessment. Because of the estimated size of the 2014 year class, spawning biomass is projected to climb rapidly through 2022, and then is expected to rapidly decrease assuming a return to average recruitment in the future. Maximum permissible ABCs are projected to rapidly increase while authors' recommended lower ABCs will still increase quickly to 20,144 t in 2020 and 40,000 t in 2021.

Projected 2019 spawning biomass is 33% of unfished spawning biomass. Spawning biomass had increased from a low of 28% of unfished biomass in 2002 to 34% in 2008 and has declined again to about 26% of unfished in 2018 but is projected to increase in 2019. The last two above-average year classes, 2000 and 2008, each comprise 8% and 11% of the projected 2019 spawning biomass, respectively. These two year classes are fully mature in 2019. The very large estimated year class for 2014 is expected to comprise about 10% of the 2019 spawning biomass, despite being less than 20% mature.

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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 a 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 met to discuss ongoing sablefish research, sablefish assessment models, and opportunities for collaboration. This meeting's discussions are captured in a technical memorandum (https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-387.pdf), which details a work plan for the group. A PhD student at the University of Washington and a Post-Doc researcher affiliated with DFO are now on board and working on coastwide growth and movement analyses. Maturity data across management regions are also being synthesized and reviewed for utility. It is hoped that this collaborative project will help form a more complete picture of the population dynamics of sablefish at a coastwide scale. Further analyses on coastwide abundance trends via simulation studies or enhanced assessment methods are in the works. 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.

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

J. Lingcod

There are no federally-managed lingcod fisheries in Alaska waters. Recreational and small-scale commercial fisheries are managed by the Alaska Department of Fish & Game.

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--NPRB project 1305. GAP

This project assessed the small-scale abundance, local exploitation rate, and essential habitat of Atka mackerel, the dominant prey of the endangered Western Steller sea lion stock. In addition, we describe species composition, relative abundance, and the environmental parameters influencing distribution patterns of other Steller sea lion prey species on a local scale relevant to Steller sea lions. Our study areas were at Seguam pass in the Eastern Aleutian Islands and all fished population centers in the Western Aleutian Islands, divided into two main regions: the 543 Nearshore region and the 543 Seamount region. Atka mackerel population sizes estimates from the tagging study were approximately 610,000 metric tons (mt) at Seguam Pass, 312,000 mt in the Western Aleutian 543 Nearshore region and 306,000 mt in the Western Aleutian 543 Seamount region. Exploitation rates in all three areas ranged from 9.8 % at Seguam Pass. 3% in the Nearshore region and 1% in the Seamount region, all below the projected fishing mortality in the Atka mackerel stock assessment. There did not seem to be evidence of localized depletion, however several study sites within the regions experienced higher fishing efforts such as Seguam Pass in the Eastern Aleutian Islands, Ingenstrem rock and Buldir West in the Western Aleutian Nearshore region, and Heck Canyon in the Western Aleutian 543 Seamount region.

In addition, we examined environmental, biological, and management factors and their influence on CPUE for five Steller sea lion prey species (Atka mackerel, northern rockfish, Pacific cod, walleye pollock) using a redundancy analysis. We examined CPUE of Atka mackerel, northern rockfish and invertebrates inside vs. outside the Trawl Exclusion zones (TEZs) and found no significant difference for Atka mackerel and northern rockfish; however, invertebrate densities were significantly higher inside the TEZs. Atka mackerel CPUE decreased from the eastern most study site (Seguam Island) to the west study sites, near Agattu and Ingenstrem, where SSL non-pup and pup counts are still in decline with tidal and bottom current being the most influential. Conversely, northern rockfish showed a steady increase from east to west with the highest CPUE occurring in the west study sites and no environmental variables were correlated with northern rockfish CPUE distributions.

We examined the spatial distribution of the ocean environment as well as Atka mackerel's biological properties on a local scale (10s of nm) such as length distribution, food habits, and reproductive maturity. Water column properties such as temperature and salinity were similar in all areas except the Agattu and Ingenstrem Rock in the Western Aleutian 543 Nearshore region, which exhibited markedly lower temperatures, salinity, and the largest seasonal temperature fluctuations, identifying them as distinct water masses. Atka mackerel decreased by size and weigh from east to west, with the largest fish at Seguam pass and the smallest fish in the Western Aleutian 543 Seamount area. Seguam Pass showed a large influx of young fish in October 2014, which was not observed in the Western Aleutian regions. Atka mackerel males in spawning color were mostly observed at Agattu in the Western Aleutians Island 543 Nearshore region. Length and age at maturity showed that fish matured at slightly larger size at Seguam (50% maturity 35.7cm) than in the Western Aleutian 543 Nearshore region and 543 Seamount region (50% maturity at 33.4 and 32.7cm, respectively). In the Western Aleutian region Atka mackerel exhibited greater stomach fullness during the spring, eating mostly euphausiids and copepods. At Seguam there was no seasonal difference in stomach fullness with euphausiids comprising the largest part of their diet. In all areas the diet in the fall was more diverse and included Atka mackerel eggs as a major component for larger fish.

Lastly, we described the habitat type and species composition in areas close to Steller sea lion rookeries, which are located in untrawlable grounds with towed stereo cameras. We conducted 63 transects and identified and quantified fish species and associated habitat. The preferred Steller sea lion prey species Atka mackerel, Irish lords and greenling were highly associated with rocky bottom, whereas rockfish and Pacific cod occurred on rocky bottom and gravel, whereas flatfish and sculpins were mostly associated with unconsolidated substrate.

In conclusion, we found the highest density and biomass of Atka mackerel, with the largest fish in best body condition at Seguam pass study site, with decreasing density, biomass estimates, and fish size in the Western area. In addition, Atka mackerel comprised a larger part of the total species composition at Seguam pass, with rockfish steadily increasing from east to West and comprising almost half of the species composition in the 543Seamount region. Steller sea lion rookeries at Seguam pass are located close the study sites, whereas in the Western Aleutian Islands only Buldir and Agattu are close to Steller sea lion rookeries with most of the Atka mackerel aggregations a greater distance apart. This might indicate the Seguam pass is an ideal area for Steller sea lion foraging success for Atka mackerel whereas the Western Aleutian Island areas are further away from the rookery, have smaller biomass and higher diversity of other less favorable prey for Steller sea lion. See the report and data at:

http://projects.nprb.org/#metadata/48a5836c-4c2d-442b-a5c0-68e2cb7e1f71/project
For more information, contact Susanne McDermott at (206) 526-4417 or Susanne.mcdermott@noaa.gov

Results of the 2016 and 2017 Central and Western Aleutian Islands Underwater Camera Survey of Steller Sea Lion Prey Fields-GAP

Recent satellite tagging efforts indicate that foraging areas of endangered adult female Steller sea lions (SSL) in the central and western Aleutian Islands include shallow, nearshore regions. However, prey availability in these regions remains poorly understood because traditional bottom trawl surveys either cannot sample or lack precision on the rocky, nearshore habitats where sea lions haul out. 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 20-100 m. Fish and associated habitat were identified, quantified, and measured along transects. While stereo image quality did not always allow for identification of all fish to the species level, it did allow for identification of many prey species (i.e. Atka mackerel (Pleurogrammus monopterygius), Pacific cod (Gadus macrocephalus)) and species groups (i.e. rockfish, flatfish, and sculpins) that are consumed by SSL during the summer. Camera transects encompassed substrates ranging from sand to high-relief boulder fields, and greater fish abundance was associated with rockier 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.

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2. Stock Assessment

Bering Sea and Aleutian Islands (REFM)
The BSAI Atka mackerel assessment uses the Assessment Model for Alaska (AMAK), a statistical catch-at-age-model. No changes to the base model were made this year. New data for 2018 included catch through 2018 (2018 projected), 2017 fishery age compositions, and 2018 AI survey biomass estimates.

Spawning biomass reached an all-time high in 2005, then decreased almost continuously through 2018 (the estimated spawning biomass in 2019 is projected to be roughly 37% of what it was in 2005). It is projected to decrease further, at least through 2020. Total biomass follows the same decreasing trend. The 1998-2001 year classes were all very strong, and the 2006 and 2007 year classes 56% and 33% above average. The projected female spawning biomass for 2019 (106,800 t) is projected to be below B40% (113,510 t), and the stock is projected to remain below B40% through 2023.

The projected 2019 maxABC at F40% = 0.44 is 68,500 t, down 26% from the 2018 ABC and down 19% from last year's projected ABC for 2019. The projected 2019 OFL at F35% = 0.53 is 79,200 t, down 27% from the 2018 OFL and down 19% from last year's projected OFL for 2019. A risk matrix was completed for this stock, with Level 1 ratings for all three categories, so no adjustment to maxABC was proposed. The four-survey weighted averaging method was used to apportion
ABC among areas: 23,970 t for Area 541 and the Bering Sea region (a 35% decrease from 2018), 14,390 t for Area 542 (a 55% decrease from 2018), and 30,140 t for Area 543 (a 30% increase from 2018).

The ecosystem considerations section of the assessment chapter was updated with the 2018 survey information. Temperature anomaly profiles from the 2018 AI survey data show that the water temperature continues to be warm at depth. Temperature may affect recruitment of Atka mackerel and availability to the bottom trawl survey. It is possible that the reduced recruitment since 2007 is due to changing environmental factors such as water temperature, which is known to affect Atka mackerel eggs, larvae, and hatching times, and could possibly have an impact on productivity and food supply for larval Atka mackerel. However, this has not yet been evaluated fully. The large drop in the Central area survey biomass was inconsistent with Atka mackerel biomass changes in the other AI areas (Eastern and Western Aleutians), and reported fishing conditions in the region. The lack of any moderate to large catches of Atka mackerel by the survey in only one area may have been due to a combination of environmental factors that could have affected catchability, Atka mackerel availability, and fish movement and behavior.

Atka mackerel is the most common prey item of the endangered western Steller sea lion throughout the year in the AI. 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, removed the TAC reduction in area 542, and re-opened areas in 541 and 542 that had been closed to directed Atka mackerel fishing.

Gulf of Alaska (REFM)
No assessment was conducted for Atka mackerel this year, but a full stock assessment will be conducted in 2019. Until then, the values generated from the previous stock assessment will be rolled over for 2019 specifications. The very patchy distribution of GOA Atka mackerel results in highly variable estimates of abundance. Therefore survey biomass estimates are considered unreliable indicators of absolute abundance or indices of trend, and harvest recommendations are based on historical catches. Since 1996, the maximum permissible ABC has been 4,700 t and the OFL has been 6,200 t.

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L. Flatfish

1. Research

Spatial variation in juvenile flatfish growth and condition in relation to thermal phases in the Bering Sea shelf--GAP

Research continues in characterizing and assessing the productivity of the habitats of yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS) in the Bering Sea. Field sampling has been conducted intermittently since 2011 as special projects of the eastern Bering Sea (EBS) annual bottom trawl survey, and on the northern Bering Sea (NBS) bottom trawl survey in 2017. The present focus is on characterizing the spatial variation in juvenile abundance, growth and condition, and relating the variability to multi-year warm-cold thermal stanzas and the long-term trend in ocean warming.

Recent studies suggest that the latitudinal shift in the distribution of NRS juveniles was linked to thermal stanzas: 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). The north and south habitats both had high prey abundance and similarly high summer bottom temperature during the present warm thermal stanza, which began around late 2013. Juvenile NRS appeared to grow faster in the south than in the north. 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, 2018). Thus, a northward shift in juvenile flatfish habitat may impact productivity.

The EBS experienced record high bottom water temperatures in 2016, during which the cold pool of $<2^{O}C$ bottom temperature almost entirely disappeared. The cold pool returned in 2017, but diminished drastically again in 2018. Results from the 2016 bottom-trawl survey indicate that the catches of juvenile YFS and NRS in 2016 were the highest in the past decade and remained high in 2017-18, supporting that there was strong juvenile recruitment during the warm stanza. The distribution of juvenile NRS also shifted north and their area of presence became wider during the warm stanza compared to the preceding cold stanza.

Juvenile (mostly age 1-4) samples have been collected since 2016 for diet and otolith analysis. Sample collection for analysis of lipids, fatty acids, and biomarkers as condition indicators began in 2017. Juveniles were collected with a beam trawl at between 12 to 21 standard bottom trawl survey stations in each year. The selected stations spanned the inner-shelf nearshore where juveniles were likely to be present based on past surveys. Benthic samples were also collected at about half of the beam trawl stations to assess prey dynamics.

The age 1-4 fish collected in 2018 would represent cohorts born during the present warm stanza, whereas the age 3-4 fish from 2016 and 2017 would represent cohorts born during the preceding cold stanza. The spatial patterns of condition, diet and growth of juveniles are being analyzed in conjunction with the prey community over the years for insights into the impacts of major changes in the thermal environment.

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

Yeung, C., Yang, M.S., 2018. Spatial variation in habitat quality for juvenile flatfish in the southeastern Bering Sea and its implications for productivity in a warming ecosystem. Journal of Sea Research 139:62-72.

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 their vertical movement and temperatures experienced in the Bering Sea. Archival tag data were recovered from 18 Greenland turbot, spanning 19–1,859 days at liberty, with mean depths and temperatures for individual fish ranging from 448–753 m and 3.2–3.7 °C, respectively. Periodic movements were identified using a continuous wavelet analysis, and significant diel vertical migration occurred between 0–53% of time at liberty. Seasonal movement towards deeper water in the winter and shallower water in the summer was evident for fish that were at liberty for one or more years (n=13), and these annual movements were consistent over multiple years for fish that were at liberty two or more years (n=5). Sex-specific movements were identified during the putative spawning period (November–March). During this time, depth profiles of males indicate a regular vertical movement pattern with a 6–12 hour periodicity, covering hundreds of meters, and persisting for many weeks, whereas depth profiles of females indicate one prominent spawning rise from deeper water (~500–900 m), to below the mixed layer (~225-m depth), and returning to depth over a period of 1–2 hours (Figure 1). Some female Greenland turbot were found to occupy shallow depths (<200-m) accompanied with cool temperatures (<2°C), indicating use of the Bering Sea cold pool: one fish for three consecutive summers (2003, 2004, and 2005), one fish for two consecutive summers (2005, 2006), and another during the winter of 2011/2012. A manuscript analyzing these tags is in preparation.

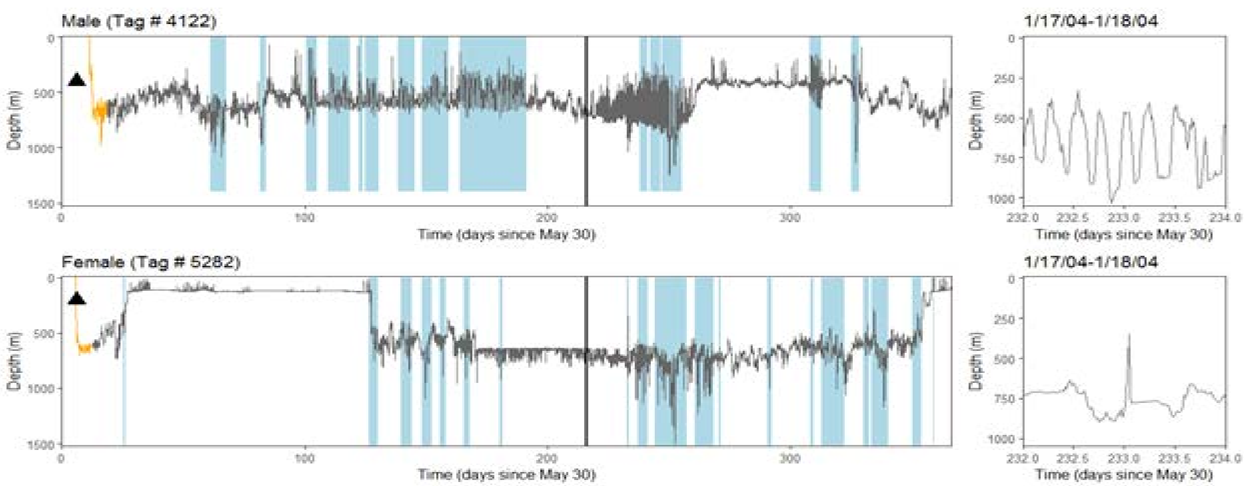

Figure 1. Example depth profiles of two Greenland turbot during the first year after release. The top panel is a male and bottom is a female. The x-axis is zeroed to 30 May 2003, approximately the date of release of both fish, and the y-axis is reversed so the surface of the water is at the top. The orange line shows an acclimation period of seven days post release that was removed before analysis. The solid black triangle indicates the depth of capture, light blue bars designate significant diel vertical migration, and the solid vertical black line demarks the start of 2004. Panels on the right are zoomed in for two days in January of 2004, a period of putative spawning behavior; the male is exhibiting a regular movement pattern and the female exhibits an isolated spawning rise. This female utilizes the continental shelf each summer, during which time there is relatively little vertical movement.

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2. Assessment

Yellowfin sole - Bering Sea and Aleutian Islands (REFM)
The yellowfin sole fishery in the EBS is the largest flatfish fishery in the world. This stock is assessed using an age-structured population dynamics model implemented in the software program AD Model Builder. Survey catchability (*q*) has been shown to be linked to bottom water temperatures, so in the model *q* is estimated as a function of an included bottom temperature index. New data for 2018 include age data through 2017 and survey and catch data through 2018.

The assessment updates last year's with results and management quantities that are lower than the 2017 assessment primarily due to (1) the 2018 survey biomass point estimate is 32% lower than the 2017 estimate and (2) the assessment model estimated a slightly lower survey catchability. The projected female spawning biomass estimate for 2019 is 850,600 t, which is 1.85× BMSY. This is a 5.0% decrease from last year's 2018 estimate (895,600 t). A general slow decline in spawning biomass of approximately 6% per year has prevailed for the most part since 1985. The recommended 2019 ABC is 263,200 t and 2019 OFL is 290,000 t. The annual harvest of yellowfin sole remains below the ABC level.

Greenland turbot - Bering Sea and Aleutian Islands (REFM)
This assessment is conducted using Stock Synthesis. The only change to the base model is that ABL longline survey catchability is now a statistically estimated parameter. Data updates include 2018 NMFS EBS shelf bottom trawl survey and ABL longline survey estimates and size compositions, age data from the 2017 trawl survey, and fishery data though 2018 (including projected values for 2018).

The projected 2019 female spawning biomass is 54,244 t, which is a 7% decrease from last year's 2018 projection of 58,035 t. Female spawning biomass is projected to increase slightly to 52,743 t in 2020. The effects of the incoming 2007-2009 year classes are creating increases 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.

The B40% value, using the mean recruitment estimated for the period 1978-2014, is 36,213 t. The projected 2019 female spawning biomass is 54,244 t, which is well above the estimate of B40% (36,213 t). The OFLs for 2019 and 2020 are 11,362 t and 10,476 t, respectively, and the corresponding maximum permissible ABCs are 9,658 t and 8,908 t, respectively. The author recommended setting ABC at the maximum permissible values for 2019 or 2020. Apportionment of ABC between the EBS and the Aleutian Islands was based on the assumption that 8% of the biomass is in the Aleutian Islands.

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Arrowtooth flounder - Bering Sea and Aleutian Islands (REFM)
Arrowtooth flounder are assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. The model used in 2018 was similar to those used in past years, with slight changes to the treatment of the age data and the exclusion of EBS slope survey from 1979-1991 based on concerns about methodology and species identification. New data included abundance and composition from the 2017 & 2018 EBS shelf surveys and the 2018 AI survey, survey age data through 2017, and fishery data through 2018 (with projected catches after October 19).

The projected age 1+ total biomass for 2019 is 892,591 t, an increase from the value of 782,840 t projected for 2019 in last year's assessment. The projected female spawning biomass for 2019 is 482,174 t which is an increase from last year's 2019 estimate of 472,562 t. The point estimates of B40% and F40% from this year's assessment are 242,495 t and 0.131, respectively. The projected 2019 spawning biomass is above B40%, so the authors recommend setting 2019 and 2020 maxABCs at 70,673 t and 71,411 t, respectively, and 2019 and 2020 OFLs at 82,939 t and 83,814 t. Arrowtooth flounder is a lightly exploited stock in the BSAI.

Arrowtooth flounder - Gulf of Alaska (REFM)
The arrowtooth flounder stock in the GOA is assessed biennially and 2018 was an "off year", so only the projection model was run with updated catch data. Based on the projection model results, recommended ABCs for 2019 and 2020 are 145,841 t and 140,865 t, respectively, and the OFLs are 174,598 t and 168,634 t. The new ABC and OFL recommendations for 2019 are similar to the 2017 ABCs and OFL developed using the 2017 full assessment model.

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Kamchatka flounder - Bering Sea and Aleutian Islands (REFM)
Before 2011, Kamchatka flounder and arrowtooth flounder were managed in aggregate as a single stock. Due to the emergence of a directed Kamchatka flounder fishery and concerns about overharvesting, the stocks were separated in 2011. Kamchatka flounder is assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. Structural changes were not made to the model for 2018. New data included abundance and composition from the 2017 & 2018 EBS shelf surveys and the 2018 AI survey, survey age data through 2017, and fishery data through 2018 (with projected catches in 2018).

The projected 2019 female spawning biomass is 54,779 t, above the B40% level of 43,069 t, and spawning biomass is projected to remain above B40% for the foreseeable future. The early shelf survey size composition data suggest that some significant recruitment events (assessed at age 2) occurred prior to 1991. Since 1991, the preferred assessment model estimates that the 2001, 2002, 2008, 2013, and 2014 year classes are all at least 80% above average. Female spawning biomass has been increasing since a drop in 2010 which coincided with the sharp peak of catch that same year. For the 2019 fishery, the recommended 2019 ABC is the maximum permissible value of 9,260 t. This value is a decrease of 5% from the 2018 ABC (9,737 t). The recommended 2019 OFL is 10,965 t, a 3% decrease from 11,347 t in 2018. Kamchatka flounder do not occur in the GOA.

Northern rock sole - Bering Sea and Aleutian Islands (REFM)
The vast majority of rock sole in the BSAI region is northern rock sole, and it is managed as a single stock. The stock is assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. No modifications were made to the assessment methodology for 2018. Data updates included survey biomass and composition data through 2018, catch data through 2018 with projected late-year 2018 catch, and age data through 2017.

The 2018 bottom trawl survey point estimate is a 21% decrease from the 2017 estimate. These two estimates are the lowest in the past 25 years and have the effect of lowering the assessment model time series abundance estimates relative to the last full assessment conducted in 2016. The model results indicate that the stock condition has been at a high and stable level but in a slow decline for the past 9 years. The female spawning biomass is now at a peak and is starting to decline as a result of the combination of strong recruitment from the 2001-2003 and 2005 year classes, which are presently at the age of maximum cohort biomass, and light fishery exploitation.The 2019 ABC harvest recommendation is 118,900 t (FABC = 0.144) and the 2019 OFL is 122,000 t (FOFL = 0.147). The 2020 ABC and OFL values are 143,700 t and 147,500 t, respectively. Recommended ABCs correspond to the maximum permissible levels. This is a stable fishery that lightly exploits the stock because it is constrained by PSC limits and the BSAI optimum yield cap. Usually the average catch/biomass ratio is about 3-4 percent.

Northern and southern rock sole - Gulf of Alaska (REFM)
Northern and southern rock sole in the GOA are managed as part of the shallow-water flatfish complex, which is discussed below.

Flathead sole - Bering Sea and Aleutian Islands (REFM)
In 2018, the BSAI flathead sole assessment was transitioned to the Stock Synthesis modeling platform. Numerous alternative models were explored during this process. Appendix B of the SAFE report has a detailed explanation of the new model structure.

Age 3+ biomass declined by 31% from 1994 through 2015, but has increased by 14% since then. Spawning biomass has declined consistently since 1998 (a 33% decline as of 2018), although spawning biomass is projected to begin increasing in 2020. No year class has been more than 60% above average since the 1987 cohort, but the 2002, 2011, and 2014 year classes are all at least 40% above average. Current reference point values are B40%=84,824 t, F40%=0.38, and F35%=0.47. Because projected spawning biomass for 2019 (153,203 t) is above B40%, the authors and Team recommend setting ABCs for 2019 and 2020 at the maximum permissible values, which are 66,625 t and 68,448 t, respectively. The 2019 and 2020 OFLs are 80,918 t and 83,190 t, respectively.

Flathead sole - Gulf of Alaska (REFM)
This assessment is conducted using Stock Synthesis on a four-year schedule.This year was an off-year thus a partial assessment was presented. The projection model was run using updated catches. The 2019 spawning biomass estimate was above B40% and projected to increase through 2020. Biomass (age 3+) for 2019 was estimated to be 283,285 t and projected to slightly decrease in 2020. For 2019, the authors’ recommendation was to use the maximum permissible ABC of 36,782 t from the updated projection. The FOFL is set at F35% (0.36) which corresponds to an OFL of 44,865 t.

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Alaska plaice - Bering Sea and Aleutian Islands (REFM)
Alaska plaice are assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. For 2018 a partial assessment was presented because it was a scheduled “off-year”. Therefore, only the projection model was run, with updated catches.

Last year’s assessment indicated that above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002 have contributed to recent highs level of female spawning biomass. The Alaska plaice spawning stock biomass is projected to decline through 2023 while remaining above B35%. The current estimates are B40% = 126,900 t, F40% = 0.124, and F35% = 0.149. Given that the projected 2019 spawning biomass of 186,100 t exceeds B40%, the recommendations for 2019 are an ABC of 33,600 t and an OFL of 39,880 t.

Rex sole - Gulf of Alaska (REFM)
This stock is on a four-year assessment cycle and a full assessment is due in 2019. This year a partial assessment was conducted, with the projection model run using updated catches. The model estimates of female spawning biomass and total biomass (3+) for the eastern area is stable and the western area appears to be increasing slightly. The recommendations for 2019 are an ABC of 14,692 t and an OFL of 17,889 t.

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"Other flatfish" complex - Bering Sea and Aleutian Islands (REFM)
The BSAI "Other flatfish" complex includes all flatfishes not managed individually, but the primary species by abundance are starry flounder, rex sole, longhead dab, Dover sole, and butter sole. This complex is on a 4-year assessment cycle and a full assessment is due in 2019. Harvest recommendations are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). The ABC and OFL are calculated separately for rex sole, Dover sole, and a single group of all remaining species; these are then aggregated to produce a single set of recommendations for the complex. Survey data through 2018 indicate that the other flatfish species group is at a high level relative to the time series average and is lightly exploited. The resultant 2019 OFL and ABC are 21,824 t and 16,368 t respectively.

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Shallow-water flatfish complex - Gulf of Alaska (REFM)
The GOA shallow-water flatfish complex includes northern and southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole, and Alaska plaice. Northern and southern rock soles are assessed using an age-structured model; for the remaining species harvest recommendations are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). The ABCs and OFLs for all groups are aggregated to produce recommendations for the complex. The complex has been moved to a 4-year assessment cycle. Last year, 2017, was the first year of the new schedule and a full assessment was completed. This year a partial
assessment was done, and the projection model for northern and southern rock sole was re-run and updated with 2017 catch and catch estimates for 2018 and 2019.

The complex total 2019 biomass estimate was 343,755 t, which is a slight (1.4%) increase from the 2018 value of 339,152 t. This slight increase is due to updated biomass for northern and southern rock sole from the projection model. Overall, biomass for shallow water flatfish is stable. The resultant 2019 OFL and ABC are 68,309 t and 55,587 t respectively. Area ABCs are apportioned based on random-effects model estimates of survey biomass.

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Deep-water flatfish complex - Gulf of Alaska (REFM)
The GOA deep-water flatfish complex includes Dover sole, Greenland turbot, and deepsea sole; Dover sole is the dominant species. Dover sole is assessed using Stock Synthesis, while Greenland turbot and deepsea sole recommendations are based on historical catch. The OFLs and ABCs for the individual species in the deepwater flatfish complex are determined and then summed for calculating a complex-level OFL and ABC. In 2018 only a partial assessment was conducted.

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 2019 OFL is 11,434 and 2019 ABC is 9,501 t; these are slight increases from the previous year's recommendation.

M. Pacific halibut

1. Research

Halibut bycatch management in the North Pacific: A prospective model of fleet behavior
There is a pressing need for conducting prospective analyses of fishing effort changes in response to management changes, including those designed to reduce bycatch. In June 2015, the North Pacific Fisheries Management Council (NPFMC) took action to reduce the prohibited species catch (PSC) limits for halibut in the Bering Sea and Aleutian Islands (BSAI) groundfish fisheries, and is currently exploring ways for tying future PSC limits to measures of halibut abundance. We are developing an empirical modeling approach for predicting the economic and ecological consequences of alternative halibut PSC management policies. Our model focuses on the dynamic decision making of vessels as they manage tradable quotas for target and bycatch species within a fishing season, and provides predictions of changes in the spatial and temporal distribution of fishing effort in response to management changes, including changes in catch limits and time/area closures. These predictions are then combined with estimated space/time distributions of species to predict the cumulative consequences for catch and quota balances, gross and net revenues, and the ecosystem resulting from alternative halibut PSC management measures.

Preliminary results suggest that the groundfish fleet is flexible in adjusting their fishing practices to reduce halibut bycatch to some degree; however, halibut bycatch reductions are costly, in terms of foregone groundfish revenue and operating costs, particularly at low levels of halibut PSC limits. Moreover, our results highlight behavioral margins that would not otherwise be predicted using models that do not account for the within-season dynamics of quota-based fisheries. While the application we pursue is specific to halibut PSC management in the BSAI groundfish fisheries, our methodological approach is capable of being applied to policy impacts in other quota-based multispecies fisheries. For further information contact Alan.Haynie@noaa.gov.

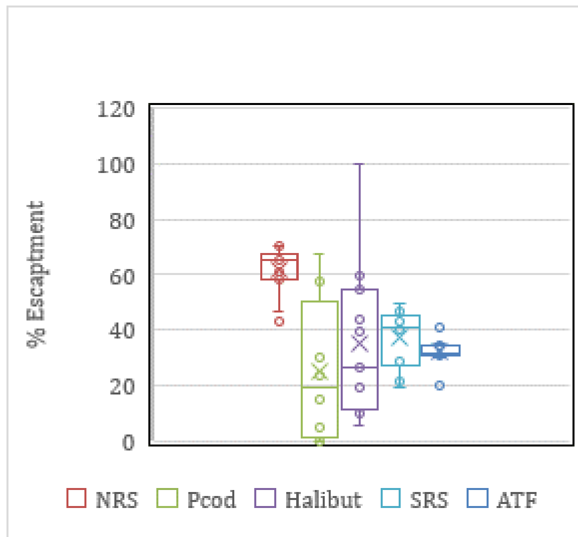
Movement of quota shares in the halibut and sablefish IFQ fisheries
The North Pacific Fishery Management Council recently finalized the first comprehensive review of the Pacific Halibut and Sablefish IFQ Program. The review showed that QS holdings have moved between rural Alaska communities based on access to transportation, which is key to moving product to the increasingly fresh market for halibut. Based on findings from the review and subsequent discussion, the Council proposed that its IFQ Committee consider several specific issues with respect to the IFQ Program.

This study directly examines these issues by assessing the factors that underlie participants' decisions to both buy and sell quota shares in the Pacific halibut and sablefish IFQ fisheries. We are examining the probability of buying and selling quota shares as a factor of the characteristics of the participant, including attributes of their community of residence such as population, access to transportation, and availability of local halibut/sablefish buyers, as well as attributes of the quota shares. In addition, this study applies social network analysis to examine any trends in how participants buy and sell quota shares over time. This study is currently in progress and will contribute to managers' understanding of how quota share sales and access to the IFQ fisheries have changed over time. For further information, contact Marysia.Szymkowiak@noaa.gov.

N. Other Groundfish Species

Other groundfish stocks assessed by the AFSC (REFM)
In addition to the assessments described above, the AFSC assesses and provides harvest recommendations for a sculpin (Cottoidea) complex and an octopus complex in both the BSAI and GOA. These are non-target species and exploitation rates are low. In addition, the AFSC produces status reports for several species groups included in the fishery management plan as "Ecosystem Components". These are stocks for which there are not active conservation concerns, but have ecosystem roles that warrant some level of monitoring. These groups currently include grenadiers, squids, and a diverse forage fish group (the osmerids capelin and eulachon, as well as Pacific sand lance, are the main species of interest).

At-Sea Experiments to Estimate Footrope Escapement for Rock Soles
During the past five years, we have conducted catch efficiency studies for the PNE bottom trawls used for the Gulf of Alaska and Aleutian Islands Bottom Trawl Survey. We are focused on empirically estimating survey catch ability for northern and southern rock soles (*Lepidopsetta polyxtra* and *L. bilineata*, respectively). Successful studies, supported with National Cooperative Research Program (NCRP) funds (FYs 2015 and 2018), led to the design, construction, and calibration of an auxiliary net fitted underneath the PNE intended to capture fish that escape under the footrope of the PNE. We used NCRP funds in 2018 to tune the new "underbag" design to critical survey net configurations and collect footrope escapement data during 12 successful trials. Preliminary results indicate a marked difference in escapement between southern and northern rock soles: 38% of southern rock sole escaped under the footrope while 58% of northern rock sole escaped (Figure 1). Selectivity functions are estimable based on these data, but with poor confidence. More data are needed to increase confidence about these results and to estimate effects of depth and habitat on the catch efficiency.



Contact Peter Munro (peter.munro@noaa.gov) for more information.

Joint Program Agreement with the Korean National Institute of Fisheries Bottom Trawl Survey Group

The National Institute of Fisheries Science of South Korea conduct systematic bottom trawl surveys of their territorial and adjacent waters. For the past several years, a cooperative agreement has led to working on survey design issues common to the Korean survey and bottom trawl surveys conducted by the AFSC. This work has included evaluating the herding effect, bottom tending and fishing configuration of research nets, and designing an expanded Korean survey. This work has led to specific research projects and exchanges of scientists between the countries. In March 2018, Peter Munro traveled to South Korea to execute a study on footrope and bridle contact with the sea floor. During the summer, Dr. Jeong Jae Mook traveled to Alaska's Aleutian Islands to participate in the 2018 Bottom Trawl Survey. AFSC's Jason Conner traveled to the NIFS laboratory to design a simulation of their bottom trawl survey to evaluate expanded trawl survey designs.

Contact Peter Munro (peter.munro@noaa.gov) for more information.

CONSERVATION ENGINEERING (CE)

The Conservation Engineering (CE) project 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. This is done through the evaluation of fish biology and behaviour, and gear design and use. In 2018, 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 Chinook 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. 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 2018 CE conducted projects (1) to determine the visual range of Chinook salmon in their ocean residency; (2) to evaluate salmon behavior in response to artificial lights; and (3) to collaborate on an industry driven project evaluating salmon behavior around excluders. Additional projects included organizing an industry workshop focused on innovation in Alaska trawl fisheries, and determining optimal ways to record fish with cameras using artificial light that is not observed by the fish species of interest.

Salmon Vision

In March 2018, during a MACE survey aboard the NOAA Ship *Oscar Dyson* in Shelikof Strait (central Gulf of Alaska), AFSC scientists Lyle Britt and Rebecca Haehn collected the retinae from trawl caught Chinook salmon and pollock to determine the visual pigments of the photoreceptors. With these data we aim to explain what color these fish can see to inform both what lights can be tested to affect salmon behavior and what lights can be used to illuminate a camera's field of view without being detected by the salmon. The data from this cruise are still being analyzed.

Salmon Response to Artificial Light

CE conducted a laboratory study at the NWFSC Manchester Research Station, in collaboration with scientists at that location (Barry Berejikian, Jeff Atkins, and Brad Gadberry) and those at AFSC (Lyle Britt, Rebecca Haehn, Rick Towler, and Paul Irvin), to evaluate if artificial light can be used to attract Chinook salmon, and whether the behavior is dependent upon light intensity, color, or flicker rate.

In June 2017, 258 age-0 Chinook salmon were transported to the NOAA Northwest Fisheries Science Center Manchester Research Station (Manchester, WA) as smolts, and transitioned into seawater within a month of transfer. In April 2018, these fish were put into a holding tank that was covered with a 6 m x 6 m x 3 m black, vinyl tent, that was fabricated using heat sealing methods to prevent light seepage through seems. Three identical tanks (one additional tank for holding, two for trials) were set up. In the trial tanks, four eight-channel PAR RGBW DMX lights were hung with the center of the LED array 0.4 m from the tank bottom, flush against the tank wall and facing into the tanks, secured with weight on the bottom of the tank and the electrical cords tethered along the tank edge. The lights were placed such that each marked the center of four equally sized quadrants. The water inflow pipe was located along a shared boundary of two of the quadrants, and each subsequent light spaced equidistantly around the tank's 15.7 m perimeter (3.93 m apart).

In May 2018, 24 trials were completed each in the two trial tanks, with five fish per trial. Four trials were conducted for three experiments: light intensity (for white light), light color (non-strobing), and light color (strobing). Each trial was completed twice, once in the morning and once in the afternoon. The trials and acclimation periods were recorded by camera. The video footage is currently being analyzed using animal behaviour software.

Collaboration on Industry-Led Excluder Research

In August 2017, John Gauvin (North Pacific Fisheries Research Foundation, NPFRF) proposed an Exempted Fishing Permit (EFP) research project to develop and test salmon excluder designs for the different trawl vessel size classes fishing for Bering Sea pollock. 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. 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 project. 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 tested during commercial operations in winter 2018. After reviewing the video footage collected during these trials, adjustments were made and a different set of excluder designs were tested in winter 2019. Review of the 2019 research is underway and a final set of excluder designs will be selected for testing in 2020.

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, and providing 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. Moreover, CE continues to support the research by being involved in the on-going sea trials, data analysis, evaluation of results, and planning.

Support of Industry Innovation

In 2018 CE organized, with the help of a steering committee, the second Fisheries Innovation for Sustainable Harvest (F.I.S.H.) Workshop from three NOAA Alaska Fisheries Science Center (AFSC) locations (Newport, OR; Seattle, WA; Kodiak, AK), connected through video. The goal of these workshops is to provide an opportunity for fishermen and those working in the fishing industry to get together and learn about and provide feedback on current research and innovation related to North Pacific trawl fishing, to learn about tools that support gear innovation, and to workshop on common problems. This year, the workshop included an opportunity for industry participants to provide feedback on Alaska Pacific University (FAST Lab) graduate students' master's research. The workshop also included an evaluation of and discussion about underwater cameras used in trawl gear, featuring: a 'field guide' to using cameras in the trawl net, presentations by six camera companies, and a panel discussion focusing on obstacles to using underwater cameras and ways to increase the usefulness of cameras for fishermen. Feedback from the over 100 participants suggests that this event was successful in providing useful and interesting information to the attendees. The success of the workshop was linked to the varied perspectives of the attendees, who work in different fisheries and ports, but all have aligned interests and commitment to innovation and sustainability.

Technology to Observe Fish Behavior

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 cameras that illuminate the field of view with white light, we imaged with low light cameras using deep red light. The field of view was much broader and the image clearer than previous trials using near infrared. From these results (and preliminary results of the salmon vision study), we are working with a camera company to make ruggedized, underwater cameras that contain deep red LED lights. Further trials will take place in 2019.

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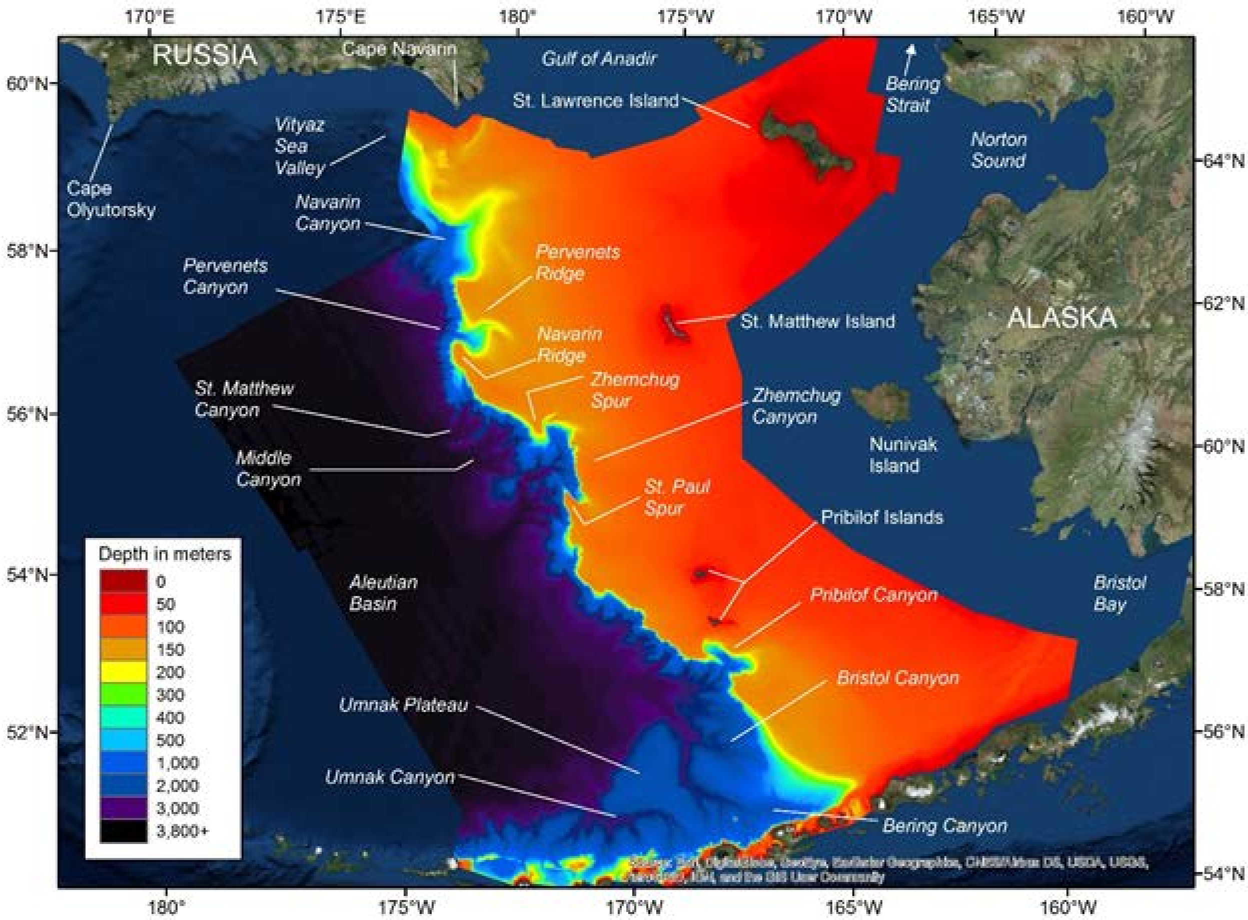
Bathymetry and Canyons of the Eastern Bering Sea Slope - RACE GAP

We created a new, 100 m horizontal resolution bathymetry raster (see below) and used it to define 29 canyons of the eastern Bering Sea (EBS) slope area off of Alaska, USA. To create this bathymetry surface we proofed, edited and digitized 18 million soundings from over 200 individual sources. We clearly defined the number and location of the area's canyons and provided the canyon centerlines, or thalwegs, as a derived product from our analysis. The legendary Zhemchug Canyon pinnacles were disproved – they were probably just schools of fish mistaken for the seafloor. We submitted 45 place name corrections, and new places names, for consideration to international, national and local seafloor naming authorities.



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Zimmermann, M., Prescott, M.M. Bathymetry and Canyons of the Eastern Bering Sea Slope. 2018. Geosciences: Special Issue Marine Geomorphometry 8(5), 184. https://doi.org/10.3390/geosciences8050184

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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The effect of random and density-dependent variation in sampling efficiency on variance of abundance estimates from fishery surveys.
Authors: Stan Kotwicki, Kotaro Ono

Abundance indices (AIs) provide information on population abundance and trends over time, while AI variance (AIV) provides information on reliability or quality of the AI. AIV is an important output from surveys and is commonly used in formal assessments of survey quality, in survey comparison studies, and in stock assessments. However, uncertainty in AIV estimates is poorly understood and studies on the precision and bias in survey AIV estimates are lacking. Typically, AIV estimates are "design-based" and are derived from sampling theory under some aspect of randomized samples. Inference on population density in these cases can be confounded by unaccounted for process errors such as those due to variable sampling efficiency (q). Here, we simulated fish distribution and surveys to assess the effect of q and variance in q on design-based estimates of AIV. Simulation results show that the bias and precision of AIV depends on the mean q and variance in q. We conclude that to fully evaluate the reliability of AI, both observation error and variability in q must be accounted for when estimating AIV. A decrease in mean q and an increase in the variance in q results in increased bias and decreased precision in survey AIV estimates. These effects are likely small in surveys with mean $q \geq 1$. However, for surveys where $q \leq 0.5$, these effects can be large. Regardless of the survey type, AIV estimates can be improved with knowledge of q and variance in q.

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Advancing Essential Fish Habitat (EFH) Species Distribution Modeling (SDM) Descriptions and Methods for North Pacific Fishery Management Plan (FMP) Species
Principal Investigators: Ned Laman (RACE Division, AFSC, Seattle, WA), Jodi Pirtle (Alaska Regional Office, Juneau, AK), Chris Rooper (DFO Canada, Nanaimo, B.C.), Tom Hurst (FBEP, AFSC, Newport, OR)
This study will address the Alaska Essential Fish Habitat (EFH) Research Plan's (referred to hereafter as the Research Plan) Research Priority #1 – *Characterize habitat utilization and productivity* (Sigler et al., 2017) by using the best available science to accomplish Objective #1 – *Develop EFH Level 1 information (distribution) for life stages and areas where missing* and Objective #2 – *Raise EFH level from 1 or 2 (habitat-related densities) to Level 3 (habitat-related growth, reproduction, or survival rates)*. We will characterize habitat utilization and productivity by generating spatial predictions of EFH from habitat-based species distribution models (SDMs) of North Pacific Fishery Management Plan (FMP) species' life stages where additional data sources (e.g., presence, presence-absence, and abundance data, updated life history schedules, and updated habitat covariate rasters) and advances in EFH information levels (e.g., availability of additional species response data and habitat-related vital rates) meet the two Research Plan objectives above. For Objective #1, we will develop EFH maps for FMP species' life stages that were not described in the 2015 EFH review because there were insufficient or no data to support modeling efforts at that time, but for which sufficient data currently exist and new data sources have been identified (e.g., small mesh trawl surveys). For Objective #2, we will raise EFH information Level 1 (L1) or Level 2 (L2) to Level 3 (L3) by integrating habitat-related vital rates generated from field and laboratory studies into updated, model-based EFH maps for those species. In addition to meeting these Research Plan objectives, we will introduce alternative SDM approaches for describing EFH both to incorporate new data sources and to optimize our modeling approaches through skill testing and simulation.

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.

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Systematics Program - RACE GAP
Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2018. 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. Continuing progress has been made in examining morphological variation related to recently revealed genetic heterogeneity in rockfishes (*Sebastes crameri*; Orr, with NWFSC) and flatfishes (*Hippoglossoides*; Orr, Spies, Paquin, Raring, and Kai); and a partial revision of the agonid genus *Pallasina* (Stevenson, Orr). Work on the molecular phylogenetics and selected morphology of snailfishes (Orr, Spies, Stevenson, with NWFSC, Kyoto University, and UW, in press) was completed, as well as a study of the developmental osteology of the bathymasterid *Ronquilus jordani* (Hilton, Stevenson, and Matarese, 2018). Documentation of new records of skates in Alaska and British Columbia were completed (Orr, Stevenson, Spies, Hoff, and Royal BC Museum, in press) and the record of a species not previously recorded in the eastern North Pacific was published (Orr et al., 2018).

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 (Orr, Stevenson, Spies, and UW). Descriptions of other new species of snailfishes, based on morphology and genetics, from Alaska, Canada, and the Arctic continues.

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. Orr, in collaboration with the UW, UCLA, and UWA, will be exploring the use of genomics in the population dynamics and ageing of rockfishes. Stevenson is also collaborating with Spies and other AFSC and UW authors on a genetic analysis of northward range expansion in Pacific cod (Spies et al., In prep), and will be collaborating with Spies on a total genomic analysis of walleye pollock. Molecular and morphological studies on *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies), *Bathyraja spinosissima* and *B. microtrachys* (Orr, Hanke, Stevenson, Hoff, and Spies), *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) to be published in June, and the biology of freshwater flatfishes (Orr, in press). Stevenson recently completed several studies documenting: the reliability of species identifications in the North Pacific Observer Program (Stevenson, 2018); changing fish distributions in the northern Bering Sea (Stevenson and Lauth, 2018); and fishery interactions with skate nursery areas in the Bering Sea (Stevenson et al., 2018). Stevenson and Orr recently concluded a collaboration with Chris Rooper and others to develop a predictive model for skate nursery habitat in the eastern Bering Sea (Rooper et al., In press), and Stevenson recently initiated a collaboration with UW graduate student Kayla Hall on the early development of skate embryos.

Orr and Stevenson have also conducted work with invertebrates. On-deck guides have now been fully 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).

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 based on nationally collected data that facilitates the integration of ecosystem and socioeconomic factors within the stock assessment process (Shotwell et al., 2018). This Ecosystem and Socioeconomic Profile or ESP can be considered a type of research template that serves as a proving ground for testing ecosystem linkages before operational use in quota setting. The ESPs serve as a corollary stock-specific process to the large-scale ecosystem status reports, effectively creating a two-pronged system for ecosystem based fisheries management at the AFSC.

The baseline or initial ESP process begins with a data evaluation of the stock to assess the priority for conducting an ESP and set tangible research priorities for the stock. Once it is established to conduct an ESP, a set of metrics are graded to determine vulnerabilities throughout the life history of the stock and assist with indicator development. Following metric grading, a sequential multi-stage testing phase ensues depending on the data availability of the stock to determine the relevant ecosystem and socioeconomic indicators for continued monitoring. Where possible this would include a decision table to convey the performance and uncertainty between different modeled relationships. The final stage of the ESP process is to produce a long- and short-form standard report to effectively and efficiently communicate the results of the ESP process to a wide variety of user groups (Shotwell et al., *In Review*).

An update on the ESP process and products was recently submitted to the North Pacific Fishery Management Council (NPFMC) at the joint Groundfish Plan Team. This report summarizes responses to recent Scientific and Statistical Committee (SSC) or Plan Team comments regarding the ESPs and includes summaries on several new developments regarding manuscripts, workshops, and web pages aimed at defining and improving the ESP framework. Three manuscripts detail the four-step ESP baseline process with associated products and describe avenues for using integrated ecosystem research to enhance ESPs for high priority stocks. Additionally, three annual workshops are planned, starting in 2019, to fine-tune the national baseline ESP framework to a more regional version that addresses the needs of the AFSC. Finally, two web applications are in development to improve communication of the ESP framework and allow timely and consistent access to regional or stock-specific ecosystem and socio-economic indicators for use in the ESPs. Altogether, these new developments will pave a clear path toward building next generation stock assessments and increase communication and collaboration across the ecosystem, economic, and stock assessment communities at the AFSC.

Please refer to the following reports for more details:

Shotwell, S.K. 2018. Update on the Ecosystem and Socio-economic Profile (ESP). NPFMC Report. 11 p. See link below and select "ESP_Update_PT-0918_Shotwell.pdf"
http://legistar2.granicus.com/npfmc/meetings/2018/9/984_A_Groundfish_Plan_Team_18-09-18_Meeting_Agenda.pdf?id=a1ffa673-eac1-44cb-89eb-1d46b7af71b1

Shotwell, S.K., K., Blackhart, D., Hanselman, C. Cunningham, K., Aydin, M., Doyle, B., Fissel, P., Lynch, P., Spencer, S., Zador. *In Review*. Creating a proving ground for operational use of ecosystem and socioeconomic considerations within next generation stock assessments.

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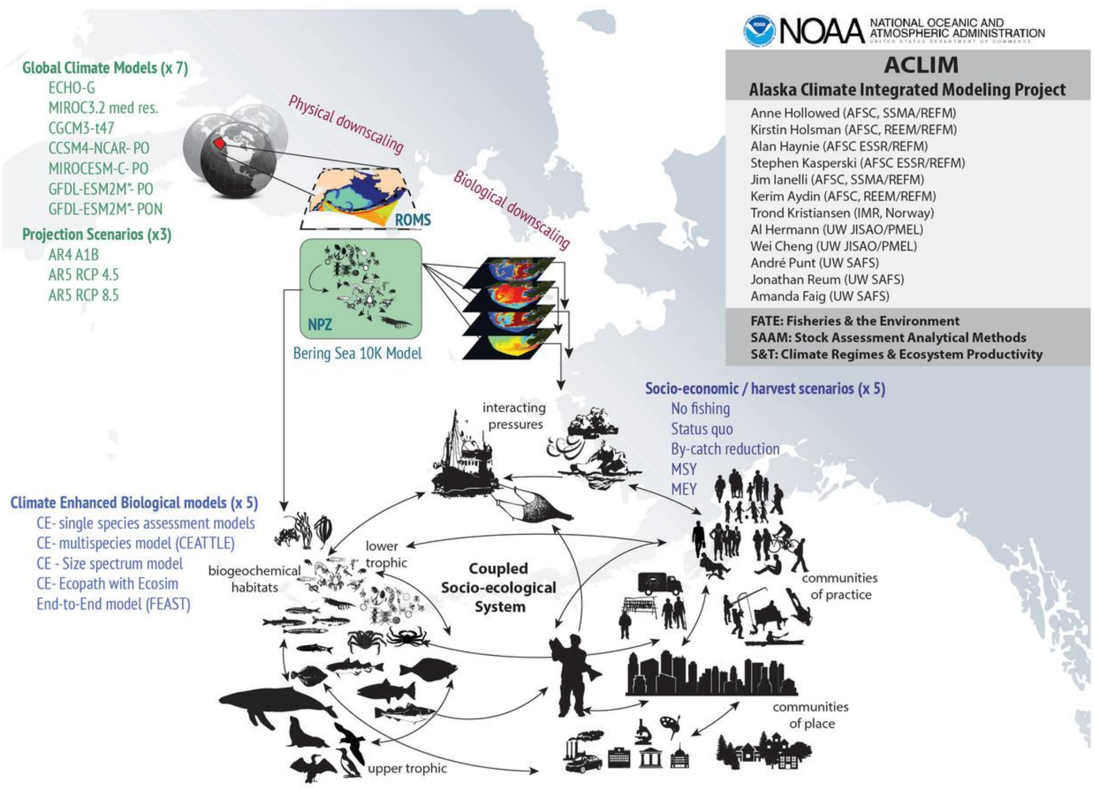
Alaska Climate Integrated Modeling Project - REFM

The Alaska Climate Integrated Modeling project represents a comprehensive effort by NOAA Fisheries and partners to describe and project responses of the Bering Sea ecosystem – both the physical environment and human communities -- to varying climate conditions. Scientists are focusing on five key species where changes in productivity have been linked to climate variability: walleye “Alaska” pollock, Pacific cod, Arrowtooth flounder, Northern rock sole and snow crab. A subset of scientists in ACLIM are also looking at impacts on other species in the food web and the broader ecosystem. To evaluate a range of possible future conditions, scientists are evaluating the effectiveness of existing fishery management actions under 11 different climate scenarios (spanning high and low CO2 futures expected to lead to different degrees of warming). They will also look at how human fishing fleets and communities can adapt to climate change through climate-informed management. Information from these integrated models is being used to make predictions at local scales. Output from these models will help decision-makers choose management measures that promote fisheries resilience, lessen climate impacts on species and communities, and take advantage of potential novel opportunities under climate change. For more information visit https://www.fisheries.noaa.gov/alaska/ecosystems/alaska-climate-integrated-modeling-project.



Gulf of Alaska Integrated Ecosystem Research Program

Scientists from the AFSC played an important role in the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), which concluded in fall 2018. More than 50 scientists from 11 institutions took part in the $17.6 million Gulf of Alaska ecosystem study that examined the physical and biological mechanisms that determine the survival of juvenile groundfishes in the Gulf of Alaska. From 2010 to 2014, oceanographers, fisheries biologists and modelers studied the gauntlet faced by commercially and ecologically important groundfishes, specifically walleye pollock, Pacific cod, Pacific ocean perch, sablefish and arrowtooth flounder, during their first year of life as these fish are transported from offshore areas where they are spawned to nearshore nursery areas. Funding was provided by the North Pacific Research Board with substantial in-kind support from participating agencies, including National Oceanic and Atmospheric Administration (Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory), U.S. Fish and Wildlife Service, and U.S. Geological Survey. More information can be found on the program website at https://www.nprb.org/gulf-of-alaska-project/about-the-project/, or contact Dr. Olav Ormseth (olav.ormseth@noaa.gov).

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

An international team of researchers investigated the influence of anomalous ocean conditions observed in the north Pacific in response to a marine heat wave (2013-2014) and a subsequent El Niño (2015). This work was supported by the North Pacific Research Board (Project #1509). Data from past and present summer bottom trawl surveys and acoustic mid-water trawl surveys were used to document groundfish movements and ocean conditions. Range statistics included centroids of abundance, as well as a new analytical approach that incorporated ontogenetic movements. These distribution indicators were statistically compared with indicators of ocean conditions. Relationships observed in 2015 (an extreme warm year) were compared with observations in cool, warm and average ocean conditions.

For a selected group of representative species (sablefish, gadids: Pacific hake, walleye pollock, rockfish: Pacific ocean perch, and flatfish: rock sole, arrowtooth flounder, and petrale sole), functional relationships between fish distribution and the environmental conditions were evaluated. Size groups were treated separately for all species. We originally planned to apply gradient forest approaches to assess the cumulative importance of different environmental predictors across a range of species in each region (as in Baker and Hollowed 2014). Upon review, a new alternative analytical approach was introduced that proved to be more useful than the gradient forest application.

Comparative assessment of indicators of species distributions in 2015 relative to other years was conducted to estimate the potential range extension possible during anomalous ocean conditions. Responses were evaluated regionally from southern California to the western Gulf of Alaska.
Relationships between groundfish distribution and ocean conditions derived from the three approaches outlined above will be used to consider projected impacts of climate change on groundfish spatial distributions from California to the western Gulf of Alaska on future fisheries. In addition, we will contrasted emergent relationships derived from various data sources to evaluate how data type, observation error, and changes in species demographics may affect index values.

Two publications have been prepared:

Yang, Q., E.D. Cokelet, P.J. Stabeno, Li L., A.B. Hollowed, W.A. Palsson, N.A. Bond, and S.J. Barbeaux. In Press. How "The Blob" affected groundfish distributions in the Gulf of Alaska. Fisheries Oceanography 2019:1-20. DOI: 10.1111/fog.12422.

Lingbo Li, Anne Hollowed, Edward Cokelet, Steve Barbeaux, Nicholas Bond, Aimee Keller, Jackie King, Michelle McClure, Wayne Palsson, Phyllis Stabeno, and Qiong Yang. In Review. Sub-regional differences in groundfish distributional responses to anomalous ocean temperatures in the northeast Pacific. Global Change Biology.

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

The energy contribution of fish eggs to the marine food web in spring - RPP
Jens M. Nielsen*, Lauren A. Rogers, David G. Kimmel, Alison L. Deary, Janet T. Duffy-Anderson

Many fishes aggregate and spawn in high densities and release large amounts of energy and nutrients to the ambient environment in the form of eggs. These spawning events can provide important dietary resources for a range of predators. Despite the likely significance of fish eggs as an energy resource for other animals, there are very few studies that have quantified their importance for marine food webs. Here we assess the magnitude and timing of egg energy from Walleye Pollock (*Gadus chalcogrammus*) and their contribution to a highly productive ecosystem in Shelikof Strait, Gulf of Alaska. Our results show that aggregate spawning events of Walleye Pollock contribute considerably to the energy and nutritional fluxes of this coastal food web in spring. Walleye Pollock egg energy constituted on average 18.9% of April and 5.8% of May copepod production in the Shelikof Strait marine food web (Fig 1). In addition, the energy contributions from eggs appear one to three weeks earlier than the spring peak rates of zooplankton production and thus occur at a time when resources are still limited for many predators. Our analysis suggests that energy pulses from spawning events provide important energetic and nutritional fluxes in marine ecosystems.

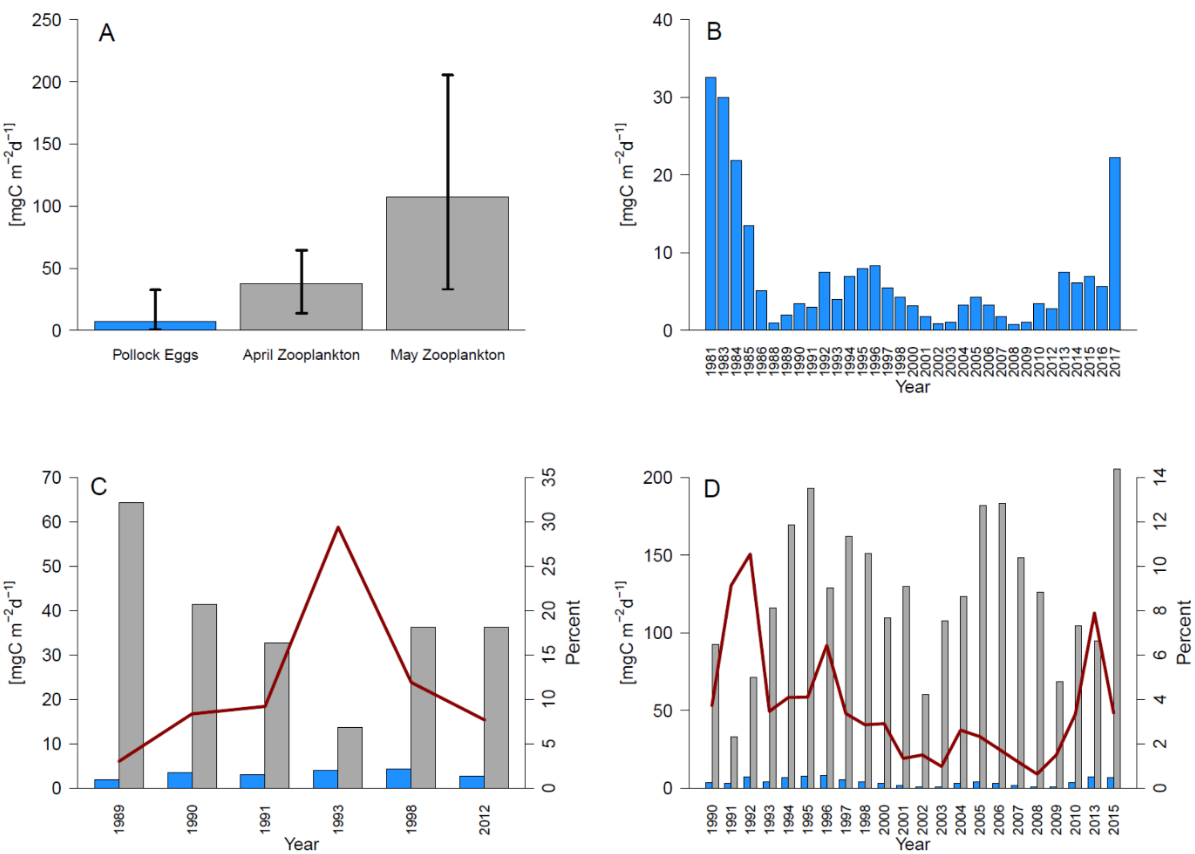


Fig 1: Estimates of, **A**) average production [mgC m^{-2} m^{-1}] of Walleye Pollock eggs deposited as energy, April and May zooplankton, **B**) annual egg production, and comparison of yearly Walleye Pollock egg production (blue) with **C**) April zooplankton (grey) and **D**) May (grey) zooplankton production. The red lines in **C** and **D** denote the relative proportion of egg production compared to total April or May zooplankton production.

Auke Bay Laboratories (ABL)

Forage fish speciation and population structure based in part on genetic data - ABL
Capelin
Species identification and population structure of capelin is being determined with microsatellite markers, DNA sequences, and morphology as a collaborative project with Jay Orr (RACE), Mayumi Arimitsu (USGS), and Kirsten Ressel and Trent Sutton (UAF). The Auke Bay Lab is preparing to use next-generation sequencing tools such as double-digest restriction associated DNA (ddRAD) to examine genetic variation of capelin collected 2013-2016 from Prince William Sound before and after the warm "blob" in the North Pacific Ocean, in collaboration with Mayumi Arimitsu (USGS).

Sandlance
Species identification of sandlance is an active area of international scientific inquiry. Additional analyses of genetic (microsatellite markers) and morphology characteristics are being used to support a previous study that described four species of sand lance in the North Pacific Ocean and its peripheral seas (Orr et al. 2015). The Auke Bay Lab is collaborating on a study of population structure of sand lance within Puget Sound (RACE, WDFW, UC Davis, UW, NWFSC, and Shoreline Comm. College).

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Orr, J. W., S. Wildes, Y. Kai, N. Raring, T. Nakabo, O. Katugin, and J. Guyon. 2015. Systematics of North Pacific sand lances of the genus *Ammodytes* based on molecular and morphological evidence, with the description of a new species from Japan. Fish. Bull. 113:129 156. doi: 10.7755/FB.113.2.3

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Spatial and temporal trends in the distribution and abundance of forage fish in the south and north eastern Bering Sea during late summer, 2002-2017 – ABL
Abundance of forage fish in pelagic waters was estimated for the north and south eastern Bering Sea during late summer of 2002-2017. Samples were collected during the Alaska Fisheries Science Centers' (AFSC) Bering Arctic Subarctic Integrated Surveys (BASIS) survey using a trawl net towed in the upper 20 m. Surveys were not conducted in the south eastern Bering Sea (SEBS) during 2013, 2015 and 2017 and the north eastern Bering Sea (NEBS) during 2008. We estimated the abundance of forage fish in the north (≥60°N) and south (<60°N) eastern Bering Sea.

Common forage fish collected during the survey included age-0 pollock (*Gadus chalcogrammus*), age-0 Pacific cod (*G. macrocephalus*), capelin (*Mallotus villosus*), herring (*Clupea pallasii*), sand lance (*Ammodytes hexapterus*), juvenile Chinook salmon (*Oncorhynchus tshawytscha*), juvenile chum salmon (*O. keta*), juvenile pink salmon (*O. gorbuscha*), and juvenile sockeye salmon (*O. nerka*). Abundance (metric tonnes) of forage fish in the survey area was estimated using geostatistical modeling methods (Thorson et al. 2015) with the VAST package version 4_2_0 (Thorson 2015; Thorson et al. 2016a, b, c). The abundance index is a standardized geostatistical index for stock assessments.

There was an increase in the productivity of forage fish in the eastern Bering Sea from 2012-2016 (Figure 1). Peak abundances occurred during 2004 and 2014 in the NEBS and during 2004, 2005, and 2014 in the SEBS and overall were higher in the NEBS than the SEBS. A positive relationship was found between sea surface temperature and the estimated abundance of forage fish in the NEBS (R^2=0.33, P=0.034) and SEBS (R^2=0.45, P=0.012). These indices can be used in stock assessment for the sampled species and for their predators.

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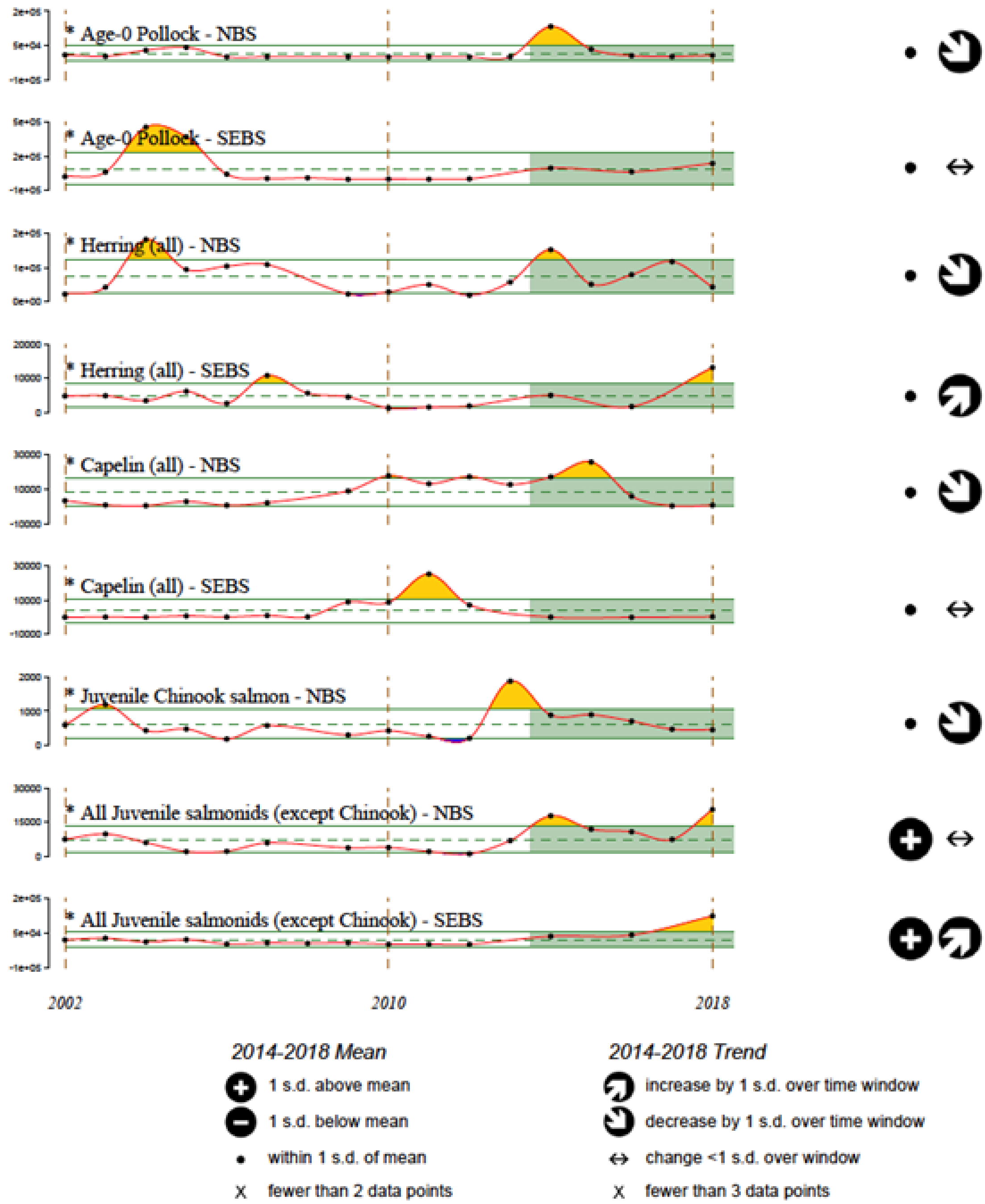

Figure 1: Relative abundance (metric tonnes) of forage fish in pelagic waters of the eastern Bering Sea during late summer, 2002-2018.

For more information contact Ellen Yasumiishi (Ellen.yasumiishi@noaa.gov).

Resource Ecology and Ecosystem Modeling Program (REFM)

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.

Ecosystem Considerations 2018: The Status of Alaska's Marine Ecosystems (REFM)
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. Comprehensive environmental data are gathered from a variety of sources. 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.

Groundfish Stomach Sample Collection and Analysis - REFM
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 2018, samples were collected during the eastern Bering Sea, northern Bering Sea, and Aleutian Islands bottom trawl surveys. Analysis of samples was conducted aboard vessels and in the laboratory. In addition, bill-load and diet samples from seabirds were analyzed for the U.S. Fish and Wildlife Service, and 22 benthic grab samples were analyzed for an Essential Fish Habitat study.

Online sources for REEM data on food habits 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.

Economics and Social Sciences Research (ESSR)

Annual economic SAFE report - ESSR
The ESSR program annually produces an economic counterpart to the stock assessment and fishery evaluation reports (SAFE) published by the North Pacific Fishery Management Council (NPFMC). Published as an appendix to the omnibus NPFMC SAFE document, the Economic Status Report presents summary statistics on catch, discards, prohibited species catch, ex-vessel and first- wholesale production and value, participation by small entities, and effort in these fisheries.

Developing better understanding of fisheries markets-REFM/ESSR
This is an ongoing project 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. An extract of the market profiles was included in *Status Report for the Groundfish Fisheries Off Alaska, 2017*. 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). An updated version of the *Alaska Fisheries Wholesale Market Profiles* report is forthcoming with an expected publication date of June 2019. For more information, contact ben.fissel@noaa.gov.

Economic data reporting in groundfish catch share programs-REFM/ESSR
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 began in 2016 to gather baseline data on costs, earnings, and employment for vessels and processors participating in GOA groundfish fisheries. For further information, contact Brian.Garber-Yonts@NOAA.gov

FishSET: a spatial economics toolbox - REFM/ESSR
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. For further information, contact Alan.Haynie@NOAA.gov

Defining the economic scope for ecosystem-based fishery management -ESSR
The emergence of ecosystem-based fisheries management (EBFM) has broadened the policy scope of fisheries management by accounting for the biological and ecological connectivity of fisheries. Less

attention, however, has been given to the economic connectivity of fisheries. If fishers consider multiple fisheries when deciding where, when, and how much to fish, then management changes in one fishery can generate spillover impacts in other fisheries. Catch share programs are a popular fisheries management framework that may be particularly prone to generating spillovers given that decreasing over-capitalization is often a primary objective. We use data from Alaska fisheries to examine spillovers from each of the main catch share programs in Alaska. We evaluate changes in participation—a traditional indicator in fisheries economics—in both the catch share and non-catch share fisheries. Using network analysis, we also investigate whether catch-share programs change the economic connectivity of fisheries, which can have implications for the socioeconomic resilience and robustness of the ecosystem, and empirically identify the set of fisheries impacted by each Alaska catch share program. We find that cross-fishery participation spillovers and changes in economic connectivity coincide with some, but not all, catch share programs. Our findings suggest that economic connectivity and the potential for cross-fishery spillovers deserves serious consideration, especially when designing and evaluating EBFM policies. Reference: Kroetz et al (2019) *Proceedings of the National Academy of Sciences* 116(10): 4188-4193. For further information contact Dan.Lew@noaa.gov.

Empirical models of fisheries production: Conflating technology with incentives? - ESSR
Conventional empirical models of fisheries production inadequately capture the primary margins of behavior along which fishermen act, rendering them ineffective for ex ante policy evaluation. We estimate a conventional production model for a fishery undergoing a transition to rights-based management and show that ex ante production data alone arrives at misleading conclusions regarding post-rationalization production possibilities— even though the technologies available to fishermen before and after rationalization were effectively unchanged. Our results emphasize the difficulty of assessing the potential impacts of a policy change on the basis of ex ante data alone. Since such data are generated under a different incentive structure than the prospective system, a purely empirical approach imposed upon a flexible functional form is likely to reflect far more about the incentives under status-quo management than the actual technological possibilities under a new policy regime. Reference: Reimer et al (2019) *Marine Resource Economics* 32(2): 169 - 190. For further information contact Alan.Haynie@noaa.gov.

Forecast effects of ocean acidification on Alaska crab and groundfish fisheries - ESSR
Coastal regions around Alaska are experiencing the most rapid and extensive onset of ocean acidification (OA) compared to anywhere else in the United States (Mathis et al. 2015). Assessing future effects of OA is inherently a multi-disciplinary problem that requires models to combine methods from oceanography and fisheries science with the necessary linkages to assess socio-economic impacts. NOAA's Alaska Fisheries Science Center (AFSC) and Pacific Marine Environmental Laboratory (PMEL) collaborate to form the Alaska Ocean Acidification Enterprise. This collaboration combines the scientific disciplines of chemical and biological oceanography, fish and crab physiology, and population and bioeconomic modeling. By integrating observational data with species response studies, OA forecast models, and human impact assessments, it has been determined that Alaska coastal communities and the vast fisheries that support them have varying degrees of vulnerability to OA, ranging from moderate to severe. The AFSC ocean acidification research plan for 2018-20 is currently available. The AFSC workplan for 2018-20 includes a project that will reconfigure and link existing crab bioeconomic models by developing a new multispecies bioeconomic model to simultaneously evaluate the combined cumulative impacts of OA on the crab fisheries off the coast of Alaska. In addition, a new single-species bioeconomic model with population dynamics for northern rock sole in the eastern Bering Sea and Gulf of Alaska will be developed. For further information, contact Michael.Dalton@noaa.gov.

Economic analysis of ecosystem tradeoffs - ESSR

Principle 4 in the NOAA Fisheries Ecosystem Based Fisheries Management (EBFM) Roadmap is to explore and address tradeoffs within an ecosystem. This project analyzes ecosystem tradeoffs that are represented by bioeconomic reference points. Maximum sustainable yield (MSY) is the most important biological reference point in single-species fisheries management. However, tradeoffs exist in achieving MSY with predator-prey relationships and other ecological factors. In this project, the definition of multi-species MSY is based on the production possibility frontier (PPF) in economics which is the classical graphical representation of tradeoffs between two (or more) goods because these show how production of one good can be increased only by diverting resources from and foregoing some of the other good. This project will derive PPFs based on predator-prey relationships in the Aleutian Islands from a bioenergetic food web model and from the classical Lotka-Volterra model applied to a 3-species system with Pacific cod, arrowtooth flounder, and walleye pollock in the Bering Sea. Results from this project will be available for consideration as part of the Bering Sea Fishery Ecosystem Plan process. For further information, contact Michael.Dalton@noaa.gov.

Optimal growth of Alaska's groundfish economy and optimum yield limits in the Bering Sea and Gulf of Alaska - ESSR

This project is joining the Ramsey optimal growth model from macroeconomics, calibrated to data from the Alaska Social Accounting Matrix (AKSAM), with harvest production functions and stock dynamics of the Schaefer model, based on Mueter and Megrey's (2006) multi-species surplus production models for groundfish complexes in the Bering Sea and Gulf of Alaska. Optimal growth represents an extension of benefits of fish consumption to the whole economy, compared to maximum economic yield (MEY), in the traditional Gordon-Schaefer bioeconomic model, which is based solely on fish sector profits and is not a true welfare measure. Since MEY ignores costs and benefits in the macroeconomy, optimal growth is generally superior to MEY in terms of social welfare. The new economic growth model currently estimates steady state optimal growth of Alaska's economy is achieved with an optimum yield limit of 1.8 million metric tons in the Bering Sea/Aleutian Islands, and 294 thousand metric tons in the Gulf of Alaska. Mueter and Megrey's estimates for effects on surplus production of the Pacific Decadal Oscillation (PDO) in the Bering Sea/Aleutian Islands, and sea bottom temperatures at the oceanographic station GAK1 in the Gulf of Alaska, are included to measure impacts of Pacific climate variability on Alaska's economy. For further information, contact Michael.Dalton@noaa.gov.

Regional and community size distribution of fishing revenues in the North Pacific - ESSR

The North Pacific fisheries generate over $4 billion in first wholesale revenues annually. However, the analysis supporting management plans focuses on describing the flow of these monies through each fishery, rather than across the individual cities and states in which harvesters live and spend their fishing returns. 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. A manuscript describing this project is currently under AFSC review. For further information, contact Ron.Felthoven@noaa.gov.

Tools to explore Alaska fishing communities - ESSR
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. A total of 196 communities from around Alaska were profiled as part of this effort. Social scientists in the AFSC Economic and Social Science Research Program have developed two web-based tools, which are updated as new data become available. All of this information is available at:
https://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/communities/profiles.php.

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

Published January 2018 through December 2018 (AFSC authors in bold text)

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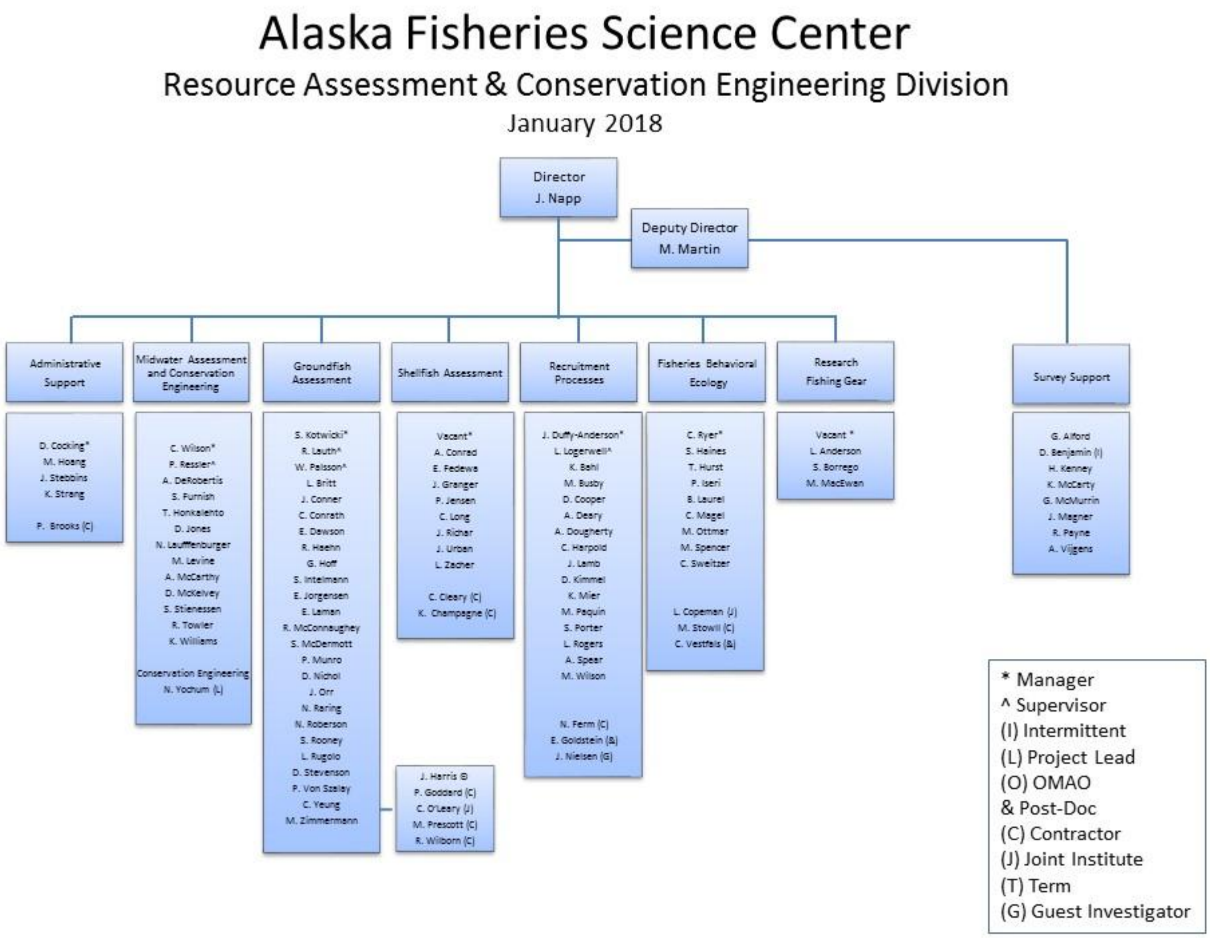
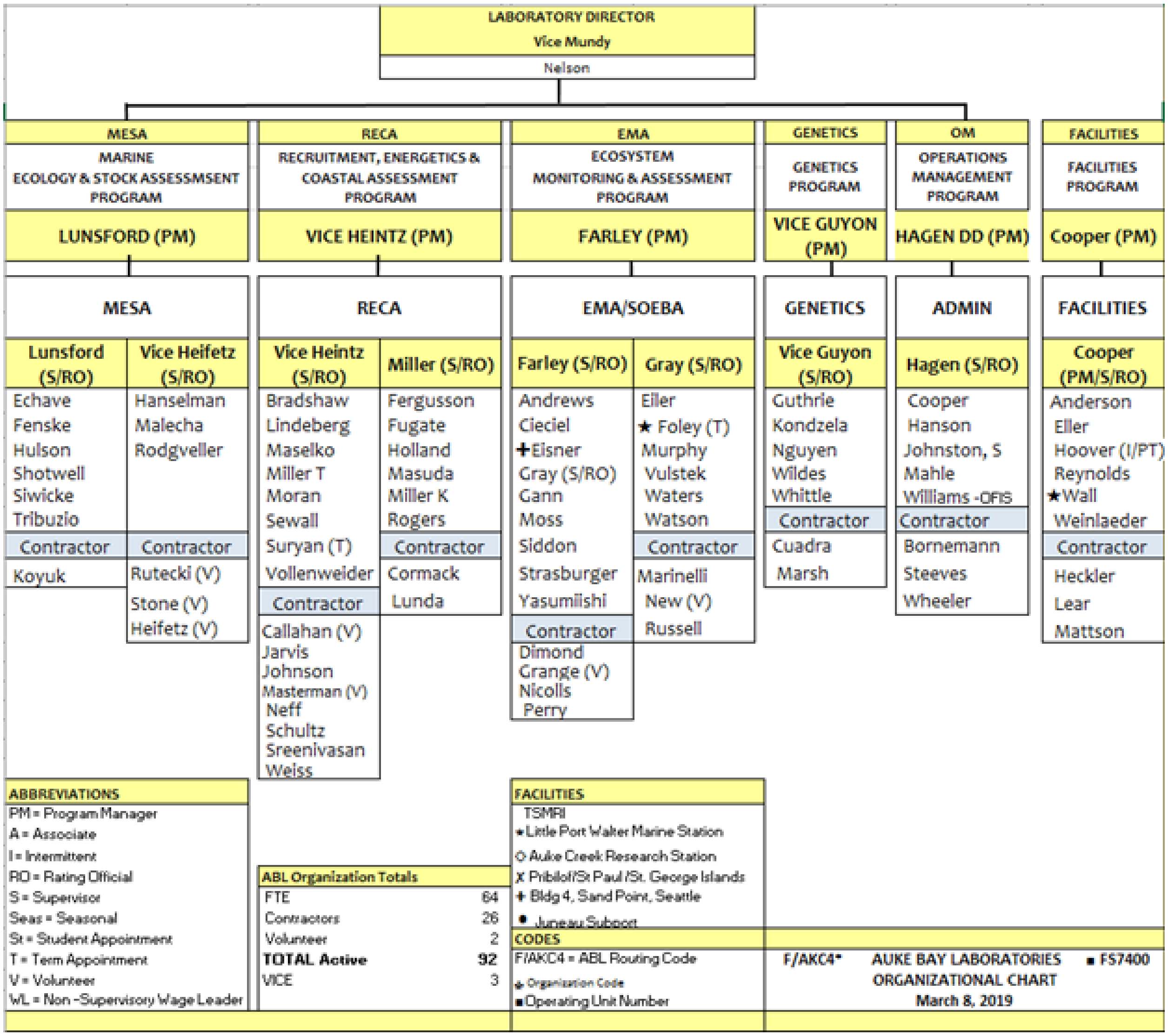
APPENDIX I. RACE ORGANIZATION CHART



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 2018

April 2019

Prepared for the 60th Annual Meeting of the
Technical Sub-Committee of the Canada-United States Groundfish Committee
April 23-24, 2019,
Double Tree by Hilton Olympia
415 Capitol Way
Olympia, WA, USA

Compiled by
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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	Ms. Lesley MacDougall
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	Vacant
Quantitative Assessment Methods	Dr. Chris Rooper
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. Ecosystem studies, marine protected areas research and planning, and habitat research is undertaken in collaboration with staff in the Ecosystems Science Division (ESD).

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 *W.E. Ricker,* was officially decommissioned in October of 2017. The replacement vessel for the *W.E. Ricker,* the *Sir John Franklin*, is currently undergoing sea trials with delivery anticipated mid-summer of 2019. In the interim period, at sea operations for groundfish surveys requiring a large vessel continue to 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. Adam Keizer) 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 Mr. John Candy. Historically Groundfish held at least two meetings per year, in which stock assessments or other documents underwent scientific peer review (including external reviewers who are often from NOAA). The resulting Science Advisory Report summarizes the advice to Fishery Managers, with the full stock assessment becoming a Research Document. Both documents can be viewed on the Canadian Stock Assessment Secretariat website: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm. The future frequency of review meetings and production of stock assessment advice for fisheries managers will depend on departmental, branch and regional priorities potentially resulting in less frequent advice.

The Trawl, Sablefish, Rockfish, Lingcod, North Pacific Spiny Dogfish, and Halibut fishery sectors continue to be managed as an integrated fishery 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 2018 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 2018-19 between Fisheries and Oceans Canada and several partner organizations to support groundfish science activities through the allocation of fish to finance the activities. These agreements will be updated for 2019-20.

II. Surveys

Databases and Data Acquisition Software

GFBioField is a data acquisition software application created in-house by DFO staff in the Groundfish Surveys Program at the Pacific Biological Station in Nanaimo British Columbia. GFBioField was designed for real-time data capture and data entry during at-sea surveys, but can also be used for dockside sampling and office-based data entry. Modified versions have been developed by Groundfish Surveys staff for use by other programs such as the Marine Invertebrates Section within the StAR Division, and the Aquatic Ecosystems and Marine Mammals Section and Regional Ecosystem Effects on Fish and Fisheries Section in the Ecosystem Science Division.

GFBioField uses a client-server architecture employing Microsoft SQL Server 2016 for the back-end data storage and business logic. Previous versions used a Microsoft Access 2007 project for the user interface. However, in 2018, DFO adopted Microsoft Office 2016 as the standard for all new workstations, and it was felt that continuing to maintain and support obsolete versions of the software would become increasingly difficult. Therefore, the GFBioField user interface was completely rebuilt as a Microsoft Access 2016 front-end. The new version will be deployed for the 2019 field season.

GFBio is an oracle database developed in-house by DFO staff in the 1990s, which houses groundfish research survey and commercial biological data collected in British Columbia from the 1940s to the present. GFBio now includes over 28 thousand trips and approximately 11.5 million individual fish specimens. In 2018, 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 other DFO surveys.

Commercial Fishery Monitoring and Biological Sampling

Groundfish commercial fisheries in British Columbia are subject to 100% catch monitoring, either by the at-sea observer program (ASOP) or by electronic monitoring, with all bottom trawl trips outside the Strait of Georgia accompanied by an at-sea observer, and all line trips subject to video monitoring. A dockside monitoring program (DMP) validates all commercial landings. Commercial fishery data from observer logs, fisher logs, and DMP are captured electronically in the groundfish modules of the Fishery Operations System (FOS) database, maintained by the Fisheries and Aquaculture Management Branch of DFO. Groundfish Science maintains GFFOS, which contains the groundfish FOS data, reformatted to be useful for scientific purposes.

In addition to monitoring catches at sea, the ASOP also provides biological samples of halibut, salmonids, and a variety of important commercial groundfish species from the observed trawl fishery. Biological samples are also collected from the hake fishery as part of the DMP. Additional commercial biological samples may also be collected by DFO staff at the dockside from sablefish trips or other trips that would not otherwise be sampled. Biological samples are uploaded to GFBio on a quarterly basis. In 2018, samples were collected from approximately 400 commercial trips, resulting in approximately 96 thousand specimen records.

Research Surveys

The Fisheries and Oceans, Canada (DFO) Groundfish section of the Stock Assessment and Research Division conducts 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 routinely participates in the Canadian portion of the Joint Canada US Hake Acoustic Survey and provides staff to collect groundfish information from a DFO Small-Mesh Bottom Trawl Survey and the International Pacific Halibut Commission (IPHC) Standardized Setline Survey (Figure 2).

The Multispecies Synoptic Bottom Trawl Surveys are conducted in four areas of the BC coast, with two areas surveyed each year, such that the whole coast is surveyed over a two year period. Typically, the West Coast of Vancouver Island (WCVI) and West Coast of Haida Gwaii (WCHG) are surveyed in even-numbered years, while Hecate Strait (HS) and Queen Charlotte Sound (QCS) are surveyed in odd-numbered years. An additional synoptic bottom trawl survey has been conducted twice in the Strait of Georgia (SOG), but vessel availability and staffing constraints have precluded establishing a regular schedule for this survey. These surveys are conducted under collaborative agreement with the Canadian Groundfish Research and Conservation Society (CGRCS), and in typical years, one survey occurs on a Canadian Coast Guard Vessel, and one survey occurs on a chartered commercial vessel. These bottom trawl surveys provide coast-wide coverage of most of the trawlable habitat between 50 and 500 meters depth. Survey data are collected electronically using GFBioField. Trawl survey data sets are updated annually and are available for download from [open maps URL].

In 2018, the Multispecies Synoptic Bottom Trawl Surveys occurred on the charted commercial trawl vessel *Nordic Pearl*. One Hundred and Ninety (190) and 132 successful tows were completed in the WCVI and WCHG regions, respectively. Off the west coast Vancouver Island the dominant species in the catch were North Pacific Spiny Dogfish, Sharpchin Rockfish, and Sablefish. Notable trends in the indices of abundance include significant increases in the trends for Sablefish, Sharpchin Rockfish, Flathead Sole, and Bocaccio, with decreasing trends for North Pacific Spiny Dogfish and Arrowtooth Flounder. Off the west coast of Haida Gwaii the dominant species in the catch were Pacific Ocean Perch, Sharpchin Rockfish, and Rougheye/Blackspotted rockfish complex. Notable trends in the abundance indices include increasing trends for Sablefish, Sharpchin Rockfish, Walleye Pollock, Redbanded Rockfish and Bocaccio, with decreasing trends for Arrowtooth Flounder, Silvergray Rockfish, and Pacific Cod.

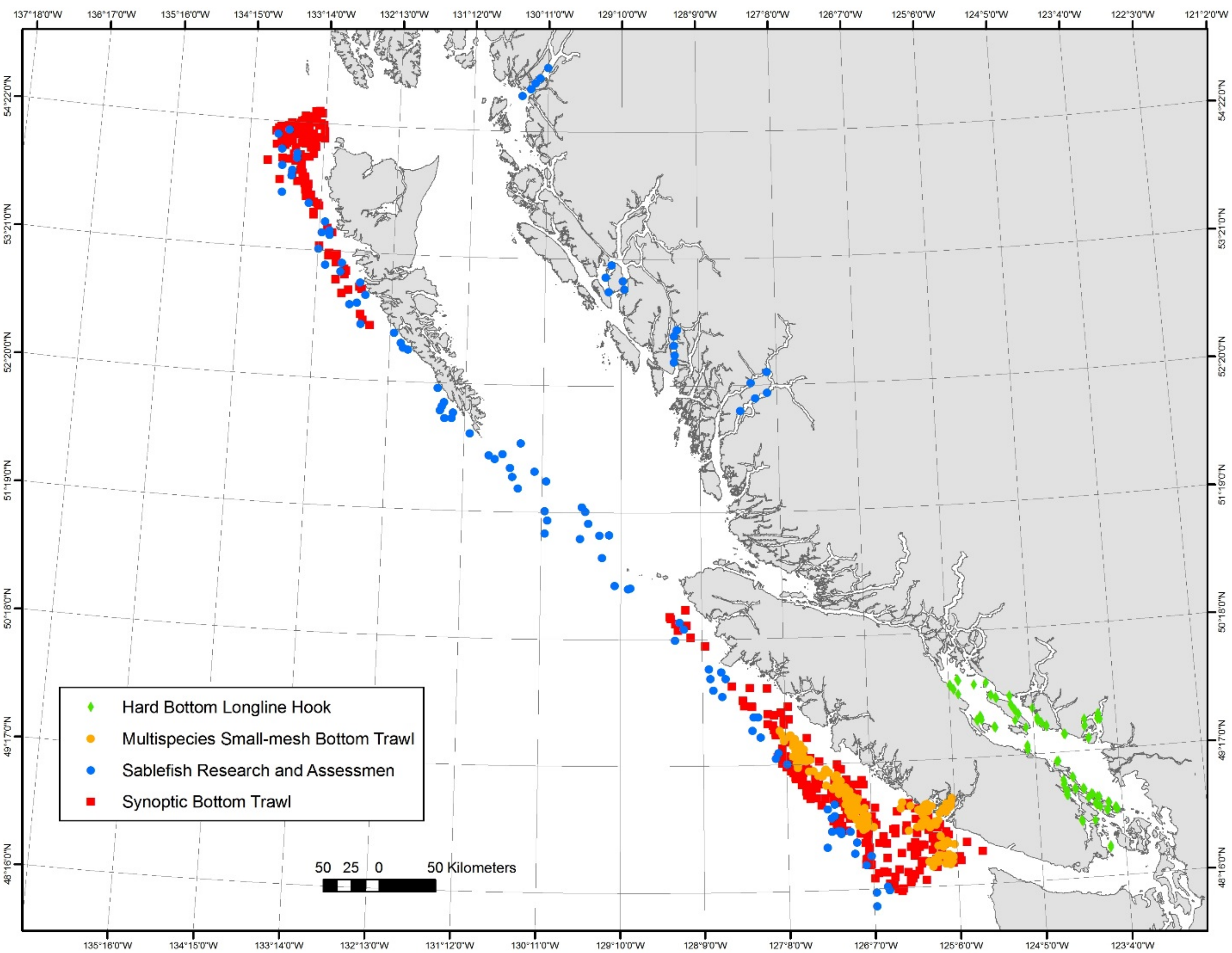

Figure 1. Fishing locations of the 2018 Groundfish surveys. The HBLL-outside and IPHC survey data have not been plotted because they were not available at the time of writing.

The Hard Bottom Longline Hook (HBLL) Surveys are conducted annually in "outside" waters (not between Vancouver Island and the mainland) and "inside" waters (between Vancouver Island and the mainland). Both the "outside" and "inside" areas are divided into northern and southern regions, and annual surveys alternate between the regions, such that the whole coast is surveyed over a two year period. The "outside" surveys are conducted under collaborative agreement with the Pacific Halibut Management Association (PHMA) and occur on chartered commercial vessels, while the "inside" surveys are conducted by DFO and occur on a Canadian Coastguard vessel. The longline hook surveys provide coast-wide coverage of most of the non-trawlable habitat between 20 and 220 meters depth. As the outside surveys are conducted on a variety of small vessels without any DFO staff present, data from these surveys are initially recorded on paper, while data from the inside survey are recorded electronically using GFBioField. The HBLL survey data sets will be available later in 2019.

In 2018, both the HBLL outside and inside surveys occurred in the southern portion of their respective survey areas. The outside surveys occurred on the chartered commercial longline vessels *Pacific Ambition*, *Western Sunset*, and *Borealis 1*, while the inside survey occurred on the Canadian Coast Guard Vessel *Neocaligus*. One Hundred ninety seven (197) and 55 successful sets were completed, respectively. In previous years, data from the outside survey have been keypunched by Archipelago Marine Research (AMR) into their data system, extracted as a series of flat files, and provided to the Groundfish Data Unit for reformatting, error checking, and uploading to GFBio. In 2018, AMR was provided with a stand-alone version of GFBioField and all data entry was directly into the GFBioField application, greatly streamlining the data processing. The most abundant species on the HBLL outside survey were Yelloweye Rockfish, Quillback Rockfish, Pacific Halibut and Sablefish, while on the HBLL Inside they were North Pacific Spiny Dogfish, Quillback Rockfish, Lingcod and Yelloweye Rockfish.

The Sablefish Research and Assessment Survey is an annual longline trap survey targeting sablefish. This survey releases tagged Sablefish at randomly selected fishing locations in offshore waters, as well as at fixed stations in four mainland inlets. The survey also provides catch rates and biological data for use in stock assessments. The survey is conducted under collaborative agreement with the Canadian Sablefish Association and occurs on a chartered commercial vessel. 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. Survey data are collected electronically using GFBioField. The sablefish research and assessment survey data sets are available on request from the Groundfish Data Unit.

In 2018, the sablefish survey completed 91and 20 successful sets in the offshore and inlet areas, respectively. The most abundant fish species encountered by weight were Sablefish, followed by Pacific Halibut, North Pacific Spiny Dogfish, Lingcod, and Yelloweye Rockfish.

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 87).

DFO, along with the Province of British Columbia and 16 First Nations, are co-leading the development of a network of MPAs for the Northern Shelf Bioregion (http://mpanetwork.ca/bcnorthernshelf/). The Marine Protected Area Technical Team (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. A draft MPA network scenario was released for comment by stakeholders on the advisory committee on February 28, 2019, with initial reviews by June 30 and MPATT accepting feedback until Jan 31. The scenario is expected to change as a result of comments and has not been publically released.

The Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA that was designated under Canada's Oceans Act in February 2017 to protect glass sponge reefs in Hecate Strait and Queen Charlotte Sound will be part of that MPA network, as will the Gwaii Haanas National Marine Conservation Area Reserve (GHNMCAR) and Haida Heritage Site. Parks Canada and the Archipelago Management Board have introduced new zoning to the GHNMCA which includes multiple use zones (IUCN protection level IV-VI) as well as high protection zones (IUCN Ib-III) and two small restricted access zones that are intertidal/terrestrial. These zones come into effect on May 1, 2019. The two RCAs that were formerly within the GHNMCA boundaries will be rescinded and replaced with the new zoning, although one small RCA remnant may remain in Crescent Inlet. Parks Canada is still also working on the Southern Gulf Islands NMCA.

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 87) (DFO 2019). 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). They are on track to make this into an MPA within 2 years.

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 other 162 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. A review of the RCA locations was completed this year (DFO 2019) and a risk assessment is also being completed and will be re-reviewed at CSAP in May 2019. 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). Eight additional sponge reefs closures in Howe Sound were announced by DFO on April 1, 2019 with the same prohibitions as the other sponge closures with the additional prohibition of the use of downrigger gear in recreational salmon fishing due to the potential risk of damage to these shallow reefs.

The Scott Islands marine National Wildlife Area (NWA), the first protected marine area established under the Canada Wildlife Act, was established on June 27th, 2018. It conserves a vital marine area for millions of seabirds on the Pacific coast. Fishing activity is currently not prohibited in the NWA (https://www.canada.ca/en/environment-climate-change/services/national-wildlife-areas/locations/scott-islands-marine.html).

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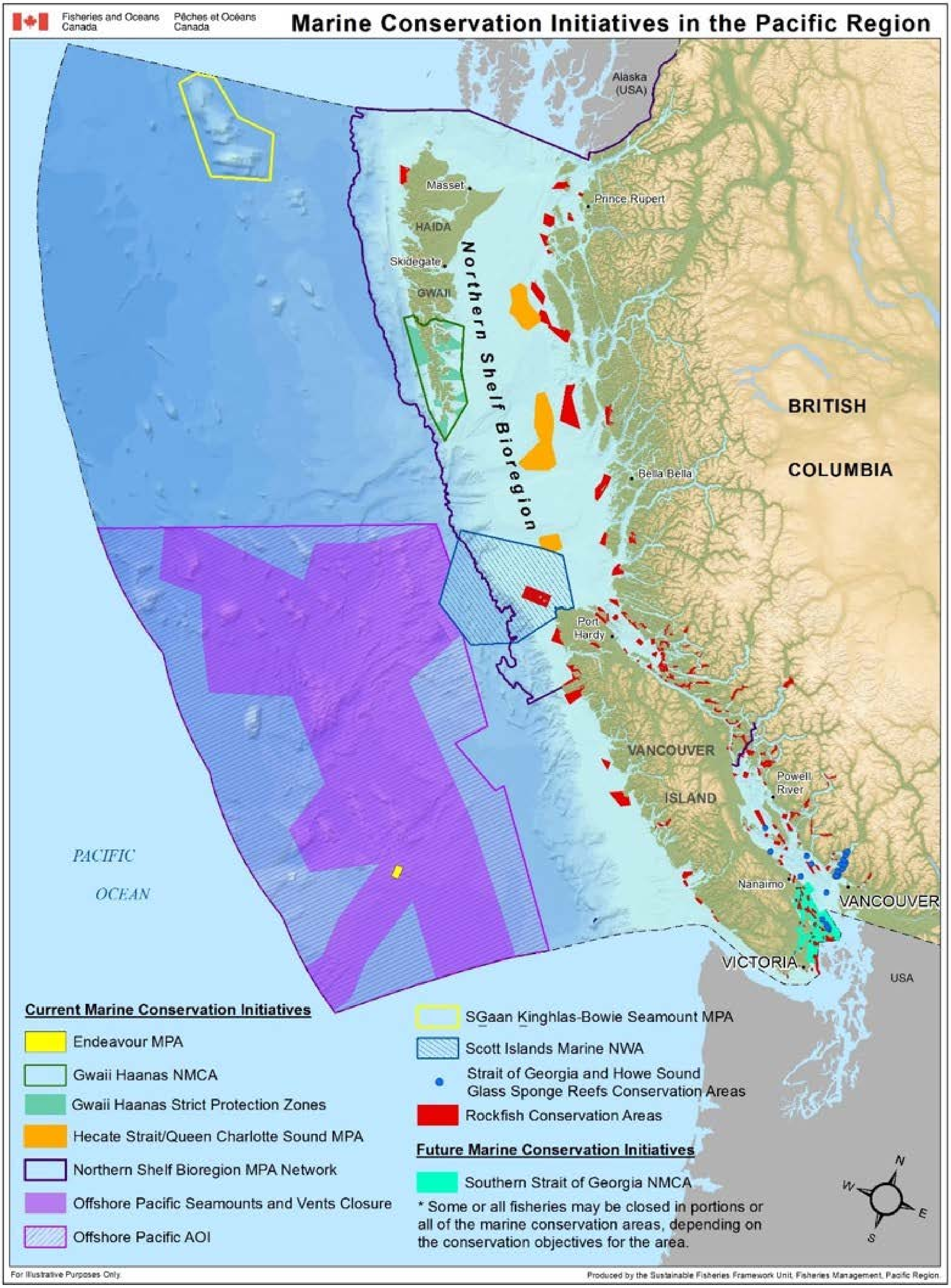


Figure 1. Map of Marine Conservation Target initiatives in British Columbia.

A. Hagfish

1. Research

No new research in 2018.

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 2018 through the Groundfish Synoptic Surveys, at-sea observer sampling, and recreational creel surveys. Anecdotal information continued to be collected through the Shark Sightings Network. Dogfish survey to be conducted Oct 2019!

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.

The committee of the status of Endangered Wildlife in Canada (COSEWIC) contracted an author to prepare an updated status report Tope (Soupfin) shark. A draft of that report was reviewed by DFO Science, the final report will be reviewed by the COSEWIC Marine fish Committee during 2019. Tope were designated as Special Concern by COSEWIC in April of 2007 and subsequently listed under the Species At Risk Act (SARA) in March of 2009 as Special Concern, this is their first re-assessment by COSEWIC.

3. Management

Dogfish are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). The current TAC for Dogfish-Outside (all waters except the Strait of Georgia) is 12000 t, for Dogfish – Inside the TAC is 2000 t, the TACs are split between the Trawl (32%) and directed Dogfish (68%) fishery fleets. There is currently no targeted fishing for Dogfish as markets have essentially collapsed with the directed dogfish fleet harvesting 0% of its TAC in 2018 and the trawl fleet intercepting only 2.7% of its TAC. All fishery induced mortality at this time is as bycatch in directed fisheries for other species with little to none of the catch being retained or landed.

For other shark species not managed using a TAC under the IFMP there is a Shark Code of Conduct intended to increase the likelihood of sharks surviving release at sea. Of the fourteen shark species in Canadian Pacific waters, three are listed under the Species At Risk Act (SARA). The Basking Shark (*Cetorhinus maximus*) is listed as Endangered, and the Bluntnose Sixgill Shark (*Hexanchus griseus*) and Tope Shark (*Galeorhinus galeus*) are species of Special Concern. The primary threats to shark species have been identified as bycatch and entanglement. As such, commercial fishing licences have been amended to include a Condition of License for Basking Sharks that specifies mitigation measures in accordance with SARA permit requirements.

Additionally, two 'Code of Conduct for Shark Encounters' documents have been developed to reduce the mortality of Basking Shark, as well as other Canadian Pacific shark species such as Bluntnose Sixgill and Tope Shark resulting from entanglement and bycatch in commercial, aquaculture, and recreational fisheries.

These documents have been posted online and can be found at the following URL links.

Code of Conduct for Basking Sharks:

http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/shark-requin/conduct_basking_conduite_pelerin-eng.html

Code of Conduct for Sharks:

http://dfo-mpo.gc.ca/species-especes/publications/sharks/coc/coc-sharks/index-eng.html

C. Skates

1. Research

Ongoing data collection continued in 2018 through surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

2. Assessment.

Skates were last assessed in 2015. No new assessment is currently planned.

3. Management

Big and Longnose skates are currently managed under sector and area TACs, for all other species of skate there are no management measures in place or limits.

Big and Longnose skates are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Big and Longnose skates are IVQ (individual vessel quota) species with 2018/19 TACs (total allowable catch) of 1,032 t and 458 t respectively coastwide. Commercial TACs for various groundfish species are allocated between Management Areas and the different groundfish sectors, the allocation for Big and Longnose skate exemplify the complexity of such a system.

Species		**Commercial Sector**						
		T (Trawl)	L (Halibut)	LC (LingCod)	ZN Inside (Rockfish)	ZN Outside (Rockfish)	K (Sablefish)	DF (Dogfish)
Longnose Skate	3CD	62.83%	14.19%	0.00%	0.00%	1.50%	11.26%	10.22%
	5AB	32.83%	48.49%	0.01%	0.00%	8.61%	9.47%	0.57%
	5CDE	20.28%	59.80%	0.00%	0.00%	8.53%	10.55%	0.84%
Big Skate	3CD	24.55%	26.72%	0.00%	0.00%	1.93%	4.16%	42.63%
	5AB	91.48%	5.97%	0.01%	0.00%	1.20%	0.72%	0.62%
	5CDE	92.07%	6.34%	0.00%	0.00%	0.56%	0.95%	0.08%

To support groundfish research and account for unavoidable mortality incurred during the 2018 Groundfish Trawl multi-species surveys, 0.2 and 1.0 t respectively were accounted for before defining the Groundfish Trawl TACs.

D. Pacific cod

1. Research

Ongoing data collection continued in 2018 through the surveys and at-sea observer sampling. Collection of DNA was initiated during 2015 in the spawning areas of Hecate Strait (PSMFC Area 5D) and continued in 2018.

2. Assessment

Updated harvest advice was produced for Pacific Cod during 2018. Four stocks are defined for management purposes in BC: Strait of Georgia (4B); West Coast Vancouver Island (3CD); Queen Charlotte Sound (5AB); and Hecate Strait (5CD). Historically each area has been assessed separately. For the purposes of this assessment, data from Areas 5AB and 5CD were combined into a single stock assessment, due to the lack of biological evidence for separate stocks and improved fits to the combined data compared to data from area 5AB alone. Area 3CD was assessed separately. Area 4B was not assessed at this time as there is no directed commercial fishery there.

Pacific Cod in BC are difficult to age, making statistical catch-age models inappropriate for this species. Therefore, stocks in Areas 5ABCD and 3CD were assessed using Bayesian delay-difference models. The models were fit to fishery-independent indices of abundance, mean annual weight in the commercial catch, and new standardized commercial catch-per-unit-effort (CPUE) indices that were developed using Tweedie generalized linear mixed effect models (GLMMs). Updated estimates of growth parameters were also incorporated into the models.

Due to uncertainty in model parameters, biological reference points based on equilibrium assumptions (e.g., maximum sustainable yield (MSY)) were not used. Instead, following the approach in previous stock assessments for Area 5CD, reference points were based on estimated historical biomass. For both stocks, the recommended upper stock reference (USR) is the average estimated biomass between 1956 and 2004; and the recommended limit reference point (LRP) is an agreed-upon undesirable low biomass state to be avoided (B2000 in Area 5ABCD; B1986 in Area 3CD). The recommended limit removal rate (LRR) is the average estimated fishing mortality between 1956 and 2004.

For each of the two assessed stock areas, advice is provided as a decision table that summarizes the probability of breaching reference points over a range of fixed catch levels for a one-year projection using a model-averaging approach. The model- averaged decision tables were constructed using unweighted posterior samples from a reference case model and six sensitivity cases for each stock, to encompass the range of parameter uncertainty in the assessments.

For Area 5ABCD, model-averaged biomass at the beginning of 2019 (B2019) was projected to be 0.60 (0.39-1.01) of unfished biomass (B0). For Area 3CD, model-averaged B2019 was projected to be 1.13 (0.78-1.73) of B0. Proportions denote median (and 2.5 - 97.5 percentiles).

3. Management

Pacific Cod is managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Pacific Cod is an IVQ (individual vessel quota) species with a 2018/19 TAC (total allowable catch) of 1,450 t coastwide (500 t in Area 3CD, 250 t in 5AB, and 700 t in 5CDE). Commercial total allowable catch for various groundfish species are usually allocated between the different groundfish sectors; however, Pacific Cod was entirely (100%) allocated to the Trawl sector.

To support groundfish research and account for unavoidable mortality incurred during the 2018 Groundfish Trawl multi-species surveys, 2.7 t were accounted for before defining the Groundfish Trawl TACs.

E. Walleye pollock

1. Research

There is no directed work being conducted on Walleye Pollock but ongoing data collection continued in 2018 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

2. Assessment

The BC Walleye Pollock assessment of 2017 was sent for publication in 2018. Two stocks were identified: BC North (PMFC 5CDE) and BC South (PMFCs 5AB+3CD + minor areas 12 & 20) based on significant differences in mean weight (fish were generally twice the size in the north as they were in the south). A delay-difference production model was used to assess each stock in a Bayesian framework, 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. Composite reference (model averaged) scenarios (Figure E.1) were used to represent each stock based on natural mortality and knife-edge combinations which generated reasonable estimates of fishing mortality (F<2).

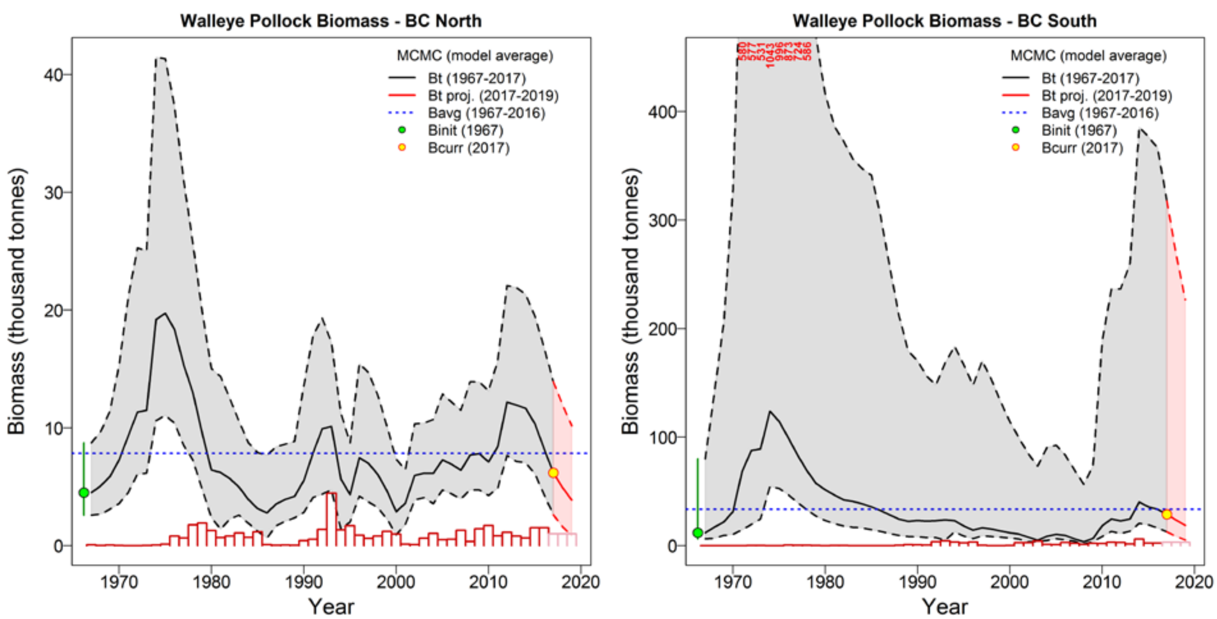


Figure E.1. Median estimates (solid black line) and 90% credibility intervals (black dashed lines, grey fill) for the model-average B_t (biomass in year t in tonnes) for Walleye Pollock. Also shown are the initial biomass B_{1967} (green circle), current biomass B_{2017} (yellow circle), two-year projections $B_{2018\text{-}19}$ (pink fill), the median of average biomass B_{avg} (blue dotted line), the historical catch (red bars) and the catch strategy (pink bars, 1000 t).

3. Management

Walleye Pollock is an IVQ (individual vessel quota) species with a 2018 TAC (total allowable catch) of 4,225 t coastwide, which is unchanged from 2017 (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 2018 Groundfish Trawl multi-species surveys planned, 1.2 t were accounted for before defining the Groundfish Trawl TACs.

Advice to managers (as decision tables) from the stock assessment used historical reference points: Bavg, the average spawning biomass from 1967-2016, was used as a proxy for BMSY, and Bmin, the minimum spawning biomass from which it subsequently recovered to Bavg, was used in place of 0.4BMSY. Twice Bmin was used in place of 0.8BMSY. Three models were used for the model average in BC North and six models contributed to the model average for BC South (Figure E.2).

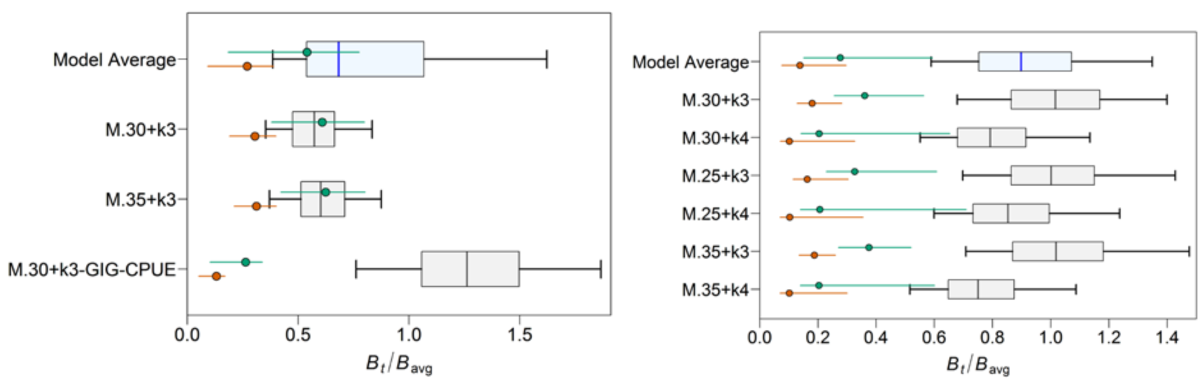


Figure E.2. Status (left: BC North, right: BC South) of the current stock B_{2017} relative to B_{avg} with the circles showing median biomass reference points (B_{min}/B_{avg} [red], $2B_{min}/B_{avg}$ [green]), where B_{avg} is a proxy for B_{MSY}, B_{min} is the limit reference point (LRP), and $2B_{min}$ 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

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. The last survey used in the assessment model took place in 2017.

An exploration of the use of sail drones was done during the summer of 2018, with multiple sail drones running along the same transect lines as the U.S. and Canadian ships. Initial results show promise in acquisition of clean acoustic data by sail drones, but they are limited to two frequencies whereas the ships have five. There is also currently a limitation of non-real-time data access because the drones need to come within range of a cell phone tower to download their data. Use of the sail drones in future surveys to gather acoustic data for use in Pacific hake backscatter calculations would still require the use of one or more catcher vessels, for opportunistic sampling of notable aggregations.

2. Assessment

As in previous years, and as required by The Agreement, 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 (SS3.30). The 2019 model had the same model structure used in 2018, with updates to catch and age compositions. Standard sensitivities requested by the Scientific Review Group were done and showed little difference from the reference model.

The largest cohort caught in the Canadian fishery was age-8's, followed by age 4's which represent the large cohorts for 2010 and 2014 respectively. There was a larger proportion than usual of Age 2's caught this year which could mean a larger than average recruitment of 2016 fish.

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 2018 was the same as it was in 2017 at 156,067 t. The shoreside/freezer trawler sectors caught 54,447 t and 38,241 t respectively which was 61.1% of the total Canadian TAC. The Joint Venture (JV) fishery received a quota of 15,000 t in 2018, and caught 2,724 t. The majority of the Canadian Pacific Hake catch for the 2018 season was taken from the west coast of Vancouver Island.

The final decision on catch advice for the 2019 fishing season was made at the Joint Management Committee (JMC) meeting in Vancouver, B.C. on Mar. 4 – Mar. 5, 2019. For the third year in a row, a coastwide TAC of 597,500 t was agreed upon for 2019. 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

Publications:

Berger, A.M., A.M. Edwards, C.J. Grandin, and K.F. Johnson. 2019. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2019. 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. 249 p.

G. Grenadiers

1. Research

There is no directed work being conducted on Grenadiers but ongoing data collection continued in 2018 through surveys and at-sea observer sampling.

2. Assessment

Grenadiers are not commercially harvested in BC and are rarely encountered during commercial fisheries, consequently there are no assessment activities planned for these species.

3. Management

There are no management objectives or tactics established for these species. These species are caught primarily as bycatch in the deep water rockfish (Rougheye/Shortraker/Thornyhead) and Dover Sole fisheries, 100% of the catch is discarded, Only about 10 t each of Pacific and Giant Grenadier are caught and discarded annually.

H. Rockfish

1. Research

The department (DFO) assesses populations of rockfish (Sebastes) species both inshore (shallow regions near shore that are accessible by many fisher groups) and offshore (BC's continental shelf and slope often only accessible by the commercial industry). DFO also tackles a variety of other issues: 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. In stock assessment, DFO collaborates with outside contractors from agencies like the Canadian Groundfish Research and Conservation Society and The School of Resource and Environmental Management (REM) at Simon Fraser University (SFU).

The Groundfish Surveys program at the Pacific Biological Station (PBS, Nanaimo BC) conducts a suite of synoptic surveys that covers most of BC's ocean bottom ecosystems. The survey team gathers information on abundance and biology (lengths, weights, maturity, otoliths, etc.).

a) Inshore Rockfish

The Inside Hard Bottom Longline (HBLL) Survey took place August 7-31, 2018 and surveyed the southern region from Campbell River to Victoria. The timing of the survey was changed and shortened by Coast Guard due to crewing issues, so blocks in Desolation Sound were not fished and will be added to the 2019 survey of the northern region. Quillback and Yelloweye Rockfishes survey trends are still declining in the Strait of Georgia (Figure 8); however, a full analysis will have to take into account the missed blocks in the NE section of the survey frame.

The Outside Hard Bottom Longline Survey (HBLL) conducted collaboratively with industry (the Pacific Halibut Management Association) was completed in August 1-September 15 2018, in the southern region. See the survey section (II) and Appendix 1 for further details. Yelloweye Rockfish catches were reported by skippers to be good in many areas.

DFO collaborated with WDFW and NOAA on an ROV survey for inshore rockfish in the Strait of Georgia on board the CCGS Vector, October 22-Nov 6, 2018. ROV transects were completed using the WDFW's Falcon ROV the Yelloweye, inside and outside of RCA. Most transects locations were randomly selected to be within modeled high probability rockfish habitat. Visual survey data are currently being annotated by WDFW and DFO (Figure 9).

Dana Haggarty is collaborating with Dr. Sarah Dudas and Dr. Stephanie Archer on a project funded by DFO's SPERA (Strategic Program for Ecosystem Based Research and Advice) fund to develop the novel method of passive acoustic monitoring (PAM) for fish using Pacific Herring as a model species because their sound production is described and their biomass is regularly estimated in relatively well-defined spatial areas during their spawning season. To pilot this approach they have deployed acoustic recorders at herring spawning sites in the Strait of Georgia and will combine acoustic data with visual survey data to build a correlation between spawning biomass and herring calls. They are also developing PAM methods for three rockfish species: Copper, Yelloweye, and Quillback Rockfishes by describing the relationship between abundance and call frequency using paired visual and audio surveys. They are testing the PAM methods by assessing temporal patterns in habitat use by deploying hydrophones in and adjacent to the Northumberland Channel RCA for one year. This project will also evaluate the impact of ship noise on the sensitivity of PAM.

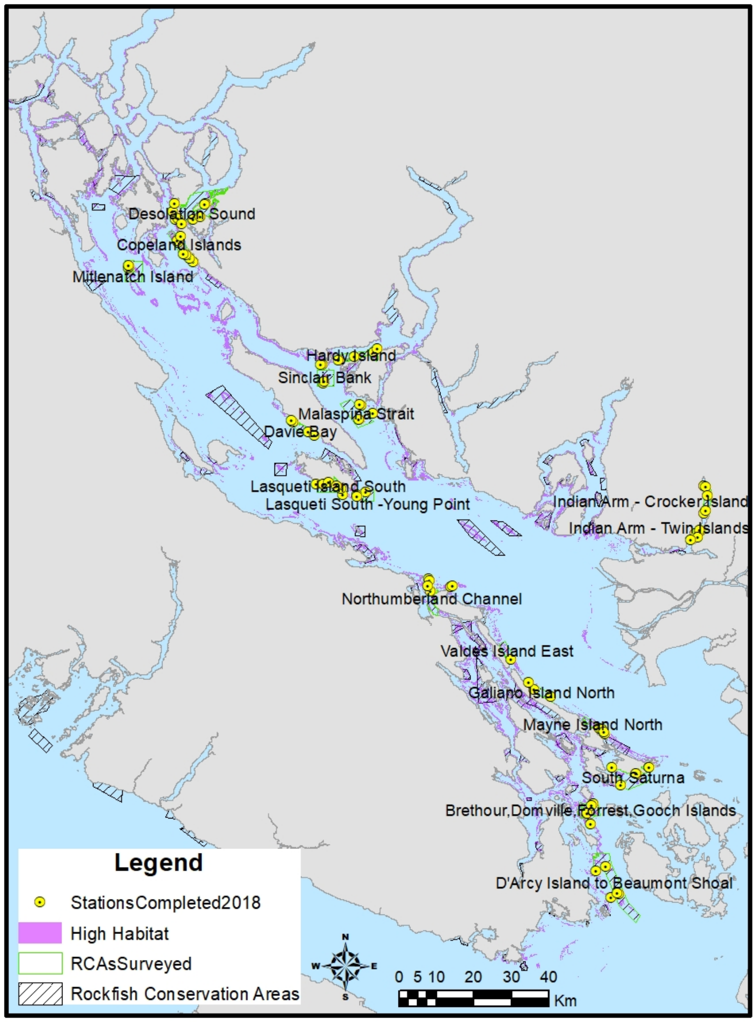


Figure 3. Map of ROV survey locations in the Strait of Georgia, October 22-November 6, 2018.

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

The most recent stock assessment for Inside (Yamanaka et al. 2011) and Outside Yelloweye Rockfish (Yamanaka et al. 2018) placed the stocks in the critical zone and therefore both stocks require rebuilding plans. Although the need for rebuilding plans are currently required by DFO policy, this requirement is about to be formalized in amendments to *Canada's Fisheries Act* put forward in *Bill C-68*. Both populations have rebuilding plans that are not compliant with DFO policy that requires monitoring, re-assessment and rebuilding projections over 1.5-2 generations (~60-90 years for Yelloweye Rockfish). DFO is collaborating with industry (the Pacific Halibut Management Association) to study Outside Yelloweye Rockfish Rebuilding with the development of operating models to describe the current state of the stock and closed loop simulations to examine the performance of harvest control rules to achieve rebuilding targets. Dr. Ashleen Benson, Dr. Sean Cox, and Beau Doherty from Landmark Fisheries Consulting are doing the modeling work. A steering committee and technical team are developing the rebuilding objectives and contributing to the work. This project will be reviewed by CSAS in October, 2019. A similar process is taking place for the inside population; however, the inside Yelloweye Rockfish population is more data limited and industry partners are absent. National-level funding to support work on rebuilding plans was secured to allow us to work with Dr. Tom Carruthers and Dr. Quang Huynh from UBC to use the Data Limited Methods Tools (DLMTools, https://www.datalimitedtoolkit.org/) in a similar simulation testing of management procedures to examine rebuilding.

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.

Yamanaka, K. L., McAllister, M.M., Olesiuk, P.F. Etienne, M., Obradovich, S.G. and Haigh, R.. (2011). Stock Assessment for the inside population of yelloweye rockfish (Sebastes ruberrimus) in British Columbia, Canada for 2010. DFO Can. Sci. Advis. Sec. Res. Doc.**:** xiv + 131 p.

b) Slope Rockfish

Pacific Ocean Perch

Pacific Ocean Perch in PMFC area 5ABC was assessed in 2017 using a catch-at-age model tuned to two fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from the two survey series (11 years of data) and the commercial fishery (34 years of data). The model starts from an assumed equilibrium state in 1940, and the survey data cover 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 estimates both sex-specific natural mortality (*M*) and steepness of the stock-recruit function (*h*). The base model run suggests 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}, is 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}.

Redstripe Rockfish

Two stocks of Redstripe Rockfish (BCN and BCS) were assessed in 2018 using a catch-at-age model tuned to fishery-independent trawl survey series (two in BCN, four in BCS), bottom trawl CPUE series, annual estimates of commercial catch since 1940, and age composition data from survey series (BCN: 5 years of data from 2 surveys; BCS: 14 years from 3 surveys) and the commercial fishery (BCN: 12 years of data; BCS: 24 years). The model starts from an assumed equilibrium state in 1940, and the survey data cover the period 1967 to 2018. The two-sex models were implemented in a Bayesian framework (using the Markov Chain Monte Carlo procedure) under a scenario that estimates both natural mortality (M) and steepness of the stock-recruit function (h). The base model runs for BCN and BCS suggest that low exploitation in the early years, including that by foreign fleets, coupled with several strong recruitment events (in 1982 and 1996 for BCN and in 1974 and 2001 for BCS) have sustained the population to the present. The spawning biomass (mature females only) at the beginning of 2018 for BCN and BCS is estimated to be 0.91 (0.69, 1.13) and 0.62 (0.47, 0.81) of unfished biomass (median and 5th and 95th quantiles of the Bayesian posterior distribution), respectively. For BCN and BCS, this biomass is estimated to be 3.16 (2.02, 4.00) and 2.43 (1.51, 3.77) of the spawning biomass at maximum sustainable yield, B_{MSY}, respectively.

Rougheye/Blackspotted Rockfish

An assessment on the Rougheye/Blackspotted (REBS) complex was initiated by a Ph.D. student in REM at SFU in collaboration with DFO. There are genetic data to delineate stocks; however, this initial assessment will treat REBS in PMFC area 5DE as Blackspotted Rockfish and REBS in PMFC areas 3CD+5AB as Rougheye Rockfish.

3. Management

a) Inshore Rockfish

Management, in consultation with the commercial industry, stepped down Outside Yelloweye Rockfish Total Allowable Catch (TAC) 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. There is also recreational non-retention of Yelloweye Rockfish coast-wide in BC. The mandatory use of descending devices by recreational fishers came into effect on April 1, 2019 with the following condition of license:

> "Anglers in vessels shall immediately return all rockfish that are not being retained to the water and to a similar depth from which they were caught by use of an inverted weighted barbless hook or other purpose-built descender device. No person shall catch and retain in a day in Management Areas 1 to 11, 21 to 27, 101 to 111, 121 to 127, 130, 142 and Subareas 20-1 to 20-4 and 12-14 more than three (3) rockfish, of which only one (1) may be a Quillback Rockfish, a China Rockfish, or a Tiger Rockfish. Note: Not one of each species, but only one of the three. No person shall catch and retain in any tidal waters the following species of rockfish: Bocaccio Rockfish (zero retention); Yelloweye Rockfish (zero retention)."

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 November 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.

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.

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 2019. Quillback Rockfish is up for reassessment by the COSEWIC by November 2019 but have been pushed off the schedule until at least 2020

f) Slope Rockfish

Pacific Ocean Perch

Pacific Ocean Perch is an IVQ (individual vessel quota) species with a 2018 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 2018 Groundfish Trawl multi-species surveys, 73.8 t, was accounted for before defining the Groundfish Trawl TACs.

Advice to managers (presented as decision tables in the assessment) provide probabilities of exceeding limit and upper stock reference points over a five-year projection period across a range of constant catches. The current stock status is typically presented as horizontal barplots, in this case for the Base Case and seven sensitivity runs (Figure H.1). The DFO provisional 'Precautionary Approach compliant' reference points were used, which specify a 'limit reference point' of 0.4BMSY and an 'upper stock reference point' of 0.8BMSY. The estimated spawning biomass at the beginning of 2017 has 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 the recent average five-year catch of 2400 t/y) indicate that, in 2022, the spawning biomass has probabilities of 0.97 of remaining above the limit reference point, and 0.71 of remaining above the upper stock reference point.

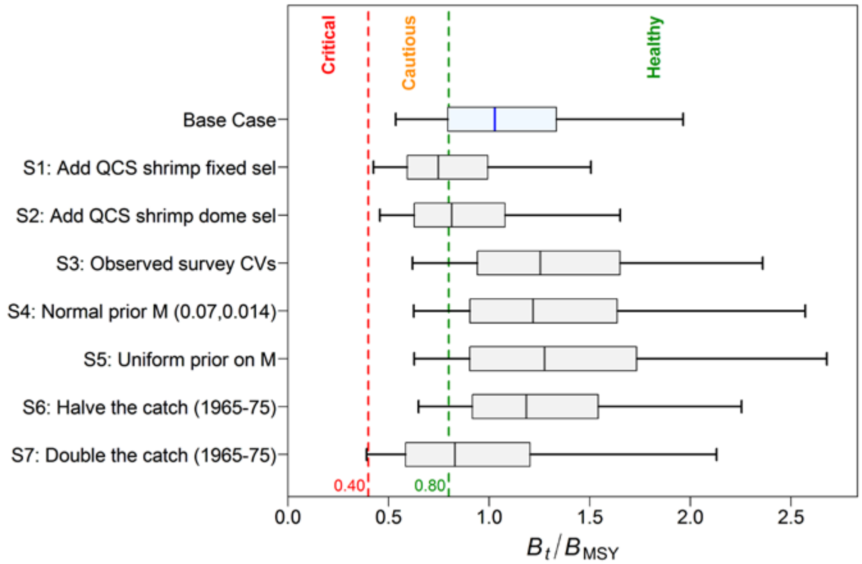


Figure H.1. Status at beginning of 2017 of the 5ABC Pacific Ocean Perch stock relative to the DFO PA provisional reference points of 0.4B_{MSY} and 0.8B_{MSY} for the base-case stock assessment and seven sensitivity runs: S1=add the QCS shrimp survey using a fixed selectivity curve; S2=add the QCS shrimp 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.

Redstripe Rockfish

Redstripe Rockfish is an IVQ (individual vessel quota) species with a 2018 trawl TAC (total allowable catch) of 1521 t coastwide (173 t in 3C, 772 t in 3D5AB, 330 t in 5CD, and 246 t in 5E). Commercial total allowable catch for various groundfish species were allocated between the different groundfish sectors; Pacific Ocean Perch was allocated 97.23% to the Trawl sector and 2.77% (43 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, 15 t, was accounted for before defining the Groundfish Trawl TACs.

Advice to managers (presented as decision tables in the assessment) provide probabilities of exceeding limit and upper stock reference points for five-year projections across a range of constant catches. The current stock status is typically presented as horizontal barplots, in this case for the Base Case and four sensitivity runs (Figure H.2). The DFO provisional 'Precautionary Approach compliant' reference points were used, which specify a 'limit reference point' (LRP) of 0.4BMSY and an 'upper stock reference point' (USR) of 0.8BMSY. The estimated spawning biomass at the beginning of 2018 has a probability of 1 of being above the LRP, and a probability of 1 of being above the USR for both stocks. Five-year projections using a constant catch of 100 t/y in BCN and 700 t/y in BCS indicate that, in 2023, the spawning biomass has probabilities of 1 (BCN) and 1 (BCS) of remaining above the LRP, and 1 (BCN) and 1 (BCS) of remaining above the USR. The uMSY reference point, however, suggests that catches in excess of 500 t in BCN and 1300 t in BCS will breach the Sustainable Fisheries Framework guidelines on fishing mortality, assuming that the manager wishes to be 95% certain that the harvest rate in 2023 will be less than uMSY.

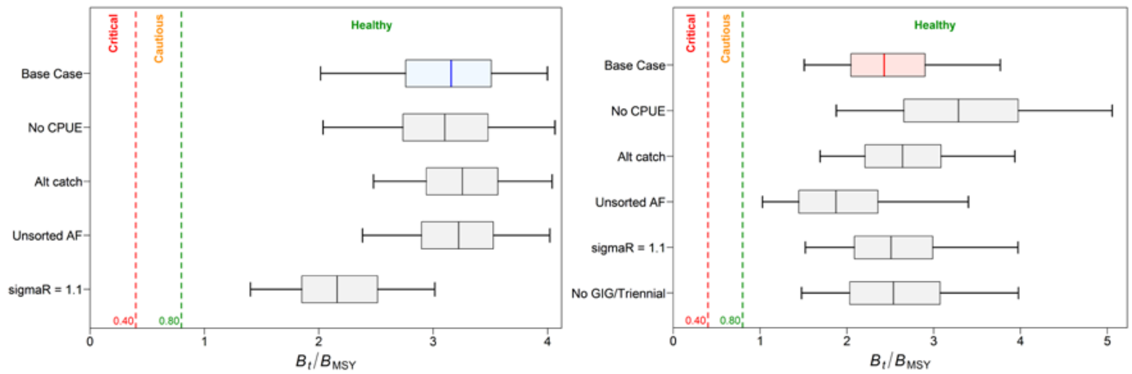


Figure H.2. Stock status at beginning of 2018 of the RSR stocks (left:BCN, right: BCS) relative to the DFO PA provisional reference points of 0.4B_{MSY} and 0.8B_{MSY} for the base case stock assessment and four sensitivity runs (S1=drop commercial trawl CPUE; S2=halve the 1965-75 and 1988-1995 catches; S3=use age frequencies from unsorted samples only; S4=increase standard deviation of σ_R from 0.6 to 1.1; S5=remove GIG Historical and WCVI Triennial surveys). Boxplots show the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles from the MCMC posterior.

I. Thornyheads

1. Research

No research occurred in 2018.

2. Assessment

No Thornyhead assessments were conducted in 2018. 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 2018 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 2018 multi-species surveys, 6.2 t of Shortspine thornyhead and 0.4 t of Longspine thornyhead was accounted for before defining the Groundfish Trawl TACs for Shortspine Thornyhead, and 0.9 t of Shortspine thornyhead was reserved for longline surveys.

J. 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). 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 2018 included the initiation of an informal collaboration among Sablefish scientists from DFO, NOAA, ADFG and academia on range-wide Sablefish ecology and management. The overarching goal of the collaboration is to develop a range-wide, spatially explicit population dynamics model for Sablefish that can be used to explore questions of biological and management relevance across the eastern North Pacific. In 2018 primary research activities towards this goal included initiating a synthesis of life history characteristics across the Sablefish range, analyses to identify and develop range-wide indices of abundance and the evaluation of movement within and among regions (e.g., Alaska, British Columbia and the US West Coast).

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 2018 research and assessment survey, the current point estimate of legal-size Sablefish biomass in BC is 37,415 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 (DFO 2017). 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. The collaboration between DFO, NOAA and ADFG identified above in the research section is working towards the development of 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.

DFO. 2014. Performance of a revised management procedure for Sablefish in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/025.

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

DFO. 2017. Evaluating the robustness of management procedures for the sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/017.

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 rate from 9.5% to 5.5% over five years. The resulting proposed TAC for the 2019/20 fishing year is 2,955 t, a ~17% increase over the 2018/19 TAC. However, fishing industry stakeholders proposed a smaller increase in TAC to enhance rebuilding of the stock and so the final proposed TAC for 2019/20 is 2656 t. An update of the MSE simulation work is planned for 2019/20.

K. Lingcod

1. Research

Ongoing data collection continued in 2018 through surveys, port sampling, at-sea observer sampling, and recreational creel surveys. Additional biological samples (Length, Weight, sex, maturity and fins for ageing) were collected on the Inside HBLL S, the Outside HBLL S, and the expanded IPHC survey in 2018.

2. Assessment

Inside, the waters within the Strait of Georgia, and Outside, the rest of the BC Coast, Lingcod populations are assessed and managed as separate units. Outside Lingcod were scheduled to be assessed in the spring of 2019; however, the assessment has been pushed back due to other program demands as well as the desire to have some age-data to inform the catchability of the longline surveys. Inside Lingcod were last assessed in 2014.

3. Management

Lingcod are managed by annual area specific TACs, the vast majority is harvested by the IVQ multi- species bottom trawl fishery and the directed Lingcod hook and line fishery, while smaller quantities are landed incidentally in targeted fisheries for Pacific Halibut, Sablefish, Rockfish and Dogfish. Details of the current management plan are available at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.html#Groundfish.

L. Atka mackerel

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

M. Flatfish

1. Research

Ongoing data collection in support of the flatfish research program, inclusive of Arrowtooth Flounder, Petrale Sole, Dover Sole and Rock Sole continued in 2018 through surveys and at-sea observer sampling.

2. Assessment

Arrowtooth Flounder was last assessed in 2016. The final assessment was finalized and published through the Canadian Science Advice Secretariat (CSAS) in 2017. Recent reports from fishery participants of localized depletion are being investigated.

Dover sole was last assessed in 1999, age matrices have been updated, catch and survey data are available, and an updated assessment is planned for 2020.

Petrale sole was last assessed in 2007. In response to a request for updated harvest advice from fishery managers aging of otoliths was completed in 2018 and an updated assessment is planned for 2019/20. T

English sole was also last assessed in 2007, no request for updated advice has been received but aging of otoliths be undertaken in 2019 in anticipation of an updated assessment sometime in 2020/21.

Rock sole was last assessed in 2016, no request for updated advice has been received but aging of otoliths will be undertaken in 2019 in anticipation of an updated assessment sometime in 2020/21.

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. 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.

N. 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) from both the trawl and line fisheries in British Columbia are provided.

O. Other groundfish species

IV. 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.

As summarized in the 2018 TSC report 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). 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.

A science steering committee was formed in the fall of 2017 to plan the current 'management procedure' phase of the project. The first technical working group meeting was convened on April 27 2018, during subsequent meeting the project was divided into two phases, the first to be a research document with visualizations of nearly all available groundfish data, with the expectation of updating this on an annual basis, and the second a research document and science advisory report outlining an agreed upon management procedure approach for British Columbia groundfish.

In November of 2018 a reproducible "synopsis" report that gives a snapshot of population and fishing trends, growth and maturity patterns, as well as data availability, for 113 species of relevance to the Groundfish Section was reviewed through the regional peer review process.

The Groundfish Section had a number of goals in developing the synopsis report. First, the report aims to facilitate regular review by groundfish scientists and managers of trends in survey indices and stock composition. Second, through the tools developed to produce the report, the project aims to generate standardized datasets and visualizations that will help assessment scientists develop stock assessments and conduct groundfish research. Third, it aims to increase data transparency between

Fisheries and Oceans Canada, the fishing industry, non-governmental organizations, and the public.

The report is structured to facilitate viewing all data for one species simultaneously and to quickly browse the data holdings for multiple stocks. The report starts with clickable indexes sorted by species code, common name, and scientific name. Then, following a series of figure captions, the report visualizes most available survey, fisheries, and biological sample data for each of the 113 species in the same two-page layout for each species (e.g., Figure 2 and 3). The first page for each species includes visualizations showing time series and maps of relative biomass from the surveys, commercial fisheries catch categorized by gear type and region, and standardized commercial catch per unit effort from the commercial bottom-trawl fleet. The second page for each species focuses on biological samples. The page starts with length and age distributions, shows length-age and length-weight growth model fits, and shows age- and length-at-maturity model fits. The second page concludes with graphical tables illustrating the number of fish that have had their length, weight, age, or maturity assessed as well as the number of available aging structures (usually otoliths) by year across all surveys and commercial samples. The main visualizations are followed by detailed appendices explaining the data processing and model fitting approaches.

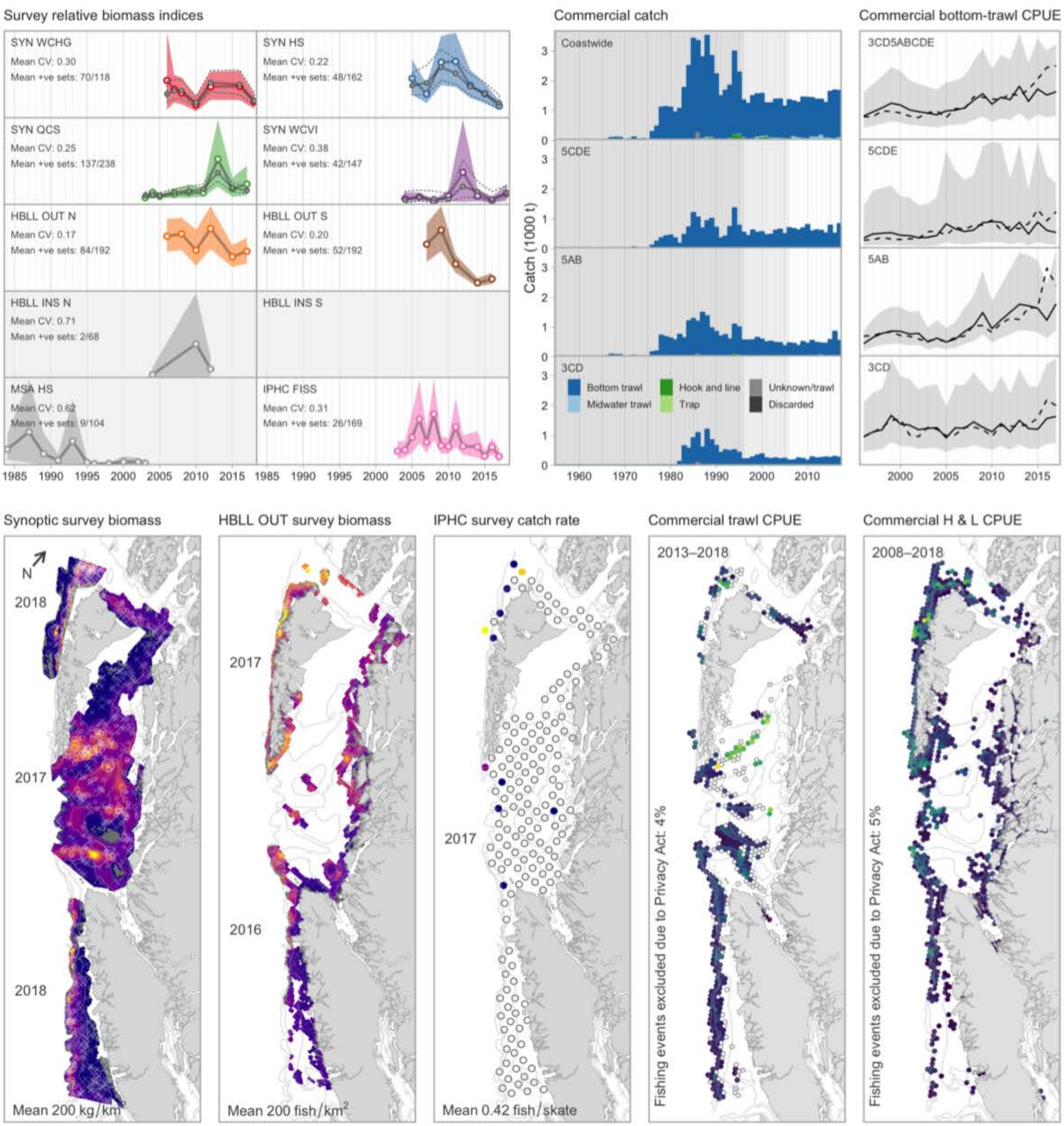
We emphasize that the outputs from the report are not a substitute for stock assessment. For example, survey and commercial index trends do not resolve population scale and the outputs in the report do not resolve conflicts in trends drawn from different sources for the same species. Furthermore, some surveys are not suitable for deriving relative biomass trends for some species, and these types of decisions require knowledge of the individual stocks and survey designs. Also, the outputs in the report are not at a scale appropriate for marine spatial planning. The report includes many other caveats that are important to consider.

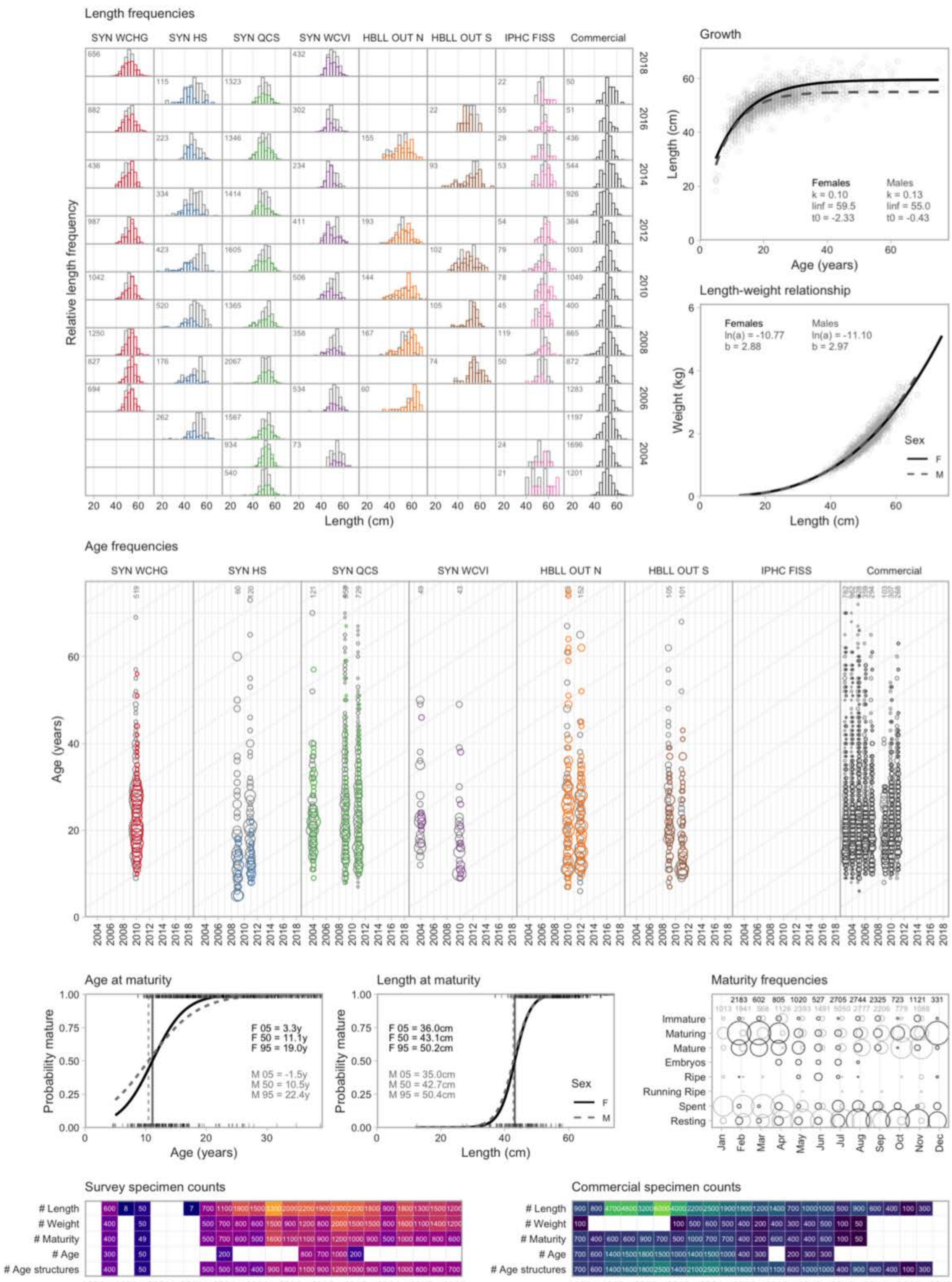
All the data extraction, data manipulation, model fitting, and visualization for the report are automated and reproducible. To accomplish this, the authors developed a series of R packages that are available on GitHub (https://github.com/pbs-assess). The packages include gfplot (for data extraction, manipulation, most model fitting, and visualization), sdmTMB (for geostatistical spatiotemporal modelling of the survey data), gfsynopsis (to call the gfplot functions as needed to generate and stitch together the main figures), and csasdown (building on previous work by other PBS scientists; for generating reproducible CSAS Research Documents with the output from gfsynopsis). The report can theoretically be generated by anyone with access to the groundfish databases housed at PBS. We plan to publish an updated version of the report every one to two years. The report has been accepted as a CSAS Research Document and is currently undergoing final formatting and translation. In the meantime, a draft can be downloaded at https://github.com/pbs-assess/gfsynopsis.

An example species report is presented below for Silvergray rockfish.

5.49 SILVERGRAY ROCKFISH

Sebastes brevispinis (405)
Order: Scorpaeniformes, Family: Scorpaenidae, FishBase link, WoRMS link
Last Research Document: Starr et al. (2016)
Last Science Advisory Report: Fisheries and Oceans Canada (2014b)





Length frequencies
SYN WCHG
SYN HS
SYN QCS
SYN WCVI
HBLL OUT N
HBLL OUT S
IPHC FISS
Commercial
Relative length frequency
Length (cm)
Growth
Length (cm)
Age (years)
Females
k = 0.10
linf = 59.5
t0 = -2.33
Males
k = 0.13
linf = 55.0
t0 = -0.43
Length-weight relationship
Females
ln(a) = -10.77
b = 2.88
Males
ln(a) = -11.10
b = 2.97
Weight (kg)
Length (cm)
Sex
F
M
Age frequencies
Age (years)
Age at maturity
Probability mature
F 05 = 3.3y
F 50 = 11.1y
F 95 = 19.0y
M 05 = -1.5y
M 50 = 10.5y
M 95 = 22.4y
Age (years)
Length at maturity
F 05 = 36.0cm
F 50 = 43.1cm
F 95 = 50.2cm
M 05 = 35.0cm
M 50 = 42.7cm
M 95 = 50.4cm
Length (cm)
Maturity frequencies
Immature
Maturing
Mature
Embryos
Ripe
Running Ripe
Spent
Resting
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Survey specimen counts
Commercial specimen counts
Length
Weight
Maturity
Age
Age structures

V. Other related studies

Nothing to report at this time.

VI. Publications

A. Primary Publications

Carrasquilla-Henao, M., Yamanaka, K.L., D.R. Haggarty and F. Juanes. 2018. "Predicting important rockfish (Sebastes spp.) habitat from large-scale longline surveys for southern British Columbia, Canada." Canadian Journal of Fisheries and Aquatic Sciences.

Haggarty, D. and L. Yamanaka. 2018. "Evaluating Rockfish Conservation Areas in southern British Columbia, Canada using a Random Forest model of rocky reef habitat." Estuarine, Coastal and Shelf Science 208: 191-204.

Starr, P. J. and Haigh, R. in press. Redstripe Rockfish (Sebastes proriger) stock assessment for British Columbia in 2018. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/nnn: iii + xxx p.

Starr, P. J. and Haigh, R. in press. Walleye Pollock (Theragra chalcogramma) stock assessment for British Columbia in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/nnn: iii + xxx p.

Haigh, R., Starr, P. J., Edwards, A. M., King, J. R. and Lecomte, J.-B. 2018. Stock assessment for Pacific Ocean Perch (Sebastes alutus) in Queen Charlotte Sound, British Columbia in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/038: v + 228 p.

Yamanaka, K.L., McAllister, M.K, Etienne, M.-P., Edwards, A., and Haigh, R. 2018. Assessment for the outside population of Yelloweye Rockfish (Sebastes ruberrimus) for British Columbia, Canada in 2014. Canadian Science Advisory Secretariat, Research Document 2018/001: ix + 150 p.

B. Other Publications

DFO. 2018. A Review of the Use of Recompression Devices as a Tool for Reducing the Effects of Barotrauma on Rockfishes in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/043. https://waves-vagues.dfo-mpo.gc.ca/Library/40716120.pdf

DFO. 2019. A Regional Assessment of Ecological Attributes in Rockfish Conservation Areas in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. In press.

Dunham, J., Yu, F., Haggarty, D., Deleys, N., Yamanaka, L. 2019. A Regional Assessment of Ecological Attributes in Rockfish Conservation Areas in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. In press

Appendix 1

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

Multispecies Synoptic Bottom Trawl Surveys

West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey

The West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between May 18 and June 14. We assessed a total of 226 blocks (Table 1, Figure 5). Of the 202 total tows conducted, 190 were successful and 12 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 155,085 kg. The mean catch per tow was 787 kg, averaging 26 different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (Squalus suckleyi), Sharpchin Rockfish (Sebastes zacentrus), Sablefish (Anoplopoma fimbria), Splitnose Rockfish (Sebastes diploproa), and Canary Rockfish (Sebastes pinniger). 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 39,229 individual fish of 50 different species (Table 3).

Table 1. 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (meters)	Rejected Prior	Rejected Inspected	Failed	Success	Not Assessed	Total
50 to 125	1	18	3	69	0	91
125 to 200	1	4	2	64	0	71
200 to 330	0	0	0	36	0	36
330 to 500	1	6	0	21	0	28
Total	**3**	**28**	**5**	**190**	**0**	**226**

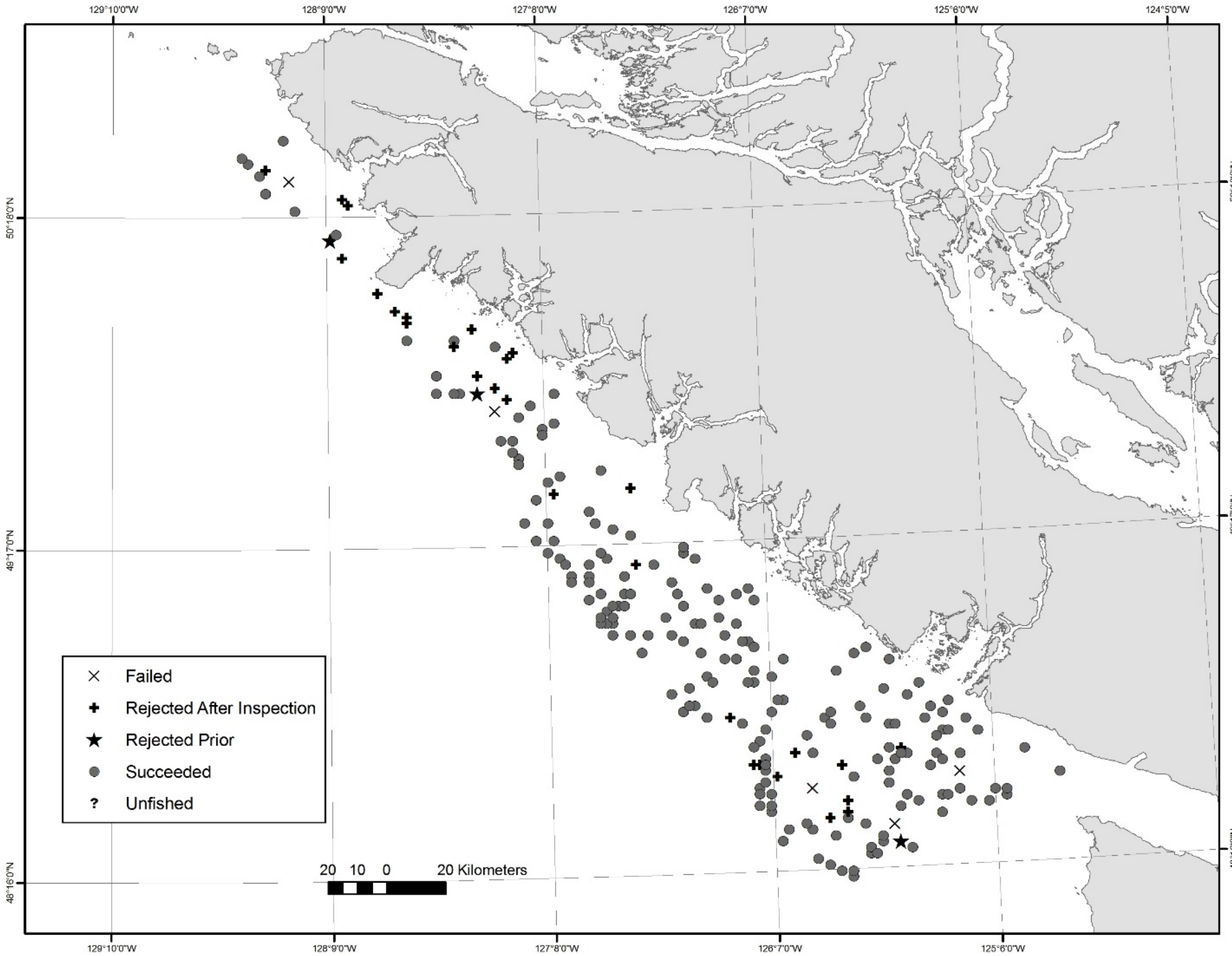


Figure 3. Final status of the allocated blocks for the 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey.

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 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
North Pacific Spiny Dogfish	*Squalus suckleyi*	132	18750	3835	0.41
Sharpchin Rockfish	*Sebastes zacentrus*	68	16954	3170	0.27
Sablefish	*Anoplopoma fimbria*	139	15917	4747	0.25
Splitnose Rockfish	*Sebastes diploproa*	36	9735	1894	0.47
Canary Rockfish	*Sebastes pinniger*	72	8861	3050	0.60
Rex Sole	*Glyptocephalus zachirus*	183	8705	4264	0.08
Arrowtooth Flounder	*Atheresthes stomias*	170	8283	2749	0.10
Pacific Ocean Perch	*Sebastes alutus*	60	8210	1680	0.28
Redstripe Rockfish	*Sebastes proriger*	50	7180	2747	0.48
Dover Sole	*Microstomus pacificus*	177	6927	3117	0.11
Pacific Hake	*Merluccius productus*	119	5900	2653	0.34
Yellowtail Rockfish	*Sebastes flavidus*	87	4932	2207	0.26
Spotted Ratfish	*Hydrolagus colliei*	179	4139	2300	0.15
Silvergray Rockfish	*Sebastes brevispinis*	54	3875	984	0.39
English Sole	*Parophrys vetulus*	133	3045	1937	0.11
Flathead Sole	*Hippoglossoides elassodon*	117	2667	1622	0.12
Pacific Sanddab	*Citharichthys sordidus*	73	2188	1562	0.16
Greenstriped Rockfish	*Sebastes elongatus*	105	2148	750	0.19
Lingcod	*Ophiodon elongatus*	113	1747	625	0.11
Petrale Sole	*Eopsetta jordani*	124	1416	740	0.15
Shortspine Thornyhead	*Sebastolobus alascanus*	53	1316	276	0.14
Longnose Skate	*Raja rhina*	104	1227	457	0.12

Bocaccio	*Sebastes paucispinis*	55	1225	456	0.57
Pacific Cod	*Gadus macrocephalus*	91	1184	553	0.21
Redbanded Rockfish	*Sebastes babcocki*	59	852	143	0.25

Table 3. Number of fish sampled for biological data during the 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey showing the number of lengths, age structures, and DNA tissue samples that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Arrowtooth Flounder	*Atheresthes stomias*	2136	196	0
Aurora Rockfish	*Sebastes aurora*	43	0	0
Big Skate	*Beringraja binoculata*	41	0	0
Bocaccio	*Sebastes paucispinis*	417	409	265
Brown Cat Shark	*Apristurus brunneus*	20	0	0
Canary Rockfish	*Sebastes pinniger*	729	645	0
Curlfin Sole	*Pleuronichthys decurrens*	140	44	0
Darkblotched Rockfish	*Sebastes crameri*	554	0	0
Dover Sole	*Microstomus pacificus*	3153	847	0
English Sole	*Parophrys vetulus*	2231	643	0
Eulachon	*Thaleichthys pacificus*	1085	0	185
Flathead Sole	*Hippoglossoides elassodon*	1729	0	0
Giant Wrymouth	*Cryptacanthodes giganteus*	1	0	0
Green Sturgeon	*Acipenser medirostris*	1	0	0
Greenstriped Rockfish	*Sebastes elongatus*	1285	215	0
Kelp Greenling	*Hexagrammos decagrammus*	26	0	0
Lingcod	*Ophiodon elongatus*	599	489	0
Longnose Skate	*Raja rhina*	369	0	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	1006	0	0
Pacific Cod	*Gadus macrocephalus*	369	236	0
Pacific Hake	*Merluccius productus*	1784	162	0
Pacific Halibut	*Hippoglossus stenolepis*	122	0	0
Pacific Ocean Perch	*Sebastes alutus*	983	614	0

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Pacific Sanddab	*Citharichthys sordidus*	1558	0	0
Pacific Tomcod	*Microgadus proximus*	506	0	0
Petrale Sole	*Eopsetta jordani*	1070	672	0
Pygmy Rockfish	*Sebastes wilsoni*	121	0	0
Quillback Rockfish	*Sebastes maliger*	40	40	34
Redbanded Rockfish	*Sebastes babcocki*	473	471	0
Redstripe Rockfish	*Sebastes proriger*	649	299	50
Rex Sole	*Glyptocephalus zachirus*	4021	430	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	764	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	239	230	289
Sablefish	*Anoplopoma fimbria*	1742	870	0
Sandpaper Skate	*Bathyraja interrupta*	52	0	0
Sharpchin Rockfish	*Sebastes zacentrus*	1089	0	0
Shortbelly Rockfish	*Sebastes jordani*	237	120	0
Shortraker Rockfish	*Sebastes borealis*	31	31	0
Shortspine Thornyhead	*Sebastolobus alascanus*	1040	110	0
Silvergray Rockfish	*Sebastes brevispinis*	432	233	0
Slender Sole	*Lyopsetta exilis*	2002	0	0
Southern Rock Sole	*Lepidopsetta bilineata*	496	257	0
Splitnose Rockfish	*Sebastes diploproa*	663	0	0
Spotted Ratfish	*Hydrolagus colliei*	1288	0	0
Stripetail Rockfish	*Sebastes saxicola*	22	0	0
Walleye Pollock	*Gadus chalcogrammus*	838	0	0
Widow Rockfish	*Sebastes entomelas*	40	0	0

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Yelloweye Rockfish	*Sebastes ruberrimus*	77	75	121
Yellowmouth Rockfish	*Sebastes reedi*	33	17	0
Yellowtail Rockfish	*Sebastes flavidus*	883	251	0

West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between September 2 and 24, 2018. We assessed a total of 132 blocks (Table 4, Figure 6). At the end of the survey, four blocks had not yet been fished but would have required not only another full day of fishing, but also the vessel was full of fish and would have had to travel to port, offload catch, and return to the grounds. As such, the decision was made to leave those four blocks as unassessed. Of the 132 total tows conducted, 119 were successful and 13 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 187,407 kg. The mean catch per tow was 1453 kg, averaging 21 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (Sebastes alutus), Sharpchin Rockfish (Sebastes zacentrus), Rougheye/Blackspotted Rockfish complex (Sebastes aleutianus/melanostictus complex), Silvergray Rockfish (Sebastes brevispinis), Shortspine Thornyhead (Sebastolobus alascanus) and Yellowmouth Rockfish (Sebastes reedi). 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 17,511 individual fish of 44 different species (Table 6). Oceanographic data, including water temperature, depth, salinity, and dissolved oxygen were also recorded for most tows.

Table 4. 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (meters)	Rejected Prior	Rejected Inspected	Failed	Success	Not Assessed	Total
180 to 330	1	5	2	67	3	78
330 to 500	2	2	0	31	0	35
500 to 800	1	0	0	10	1	12
800 to 1,300	0	0	0	11	0	11
Total	**4**	**7**	**2**	**119**	**4**	**136**

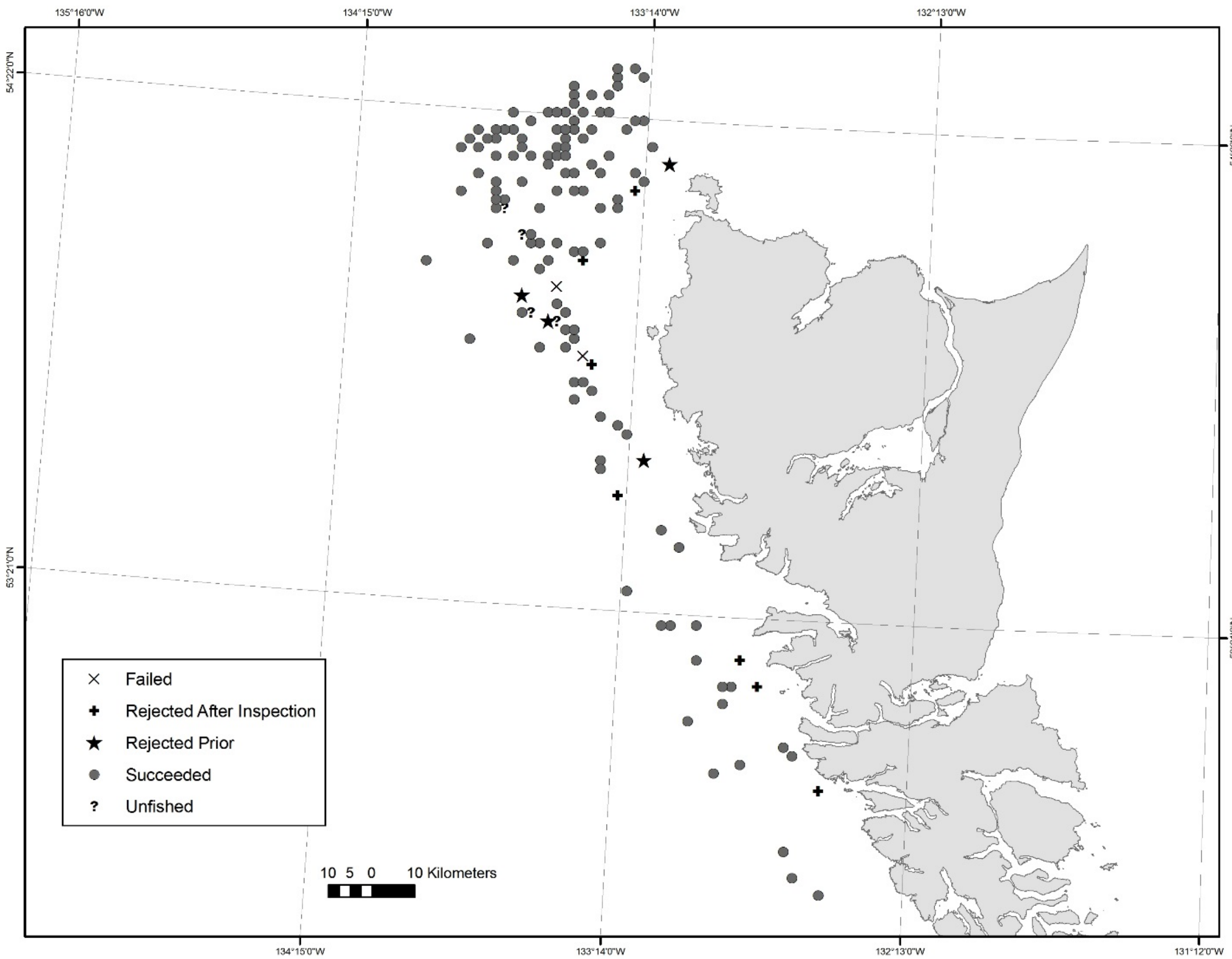


Figure 4. Final status of the allocated blocks for the 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey.

Table 5. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2017 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Pacific Ocean Perch	*Sebastes alutus*	91	116845	19173	0.21
Sharpchin Rockfish	*Sebastes zacentrus*	68	17948	2363	0.34
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	54	10949	2772	0.27
Silvergray Rockfish	*Sebastes brevispinis*	66	5097	676	0.23
Shortspine Thornyhead	*Sebastolobus alascanus*	112	4787	1307	0.08
Yellowmouth Rockfish	*Sebastes reedi*	44	4729	666	0.52
Redstripe Rockfish	*Sebastes proriger*	61	4334	551	0.31
Sablefish	*Anoplopoma fimbria*	104	3725	1742	0.15
Arrowtooth Flounder	*Atheresthes stomias*	83	3251	455	0.51
Splitnose Rockfish	*Sebastes diploproa*	14	1282	165	0.69
Dover Sole	*Microstomus pacificus*	99	1048	321	0.13
Redbanded Rockfish	*Sebastes babcocki*	73	986	152	0.18
Shortraker Rockfish	*Sebastes borealis*	19	821	367	0.55
Canary Rockfish	*Sebastes pinniger*	13	735	91	0.59
Rosethorn Rockfish	*Sebastes helvomaculatus*	65	709	100	0.14
Pacific Hake	*Merluccius productus*	43	649	157	0.21
Longspine Thornyhead	*Sebastolobus altivelis*	23	584	541	0.19
Rex Sole	*Glyptocephalus zachirus*	97	554	103	0.16
Walleye Pollock	*Gadus chalcogrammus*	41	434	94	0.44
Giant Grenadier	*Albatrossia pectoralis*	17	399	446	0.4
Pacific Grenadier	*Coryphaenoides acrolepis*	18	360	474	0.36
Widow Rockfish	*Sebastes entomelas*	28	360	50	0.33
Spotted Ratfish	*Hydrolagus colliei*	69	338	53	0.24

Longnose Skate	*Raja rhina*	31	320	58	0.18
Lingcod	*Ophiodon elongatus*	25	310	48	0.27

Table 6. Number of fish sampled for biological data during the 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Aleutian Skate	*Bathyraja aleutica*	9	0	0
Arrowtooth Flounder	*Atheresthes stomias*	148	66	0
Bocaccio	*Sebastes paucispinis*	21	19	21
Brown Cat Shark	*Apristurus brunneus*	19	0	0
Canary Rockfish	*Sebastes pinniger*	82	72	0
Darkblotched Rockfish	*Sebastes crameri*	34	29	0
Dover Sole	*Microstomus pacificus*	783	289	0
English Sole	*Parophrys vetulus*	27	0	0
Giant Grenadier	*Albatrossia pectoralis*	165	152	0
Greenstriped Rockfish	*Sebastes elongatus*	237	0	0
Harlequin Rockfish	*Sebastes variegatus*	186	0	0
Lingcod	*Ophiodon elongatus*	43	5	0
Longnose Skate	*Raja rhina*	44	0	0
Longspine Thornyhead	*Sebastolobus altivelis*	667	615	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	2	0	0
Pacific Cod	*Gadus macrocephalus*	37	0	0
Pacific Flatnose	*Antimora microlepis*	50	49	0
Pacific Grenadier	*Coryphaenoides acrolepis*	438	0	0
Pacific Hake	*Merluccius productus*	264	0	0
Pacific Halibut	*Hippoglossus stenolepis*	44	0	0
Pacific Ocean Perch	*Sebastes alutus*	2195	1799	0
Petrale Sole	*Eopsetta jordani*	27	15	0
Popeye	*Coryphaenoides cinereus*	341	0	0
Pygmy Rockfish	*Sebastes wilsoni*	25	0	0

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Redbanded Rockfish	*Sebastes babcocki*	627	615	50
Redstripe Rockfish	*Sebastes proriger*	969	411	0
Rex Sole	*Glyptocephalus zachirus*	850	27	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	1089	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	757	755	756
Roughtail Skate	*Bathyraja trachura*	6	0	0
Sablefish	*Anoplopoma fimbria*	1126	502	0
Sandpaper Skate	*Bathyraja interrupta*	37	0	0
Sharpchin Rockfish	*Sebastes zacentrus*	1432	0	0
Shortraker Rockfish	*Sebastes borealis*	161	161	50
Shortspine Thornyhead	*Sebastolobus alascanus*	2783	628	0
Silvergray Rockfish	*Sebastes brevispinis*	657	393	50
Slender Sole	*Lyopsetta exilis*	25	0	0
Splitnose Rockfish	*Sebastes diploproa*	129	0	0
Spotted Ratfish	*Hydrolagus colliei*	97	0	0
Walleye Pollock	*Gadus chalcogrammus*	362	0	0
Whitebrow Skate	*Bathyraja minispinosa*	1	0	0
Widow Rockfish	*Sebastes entomelas*	162	24	0
Yelloweye Rockfish	*Sebastes ruberrimus*	8	8	8
Yellowmouth Rockfish	*Sebastes reedi*	345	222	0

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 program is intended to cover areas that are not covered by the synoptic bottom trawl surveys with a focus on inshore rockfish species habitat. The goal of the survey 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 “outside” area was intended to include “hard” bottom areas not covered by the synoptic bottom trawl surveys and was selected by including 95% of all Quillback and Yelloweye rockfish catches reported from the commercial Halibut and rockfish fisheries from 1996 to 2005. 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 southern region in even numbered years and the northern region in odd 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 odd numbered years while the southern region is surveyed in even 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 2018 the southern region of the outside area and the southern region of the inside area were surveyed.

Outside (Pacific Halibut Management Association) Survey

The 2018 Outside Hard Bottom Longline Hook Survey was conducted in the southern region but at the time of writing, the data are not yet finalized and so have not been included in this report

Inside (DFO) Survey

The Inside Hard Bottom Longline Hook Survey was conducted in the southern portion of the inside area on board the Canadian Coast Guard vessel Neocaligus from August 21 to September 7, 2018. The survey was later than the standard August period and shortened due to crewing limitations and vessel mechanical issues. As such, we were not able to visit all of the 70 blocks originally selected. We chose to leave the most northern blocks unassessed and those blocks will be added to the 2019 survey of the northern area. A total of 55 sets were completed (Figure 7). The total catch of the survey was 11,860 kg (Table 7). The average catch per set was 215 kg, averaging four different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (Squalus suckleyi), Quillback Rockfish (Sebastes maliger), Lingcod (Ophiodon elongatus), Yelloweye Rockfish (Sebastes ruberrimus), Longnose Skate (Raja rhina), and Copper Rockfish (Sebastes caurinus). The number of sets where the species was captured as well as the total catch count and proportion of the total catch of all fish species are shown in Table 8. An annual summary of catch by species in the southern area is shown in Table 9. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 5647 individual fish of 15 different species (Table 10). An annual summary of the number of fish sampled for biological data in the southern area is shown in Table 11.

One vertical CTD (conductivity, temperature, and depth recorder) cast was made at each selected block during the 2018 Inside Hard Bottom Longline Hook Survey. The CTD also included a dissolved oxygen sensor. In addition, a temperature depth recorder was deployed at the start, middle, and end of every fishing set.

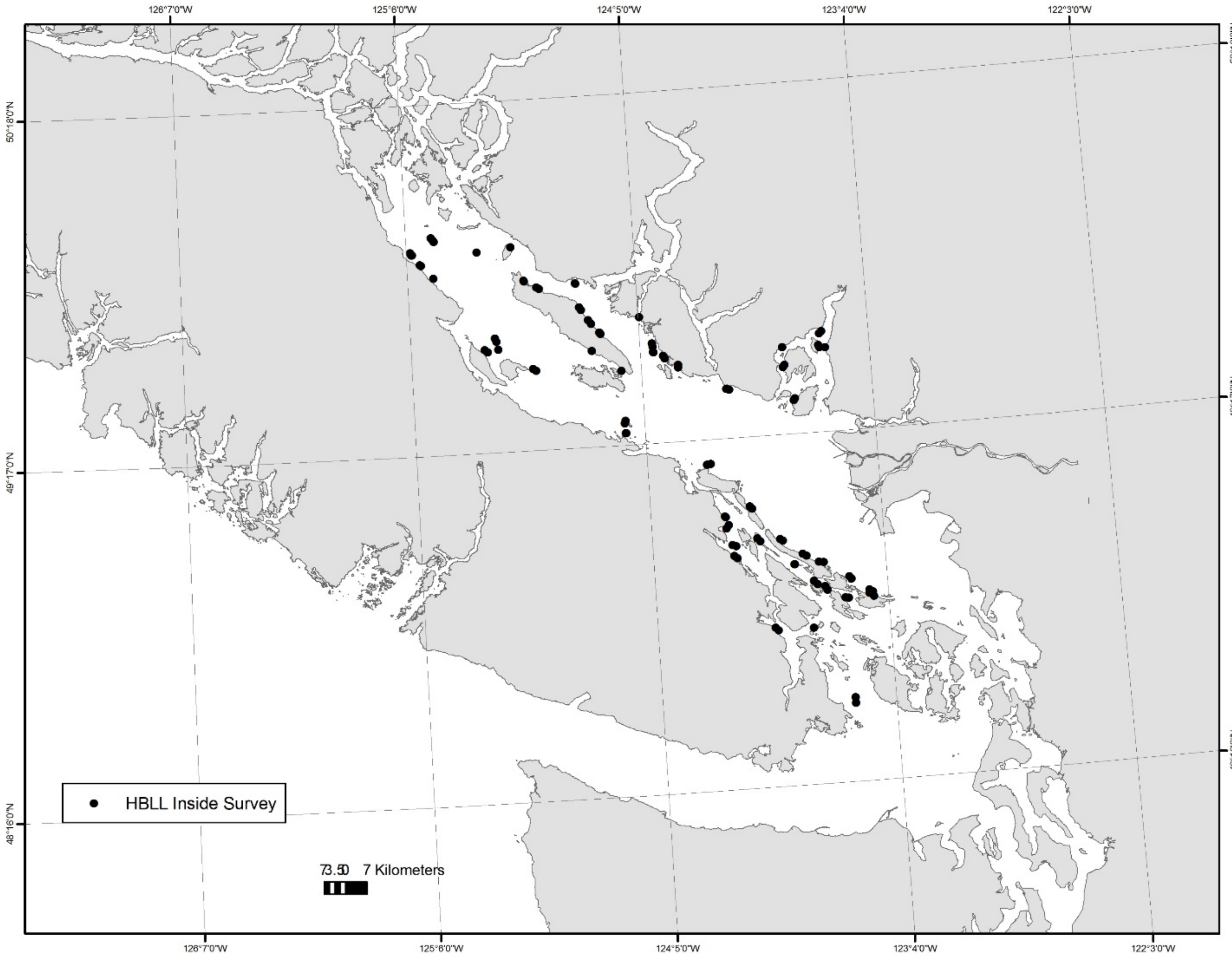


Figure 5. Longline set locations of the 2018 Inside Hard Bottom Longline Hook Survey.

Table 7. Total catch, showing both piece count and weight by species for the 2018 Inside Hard Bottom Longline Hook Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
North Pacific Spiny Dogfish	*Squalus suckleyi*	5302	10816
Quillback Rockfish	*Sebastes maliger*	88	73
Lingcod	*Ophiodon elongatus*	60	306
Yelloweye Rockfish	*Sebastes ruberrimus*	55	106
Longnose Skate	*Raja rhina*	53	138
Copper Rockfish	*Sebastes caurinus*	37	53
Canary Rockfish	*Sebastes pinniger*	26	53
Big Skate	*Beringraja binoculata*	23	264
Spotted Ratfish	*Hydrolagus colliei*	11	6
Red Rock Crab	*Cancer productus*	11	3
	Metridium	7	1
Pacific Cod	*Gadus macrocephalus*	6	5
Bluntnose Sixgill Shark	*Hexanchus griseus*	5	
Southern Rock Sole	*Lepidopsetta bilineata*	5	2
Sponges	*Porifera*	4	0
Cabezon	*Scorpaenichthys marmoratus*	3	13
Sunflower Starfish	*Pycnopodia helianthoides*	3	2
Fish-eating Star	*Stylasterias forreri*	3	0
Pink Short-spined Star	*Pisaster brevispinus*	2	2
Sea Lilies And Feather Stars	*Crinoidea*	2	
Pacific Sanddab	*Citharichthys sordidus*	2	0
Greenstriped Rockfish	*Sebastes elongatus*	2	0
Vermilion Rockfish	*Sebastes miniatus*	1	2

Kelp Greenling	*Hexagrammos decagrammus*	1	1
Glass Sponges	*Hexactinellida*	1	
Arrowtooth Flounder	*Atheresthes stomias*	1	
Flathead Sole	*Hippoglossoides elassodon*	1	0
Dungeness Crab	*Metacarcinus magister*	1	0
	Antedonidae	1	
	Henricia	1	
	Solaster	1	0
Pacific Staghorn Sculpin	*Leptocottus armatus*	1	0
Mottled Star	*Evasterias troschelii*	1	0
	Mytilus		2
Sea Whip	*Balticina septentrionalis*		

Table 8. Number of sets, catch (piece count), and proportion of the total fish catch for fish species caught during the 2018 DFO Hard Bottom Longline Hook Survey.

Species	Number of Sets	Catch (count)	Proportion of Total Catch (%)
North Pacific Spiny Dogfish	54	5302	93.30
Quillback Rockfish	26	88	1.55
Lingcod	21	60	1.06
Yelloweye Rockfish	15	55	0.97
Longnose Skate	24	53	0.93
Copper Rockfish	13	37	0.65
Canary Rockfish	5	26	0.46
Big Skate	11	23	0.40
Spotted Ratfish	5	11	0.19
Pacific Cod	3	6	0.11
Bluntnose Sixgill Shark	3	5	0.09
Southern Rock Sole	2	5	0.09
Cabezon	3	3	0.05
Greenstriped Rockfish	2	2	0.04
Pacific Sanddab	2	2	0.04
Vermilion Rockfish	1	1	0.02
Pacific Staghorn Sculpin	1	1	0.02
Kelp Greenling	1	1	0.02
Flathead Sole	1	1	0.02
Arrowtooth Flounder	1	1	0.02

Table 9. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the Inside Hard Bottom Longline Survey southern region.

Species	2005	2009	2011	2013	2015	2018	Total
North Pacific Spiny Dogfish	10847	3258	5744	5615	5283	5302	36049
Yelloweye Rockfish	215	10	266	223	209	55	978
Quillback Rockfish	196	40	297	199	154	88	974
Spotted Ratfish	186	91	4	5	11	11	308
Copper Rockfish	44	13	21	21	64	37	200
Lingcod	50	2	17	22	28	60	179
Longnose Skate	25	4	17	13	48	53	160
Pacific Cod	48	18	33	17	33	6	155
Canary Rockfish	52	0	14	14	25	26	131
Big Skate	24	5	1	13	29	23	95
Pacific Sanddab	22	25	3	8	11	2	71
Greenstriped Rockfish	8	3	16	11	3	2	43
Cabezon	23	5	2	2	7	3	42
Pacific Halibut	6	13	2	3	3	0	27
Southern Rock Sole	4	1	8	2	6	5	26
Red Irish Lord	3	1	1	7	6	0	18
Arrowtooth Flounder	15	1	0	0	0	1	17
Pacific Staghorn Sculpin	0	10	1	2	2	1	16
Tiger Rockfish	9	0	1	0	0	0	10
Brown Irish Lord	0	1	9	0	0	0	10
Bluntnose Sixgill Shark	2	1	0	0	2	5	10
Kelp Greenling	3	0	0	1	2	1	7
Vermilion Rockfish	4	0	0	0	0	1	5
Yellowtail Rockfish	1	2	0	0	1	0	4
Deacon Rockfish	4	0	0	0	0	0	4

Table 10. Number of fish sampled for biological data during the 2018 Inside Hard Bottom Longline Hook survey showing the number of lengths, age structures, and DNA tissue samples that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Collected
Big Skate	*Beringraja binoculata*	22	0	0
Cabezon	*Scorpaenichthys marmoratus*	3	0	0
Canary Rockfish	*Sebastes pinniger*	22	17	20
Copper Rockfish	*Sebastes caurinus*	30	27	30
Kelp Greenling	*Hexagrammos decagrammus*	1	0	0
Lingcod	*Ophiodon elongatus*	60	60	0
Longnose Skate	*Raja rhina*	52	0	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	5300	0	0
Pacific Cod	*Gadus macrocephalus*	1	0	0
Pacific Sanddab	*Citharichthys sordidus*	2	0	0
Quillback Rockfish	*Sebastes maliger*	83	81	0
Southern Rock Sole	*Lepidopsetta bilineata*	4	0	0
Spotted Ratfish	*Hydrolagus colliei*	11	0	0
Vermilion Rockfish	*Sebastes miniatus*	1	0	0
Yelloweye Rockfish	*Sebastes ruberrimus*	55	54	54

Table 11. Annual summary of the number of fish sampled for biological data during the Inside Hard Bottom Longline Survey in the southern region.

Species	2005	2009	2011	2013	2015	2018	Total
North Pacific Spiny Dogfish	5671	1176	5720	5770	5274	5300	28911
Yelloweye Rockfish	206	10	264	222	205	55	962
Quillback Rockfish	187	40	290	195	147	83	942
Spotted Ratfish	152	63	4	4	6	11	240
Copper Rockfish	44	12	19	20	64	30	189
Lingcod	44	2	17	20	28	60	171
Longnose Skate	22	3	16	13	47	52	153
Canary Rockfish	51	0	12	14	25	22	124
Pacific Cod	39	11	15	17	24	1	107
Big Skate	22	5	1	13	27	22	90
Cabezon	23	0	1	2	7	3	36
Greenstriped Rockfish	7	3	4	10	2	0	26
Southern Rock Sole	4	0	6	2	5	4	21
Pacific Sanddab	12	0	1	2	3	2	20
Pacific Halibut	6	8	0	3	2	0	19
Red Irish Lord	3	0	0	5	6	0	14
Tiger Rockfish	9	0	1	0	0	0	10
Kelp Greenling	3	0	0	1	2	1	7
Vermilion Rockfish	4	0	0	0	0	1	5
Sandpaper Skate	4	0	0	0	0	0	4
Walleye Pollock	0	0	1	0	2	0	3
Silvergray Rockfish	1	0	0	2	0	0	3
Deacon Rockfish	3	0	0	0	0	0	3
Yellowtail Rockfish	1	0	0	0	1	0	2

Arrowtooth Flounder	1	0	0	0	0	0	1
Wolf Eel	0	0	0	1	0	0	1
Sculpins	1	0	0	0	0	0	1
Petrale Sole	0	1	0	0	0	0	1
China Rockfish	1	0	0	0	0	0	1
Redstripe Rockfish	1	0	0	0	0	0	1
Sablefish	0	0	0	0	1	0	1

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 now 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 now 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 8). 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 2018 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. These sets also produce a time series of catch rate and biological data that can be used for assessing changes in stock abundance.

An **Inlets Program** that releases tagged Sablefish from fixed-stations at four mainland inlet localities (Figure 9). 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. Trap-mounted accelerometers recorded motion and orientation of the traps while oceanographic data from trap-mounted recorders collected temperature, depth, and salinity. The autonomous, trap-mounted cameras used in recent years were not deployed in 2018.

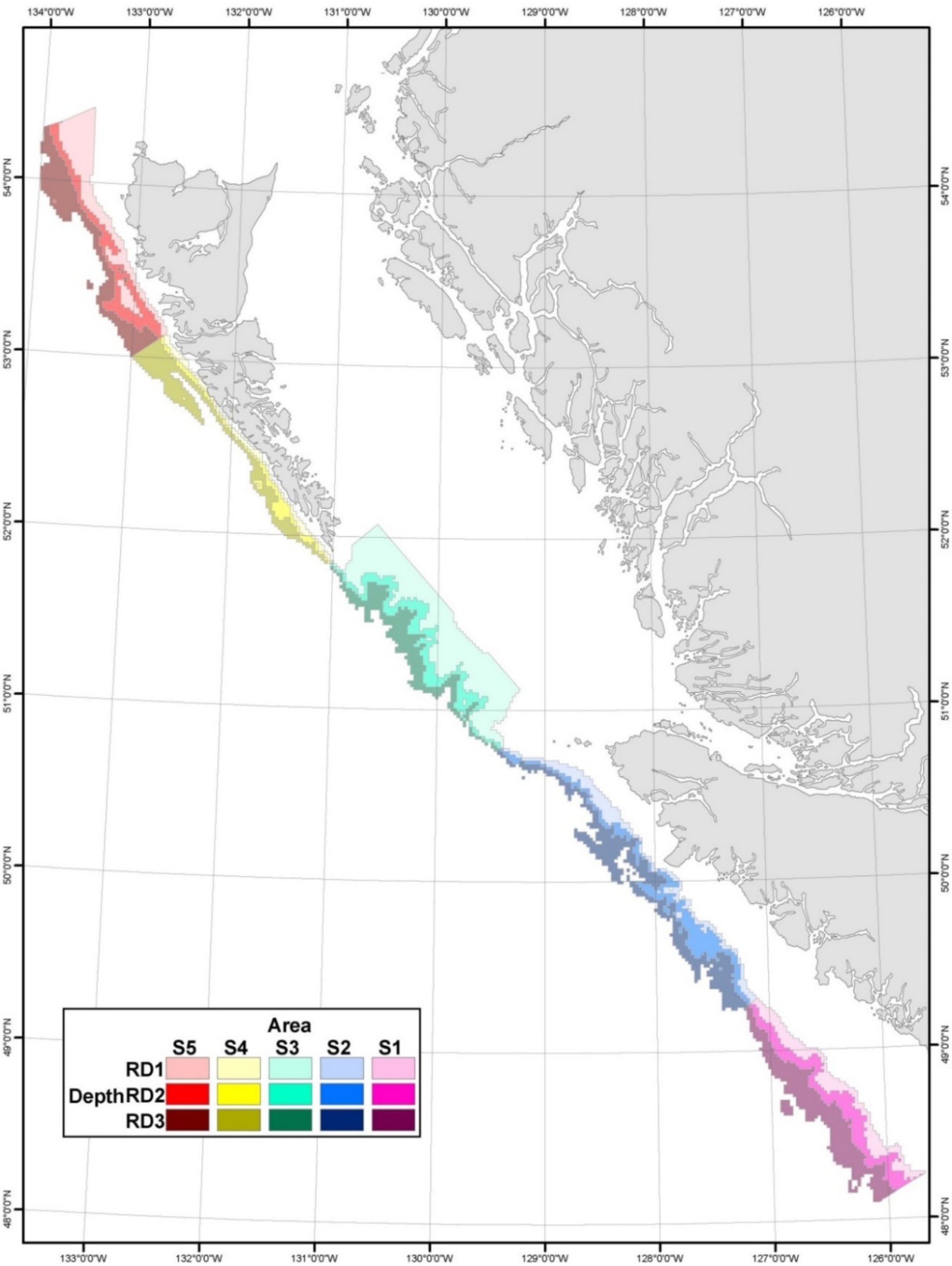


Figure 6. Sablefish Research and Assessment Survey randomized tagging program design showing the boundaries of each of the spatial and depth strata.

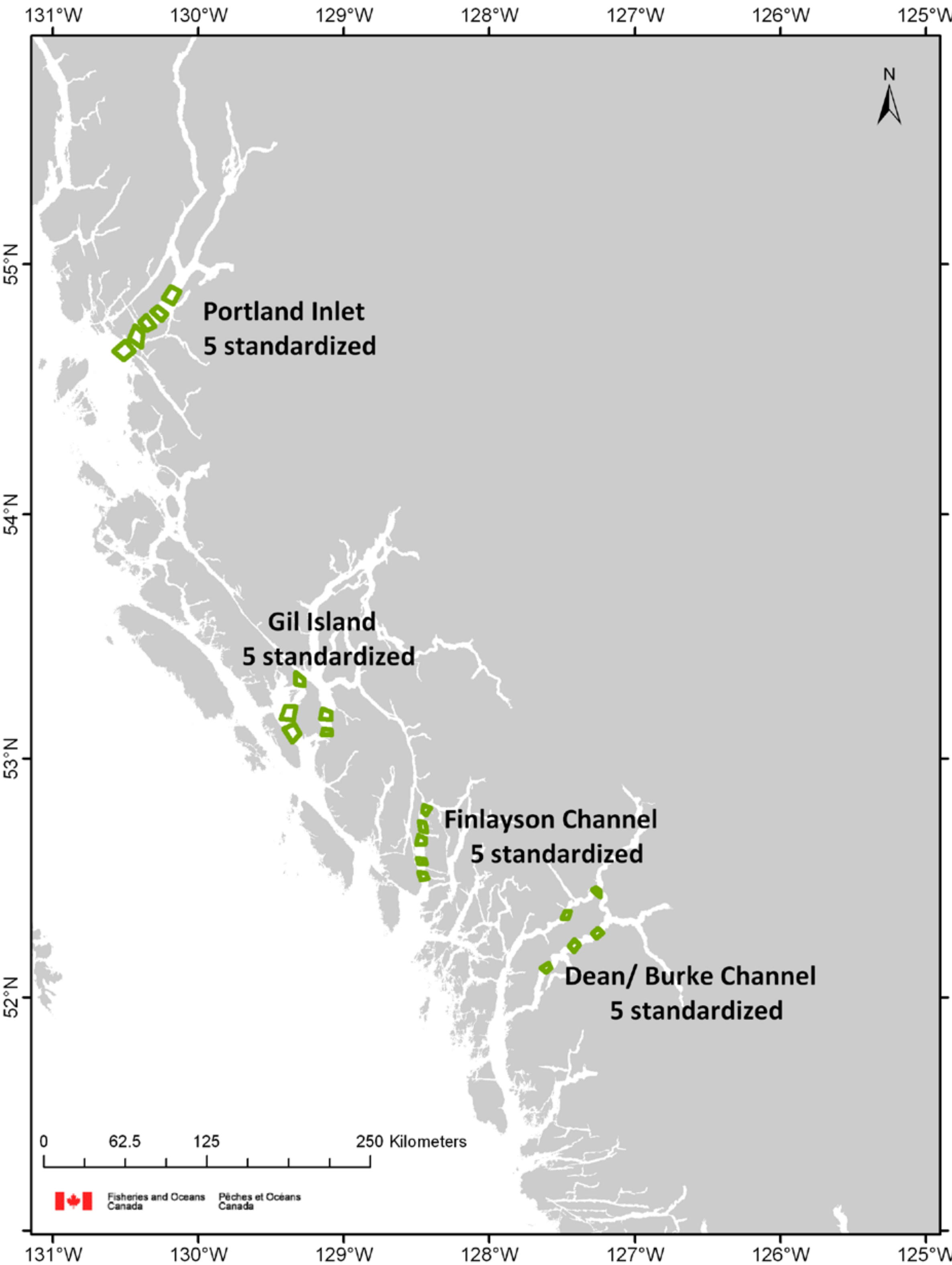


Figure 7. Sablefish Research and Assessment Survey Inlets program locations.

The 2018 Sablefish Research and Assessment Survey was conducted on the Ocean Pearl from October 9 to November 19, 2018. A total of 111 sets were completed (Figure 10) including 91 Randomized Tagging Program sets (Table 12) and 20 Inlets Program sets (Table 13).

The total catch of the survey was 130,719 kg (Table 14) and the average catch per set was 1178 kg. The most abundant fish species encountered by weight were Sablefish (Anoplopoma fimbria), followed by Pacific Halibut (Hippoglossus stenolepis), North Pacific Spiny Dogfish (Squalus suckleyi), Lingcod (Ophiodon elongatus), and Yelloweye Rockfish (Sebastes ruberrimus). The number of sets where the species was captured as well as the total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species captured during the Randomized Tagging Program are shown in Table 15. Annual summaries of catch for common species are shown for the Randomized Tagging Program in Table 16 and in Table 17 for the Inlet Program. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 17,322 individual fish of 5 different species (Table 18). An annual summary of the number of fish sampled for biological data during the Randomized Tagging Program is shown in Table 19 and in Table 20 for the Inlets Program.

Table 12. Summary of sets made during the 2018 Sablefish Randomized Tagging Program showing the number of sets in each combination of spatial and depth strata.

Spatial Strata	Depth Strata			
	RD1 (100-250 fm)	RD2 (250-450 fm)	RD3 (450-750)	**Total**
S1 (South West Coast Vancouver Island or SWCVI)	6	8	5	19
S2 (North West Coast Vancouver Island or NWCVI)	6	7	5	18
S3 (Queen Charlotte Sound or QCS)	8	6	5	19
S4 (South West Coast Haida Gwaii or SWCHG)	6	6	5	17
S5 (North West Coast Haida Gwaii or NWCHG)	6	7	5	18
Total	**32**	**34**	**25**	**91**

Table 13. Summary of sets made during the 2108 Sablefish Inlets Program.

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

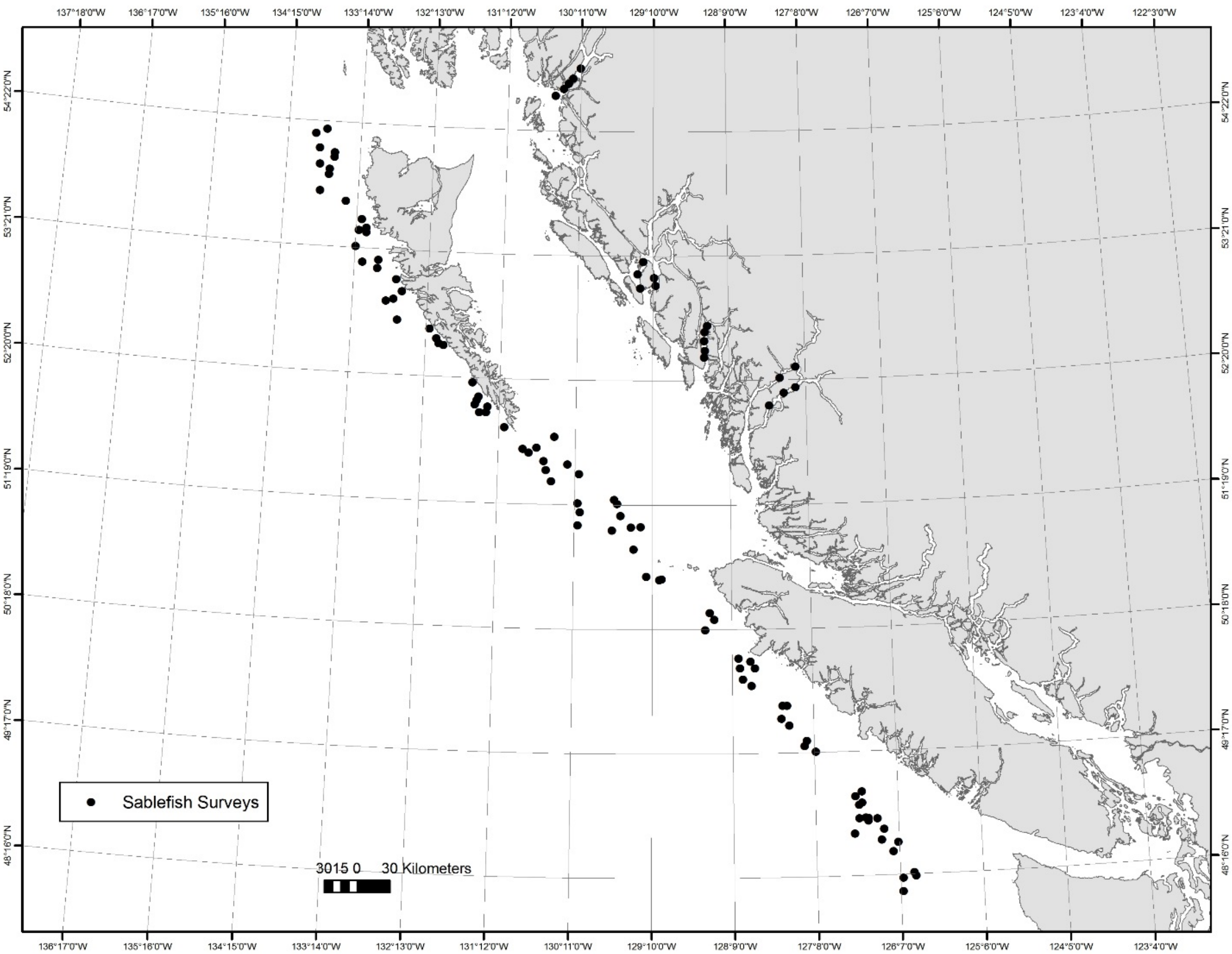


Figure 8. Set locations of the 2018 Sablefish Research and Assessment Survey.

Table 14. Total catch for the top 35 species (by weight) captured during the 2018 Sablefish Research and Assessment Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Sablefish	*Anoplopoma fimbria*	58415	119154
Pacific Halibut	*Hippoglossus stenolepis*	387	2986
North Pacific Spiny Dogfish	*Squalus suckleyi*	964	2973
Lingcod	*Ophiodon elongatus*	192	1912
Yelloweye Rockfish	*Sebastes ruberrimus*	311	1157
Arrowtooth Flounder	*Atheresthes stomias*	354	711
Redbanded Rockfish	*Sebastes babcocki*	219	389
Giant Grenadier	*Albatrossia pectoralis*	106	376
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	180	346
Pacific Grenadier	*Coryphaenoides acrolepis*	346	331
Grooved Tanner Crab	*Chionoecetes tanneri*	342	118
Shortraker Rockfish	*Sebastes borealis*	25	86
Shortspine Thornyhead	*Sebastolobus alascanus*	51	62
Canary Rockfish	*Sebastes pinniger*	7	17
	Lithodes couesi	27	13
Pacific Cod	*Gadus macrocephalus*	3	11
Pink Snailfish	*Paraliparis rosaceus*	26	10
	Paralomis multispina	25	9
Pacific Flatnose	*Antimora microlepis*	7	8
Dover Sole	*Microstomus pacificus*	8	8
Fragile Urchin	*Allocentrotus fragilis*	58	8
Brown Box Crab	*Lopholithodes foraminatus*	5	4
Oregontriton	*Fusitriton oregonensis*	109	3
	Neptuneidae	58	2

Rosethorn Rockfish	*Sebastes helvomaculatus*	5	1
Silvergray Rockfish	*Sebastes brevispinis*	1	1
Aurora Rockfish	*Sebastes aurora*	2	1
Fish-eating Star	*Stylasterias forreri*	7	1
Black Hagfish	*Eptatretus deani*	3	1
Golden King Crab	*Lithodes aequispinus*	1	1
Spotted Ratfish	*Hydrolagus colliei*	1	0
	Neptunea	40	0
Pacific Ocean Perch	*Sebastes alutus*	1	0
Sharpchin Rockfish	*Sebastes zacentrus*	2	0
Rockfishes	*Sebastes*	1	0

Table 15. Number of sets where the species was captured, total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species (by weight) captured during the 2018 Sablefish Research and Assessment Survey Randomized Tagging Program sets.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)	4B	3C	3D	5A	5B	5C	5D	5E
Sablefish	*Anoplopoma fimbria*	110	58415	94.80	0	11591	7680	3946	7764	6407	3616	17411
North Pacific Spiny Dogfish	*Squalus suckleyi*	33	964	1.56	0	44	156	171	140	0	0	453
Pacific Halibut	*Hippoglossus stenolepis*	49	387	0.63	0	21	120	46	31	15	44	110
Arrowtooth Flounder	*Atheresthes stomias*	46	354	0.57	0	130	15	32	44	9	1	123
Pacific Grenadier	*Coryphaenoides acrolepis*	17	346	0.56	0	19	48	0	163	0	0	116
Yelloweye Rockfish	*Sebastes ruberrimus*	12	311	0.50	0	3	3	27	126	0	0	152
Redbanded Rockfish	*Sebastes babcocki*	29	219	0.36	0	16	23	53	52	0	0	75
Lingcod	*Ophiodon elongatus*	25	192	0.31	0	1	80	22	27	0	0	62
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/ melanostictus* complex	19	180	0.29	0	16	1	30	4	0	3	126
Giant Grenadier	*Albatrossia pectoralis*	27	106	0.17	0	20	23	3	16	0	0	44
Shortspine Thornyhead	*Sebastolobus alascanus*	34	51	0.08	0	8	17	5	5	0	1	15
Pink Snailfish	*Paraliparis rosaceus*	7	26	0.04	0	7	13	1	5	0	0	0
Shortraker Rockfish	*Sebastes borealis*	12	25	0.04	0	1	7	8	5	1	0	3
Dover Sole	*Microstomus pacificus*	8	8	0.01	0	4	0	2	0	0	0	2
Canary Rockfish	*Sebastes pinniger*	2	7	0.01	0	1	6	0	0	0	0	0

Pacific Flatnose	*Antimora microlepis*	4	7	0.01	0	2	0	0	1	0	0	4
Rosethorn Rockfish	*Sebastes helvomaculatus*	4	5	0.01	0	0	0	2	2	0	0	1
Pacific Cod	*Gadus macrocephalus*	3	3	0.00	0	1	1	0	0	0	0	1
Black Hagfish	*Eptatretus deani*	2	3	0.00	0	0	0	0	3	0	0	0
Longspine Thornyhead	*Sebastolobus altivelis*	2	2	0.00	0	0	1	0	0	0	0	1
Aurora Rockfish	*Sebastes aurora*	2	2	0.00	0	0	1	0	0	0	1	0
Sharpchin Rockfish	*Sebastes zacentrus*	1	2	0.00	0	0	0	0	2	0	0	0
Spotted Ratfish	*Hydrolagus colliei*	1	1	0.00	0	0	1	0	0	0	0	0
Silvergray Rockfish	*Sebastes brevispinis*	1	1	0.00	0	0	0	0	1	0	0	0
Pacific Ocean Perch	*Sebastes alutus*	1	1	0.00	0	0	0	0	1	0	0	0

Table 16. 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. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	17730	24105	18833	20326	15529	17375	22568	16845	18095	14266	25428	18073	36604	46808	350988
Arrowtooth Flounder	598	763	1655	1163	1787	553	1037	921	414	864	610	427	686	336	12831
Pacific Grenadier	399	313	880	608	829	676	742	715	254	534	686	627	276	346	8867
North Pacific Spiny Dogfish	465	317	437	162	565	414	868	966	386	287	365	699	158	964	8385
Rougheye/Blackspotted Rockfish complex	166	355	558	513	418	406	266	941	223	488	320	386	257	177	6059
Pacific Halibut	114	163	185	125	224	172	256	342	99	447	444	283	165	323	3489
Redbanded Rockfish	113	93	154	257	150	131	244	208	127	241	295	217	287	219	2948
Lingcod	128	108	201	109	93	97	165	71	88	92	121	154	106	192	1890
Giant Grenadier	97	67	162	146	179	118	105	195	80	87	206	72	67	106	1848
Yelloweye Rockfish	33	22	71	58	60	21	106	34	13	17	81	97	22	311	1005

Table 17. 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. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	7066	5062	3453	2498	4339	7507	11034	6213	3271	3341	2708	5050	8110	11607	101156
Pacific Halibut	72	104	111	99	78	109	108	113	88	265	333	243	90	64	1979
Arrowtooth Flounder	23	46	101	108	49	25	11	20	11	49	30	24	14	18	553
North Pacific Spiny Dogfish	6	6	8	1	2	15	18	12	4	5	44	14	1	0	142
Dover Sole	4	4	4	23	1	0	0	1	2	5	1	1	2	0	49
Walleye Pollock	7	1	6	3	3	3	3	4	1	4	2	2	1	0	42
Pacific Sleeper Shark	1	5	5	4	2	0	1	0	0	2	0	2	0	0	29
Shortraker Rockfish	0	4	4	5	4	1	3	2	0	0	3	0	0	1	27
Pacific Cod	0	0	0	8	1	5	0	1	1	2	1	0	1	0	20
Rougheye/Blackspotted Rockfish complex	0	1	2	1	1	1	0	2	0	2	0	1	1	3	17

Table 18. Number of fish sampled for biological data during the 2018 Sablefish Research and Assessment Survey showing the number of tag releases, lengths, age structures, and DNA tissue samples that were collected by species.

Species	Scientific Name	Tags	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Pacific Halibut	*Hippoglossus stenolepis*	0	325	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	0	147	147	147
Sablefish	*Anoplopoma fimbria*	10965	16706	5492	0
Shortraker Rockfish	*Sebastes borealis*	0	25	25	0
Yelloweye Rockfish	*Sebastes ruberrimus*	0	150	144	102

Table 19. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Tagging Program sets. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	8999	12210	10385	11059	9331	10270	12463	10486	10118	8204	12094	9910	15841	13094	184318
Rougheye/Blackspotted Rockfish complex	0	56	0	282	289	266	240	393	179	373	270	270	183	144	2945
Pacific Grenadier	0	0	0	461	562	378	471	380	188	0	0	0	0	0	2440
Arrowtooth Flounder	0	0	0	441	379	245	400	656	140	0	0	0	0	0	2261
North Pacific Spiny Dogfish	0	0	0	0	219	326	440	674	207	0	0	0	0	0	1866
Redbanded Rockfish	0	0	0	224	145	131	243	204	113	0	0	0	29	0	1089
Giant Grenadier	0	0	0	129	141	111	99	195	79	0	0	0	0	0	754
Yelloweye Rockfish	0	0	0	55	60	21	106	32	12	0	75	58	21	150	590
Pacific Halibut	0	0	0	0	2	60	5	15	0	0	0	0	158	261	501
Shortraker Rockfish	0	0	0	53	65	73	18	59	18	13	10	59	26	24	426
Pacific Flatnose	0	0	0	18	39	27	17	24	11	0	0	10	0	0	146
Shortspine Thornyhead	0	0	0	1	9	26	22	53	34	0	0	0	0	0	145
Lingcod	0	0	0	0	27	36	1	3	1	0	0	0	0	0	68
Rosethorn Rockfish	0	0	0	8	6	2	23	7	3	0	0	0	0	0	49

Dover Sole	0	0	0	3	1	3	13	18	3	0	0	0	0	0	41
Pink Snailfish	0	0	0	30	0	0	1	0	0	0	0	0	0	0	31

Table 20. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Inlet Program sets. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	4394	3506	2554	1993	3070	5064	5984	3900	2503	2379	2234	3272	4693	3582	60647
Pacific Halibut	0	0	0	0	0	0	0	4	0	0	0	0	90	63	157
North Pacific Spiny Dogfish	6	0	0	0	0	0	8	11	0	0	0	0	0	0	25
Arrowtooth Flounder	0	0	0	0	0	0	3	18	0	0	0	0	0	0	21
Shortraker Rockfish	0	0	0	0	3	1	2	2	0	0	3	0	0	1	12
Rougheye/Blackspotted Rockfish complex	0	0	0	0	0	1	0	2	0	2	0	1	1	3	10
Walleye Pollock	7	0	0	0	0	0	1	1	0	0	0	0	0	0	9

Multi-species Small-mesh Bottom Trawl Survey

An annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island was initiated in 1973. In 1998, areas in Eastern Queen Charlotte Sound were added to the survey. Given that the survey is conducted using a shrimp bottom trawl without an excluder device, groundfish can make up a significant portion of the catch in many of the tows. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Although catch rates are useful indicators of stock status, additional information such as the size and age composition of the catch improves the usefulness of the indices. Consequently, a program was initiated in 2003 to collect biological samples from all groundfish species caught during the survey. Groundfish staff 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 Canadian Coast Guard Ship 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, 2017, and 2018 due to staffing limitations.

The 2018 survey was conducted onboard the F/V Nordic Pearl and ran from May 2 to May 17. A total of 126 tows were completed, of which 122 were usable (Figure 11). 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 50,850 kg. The mean catch per tow was 416 kg, averaging 39 different species of fish and invertebrates in each. Over all tows over the entire survey, the most abundant fish species encountered were Rex Sole (Glyptocephalus zachirus), Dover Sole (Microstomus pacificus), Flathead Sole (Hippoglossoides elassodon), Slender Sole (Lyopsetta exilis), Spotted Ratfish (Hydrolagus colliei), and Pacific Hake (Merluccius productus). 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 21 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 10,377 individual fish from 17 different species (Table 22). Most biological samples included fish length and sex but age structures were also collected for Bocaccio (Sebastes paucispsinis) and Lingcod (Ophiodon elongatus) 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).

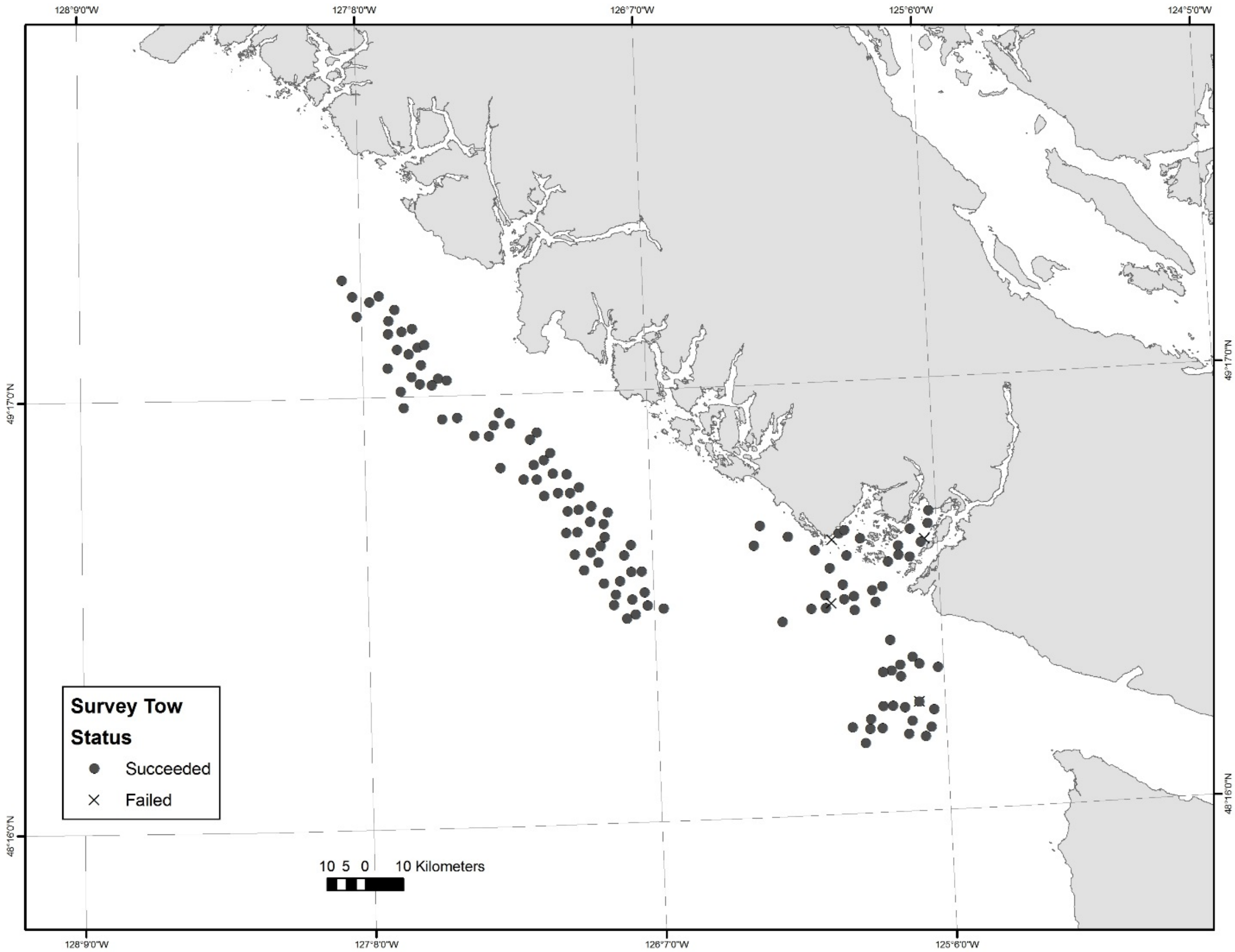


Figure 9. Tow locations of the 2018 Multi-species Small-mesh Bottom Trawl Survey.

Table 21. 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 2018 Multi-species Small-mesh Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Rex Sole	*Glyptocephalus zachirus*	72	4635	3864	0.05
Dover Sole	*Microstomus pacificus*	71	4427	3759	0.09
Flathead Sole	*Hippoglossoides elassodon*	71	2733	2500	0.16
Pacific Hake	*Merluccius productus*	61	2158	1676	0.24
Slender Sole	*Lyopsetta exilis*	71	1946	1694	0.1
Pacific Sanddab	*Citharichthys sordidus*	46	980	788	0.19
Arrowtooth Flounder	*Atheresthes stomias*	69	908	819	0.15
Spotted Ratfish	*Hydrolagus colliei*	69	749	604	0.12
English Sole	*Parophrys vetulus*	65	632	518	0.17
Sablefish	*Anoplopoma fimbria*	69	561	468	0.39
North Pacific Spiny Dogfish	*Squalus suckleyi*	39	497	370	0.2
Pacific Cod	*Gadus macrocephalus*	39	452	391	0.24
Longnose Skate	*Raja rhina*	69	440	354	0.08
Petrale Sole	*Eopsetta jordani*	60	439	380	0.14
Greenstriped Rockfish	*Sebastes elongatus*	62	281	221	0.19
Lingcod	*Ophiodon elongatus*	49	262	220	0.15
Yellowtail Rockfish	*Sebastes flavidus*	35	241	212	0.25
Walleye Pollock	*Gadus chalcogrammus*	61	220	179	0.17
Eulachon	*Thaleichthys pacificus*	61	146	123	0.16
Pacific Halibut	*Hippoglossus stenolepis*	27	143	124	0.19
Darkblotched Rockfish	*Sebastes crameri*	56	124	100	0.19
Blackbelly Eelpout	*Lycodes pacificus*	62	117	96	0.13
Pacific Ocean Perch	*Sebastes alutus*	15	102	70	0.9

Big Skate	*Beringraja binoculata*	11	78	61	0.37
Pacific Herring	*Clupea pallasii*	38	68	69	0.77

Table 22. Number of fish sampled for biological data during the 2018 Multi-species 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	DNA Tissue Collected
American Shad	*Alosa sapidissima*	78	0	0
Arrowtooth Flounder	*Atheresthes stomias*	195	0	0
Big Skate	*Beringraja binoculata*	55	0	0
Bocaccio	*Sebastes paucispinis*	35	35	0
Dover Sole	*Microstomus pacificus*	1167	0	0
English Sole	*Parophrys vetulus*	377	0	0
Eulachon	*Thaleichthys pacificus*	4680	0	424
Lingcod	*Ophiodon elongatus*	170	127	0
Longnose Skate	*Raja rhina*	870	0	0
Pacific Cod	*Gadus macrocephalus*	80	0	0
Pacific Halibut	*Hippoglossus stenolepis*	40	0	0
Petrale Sole	*Eopsetta jordani*	359	0	0
Rex Sole	*Glyptocephalus zachirus*	1467	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus complex*	42	42	42
Sablefish	*Anoplopoma fimbria*	134	0	0
Sandpaper Skate	*Bathyraja interrupta*	99	0	0
Walleye Pollock	*Gadus chalcogrammus*	529	0	0

CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2018

April 2019

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Table of Contents

VII. *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	Ms. Lesley MacDougall
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	Vacant
Quantitative Assessment Methods	Dr. Chris Rooper
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. Ecosystem studies, marine protected areas research and planning, and habitat research is undertaken in collaboration with staff in the Ecosystems Science Division (ESD).

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 *W.E. Ricker,* was officially decommissioned in October of 2017. The replacement vessel for the *W.E. Ricker,* the *Sir John Franklin*, is currently undergoing sea trials with delivery anticipated mid-summer of 2019. In the interim period, at sea operations for groundfish surveys requiring a large vessel continue to 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. Adam Keizer) 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 Mr. John Candy. Historically Groundfish held at least two meetings per year, in which stock assessments or other documents underwent scientific peer review (including external reviewers who are often from NOAA). The resulting Science Advisory Report summarizes the advice to Fishery Managers, with the full stock assessment becoming a Research Document. Both documents can be viewed on the Canadian Stock Assessment Secretariat website: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm. The future frequency of review meetings and production of stock assessment advice for fisheries managers will depend on departmental, branch and regional priorities potentially resulting in less frequent advice.

The Trawl, Sablefish, Rockfish, Lingcod, North Pacific Spiny Dogfish, and Halibut fishery sectors continue to be managed as an integrated fishery 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 2018 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 2018-19 between Fisheries and Oceans Canada and several partner organizations to support groundfish science activities through the allocation of fish to finance the activities. These agreements will be updated for 2019-20.

VIII. Surveys

Databases and Data Acquisition Software

GFBioField is a data acquisition software application created in-house by DFO staff in the Groundfish Surveys Program at the Pacific Biological Station in Nanaimo British Columbia. GFBioField was designed for real-time data capture and data entry during at-sea surveys, but can also be used for dockside sampling and office-based data entry. Modified versions have been developed by Groundfish Surveys staff for use by other programs such as the Marine Invertebrates Section within the StAR Division, and the Aquatic Ecosystems and Marine Mammals Section and Regional Ecosystem Effects on Fish and Fisheries Section in the Ecosystem Science Division.

GFBioField uses a client-server architecture employing Microsoft SQL Server 2016 for the back-end data storage and business logic. Previous versions used a Microsoft Access 2007 project for the user interface. However, in 2018, DFO adopted Microsoft Office 2016 as the standard for all new workstations, and it was felt that continuing to maintain and support obsolete versions of the software would become increasingly difficult. Therefore, the GFBioField user interface was completely rebuilt as a Microsoft Access 2016 front-end. The new version will be deployed for the 2019 field season.

GFBio is an oracle database developed in-house by DFO staff in the 1990s, which houses groundfish research survey and commercial biological data collected in British Columbia from the 1940s to the present. GFBio now includes over 28 thousand trips and approximately 11.5 million individual fish specimens. In 2018, 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 other DFO surveys.

Commercial Fishery Monitoring and Biological Sampling

Groundfish commercial fisheries in British Columbia are subject to 100% catch monitoring, either by the at-sea observer program (ASOP) or by electronic monitoring, with all bottom trawl trips outside the Strait of Georgia accompanied by an at-sea observer, and all line trips subject to video monitoring. A dockside monitoring program (DMP) validates all commercial landings. Commercial fishery data from observer logs, fisher logs, and DMP are captured electronically in the groundfish modules of the Fishery Operations System (FOS) database, maintained by the Fisheries and Aquaculture Management Branch of DFO. Groundfish Science maintains GFFOS, which contains the groundfish FOS data, reformatted to be useful for scientific purposes.

In addition to monitoring catches at sea, the ASOP also provides biological samples of halibut, salmonids, and a variety of important commercial groundfish species from the observed trawl fishery. Biological samples are also collected from the hake fishery as part of the DMP. Additional commercial biological samples may also be collected by DFO staff at the dockside from sablefish trips or other trips that would not otherwise be sampled. Biological samples are uploaded to GFBio on a quarterly basis. In 2018, samples were collected from approximately 400 commercial trips, resulting in approximately 96 thousand specimen records.

Research Surveys

The Fisheries and Oceans, Canada (DFO) Groundfish section of the Stock Assessment and Research Division conducts 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 routinely participates in the Canadian portion of the Joint Canada US Hake Acoustic Survey and provides staff to collect groundfish information from a DFO Small-Mesh Bottom Trawl Survey and the International Pacific Halibut Commission (IPHC) Standardized Setline Survey (Figure 2).

The Multispecies Synoptic Bottom Trawl Surveys are conducted in four areas of the BC coast, with two areas surveyed each year, such that the whole coast is surveyed over a two year period. Typically, the West Coast of Vancouver Island (WCVI) and West Coast of Haida Gwaii (WCHG) are surveyed in even-numbered years, while Hecate Strait (HS) and Queen Charlotte Sound (QCS) are surveyed in odd-numbered years. An additional synoptic bottom trawl survey has been conducted twice in the Strait of Georgia (SOG), but vessel availability and staffing constraints have precluded establishing a regular schedule for this survey. These surveys are conducted under collaborative agreement with the Canadian Groundfish Research and Conservation Society (CGRCS), and in typical years, one survey occurs on a Canadian Coast Guard Vessel, and one survey occurs on a chartered commercial vessel. These bottom trawl surveys provide coast-wide coverage of most of the trawlable habitat between 50 and 500 meters depth. Survey data are collected electronically using GFBioField. Trawl survey data sets are updated annually and are available for download from [open maps URL].

In 2018, the Multispecies Synoptic Bottom Trawl Surveys occurred on the charted commercial trawl vessel *Nordic Pearl*. One Hundred and Ninety (190) and 132 successful tows were completed in the WCVI and WCHG regions, respectively. Off the west coast Vancouver Island the dominant species in the catch were North Pacific Spiny Dogfish, Sharpchin Rockfish, and Sablefish. Notable trends in the indices of abundance include significant increases in the trends for Sablefish, Sharpchin Rockfish, Flathead Sole, and Bocaccio, with decreasing trends for North Pacific Spiny Dogfish and Arrowtooth Flounder. Off the west coast of Haida Gwaii the dominant species in the catch were Pacific Ocean Perch, Sharpchin Rockfish, and Rougheye/Blackspotted rockfish complex. Notable trends in the abundance indices include increasing trends for Sablefish, Sharpchin Rockfish, Walleye Pollock, Redbanded Rockfish and Bocaccio, with decreasing trends for Arrowtooth Flounder, Silvergray Rockfish, and Pacific Cod.

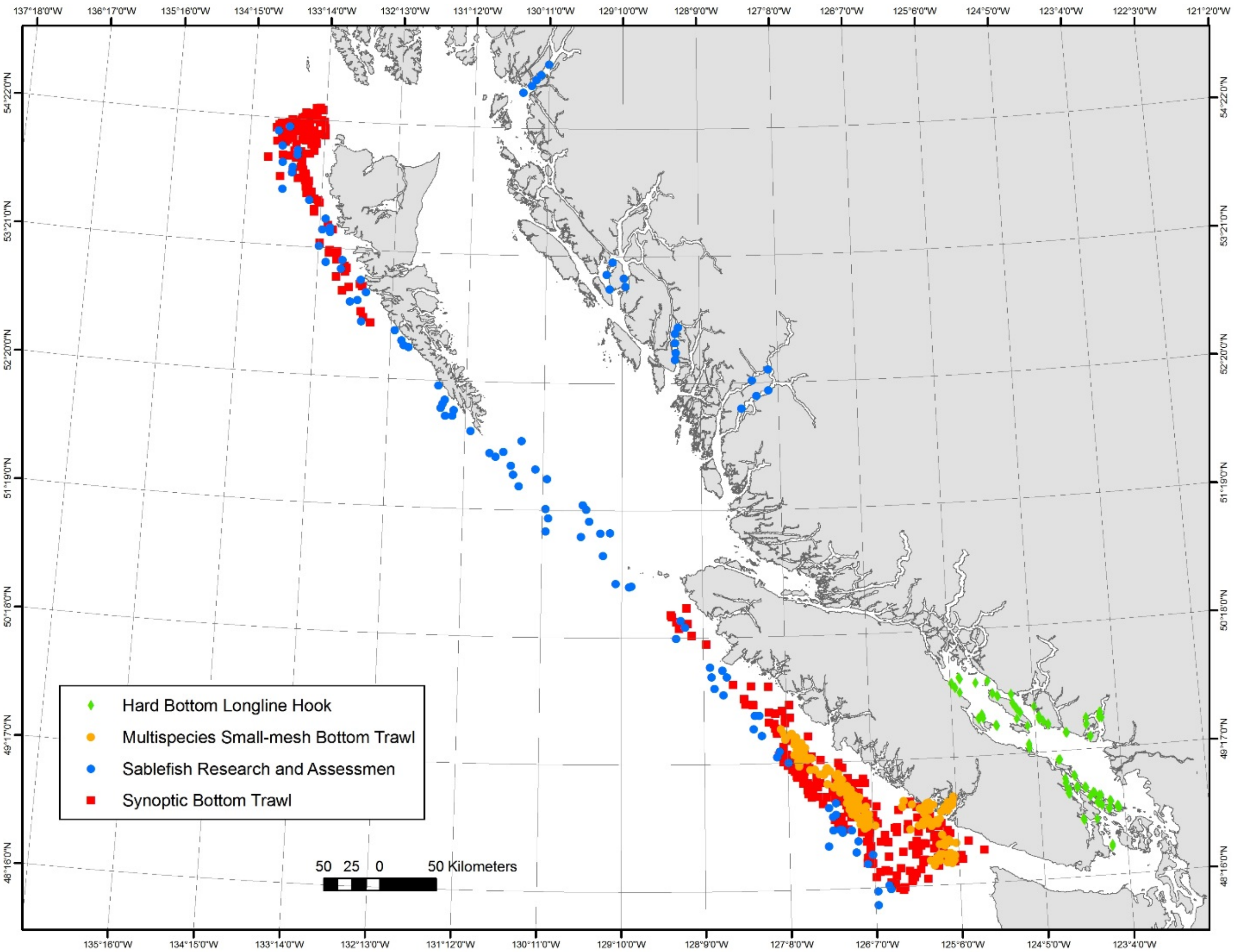

Figure 1. Fishing locations of the 2018 Groundfish surveys. The HBLL-outside and IPHC survey data have not been plotted because they were not available at the time of writing.

The Hard Bottom Longline Hook (HBLL) Surveys are conducted annually in "outside" waters (not between Vancouver Island and the mainland) and "inside" waters (between Vancouver Island and the mainland). Both the "outside" and "inside" areas are divided into northern and southern regions, and annual surveys alternate between the regions, such that the whole coast is surveyed over a two year period. The "outside" surveys are conducted under collaborative agreement with the Pacific Halibut Management Association (PHMA) and occur on chartered commercial vessels, while the "inside" surveys are conducted by DFO and occur on a Canadian Coastguard vessel. The longline hook surveys provide coast-wide coverage of most of the non-trawlable habitat between 20 and 220 meters depth. As the outside surveys are conducted on a variety of small vessels without any DFO staff present, data from these surveys are initially recorded on paper, while data from the inside survey are recorded electronically using GFBioField. The HBLL survey data sets will be available later in 2019.

In 2018, both the HBLL outside and inside surveys occurred in the southern portion of their respective survey areas. The outside surveys occurred on the chartered commercial longline vessels *Pacific Ambition*, *Western Sunset*, and *Borealis 1*, while the inside survey occurred on the Canadian Coast Guard Vessel *Neocaligus*. One Hundred ninety seven (197) and 55 successful sets were completed, respectively. In previous years, data from the outside survey have been keypunched by Archipelago Marine Research (AMR) into their data system, extracted as a series of flat files, and provided to the Groundfish Data Unit for reformatting, error checking, and uploading to GFBio. In 2018, AMR was provided with a stand-alone version of GFBioField and all data entry was directly into the GFBioField application, greatly streamlining the data processing. The most abundant species on the HBLL outside survey were Yelloweye Rockfish, Quillback Rockfish, Pacific Halibut and Sablefish, while on the HBLL Inside they were North Pacific Spiny Dogfish, Quillback Rockfish, Lingcod and Yelloweye Rockfish.

The Sablefish Research and Assessment Survey is an annual longline trap survey targeting sablefish. This survey releases tagged Sablefish at randomly selected fishing locations in offshore waters, as well as at fixed stations in four mainland inlets. The survey also provides catch rates and biological data for use in stock assessments. The survey is conducted under collaborative agreement with the Canadian Sablefish Association and occurs on a chartered commercial vessel. 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. Survey data are collected electronically using GFBioField. The sablefish research and assessment survey data sets are available on request from the Groundfish Data Unit.

In 2018, the sablefish survey completed 91and 20 successful sets in the offshore and inlet areas, respectively. The most abundant fish species encountered by weight were Sablefish, followed by Pacific Halibut, North Pacific Spiny Dogfish, Lingcod, and Yelloweye Rockfish.

IX. 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 87).

DFO, along with the Province of British Columbia and 16 First Nations, are co-leading the development of a network of MPAs for the Northern Shelf Bioregion (http://mpanetwork.ca/bcnorthernshelf/). The Marine Protected Area Technical Team (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. A draft MPA network scenario was released for comment by stakeholders on the advisory committee on February 28, 2019, with initial reviews by June 30 and MPATT accepting feedback until Jan 31. The scenario is expected to change as a result of comments and has not been publically released.

The Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA that was designated under Canada’s Oceans Act in February 2017 to protect glass sponge reefs in Hecate Strait and Queen Charlotte Sound will be part of that MPA network, as will the Gwaii Haanas National Marine Conservation Area Reserve (GHNMCAR) and Haida Heritage Site. Parks Canada and the Archipelago Management Board have introduced new zoning to the GHNMCA which includes multiple use zones (IUCN protection level IV-VI) as well as high protection zones (IUCN Ib-III) and two small restricted access zones that are intertidal/terrestrial. These zones come into effect on May 1, 2019. The two RCAs that were formerly within the GHNMCA boundaries will be rescinded and replaced with the new zoning, although one small RCA remnant may remain in Crescent Inlet. Parks Canada is still also working on the Southern Gulf Islands NMCA.

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 87) (DFO 2019). 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). They are on track to make this into an MPA within 2 years.

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 other 162 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. A review of the RCA locations was completed this year (DFO 2019) and a risk assessment is also being completed and will be re-reviewed at CSAP in May 2019. 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). Eight additional sponge reefs closures in Howe Sound were announced by DFO on April 1, 2019 with the same prohibitions as the other sponge closures with the additional prohibition of the use of downrigger gear in recreational salmon fishing due to the potential risk of damage to these shallow reefs.

The Scott Islands marine National Wildlife Area (NWA), the first protected marine area established under the Canada Wildlife Act, was established on June 27th, 2018. It conserves a vital marine area for millions of seabirds on the Pacific coast. Fishing activity is currently not prohibited in the NWA (https://www.canada.ca/en/environment-climate-change/services/national-wildlife-areas/locations/scott-islands-marine.html).

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DFO. 2019. A Regional Assessment of Ecological Attributes in Rockfish Conservation Areas in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. In press.

DFO. 2019. Biophysical and Ecological Overview of the Offshore Pacific Area of Interest (AOI). DFO Can. Sci. Advis. Sec. Sci. Resp. 2019/011.

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

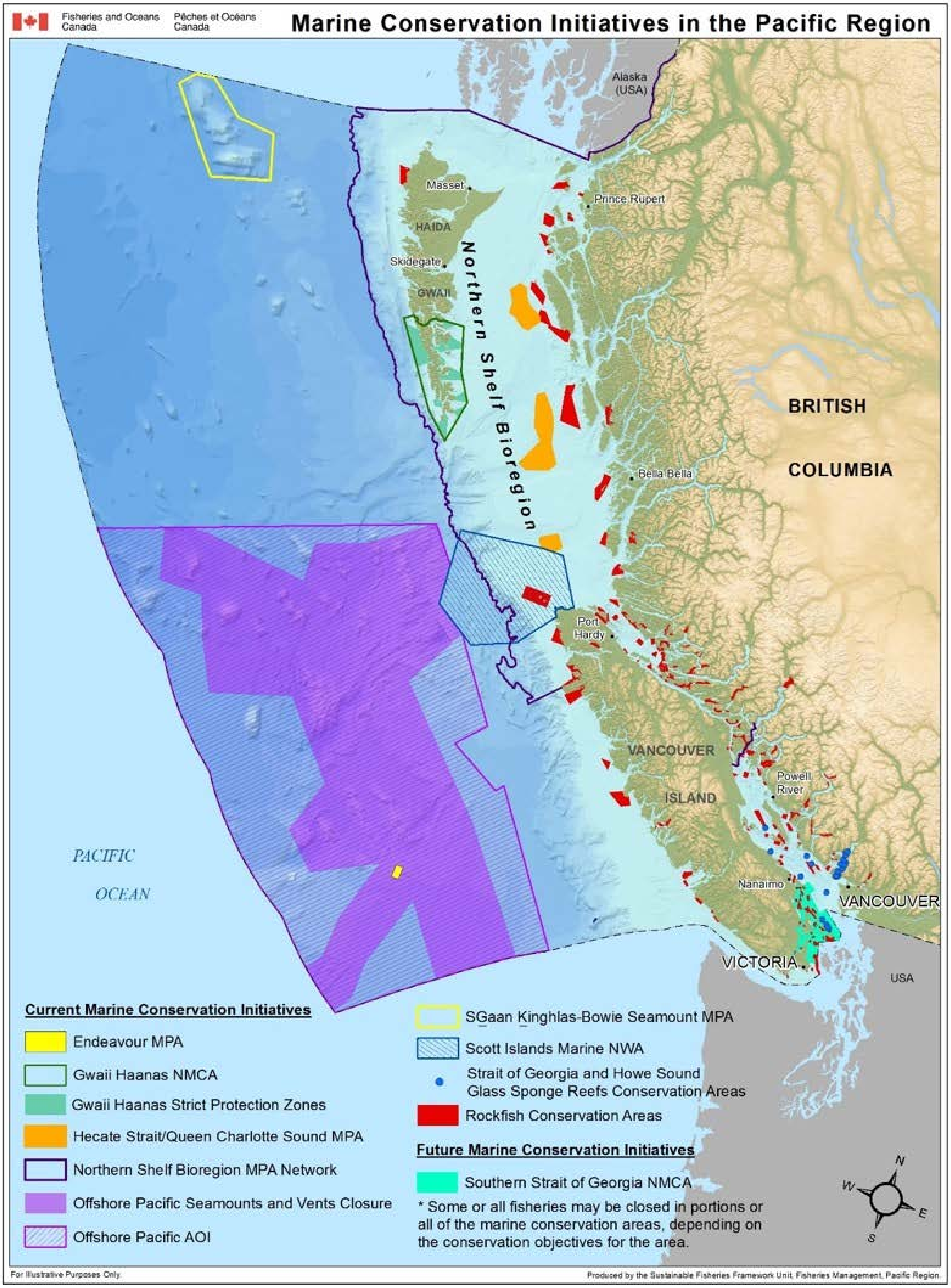

Figure 10. Map of Marine Conservation Target initiatives in British Columbia.

Review of Agency Groundfish Research, Assessment and Management

A. *Hagfish*

1. *Research*

No new research in 2018.

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 2018 through the Groundfish Synoptic Surveys, at-sea observer sampling, and recreational creel surveys. Anecdotal information continued to be collected through the Shark Sightings Network. Dogfish survey to be conducted Oct 2019!

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.

The committee of the status of Endangered Wildlife in Canada (COSEWIC) contracted an author to prepare an updated status report Tope (Soupfin) shark. A draft of that report was reviewed by DFO Science, the final report will be reviewed by the COSEWIC Marine fish Committee during 2019. Tope were designated as Special Concern by COSEWIC in April of 2007 and subsequently listed under the Species At Risk Act (SARA) in March of 2009 as Special Concern, this is their first re-assessment by COSEWIC.

3. *Management*

Dogfish are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). The current TAC for Dogfish-Outside (all waters except the Strait of Georgia) is 12000 t, for Dogfish – Inside the TAC is 2000 t, the TACs are split between the Trawl (32%) and directed Dogfish (68%) fishery fleets. There is currently no targeted fishing for Dogfish as markets have essentially collapsed with the directed dogfish fleet harvesting 0% of its TAC in 2018 and the trawl fleet intercepting only 2.7% of its TAC. All fishery induced mortality at this time is as bycatch in directed fisheries for other species with little to none of the catch being retained or landed.

For other shark species not managed using a TAC under the IFMP there is a Shark Code of Conduct intended to increase the likelihood of sharks surviving release at sea. Of the fourteen shark species in Canadian Pacific waters, three are listed under the Species At Risk Act (SARA). The Basking Shark (*Cetorhinus maximus*) is listed as Endangered, and the Bluntnose Sixgill Shark (*Hexanchus griseus*) and Tope Shark (*Galeorhinus galeus*) are species of Special Concern. The primary threats to shark species have been identified as bycatch and entanglement. As such, commercial fishing licences have been amended to include a Condition of License for Basking Sharks that specifies mitigation measures in accordance with SARA permit requirements.

Additionally, two 'Code of Conduct for Shark Encounters' documents have been developed to reduce the mortality of Basking Shark, as well as other Canadian Pacific shark species such as Bluntnose Sixgill and Tope Shark resulting from entanglement and bycatch in commercial, aquaculture, and recreational fisheries.

These documents have been posted online and can be found at the following URL links.

Code of Conduct for Basking Sharks:

http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/shark-requin/conduct_basking_conduite_pelerin-eng.html

Code of Conduct for Sharks:

http://dfo-mpo.gc.ca/species-especes/publications/sharks/coc/coc-sharks/index-eng.html

C. *Skates*

1. *Research*

Ongoing data collection continued in 2018 through surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

II.

2. *Assessment.*

Skates were last assessed in 2015. No new assessment is currently planned.

III.

3. *Management*

Big and Longnose skates are currently managed under sector and area TACs, for all other species of skate there are no management measures in place or limits.

Big and Longnose skates are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Big and Longnose skates are IVQ (individual vessel quota) species with 2018/19 TACs (total allowable catch) of 1,032 t and 458 t respectively coastwide. Commercial TACs for various groundfish species are allocated between Management Areas and the different groundfish sectors, the allocation for Big and Longnose skate exemplify the complexity of such a system.

Species	**Commercial Sector**						
	T (Trawl)	L (Halibut)	LC (LingCod)	ZN Inside (Rockfish)	ZN Outside (Rockfish)	K (Sablefish)	DF (Dogfish)

Longnose Skate	3CD	62.83%	14.19%	0.00%	0.00%	1.50%	11.26%	10.22%
	5AB	32.83%	48.49%	0.01%	0.00%	8.61%	9.47%	0.57%
	5CDE	20.28%	59.80%	0.00%	0.00%	8.53%	10.55%	0.84%
Big Skate	3CD	24.55%	26.72%	0.00%	0.00%	1.93%	4.16%	42.63%
	5AB	91.48%	5.97%	0.01%	0.00%	1.20%	0.72%	0.62%
	5CDE	92.07%	6.34%	0.00%	0.00%	0.56%	0.95%	0.08%

To support groundfish research and account for unavoidable mortality incurred during the 2018 Groundfish Trawl multi-species surveys, 0.2 and 1.0 t respectively were accounted for before defining the Groundfish Trawl TACs.

D. *Pacific cod*

1. *Research*

Ongoing data collection continued in 2018 through the surveys and at-sea observer sampling. Collection of DNA was initiated during 2015 in the spawning areas of Hecate Strait (PSMFC Area 5D) and continued in 2018.

2. *Assessment*

Updated harvest advice was produced for Pacific Cod during 2018. Four stocks are defined for management purposes in BC: Strait of Georgia (4B); West Coast Vancouver Island (3CD); Queen Charlotte Sound (5AB); and Hecate Strait (5CD). Historically each area has been assessed separately. For the purposes of this assessment, data from Areas 5AB and 5CD were combined into a single stock assessment, due to the lack of biological evidence for separate stocks and improved fits to the combined data compared to data from area 5AB alone. Area 3CD was assessed separately. Area 4B was not assessed at this time as there is no directed commercial fishery there.

Pacific Cod in BC are difficult to age, making statistical catch-age models inappropriate for this species. Therefore, stocks in Areas 5ABCD and 3CD were assessed using Bayesian delay-difference models. The models were fit to fishery-independent indices of abundance, mean annual weight in the commercial catch, and new standardized commercial catch-per-unit-effort (CPUE) indices that were developed using Tweedie generalized linear mixed effect models (GLMMs). Updated estimates of growth parameters were also incorporated into the models.

Due to uncertainty in model parameters, biological reference points based on equilibrium assumptions (e.g., maximum sustainable yield (MSY)) were not used. Instead, following the approach in previous stock assessments for Area 5CD, reference points were based on estimated historical biomass. For both stocks, the recommended upper stock reference (USR) is the average estimated biomass between 1956 and 2004; and the recommended limit reference point (LRP) is an agreed-upon undesirable low biomass state to be avoided (B2000 in Area 5ABCD;

B1986 in Area 3CD). The recommended limit removal rate (LRR) is the average estimated fishing mortality between 1956 and 2004.
For each of the two assessed stock areas, advice is provided as a decision table that summarizes the probability of breaching reference points over a range of fixed catch levels for a one-year projection using a model-averaging approach. The model- averaged decision tables were constructed using unweighted posterior samples from a reference case model and six sensitivity cases for each stock, to encompass the range of parameter uncertainty in the assessments.

For Area 5ABCD, model-averaged biomass at the beginning of 2019 (B2019) was projected to be 0.60 (0.39-1.01) of unfished biomass (B0). For Area 3CD, model-averaged B2019 was projected to be 1.13 (0.78-1.73) of B0. Proportions denote median (and 2.5 - 97.5 percentiles).

IV.

3. *Management*

Pacific Cod is managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Pacific Cod is an IVQ (individual vessel quota) species with a 2018/19 TAC (total allowable catch) of 1,450 t coastwide (500 t in Area 3CD, 250 t in 5AB, and 700 t in 5CDE). Commercial total allowable catch for various groundfish species are usually allocated between the different groundfish sectors; however, Pacific Cod was entirely (100%) allocated to the Trawl sector.

To support groundfish research and account for unavoidable mortality incurred during the 2018 Groundfish Trawl multi-species surveys, 2.7 t were accounted for before defining the Groundfish Trawl TACs.

E. *Walleye pollock*

4. Research

There is no directed work being conducted on Walleye Pollock but ongoing data collection continued in 2018 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

5. Assessment

The BC Walleye Pollock assessment of 2017 was sent for publication in 2018. Two stocks were identified: BC North (PMFC 5CDE) and BC South (PMFCs 5AB+3CD + minor areas 12 & 20) based on significant differences in mean weight (fish were generally twice the size in the north as they were in the south). A delay-difference production model was used to assess each stock in a Bayesian framework, 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. Composite reference (model averaged) scenarios (Figure E.1) were used to represent each stock based on natural mortality and knife-edge combinations which generated reasonable estimates of fishing mortality (F<2).

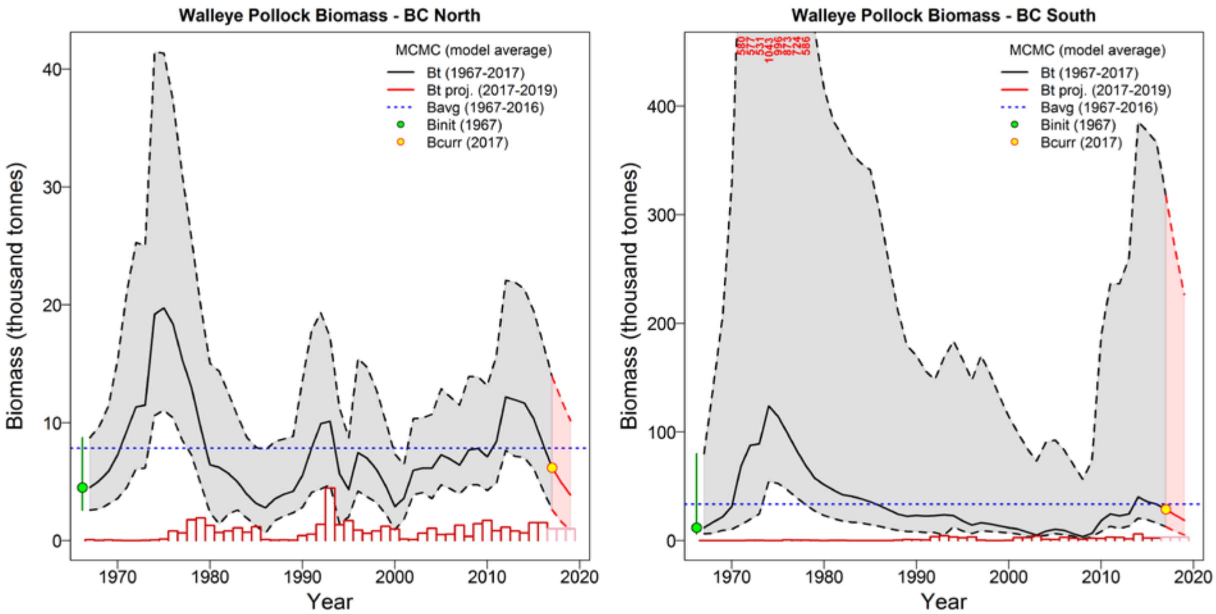

Figure E.1. Median estimates (solid black line) and 90% credibility intervals (black dashed lines, grey fill) for the model-average B_t (biomass in year t in tonnes) for Walleye Pollock. Also shown are the initial biomass B_{1967} (green circle), current biomass B_{2017} (yellow circle), two-year projections $B_{2018\text{-}19}$ (pink fill), the median of average biomass B_{avg} (blue dotted line), the historical catch (red bars) and the catch strategy (pink bars, 1000 t).

6. Management

Walleye Pollock is an IVQ (individual vessel quota) species with a 2018 TAC (total allowable catch) of 4,225 t coastwide, which is unchanged from 2017 (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 2018 Groundfish Trawl multi-species surveys planned, 1.2 t were accounted for before defining the Groundfish Trawl TACs.

Advice to managers (as decision tables) from the stock assessment used historical reference points: Bavg, the average spawning biomass from 1967-2016, was used as a proxy for BMSY, and Bmin, the minimum spawning biomass from which it subsequently recovered to Bavg, was used in place of 0.4BMSY. Twice Bmin was used in place of 0.8BMSY. Three models were used for the model average in BC North and six models contributed to the model average for BC South (Figure E.2).

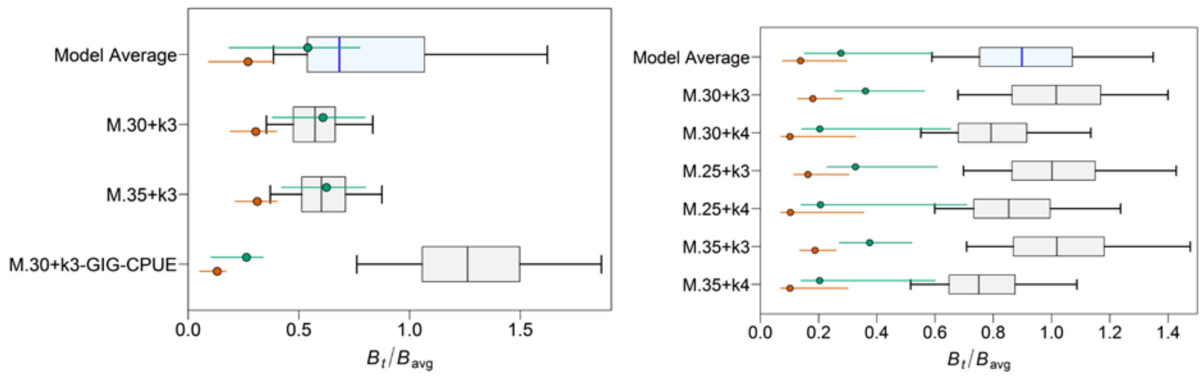

Figure E.2. Status (left: BC North, right: BC South) of the current stock B_{2017} relative to B_{avg} with the circles showing median biomass reference points (B_{min}/B_{avg} [red], $2B_{min}/B_{avg}$ [green]), where B_{avg} is a proxy for B_{MSY}, B_{min} is the limit reference point (LRP), and $2B_{min}$ 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

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. The last survey used in the assessment model took place in 2017.

An exploration of the use of sail drones was done during the summer of 2018, with multiple sail drones running along the same transect lines as the U.S. and Canadian ships. Initial results show promise in acquisition of clean acoustic data by sail drones, but they are limited to two frequencies whereas the ships have five. There is also currently a limitation of non-real-time data access because the drones need to come within range of a cell phone tower to download their data. Use of the sail drones in future surveys to gather acoustic data for use in Pacific hake backscatter calculations would still require the use of one or more catcher vessels, for opportunistic sampling of notable aggregations.

2. *Assessment*

V.

As in previous years, and as required by The Agreement, 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 (SS3.30). The 2019 model had the same model structure used in 2018, with updates to catch and age compositions. Standard sensitivities requested by the Scientific Review Group were done and showed little difference from the reference model.

The largest cohort caught in the Canadian fishery was age-8's, followed by age 4's which represent the large cohorts for 2010 and 2014 respectively. There was a larger proportion than usual of Age 2's caught this year which could mean a larger than average recruitment of 2016 fish.

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*

VI.

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 2018 was the same as it was in 2017 at 156,067 t. The shoreside/freezer trawler sectors caught 54,447 t and 38,241 t respectively which was 61.1% of the total Canadian TAC. The Joint Venture (JV) fishery received a quota of 15,000 t in 2018, and caught 2,724 t. The majority of the Canadian Pacific Hake catch for the 2018 season was taken from the west coast of Vancouver Island.

The final decision on catch advice for the 2019 fishing season was made at the Joint Management Committee (JMC) meeting in Vancouver, B.C. on Mar. 4 – Mar. 5, 2019. For the third year in a row, a coastwide TAC of 597,500 t was agreed upon for 2019. 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

Publications:

Berger, A.M., A.M. Edwards, C.J. Grandin, and K.F. Johnson. 2019. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2019. 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. 249 p.

G. *Grenadiers*

1. *Research*

There is no directed work being conducted on Grenadiers but ongoing data collection continued in 2018 through surveys and at-sea observer sampling.

2. *Assessment*

VII. *Grenadiers are not commercially harvested in BC and are rarely encountered during commercial fisheries, consequently there are no assessment activities planned for these species.*

3. *Management*

There are no management objectives or tactics established for these species. These species are caught primarily as bycatch in the deep water rockfish (Rougheye/Shortraker/Thornyhead) and Dover Sole fisheries, 100% of the catch is discarded, Only about 10 t each of Pacific and Giant Grenadier are caught and discarded annually.

H. *Rockfish*

1. *Research*

The department (DFO) assesses populations of rockfish (Sebastes) species both inshore (shallow regions near shore that are accessible by many fisher groups) and offshore (BC's continental shelf and slope often only accessible by the commercial industry). DFO also tackles a variety of other issues: 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. In stock assessment, DFO collaborates with outside contractors from agencies like the Canadian Groundfish Research and Conservation Society and The School of Resource and Environmental Management (REM) at Simon Fraser University (SFU).

The Groundfish Surveys program at the Pacific Biological Station (PBS, Nanaimo BC) conducts a suite of synoptic surveys that covers most of BC's ocean bottom ecosystems. The survey team gathers information on abundance and biology (lengths, weights, maturity, otoliths, etc.).

c) Inshore Rockfish

The Inside Hard Bottom Longline (HBLL) Survey took place August 7-31, 2018 and surveyed the southern region from Campbell River to Victoria. The timing of the survey was changed and shortened by Coast Guard due to crewing issues, so blocks in Desolation Sound were not fished and will be added to the 2019 survey of the northern region. Quillback and Yelloweye Rockfishes survey trends are still declining in the Strait of Georgia (Figure 8); however, a full analysis will have to take into account the missed blocks in the NE section of the survey frame.

The Outside Hard Bottom Longline Survey (HBLL) conducted collaboratively with industry (the Pacific Halibut Management Association) was completed in August 1-September 15 2018, in the southern region. See the survey section (II) and Appendix 1 for further details. Yelloweye Rockfish catches were reported by skippers to be good in many areas.

DFO collaborated with WDFW and NOAA on an ROV survey for inshore rockfish in the Strait of Georgia on board the CCGS Vector, October 22-Nov 6, 2018. ROV transects were completed using the WDFW's Falcon ROV the Yelloweye, inside and outside of RCA. Most transects locations were randomly selected to be within modeled high probability rockfish habitat. Visual survey data are currently being annotated by WDFW and DFO (Figure 9).

Dana Haggarty is collaborating with Dr. Sarah Dudas and Dr. Stephanie Archer on a project funded by DFO's SPERA (Strategic Program for Ecosystem Based Research and Advice) fund to develop the novel method of passive acoustic monitoring (PAM) for fish using Pacific Herring as a model species because their sound production is described and their biomass is regularly estimated in relatively well-defined spatial areas during their spawning season. To pilot this approach they have deployed acoustic recorders at herring spawning sites in the Strait of Georgia and will combine acoustic data with visual survey data to build a correlation between spawning biomass and herring calls. They are also developing PAM methods for three rockfish species: Copper, Yelloweye, and Quillback Rockfishes by describing the relationship between abundance and call frequency using paired visual and audio surveys. They are testing the PAM methods by assessing temporal patterns in habitat use by deploying hydrophones in and adjacent to the Northumberland Channel RCA for one year. This project will also evaluate the impact of ship noise on the sensitivity of PAM.

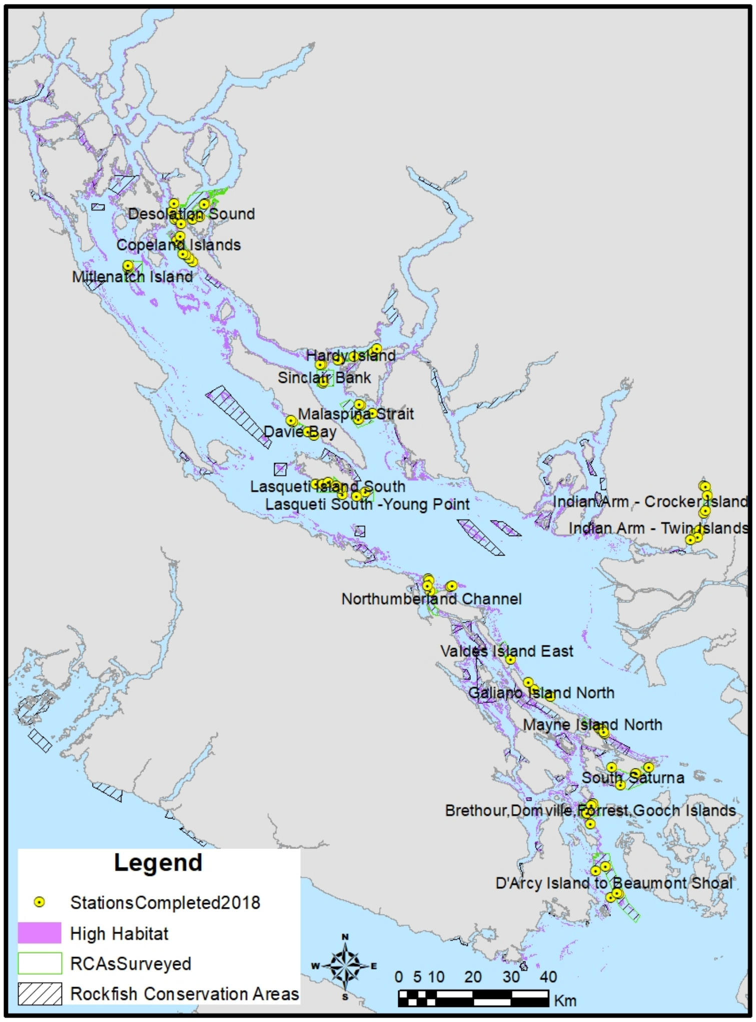

Figure 3. Map of ROV survey locations in the Strait of Georgia, October 22-November 6, 2018.

d)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

VIII. Inshore Rockfish

The most recent stock assessment for Inside (Yamanaka et al. 2011) and Outside Yelloweye Rockfish (Yamanaka et al. 2018) placed the stocks in the critical zone and therefore both stocks require rebuilding plans. Although the need for rebuilding plans are currently required by DFO policy, this requirement is about to be formalized in amendments to *Canada's Fisheries Act* put forward in *Bill C-68*. Both populations have rebuilding plans that are not compliant with DFO policy that requires monitoring, re-assessment and rebuilding projections over 1.5-2 generations (~60-90 years for Yelloweye Rockfish). DFO is collaborating with industry (the Pacific Halibut Management Association) to study Outside Yelloweye Rockfish Rebuilding with the development of operating models to describe the current state of the stock and closed loop simulations to examine the performance of harvest control rules to achieve rebuilding targets. Dr. Ashleen Benson, Dr. Sean Cox, and Beau Doherty from Landmark Fisheries Consulting are doing the modeling work. A steering committee and technical team are developing the rebuilding objectives and contributing to the work. This project will be reviewed by CSAS in October, 2019. A similar process is taking place for the inside population; however, the inside Yelloweye Rockfish population is more data limited and industry partners are absent. National-level funding to support work on rebuilding plans was secured to allow us to work with Dr. Tom Carruthers and Dr. Quang Huynh from UBC to use the Data Limited Methods Tools (DLMTools, https://www.datalimitedtoolkit.org/) in a similar simulation testing of management procedures to examine rebuilding.

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.

Yamanaka, K. L., McAllister, M.M., Olesiuk, P.F. Etienne, M., Obradovich, S.G. and Haigh, R.. (2011). Stock Assessment for the inside population of yelloweye rockfish (Sebastes ruberrimus) in British Columbia, Canada for 2010. DFO Can. Sci. Advis. Sec. Res. Doc.**:** xiv + 131 p.

IX. Slope Rockfish

X.

(1) Pacific Ocean Perch

Pacific Ocean Perch in PMFC area 5ABC was assessed in 2017 using a catch-at-age model tuned to two fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from the two survey series (11 years of data) and the commercial fishery (34 years of data). The model starts from an assumed equilibrium state in 1940, and the survey data cover 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 estimates both sex-specific natural mortality (M) and steepness of the stock-recruit function (h). The base model run suggests 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}, is 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}.

(2) Redstripe Rockfish

Two stocks of Redstripe Rockfish (BCN and BCS) were assessed in 2018 using a catch-at-age model tuned to fishery-independent trawl survey series (two in BCN, four in BCS), bottom trawl CPUE series, annual estimates of commercial catch since 1940, and age composition data from survey series (BCN: 5 years of data from 2 surveys; BCS: 14 years from 3 surveys) and the commercial fishery (BCN: 12 years of data; BCS: 24 years). The model starts from an assumed equilibrium state in 1940, and the survey data cover the period 1967 to 2018. The two-sex models were implemented in a Bayesian framework (using the Markov Chain Monte Carlo procedure) under a scenario that estimates both natural mortality (M) and steepness of the stock-recruit function (h). The base model runs for BCN and BCS suggest that low exploitation in the early years, including that by foreign fleets, coupled with several strong recruitment events (in 1982 and 1996 for BCN and in 1974 and 2001 for BCS) have sustained the population to the present. The spawning biomass (mature females only) at the beginning of 2018 for BCN and BCS is estimated to be 0.91 (0.69, 1.13) and 0.62 (0.47, 0.81) of unfished biomass (median and 5th and 95th quantiles of the Bayesian posterior distribution), respectively. For BCN and BCS, this biomass is estimated to be 3.16 (2.02, 4.00) and 2.43 (1.51, 3.77) of the spawning biomass at maximum sustainable yield, B_{MSY}, respectively.

(3) Rougheye/Blackspotted Rockfish

An assessment on the Rougheye/Blackspotted (REBS) complex was initiated by a Ph.D. student in REM at SFU in collaboration with DFO. There are genetic data to delineate stocks; however, this initial assessment will treat REBS in PMFC area 5DE as Blackspotted Rockfish and REBS in PMFC areas 3CD+5AB as Rougheye Rockfish.

3. Management

XI.

b) Inshore Rockfish

XII.

Management, in consultation with the commercial industry, stepped down Outside Yelloweye Rockfish Total Allowable Catch (TAC) 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. There is also recreational non-retention of Yelloweye Rockfish coast-wide in BC. The mandatory use of descending devices by recreational fishers came into effect on April 1, 2019 with the following condition of license:

> "Anglers in vessels shall immediately return all rockfish that are not being retained to the water and to a similar depth from which they were caught by use of an inverted weighted barbless hook or other purpose-built descender device. No person shall catch and retain in a day in Management Areas 1 to 11, 21 to 27, 101 to 111, 121 to 127, 130, 142 and Subareas 20-1 to 20-4 and 12-14 more than three (3) rockfish, of which only one (1) may be a Quillback Rockfish, a China Rockfish, or a Tiger Rockfish. Note: Not one of each species, but only one of the three. No person shall catch and retain in any tidal waters the following

species of rockfish: Bocaccio Rockfish (zero retention); Yelloweye Rockfish (zero retention)."

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 November 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.

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.

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 2019. Quillback Rockfish is up for reassessment by the COSEWIC by November 2019 but have been pushed off the schedule until at least 2020

f) Slope Rockfish

(4) <u>Pacific Ocean Perch</u>

Pacific Ocean Perch is an IVQ (individual vessel quota) species with a 2018 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 2018 Groundfish Trawl multi-species surveys, 73.8 t, was accounted for before defining the Groundfish Trawl TACs.

Advice to managers (presented as decision tables in the assessment) provide probabilities of exceeding limit and upper stock reference points over a five-year projection period across a range of constant catches. The current stock status is typically presented as horizontal barplots, in this case for the Base Case and seven sensitivity runs (Figure H.1). The DFO provisional 'Precautionary Approach compliant' reference points were used, which specify a 'limit reference point' of 0.4BMSY and an 'upper stock reference point' of 0.8BMSY. The estimated spawning biomass at the beginning of 2017 has 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 the recent average five-year catch of 2400 t/y) indicate that, in 2022, the spawning biomass has probabilities of 0.97 of remaining above the limit reference point, and 0.71 of remaining above the upper stock reference point.

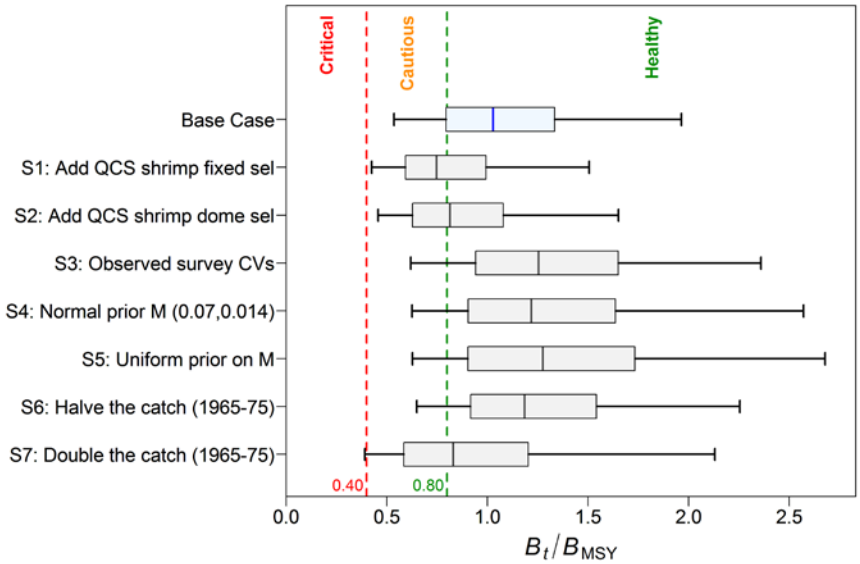

Figure H.1. Status at beginning of 2017 of the 5ABC Pacific Ocean Perch stock relative to the DFO PA provisional reference points of 0.4B_{MSY} and 0.8B_{MSY} for the base-case stock assessment and seven sensitivity runs: S1=add the QCS shrimp survey using a fixed selectivity curve; S2=add the QCS shrimp 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.

(5) Redstripe Rockfish

Redstripe Rockfish is an IVQ (individual vessel quota) species with a 2018 trawl TAC (total allowable catch) of 1521 t coastwide (173 t in 3C, 772 t in 3D5AB, 330 t in 5CD, and 246 t in 5E). Commercial total allowable catch for various groundfish species were allocated between the different groundfish sectors; Pacific Ocean Perch was allocated 97.23% to the Trawl sector and 2.77% (43 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, 15 t, was accounted for before defining the Groundfish Trawl TACs.

Advice to managers (presented as decision tables in the assessment) provide probabilities of exceeding limit and upper stock reference points for five-year projections across a range of constant catches. The current stock status is typically presented as horizontal barplots, in this case for the Base Case and four sensitivity runs (Figure H.2). The DFO provisional ‘Precautionary Approach compliant’ reference points were used, which specify a ‘limit reference point’ (LRP) of 0.4BMSY and an ‘upper stock reference point’ (USR) of 0.8BMSY. The estimated spawning biomass at the beginning of 2018 has a probability of 1 of being above the LRP, and a probability of 1 of being above the USR for both stocks. Five-year projections using a constant catch of 100 t/y in BCN and 700 t/y in BCS indicate that, in 2023, the spawning biomass has probabilities of 1 (BCN) and 1 (BCS) of remaining above the LRP, and 1 (BCN) and 1 (BCS) of remaining above the USR. The uMSY reference point, however, suggests that catches in excess of 500 t in BCN and 1300 t in BCS will breach the Sustainable Fisheries Framework guidelines on fishing mortality, assuming that the manager wishes to be 95% certain that the harvest rate in 2023 will be less than uMSY.

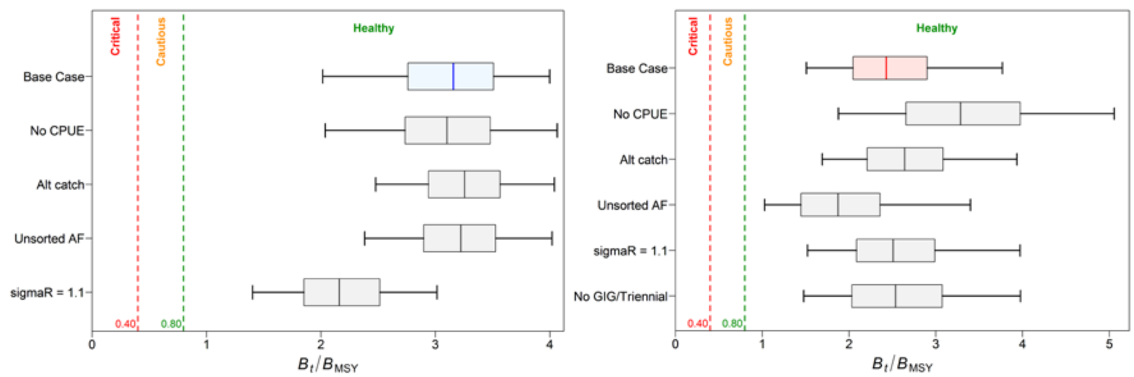

Figure H.2. Stock status at beginning of 2018 of the RSR stocks (left:BCN, right: BCS) relative to the DFO PA provisional reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$ for the base case stock assessment and four sensitivity runs (S1=drop commercial trawl CPUE; S2=halve the 1965-75 and 1988-1995 catches; S3=use age frequencies from unsorted samples only; S4=increase standard deviation of σ_R from 0.6 to 1.1; S5=remove GIG Historical and WCVI Triennial surveys). Boxplots show the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles from the MCMC posterior.

XIII. *Thornyheads*

1. *Research*

No research occurred in 2018.

2. *Assessment*

No Thornyhead assessments were conducted in 2018. 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 2018 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 2018 multi-species surveys, 6.2 t of Shortspine thornyhead and 0.4 t of Longspine thornyhead was accounted for before defining the Groundfish Trawl TACs for Shortspine Thornyhead, and 0.9 t of Shortspine thornyhead was reserved for longline surveys.

P. *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). 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 2018 included the initiation of an informal collaboration among Sablefish scientists from DFO, NOAA, ADFG and academia on range-wide Sablefish ecology and management. The overarching goal of the collaboration is to develop a range-wide, spatially explicit population dynamics model for Sablefish that can be used to explore questions of biological and management relevance across the eastern North Pacific. In 2018 primary research activities towards this goal included initiating a synthesis of life history characteristics across the Sablefish range, analyses to identify and develop range-wide indices of abundance and the evaluation of movement within and among regions (e.g., Alaska, British Columbia and the US West Coast).

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 2018 research and assessment survey, the current point estimate of legal-size Sablefish biomass in BC is 37,415 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 (DFO 2017). 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. The collaboration between DFO, NOAA and ADFG identified above in the research section is working towards the development of 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.

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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 rate from 9.5% to 5.5% over five years. The resulting proposed TAC for the 2019/20 fishing year is 2,955 t, a ~17% increase over the 2018/19 TAC. However, fishing industry stakeholders proposed a smaller increase in TAC to enhance rebuilding of the stock and so the final proposed TAC for 2019/20 is 2656 t. An update of the MSE simulation work is planned for 2019/20.

Q. Lingcod

1. Research

Ongoing data collection continued in 2018 through surveys, port sampling, at-sea observer sampling, and recreational creel surveys. Additional biological samples (Length, Weight, sex, maturity and fins for ageing) were collected on the Inside HBLL S, the Outside HBLL S, and the expanded IPHC survey in 2018.

2. Assessment

Inside, the waters within the Strait of Georgia, and Outside, the rest of the BC Coast, Lingcod populations are assessed and managed as separate units. Outside Lingcod were scheduled to be assessed in the spring of 2019; however, the assessment has been pushed back due to other program demands as well as the desire to have some age-data to inform the catchability of the longline surveys. Inside Lingcod were last assessed in 2014.

3. Management

Lingcod are managed by annual area specific TACs, the vast majority is harvested by the IVQ multi- species bottom trawl fishery and the directed Lingcod hook and line fishery, while smaller quantities are landed incidentally in targeted fisheries for Pacific Halibut, Sablefish, Rockfish and Dogfish. Details of the current management plan are available at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.html#Groundfish.

R. Atka mackerel

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

S. Flatfish

1. Research

Ongoing data collection in support of the flatfish research program, inclusive of Arrowtooth Flounder, Petrale Sole, Dover Sole and Rock Sole continued in 2018 through surveys and at-sea observer sampling.

2. Assessment

Arrowtooth Flounder was last assessed in 2016. The final assessment was finalized and published through the Canadian Science Advice Secretariat (CSAS) in 2017. Recent reports from fishery participants of localized depletion are being investigated.

Dover sole was last assessed in 1999, age matrices have been updated, catch and survey data are available, and an updated assessment is planned for 2020.

Petrale sole was last assessed in 2007. In response to a request for updated harvest advice from fishery managers aging of otoliths was completed in 2018 and an updated assessment is planned for 2019/20. T

English sole was also last assessed in 2007, no request for updated advice has been received but aging of otoliths be undertaken in 2019 in anticipation of an updated assessment sometime in 2020/21.

Rock sole was last assessed in 2016, no request for updated advice has been received but aging of otoliths will be undertaken in 2019 in anticipation of an updated assessment sometime in 2020/21.

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. 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.

T. *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) from both the trawl and line fisheries in British Columbia are provided.

U. *Other groundfish species*

X. *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.

As summarized in the 2018 TSC report 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). 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.

A science steering committee was formed in the fall of 2017 to plan the current 'management procedure' phase of the project. The first technical working group meeting was convened on April 27 2018, during subsequent meeting the project was divided into two phases, the first to be a research document with visualizations of nearly all available groundfish data, with the expectation of updating this on an annual basis, and the second a research document and science advisory report outlining an agreed upon management procedure approach for British Columbia groundfish.

In November of 2018 a reproducible “synopsis” report that gives a snapshot of population and fishing trends, growth and maturity patterns, as well as data availability, for 113 species of relevance to the Groundfish Section was reviewed through the regional peer review process.

The Groundfish Section had a number of goals in developing the synopsis report. First, the report aims to facilitate regular review by groundfish scientists and managers of trends in survey indices and stock composition. Second, through the tools developed to produce the report, the project aims to generate standardized datasets and visualizations that will help assessment scientists develop stock assessments and conduct groundfish research. Third, it aims to increase data transparency between Fisheries and Oceans Canada, the fishing industry, non-governmental organizations, and the public.

The report is structured to facilitate viewing all data for one species simultaneously and to quickly browse the data holdings for multiple stocks. The report starts with clickable indexes sorted by species code, common name, and scientific name. Then, following a series of figure captions, the report visualizes most available survey, fisheries, and biological sample data for each of the 113 species in the same two-page layout for each species (e.g., Figure 2 and 3). The first page for each species includes visualizations showing time series and maps of relative biomass from the surveys, commercial fisheries catch categorized by gear type and region, and standardized commercial catch per unit effort from the commercial bottom-trawl fleet. The second page for each species focuses on biological samples. The page starts with length and age distributions, shows length-age and length-weight growth model fits, and shows age- and length-at-maturity model fits. The second page concludes with graphical tables illustrating the number of fish that have had their length, weight, age, or maturity assessed as well as the number of available aging structures (usually otoliths) by year across all surveys and commercial samples. The main visualizations are followed by detailed appendices explaining the data processing and model fitting approaches.

We emphasize that the outputs from the report are not a substitute for stock assessment. For example, survey and commercial index trends do not resolve population scale and the outputs in the report do not resolve conflicts in trends drawn from different sources for the same species. Furthermore, some surveys are not suitable for deriving relative biomass trends for some species, and these types of decisions require knowledge of the individual stocks and survey designs. Also, the outputs in the report are not at a scale appropriate for marine spatial planning. The report includes many other caveats that are important to consider.

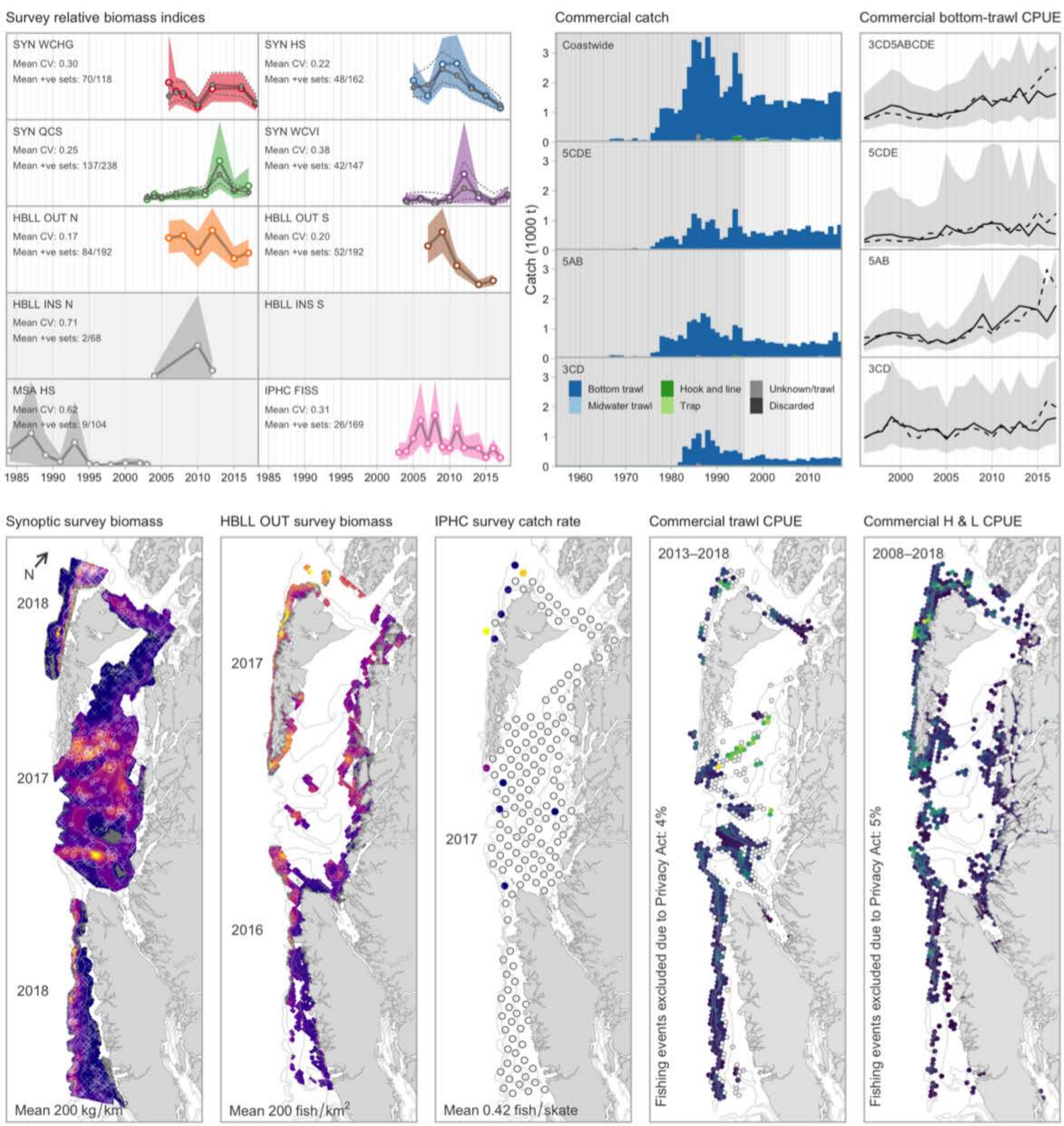
All the data extraction, data manipulation, model fitting, and visualization for the report are automated and reproducible. To accomplish this, the authors developed a series of R packages that are available on GitHub (https://github.com/pbs-assess). The packages include gfplot (for data extraction, manipulation, most model fitting, and visualization), sdmTMB (for geostatistical spatiotemporal modelling of the survey data), gfsynopsis (to call the gfplot functions as needed to generate and stitch together the main figures), and csasdown (building on previous work by other PBS scientists; for generating reproducible CSAS Research Documents with the output from gfsynopsis). The report can theoretically be generated by anyone with access to the groundfish databases housed at PBS. We plan to publish an updated version of the report every one to two years. The report has been accepted as a CSAS Research

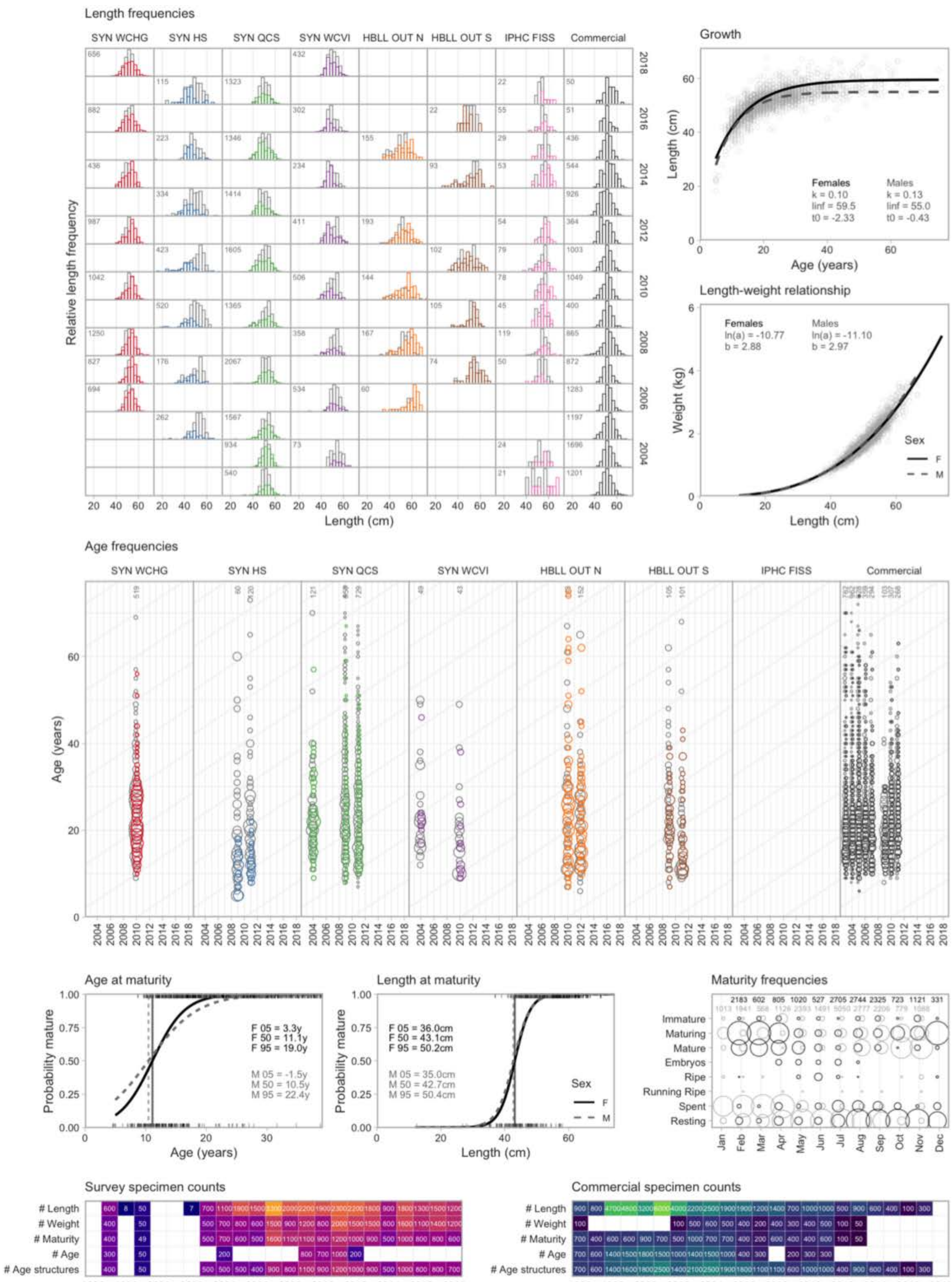
Document and is currently undergoing final formatting and translation. In the meantime, a draft can be downloaded at https://github.com/pbs-assess/gfsynopsis.

An example species report is presented below for Silvergray rockfish.

5.49 SILVERGRAY ROCKFISH

Sebastes brevispinis (405)
Order: Scorpaeniformes, Family: Scorpaenidae, FishBase link, WoRMS link
Last Research Document: Starr et al. (2016)
Last Science Advisory Report: Fisheries and Oceans Canada (2014b)





Length frequencies
SYN WCHG
SYN HS
SYN QCS
SYN WCVI
HBLL OUT N
HBLL OUT S
IPHC FISS
Commercial
Relative length frequency
Length (cm)
Growth
Length (cm)
Age (years)
Females
k = 0.10
linf = 59.5
t0 = -2.33
Males
k = 0.13
linf = 55.0
t0 = -0.43
Length-weight relationship
Females
ln(a) = -10.77
b = 2.88
Males
ln(a) = -11.10
b = 2.97
Weight (kg)
Sex
F
M
Age frequencies
Age (years)
Age at maturity
Probability mature
F 05 = 3.3y
F 50 = 11.1y
F 95 = 19.0y
M 05 = -1.5y
M 50 = 10.5y
M 95 = 22.4y
Age (years)
Length at maturity
F 05 = 36.0cm
F 50 = 43.1cm
F 95 = 50.2cm
M 05 = 35.0cm
M 50 = 42.7cm
M 95 = 50.4cm
Length (cm)
Maturity frequencies
Immature
Maturing
Mature
Embryos
Ripe
Running Ripe
Spent
Resting
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Survey specimen counts
Length
Weight
Maturity
Age
Age structures
Commercial specimen counts

XI. Other related studies

XIV.

Nothing to report at this time.

XII. Publications

A. Primary Publications

Carrasquilla-Henao, M., Yamanaka, K.L., D.R. Haggarty and F. Juanes. 2018. "Predicting important rockfish (Sebastes spp.) habitat from large-scale longline surveys for southern British Columbia, Canada." Canadian Journal of Fisheries and Aquatic Sciences.

Haggarty, D. and L. Yamanaka. 2018. "Evaluating Rockfish Conservation Areas in southern British Columbia, Canada using a Random Forest model of rocky reef habitat." Estuarine, Coastal and Shelf Science 208: 191-204.

Starr, P. J. and Haigh, R. in press. Redstripe Rockfish (Sebastes proriger) stock assessment for British Columbia in 2018. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/nnn: iii + xxx p.

Starr, P. J. and Haigh, R. in press. Walleye Pollock (Theragra chalcogramma) stock assessment for British Columbia in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/nnn: iii + xxx p.

Haigh, R., Starr, P. J., Edwards, A. M., King, J. R. and Lecomte, J.-B. 2018. Stock assessment for Pacific Ocean Perch (Sebastes alutus) in Queen Charlotte Sound, British Columbia in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/038: v + 228 p.

Yamanaka, K.L., McAllister, M.K, Etienne, M.-P., Edwards, A., and Haigh, R. 2018. Assessment for the outside population of Yelloweye Rockfish (Sebastes ruberrimus) for British Columbia, Canada in 2014. Canadian Science Advisory Secretariat, Research Document 2018/001: ix + 150 p.

B. Other Publications

DFO. 2018. A Review of the Use of Recompression Devices as a Tool for Reducing the Effects of Barotrauma on Rockfishes in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/043. https://waves-vagues.dfo-mpo.gc.ca/Library/40716120.pdf

DFO. 2019. A Regional Assessment of Ecological Attributes in Rockfish Conservation Areas in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. In press.

Dunham, J., Yu, F., Haggarty, D., Deleys, N., Yamanaka, L. 2019. A Regional Assessment of Ecological Attributes in Rockfish Conservation Areas in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. In press

Appendix 1

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

Multispecies Synoptic Bottom Trawl Surveys

West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey

The West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between May 18 and June 14. We assessed a total of 226 blocks (Table 1, Figure 5). Of the 202 total tows conducted, 190 were successful and 12 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 155,085 kg. The mean catch per tow was 787 kg, averaging 26 different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (Squalus suckleyi), Sharpchin Rockfish (Sebastes zacentrus), Sablefish (Anoplopoma fimbria), Splitnose Rockfish (Sebastes diploproa), and Canary Rockfish (Sebastes pinniger). 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 39,229 individual fish of 50 different species (Table 3).

Table 23. 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (meters)	Rejected Prior	Rejected Inspected	Failed	Success	Not Assessed	Total
50 to 125	1	18	3	69	0	91
125 to 200	1	4	2	64	0	71
200 to 330	0	0	0	36	0	36
330 to 500	1	6	0	21	0	28
Total	**3**	**28**	**5**	**190**	**0**	**226**

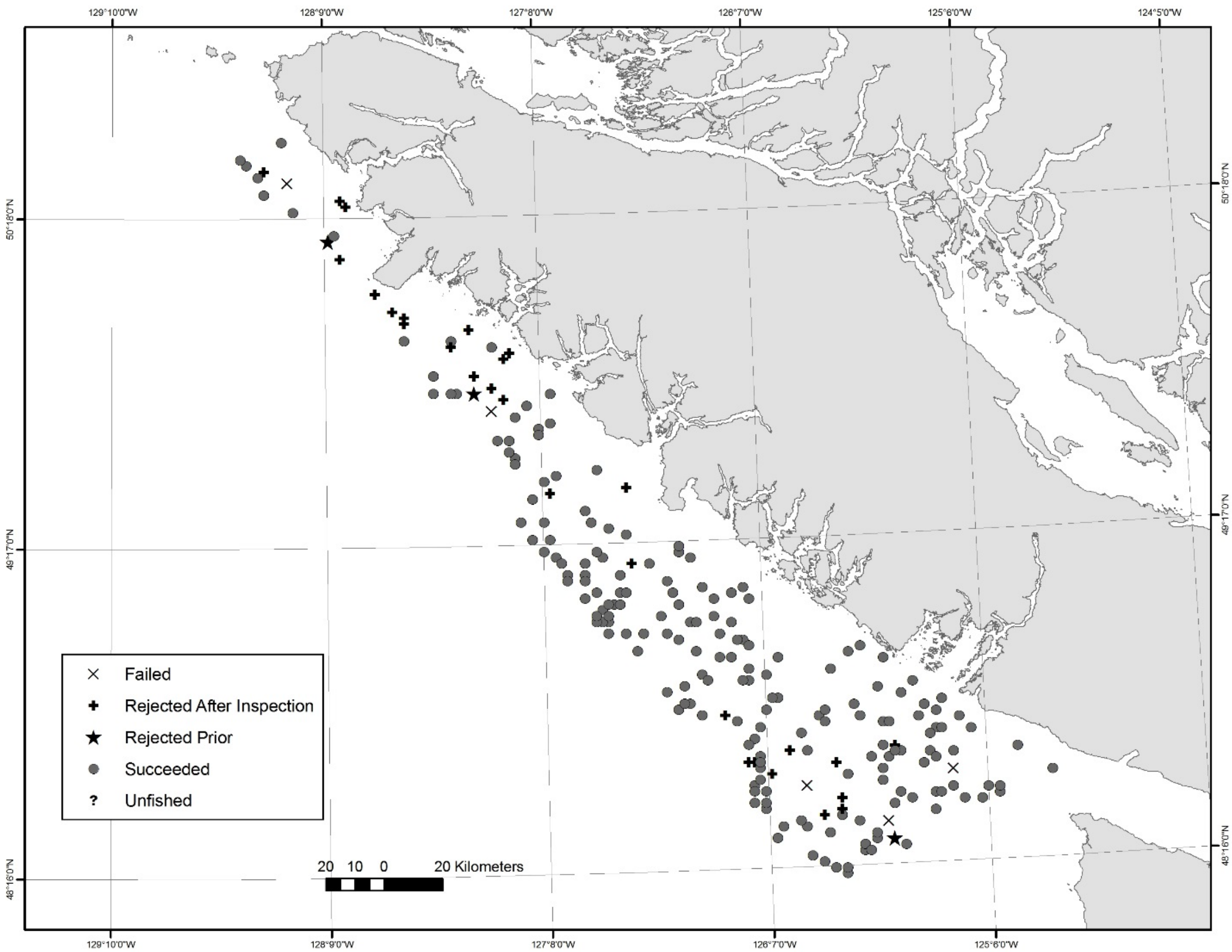


Figure 3. Final status of the allocated blocks for the 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey.

Table 24. 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 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
North Pacific Spiny Dogfish	*Squalus suckleyi*	132	18750	3835	0.41
Sharpchin Rockfish	*Sebastes zacentrus*	68	16954	3170	0.27
Sablefish	*Anoplopoma fimbria*	139	15917	4747	0.25
Splitnose Rockfish	*Sebastes diploproa*	36	9735	1894	0.47
Canary Rockfish	*Sebastes pinniger*	72	8861	3050	0.60
Rex Sole	*Glyptocephalus zachirus*	183	8705	4264	0.08
Arrowtooth Flounder	*Atheresthes stomias*	170	8283	2749	0.10
Pacific Ocean Perch	*Sebastes alutus*	60	8210	1680	0.28
Redstripe Rockfish	*Sebastes proriger*	50	7180	2747	0.48
Dover Sole	*Microstomus pacificus*	177	6927	3117	0.11
Pacific Hake	*Merluccius productus*	119	5900	2653	0.34
Yellowtail Rockfish	*Sebastes flavidus*	87	4932	2207	0.26
Spotted Ratfish	*Hydrolagus colliei*	179	4139	2300	0.15
Silvergray Rockfish	*Sebastes brevispinis*	54	3875	984	0.39
English Sole	*Parophrys vetulus*	133	3045	1937	0.11
Flathead Sole	*Hippoglossoides elassodon*	117	2667	1622	0.12
Pacific Sanddab	*Citharichthys sordidus*	73	2188	1562	0.16
Greenstriped Rockfish	*Sebastes elongatus*	105	2148	750	0.19
Lingcod	*Ophiodon elongatus*	113	1747	625	0.11
Petrale Sole	*Eopsetta jordani*	124	1416	740	0.15
Shortspine Thornyhead	*Sebastolobus alascanus*	53	1316	276	0.14
Longnose Skate	*Raja rhina*	104	1227	457	0.12
Bocaccio	*Sebastes paucispinis*	55	1225	456	0.57
Pacific Cod	*Gadus macrocephalus*	91	1184	553	0.21
Redbanded Rockfish	*Sebastes babcocki*	59	852	143	0.25

Table 25. Number of fish sampled for biological data during the 2018 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey showing the number of lengths, age structures, and DNA tissue samples that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**	**DNA Tissue Collected**
Arrowtooth Flounder	*Atheresthes stomias*	2136	196	0
Aurora Rockfish	*Sebastes aurora*	43	0	0
Big Skate	*Beringraja binoculata*	41	0	0
Bocaccio	*Sebastes paucispinis*	417	409	265
Brown Cat Shark	*Apristurus brunneus*	20	0	0
Canary Rockfish	*Sebastes pinniger*	729	645	0
Curlfin Sole	*Pleuronichthys decurrens*	140	44	0
Darkblotched Rockfish	*Sebastes crameri*	554	0	0
Dover Sole	*Microstomus pacificus*	3153	847	0
English Sole	*Parophrys vetulus*	2231	643	0
Eulachon	*Thaleichthys pacificus*	1085	0	185
Flathead Sole	*Hippoglossoides elassodon*	1729	0	0
Giant Wrymouth	*Cryptacanthodes giganteus*	1	0	0
Green Sturgeon	*Acipenser medirostris*	1	0	0
Greenstriped Rockfish	*Sebastes elongatus*	1285	215	0
Kelp Greenling	*Hexagrammos decagrammus*	26	0	0
Lingcod	*Ophiodon elongatus*	599	489	0
Longnose Skate	*Raja rhina*	369	0	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	1006	0	0
Pacific Cod	*Gadus macrocephalus*	369	236	0
Pacific Hake	*Merluccius productus*	1784	162	0
Pacific Halibut	*Hippoglossus stenolepis*	122	0	0
Pacific Ocean Perch	*Sebastes alutus*	983	614	0
Pacific Sanddab	*Citharichthys sordidus*	1558	0	0
Pacific Tomcod	*Microgadus proximus*	506	0	0
Petrale Sole	*Eopsetta jordani*	1070	672	0
Pygmy Rockfish	*Sebastes wilsoni*	121	0	0
Quillback Rockfish	*Sebastes maliger*	40	40	34
Redbanded Rockfish	*Sebastes babcocki*	473	471	0
Redstripe Rockfish	*Sebastes proriger*	649	299	50
Rex Sole	*Glyptocephalus zachirus*	4021	430	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	764	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	239	230	289
Sablefish	*Anoplopoma fimbria*	1742	870	0
Sandpaper Skate	*Bathyraja interrupta*	52	0	0
Sharpchin Rockfish	*Sebastes zacentrus*	1089	0	0
Shortbelly Rockfish	*Sebastes jordani*	237	120	0
Shortraker Rockfish	*Sebastes borealis*	31	31	0
Shortspine Thornyhead	*Sebastolobus alascanus*	1040	110	0
Silvergray Rockfish	*Sebastes brevispinis*	432	233	0
Slender Sole	*Lyopsetta exilis*	2002	0	0
Southern Rock Sole	*Lepidopsetta bilineata*	496	257	0
Splitnose Rockfish	*Sebastes diploproa*	663	0	0
Spotted Ratfish	*Hydrolagus colliei*	1288	0	0
Stripetail Rockfish	*Sebastes saxicola*	22	0	0
Walleye Pollock	*Gadus chalcogrammus*	838	0	0
Widow Rockfish	*Sebastes entomelas*	40	0	0

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Yelloweye Rockfish	*Sebastes ruberrimus*	77	75	121
Yellowmouth Rockfish	*Sebastes reedi*	33	17	0
Yellowtail Rockfish	*Sebastes flavidus*	883	251	0

West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between September 2 and 24, 2018. We assessed a total of 132 blocks (Table 4, Figure 6). At the end of the survey, four blocks had not yet been fished but would have required not only another full day of fishing, but also the vessel was full of fish and would have had to travel to port, offload catch, and return to the grounds. As such, the decision was made to leave those four blocks as unassessed. Of the 132 total tows conducted, 119 were successful and 13 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 187,407 kg. The mean catch per tow was 1453 kg, averaging 21 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (Sebastes alutus), Sharpchin Rockfish (Sebastes zacentrus), Rougheye/Blackspotted Rockfish complex (Sebastes aleutianus/melanostictus complex), Silvergray Rockfish (Sebastes brevispinis), Shortspine Thornyhead (Sebastolobus alascanus) and Yellowmouth Rockfish (Sebastes reedi). 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 17,511 individual fish of 44 different species (Table 6). Oceanographic data, including water temperature, depth, salinity, and dissolved oxygen were also recorded for most tows.

Table 26. 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master’s knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (meters)	**Rejected Prior**	**Rejected Inspected**	**Failed**	**Success**	**Not Assessed**	**Total**
180 to 330	1	5	2	67	3	78
330 to 500	2	2	0	31	0	35
500 to 800	1	0	0	10	1	12
800 to 1,300	0	0	0	11	0	11
Total	**4**	**7**	**2**	**119**	**4**	**136**

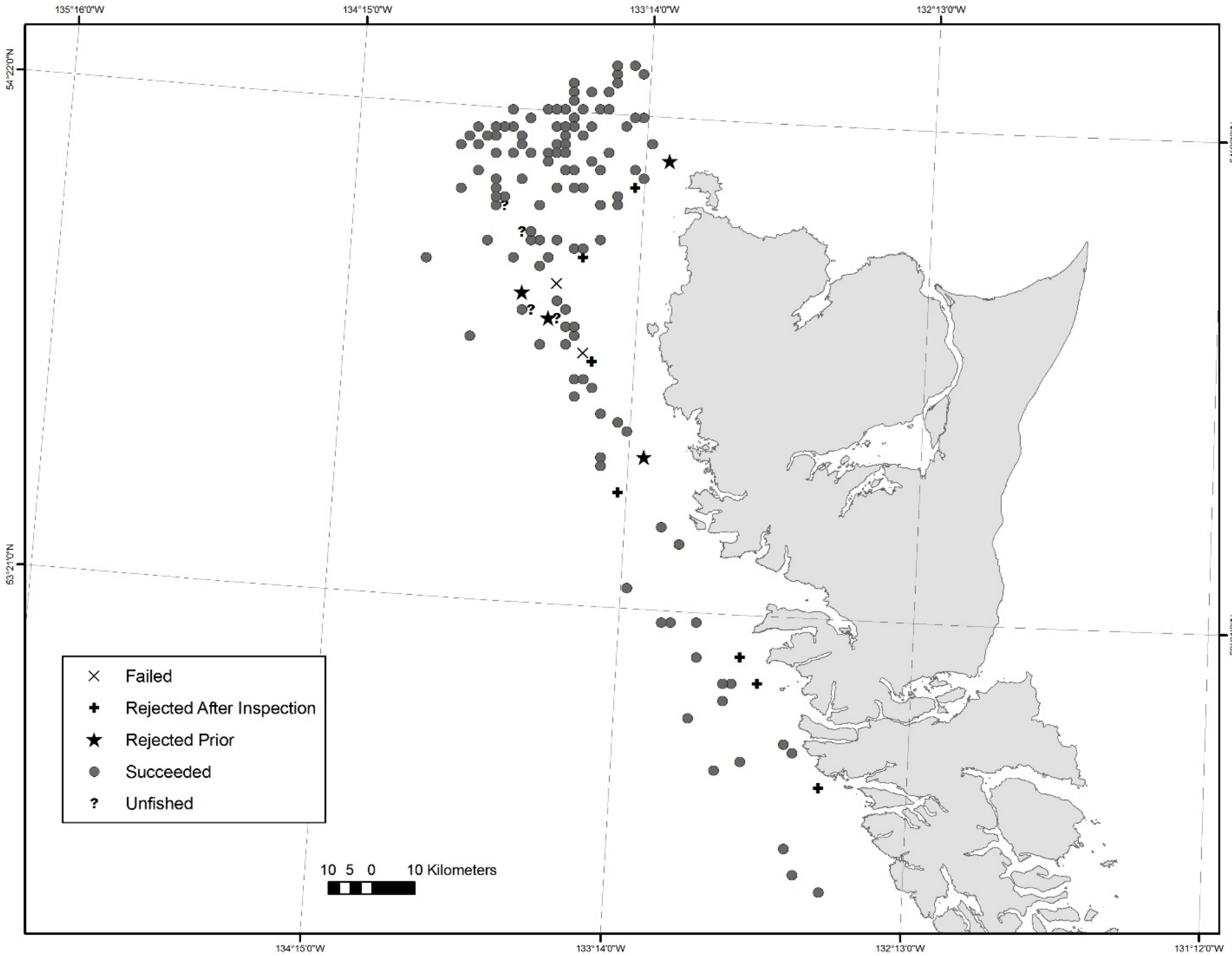


Figure 4. Final status of the allocated blocks for the 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey.

Table 27. 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 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
Pacific Ocean Perch	*Sebastes alutus*	91	116845	19173	0.21
Sharpchin Rockfish	*Sebastes zacentrus*	68	17948	2363	0.34
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	54	10949	2772	0.27
Silvergray Rockfish	*Sebastes brevispinis*	66	5097	676	0.23
Shortspine Thornyhead	*Sebastolobus alascanus*	112	4787	1307	0.08
Yellowmouth Rockfish	*Sebastes reedi*	44	4729	666	0.52
Redstripe Rockfish	*Sebastes proriger*	61	4334	551	0.31
Sablefish	*Anoplopoma fimbria*	104	3725	1742	0.15
Arrowtooth Flounder	*Atheresthes stomias*	83	3251	455	0.51
Splitnose Rockfish	*Sebastes diploproa*	14	1282	165	0.69
Dover Sole	*Microstomus pacificus*	99	1048	321	0.13
Redbanded Rockfish	*Sebastes babcocki*	73	986	152	0.18
Shortraker Rockfish	*Sebastes borealis*	19	821	367	0.55
Canary Rockfish	*Sebastes pinniger*	13	735	91	0.59
Rosethorn Rockfish	*Sebastes helvomaculatus*	65	709	100	0.14
Pacific Hake	*Merluccius productus*	43	649	157	0.21
Longspine Thornyhead	*Sebastolobus altivelis*	23	584	541	0.19
Rex Sole	*Glyptocephalus zachirus*	97	554	103	0.16
Walleye Pollock	*Gadus chalcogrammus*	41	434	94	0.44
Giant Grenadier	*Albatrossia pectoralis*	17	399	446	0.4
Pacific Grenadier	*Coryphaenoides acrolepis*	18	360	474	0.36
Widow Rockfish	*Sebastes entomelas*	28	360	50	0.33
Spotted Ratfish	*Hydrolagus colliei*	69	338	53	0.24
Longnose Skate	*Raja rhina*	31	320	58	0.18
Lingcod	*Ophiodon elongatus*	25	310	48	0.27

Table 28. Number of fish sampled for biological data during the 2018 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Aleutian Skate	*Bathyraja aleutica*	9	0	0
Arrowtooth Flounder	*Atheresthes stomias*	148	66	0
Bocaccio	*Sebastes paucispinis*	21	19	21
Brown Cat Shark	*Apristurus brunneus*	19	0	0
Canary Rockfish	*Sebastes pinniger*	82	72	0
Darkblotched Rockfish	*Sebastes crameri*	34	29	0
Dover Sole	*Microstomus pacificus*	783	289	0
English Sole	*Parophrys vetulus*	27	0	0
Giant Grenadier	*Albatrossia pectoralis*	165	152	0
Greenstriped Rockfish	*Sebastes elongatus*	237	0	0
Harlequin Rockfish	*Sebastes variegatus*	186	0	0
Lingcod	*Ophiodon elongatus*	43	5	0
Longnose Skate	*Raja rhina*	44	0	0
Longspine Thornyhead	*Sebastolobus altivelis*	667	615	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	2	0	0
Pacific Cod	*Gadus macrocephalus*	37	0	0
Pacific Flatnose	*Antimora microlepis*	50	49	0
Pacific Grenadier	*Coryphaenoides acrolepis*	438	0	0
Pacific Hake	*Merluccius productus*	264	0	0
Pacific Halibut	*Hippoglossus stenolepis*	44	0	0
Pacific Ocean Perch	*Sebastes alutus*	2195	1799	0
Petrale Sole	*Eopsetta jordani*	27	15	0
Popeye	*Coryphaenoides cinereus*	341	0	0
Pygmy Rockfish	*Sebastes wilsoni*	25	0	0
Redbanded Rockfish	*Sebastes babcocki*	627	615	50
Redstripe Rockfish	*Sebastes proriger*	969	411	0
Rex Sole	*Glyptocephalus zachirus*	850	27	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	1089	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	757	755	756
Roughtail Skate	*Bathyraja trachura*	6	0	0
Sablefish	*Anoplopoma fimbria*	1126	502	0
Sandpaper Skate	*Bathyraja interrupta*	37	0	0
Sharpchin Rockfish	*Sebastes zacentrus*	1432	0	0
Shortraker Rockfish	*Sebastes borealis*	161	161	50
Shortspine Thornyhead	*Sebastolobus alascanus*	2783	628	0
Silvergray Rockfish	*Sebastes brevispinis*	657	393	50
Slender Sole	*Lyopsetta exilis*	25	0	0
Splitnose Rockfish	*Sebastes diploproa*	129	0	0
Spotted Ratfish	*Hydrolagus colliei*	97	0	0
Walleye Pollock	*Gadus chalcogrammus*	362	0	0
Whitebrow Skate	*Bathyraja minispinosa*	1	0	0
Widow Rockfish	*Sebastes entomelas*	162	24	0
Yelloweye Rockfish	*Sebastes ruberrimus*	8	8	8
Yellowmouth Rockfish	*Sebastes reedi*	345	222	0

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 program is intended to cover areas that are not covered by the synoptic bottom trawl surveys with a focus on inshore rockfish species habitat. The goal of the survey 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 “outside” area was intended to include “hard” bottom areas not covered by the synoptic bottom trawl surveys and was selected by including 95% of all Quillback and Yelloweye rockfish catches reported from the commercial Halibut and rockfish fisheries from 1996 to 2005. 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 southern region in even numbered years and the northern region in odd 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 odd numbered years while the southern region is surveyed in even 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 2018 the southern region of the outside area and the southern region of the inside area were surveyed.

Outside (Pacific Halibut Management Association) Survey

The 2018 Outside Hard Bottom Longline Hook Survey was conducted in the southern region but at the time of writing, the data are not yet finalized and so have not been included in this report.

Inside (DFO) Survey

The Inside Hard Bottom Longline Hook Survey was conducted in the southern portion of the inside area on board the Canadian Coast Guard vessel Neocaligus from August 21 to September 7, 2018. The survey was later than the standard August period and shortened due to crewing limitations and vessel mechanical issues. As such, we were not able to visit all of the 70 blocks originally selected. We chose to leave the most northern blocks unassessed and those blocks will be added to the 2019 survey of the northern area. A total of 55 sets were completed (Figure 7). The total catch of the survey was 11,860 kg (Table 7). The average catch per set was 215 kg, averaging four different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (Squalus suckleyi), Quillback Rockfish (Sebastes maliger), Lingcod (Ophiodon elongatus), Yelloweye Rockfish (Sebastes ruberrimus), Longnose Skate (Raja rhina), and Copper Rockfish (Sebastes caurinus). The number of sets where the species was captured as well as the total catch count and proportion of the total catch of all fish species are shown in Table 8. An annual summary of catch by species in the southern area is shown in Table 9. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 5647 individual fish of 15 different species (Table 10). An annual summary of the number of fish sampled for biological data in the southern area is shown in Table 11.

One vertical CTD (conductivity, temperature, and depth recorder) cast was made at each selected block during the 2018 Inside Hard Bottom Longline Hook Survey. The CTD also included a dissolved oxygen sensor. In addition, a temperature depth recorder was deployed at the start, middle, and end of every fishing set.

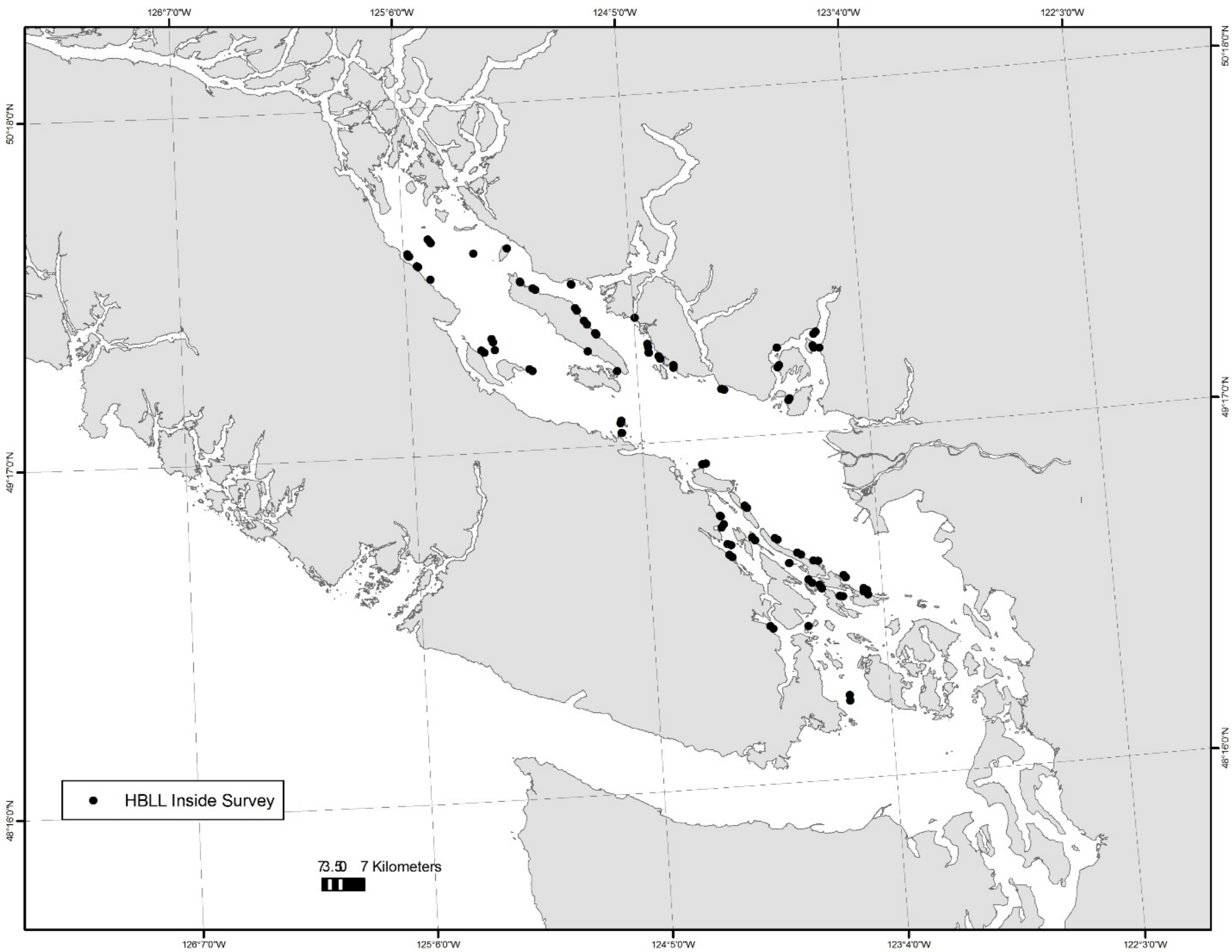


Figure 5. Longline set locations of the 2018 Inside Hard Bottom Longline Hook Survey.

Table 29. Total catch, showing both piece count and weight by species for the 2018 Inside Hard Bottom Longline Hook Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
North Pacific Spiny Dogfish	*Squalus suckleyi*	5302	10816
Quillback Rockfish	*Sebastes maliger*	88	73
Lingcod	*Ophiodon elongatus*	60	306
Yelloweye Rockfish	*Sebastes ruberrimus*	55	106
Longnose Skate	*Raja rhina*	53	138
Copper Rockfish	*Sebastes caurinus*	37	53
Canary Rockfish	*Sebastes pinniger*	26	53
Big Skate	*Beringraja binoculata*	23	264
Spotted Ratfish	*Hydrolagus colliei*	11	6
Red Rock Crab	*Cancer productus*	11	3
	Metridium	7	1
Pacific Cod	*Gadus macrocephalus*	6	5
Bluntnose Sixgill Shark	*Hexanchus griseus*	5	
Southern Rock Sole	*Lepidopsetta bilineata*	5	2
Sponges	*Porifera*	4	0
Cabezon	*Scorpaenichthys marmoratus*	3	13
Sunflower Starfish	*Pycnopodia helianthoides*	3	2
Fish-eating Star	*Stylasterias forreri*	3	0
Pink Short-spined Star	*Pisaster brevispinus*	2	2
Sea Lilies And Feather Stars	*Crinoidea*	2	
Pacific Sanddab	*Citharichthys sordidus*	2	0
Greenstriped Rockfish	*Sebastes elongatus*	2	0
Vermilion Rockfish	*Sebastes miniatus*	1	2
Kelp Greenling	*Hexagrammos decagrammus*	1	1
Glass Sponges	*Hexactinellida*	1	
Arrowtooth Flounder	*Atheresthes stomias*	1	
Flathead Sole	*Hippoglossoides elassodon*	1	0
Dungeness Crab	*Metacarcinus magister*	1	0
	Antedonidae	1	
	Henricia	1	
	Solaster	1	0
Pacific Staghorn Sculpin	*Leptocottus armatus*	1	0
Mottled Star	*Evasterias troschelii*	1	0
	Mytilus		2
Sea Whip	*Balticina septentrionalis*		

Table 30. Number of sets, catch (piece count), and proportion of the total fish catch for fish species caught during the 2018 DFO Hard Bottom Longline Hook Survey.

Species	Number of Sets	Catch (count)	Proportion of Total Catch (%)
North Pacific Spiny Dogfish	54	5302	93.30
Quillback Rockfish	26	88	1.55
Lingcod	21	60	1.06
Yelloweye Rockfish	15	55	0.97
Longnose Skate	24	53	0.93
Copper Rockfish	13	37	0.65
Canary Rockfish	5	26	0.46
Big Skate	11	23	0.40
Spotted Ratfish	5	11	0.19
Pacific Cod	3	6	0.11
Bluntnose Sixgill Shark	3	5	0.09
Southern Rock Sole	2	5	0.09
Cabezon	3	3	0.05
Greenstriped Rockfish	2	2	0.04
Pacific Sanddab	2	2	0.04
Vermilion Rockfish	1	1	0.02
Pacific Staghorn Sculpin	1	1	0.02
Kelp Greenling	1	1	0.02
Flathead Sole	1	1	0.02
Arrowtooth Flounder	1	1	0.02

Table 31. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the Inside Hard Bottom Longline Survey southern region.

Species	2005	2009	2011	2013	2015	2018	Total
North Pacific Spiny Dogfish	10847	3258	5744	5615	5283	5302	36049
Yelloweye Rockfish	215	10	266	223	209	55	978
Quillback Rockfish	196	40	297	199	154	88	974
Spotted Ratfish	186	91	4	5	11	11	308
Copper Rockfish	44	13	21	21	64	37	200
Lingcod	50	2	17	22	28	60	179
Longnose Skate	25	4	17	13	48	53	160
Pacific Cod	48	18	33	17	33	6	155
Canary Rockfish	52	0	14	14	25	26	131
Big Skate	24	5	1	13	29	23	95
Pacific Sanddab	22	25	3	8	11	2	71
Greenstriped Rockfish	8	3	16	11	3	2	43
Cabezon	23	5	2	2	7	3	42
Pacific Halibut	6	13	2	3	3	0	27
Southern Rock Sole	4	1	8	2	6	5	26
Red Irish Lord	3	1	1	7	6	0	18
Arrowtooth Flounder	15	1	0	0	0	1	17
Pacific Staghorn Sculpin	0	10	1	2	2	1	16
Tiger Rockfish	9	0	1	0	0	0	10
Brown Irish Lord	0	1	9	0	0	0	10
Bluntnose Sixgill Shark	2	1	0	0	2	5	10
Kelp Greenling	3	0	0	1	2	1	7
Vermilion Rockfish	4	0	0	0	0	1	5
Yellowtail Rockfish	1	2	0	0	1	0	4
Deacon Rockfish	4	0	0	0	0	0	4

Table 32. Number of fish sampled for biological data during the 2018 Inside Hard Bottom Longline Hook survey showing the number of lengths, age structures, and DNA tissue samples that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**	**DNA Collected**
Big Skate	*Beringraja binoculata*	22	0	0
Cabezon	*Scorpaenichthys marmoratus*	3	0	0
Canary Rockfish	*Sebastes pinniger*	22	17	20
Copper Rockfish	*Sebastes caurinus*	30	27	30
Kelp Greenling	*Hexagrammos decagrammus*	1	0	0
Lingcod	*Ophiodon elongatus*	60	60	0
Longnose Skate	*Raja rhina*	52	0	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	5300	0	0
Pacific Cod	*Gadus macrocephalus*	1	0	0
Pacific Sanddab	*Citharichthys sordidus*	2	0	0
Quillback Rockfish	*Sebastes maliger*	83	81	0
Southern Rock Sole	*Lepidopsetta bilineata*	4	0	0
Spotted Ratfish	*Hydrolagus colliei*	11	0	0
Vermilion Rockfish	*Sebastes miniatus*	1	0	0
Yelloweye Rockfish	*Sebastes ruberrimus*	55	54	54

Table 33. Annual summary of the number of fish sampled for biological data during the Inside Hard Bottom Longline Survey in the southern region.

Species	**2005**	**2009**	**2011**	**2013**	**2015**	**2018**	**Total**
North Pacific Spiny Dogfish	5671	1176	5720	5770	5274	5300	28911
Yelloweye Rockfish	206	10	264	222	205	55	962
Quillback Rockfish	187	40	290	195	147	83	942
Spotted Ratfish	152	63	4	4	6	11	240
Copper Rockfish	44	12	19	20	64	30	189
Lingcod	44	2	17	20	28	60	171
Longnose Skate	22	3	16	13	47	52	153
Canary Rockfish	51	0	12	14	25	22	124
Pacific Cod	39	11	15	17	24	1	107
Big Skate	22	5	1	13	27	22	90
Cabezon	23	0	1	2	7	3	36
Greenstriped Rockfish	7	3	4	10	2	0	26
Southern Rock Sole	4	0	6	2	5	4	21
Pacific Sanddab	12	0	1	2	3	2	20
Pacific Halibut	6	8	0	3	2	0	19
Red Irish Lord	3	0	0	5	6	0	14
Tiger Rockfish	9	0	1	0	0	0	10
Kelp Greenling	3	0	0	1	2	1	7
Vermilion Rockfish	4	0	0	0	0	1	5
Sandpaper Skate	4	0	0	0	0	0	4
Walleye Pollock	0	0	1	0	2	0	3
Silvergray Rockfish	1	0	0	2	0	0	3
Deacon Rockfish	3	0	0	0	0	0	3
Yellowtail Rockfish	1	0	0	0	1	0	2
Arrowtooth Flounder	1	0	0	0	0	0	1
Wolf Eel	0	0	0	1	0	0	1
Sculpins	1	0	0	0	0	0	1
Petrale Sole	0	1	0	0	0	0	1
China Rockfish	1	0	0	0	0	0	1
Redstripe Rockfish	1	0	0	0	0	0	1
Sablefish	0	0	0	0	1	0	1

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 now 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 now 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 8). 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 2018 Sablefish research and assessment survey was comprised of two main components:

2. A **Randomized Tagging Program** that releases tagged Sablefish at randomly selected fishing locations in offshore waters. These sets also produce a time series of catch rate and biological data that can be used for assessing changes in stock abundance.

3. An **Inlets Program** that releases tagged Sablefish from fixed-stations at four mainland inlet localities (Figure 9). 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. Trap-mounted accelerometers recorded motion and orientation of the traps while oceanographic data from trap-mounted recorders collected temperature, depth, and salinity. The autonomous, trap-mounted cameras used in recent years were not deployed in 2018.

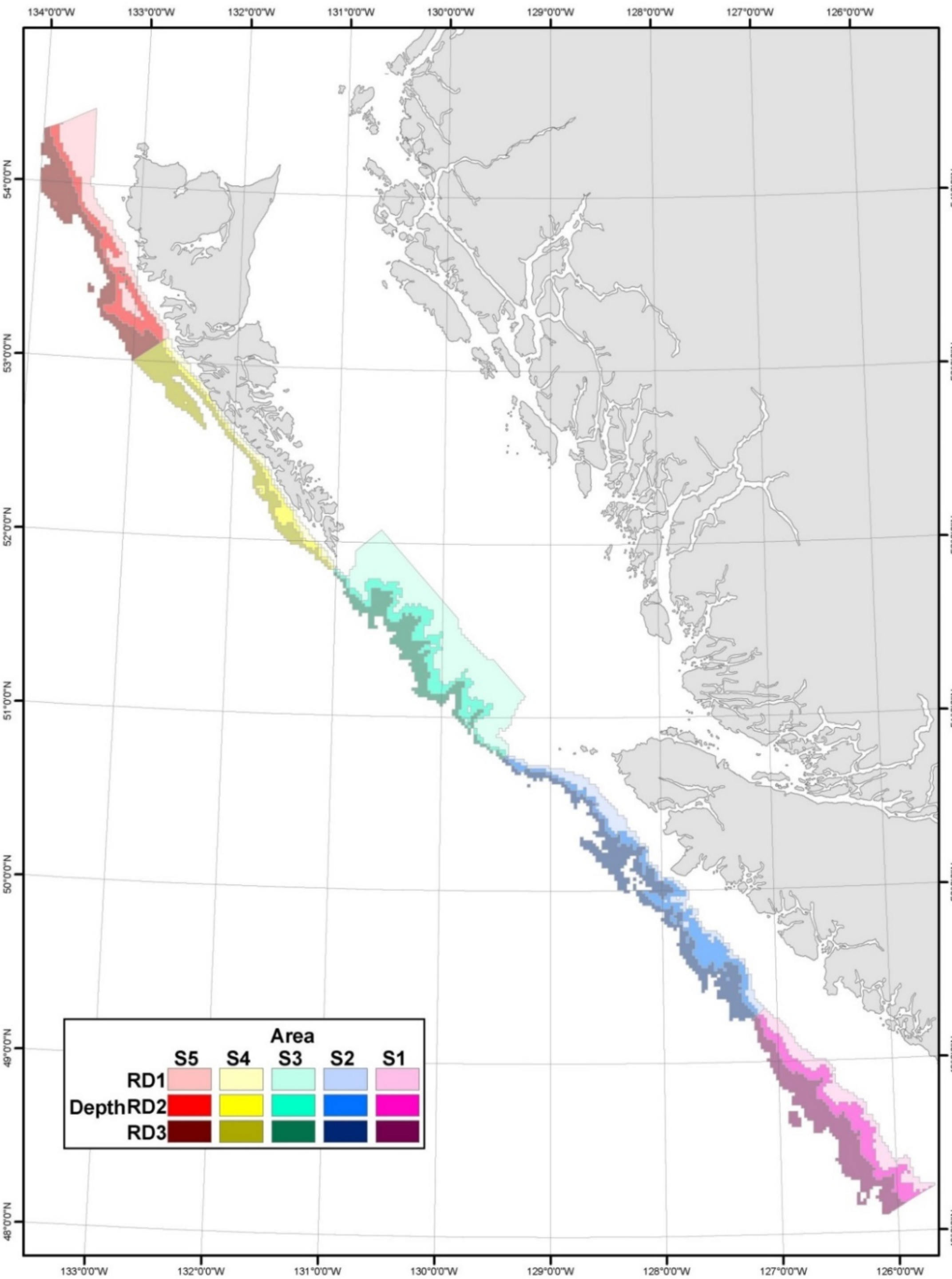


Figure 6. Sablefish Research and Assessment Survey randomized tagging program design showing the boundaries of each of the spatial and depth strata.

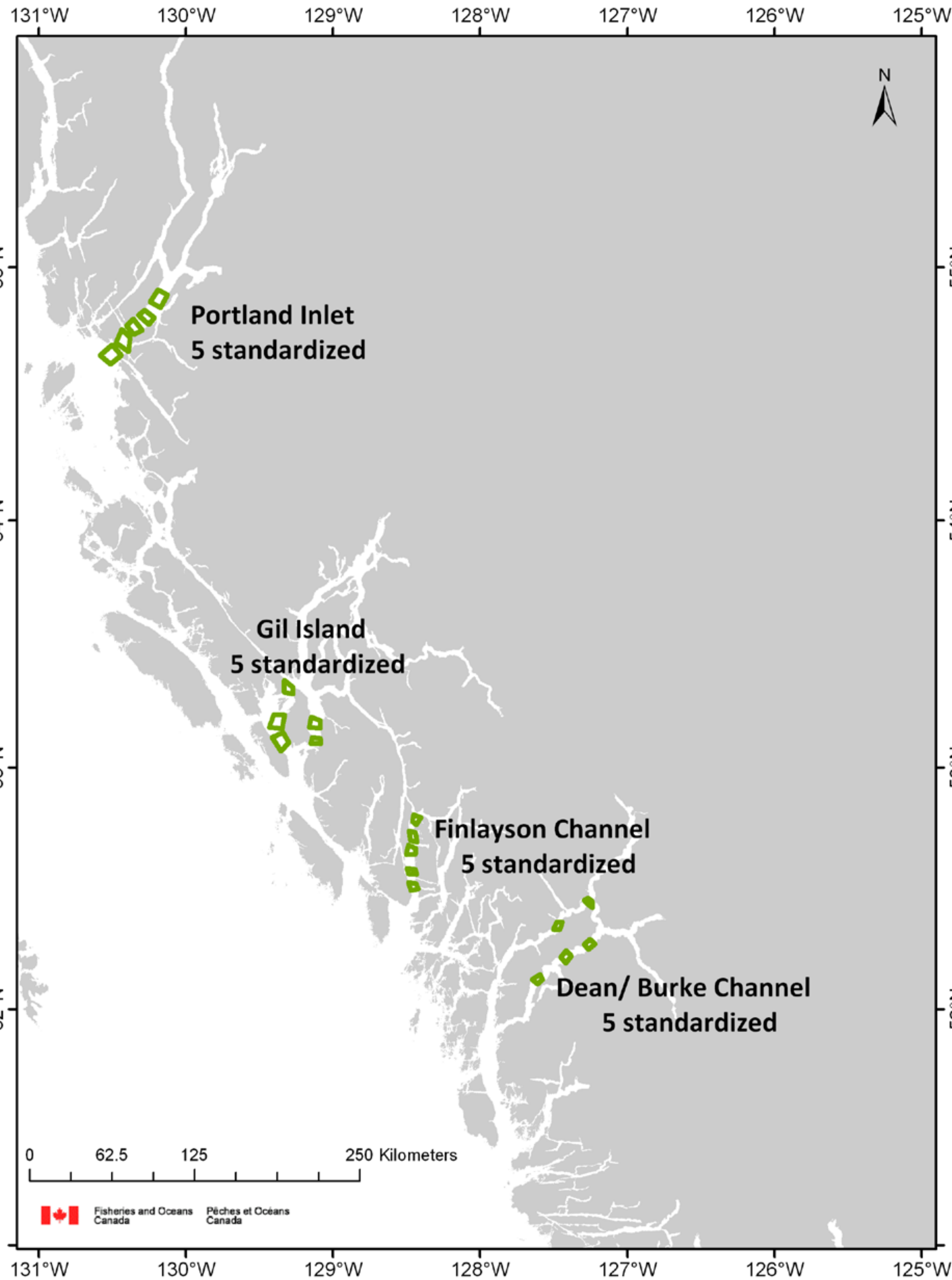


Figure 7. Sablefish Research and Assessment Survey Inlets program locations.

The 2018 Sablefish Research and Assessment Survey was conducted on the Ocean Pearl from October 9 to November 19, 2018. A total of 111 sets were completed (Figure 10) including 91 Randomized Tagging Program sets (Table 12) and 20 Inlets Program sets (Table 13).

The total catch of the survey was 130,719 kg (Table 14) and the average catch per set was 1178 kg. The most abundant fish species encountered by weight were Sablefish (Anoplopoma fimbria), followed by Pacific Halibut (Hippoglossus stenolepis), North Pacific Spiny Dogfish (Squalus suckleyi), Lingcod (Ophiodon elongatus), and Yelloweye Rockfish (Sebastes ruberrimus). The number of sets where the species was captured as well as the total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species captured during the Randomized Tagging Program are shown in Table 15. Annual summaries of catch for common species are shown for the Randomized Tagging Program in Table 16 and in Table 17 for the Inlet Program. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 17,322 individual fish of 5 different species (Table 18). An annual summary of the number of fish sampled for biological data during the Randomized Tagging Program is shown in Table 19 and in Table 20 for the Inlets Program.

Table 34. Summary of sets made during the 2018 Sablefish Randomized Tagging Program showing the number of sets in each combination of spatial and depth strata.

Spatial Strata	**Depth Strata**			**Total**
	RD1 (100-250 fm)	RD2 (250-450 fm)	RD3 (450-750)	
S1 (South West Coast Vancouver Island or SWCVI)	6	8	5	19
S2 (North West Coast Vancouver Island or NWCVI)	6	7	5	18
S3 (Queen Charlotte Sound or QCS)	8	6	5	19
S4 (South West Coast Haida Gwaii or SWCHG)	6	6	5	17
S5 (North West Coast Haida Gwaii or NWCHG)	6	7	5	18
Total	**32**	**34**	**25**	**91**

Table 35. Summary of sets made during the 2108 Sablefish Inlets Program.

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

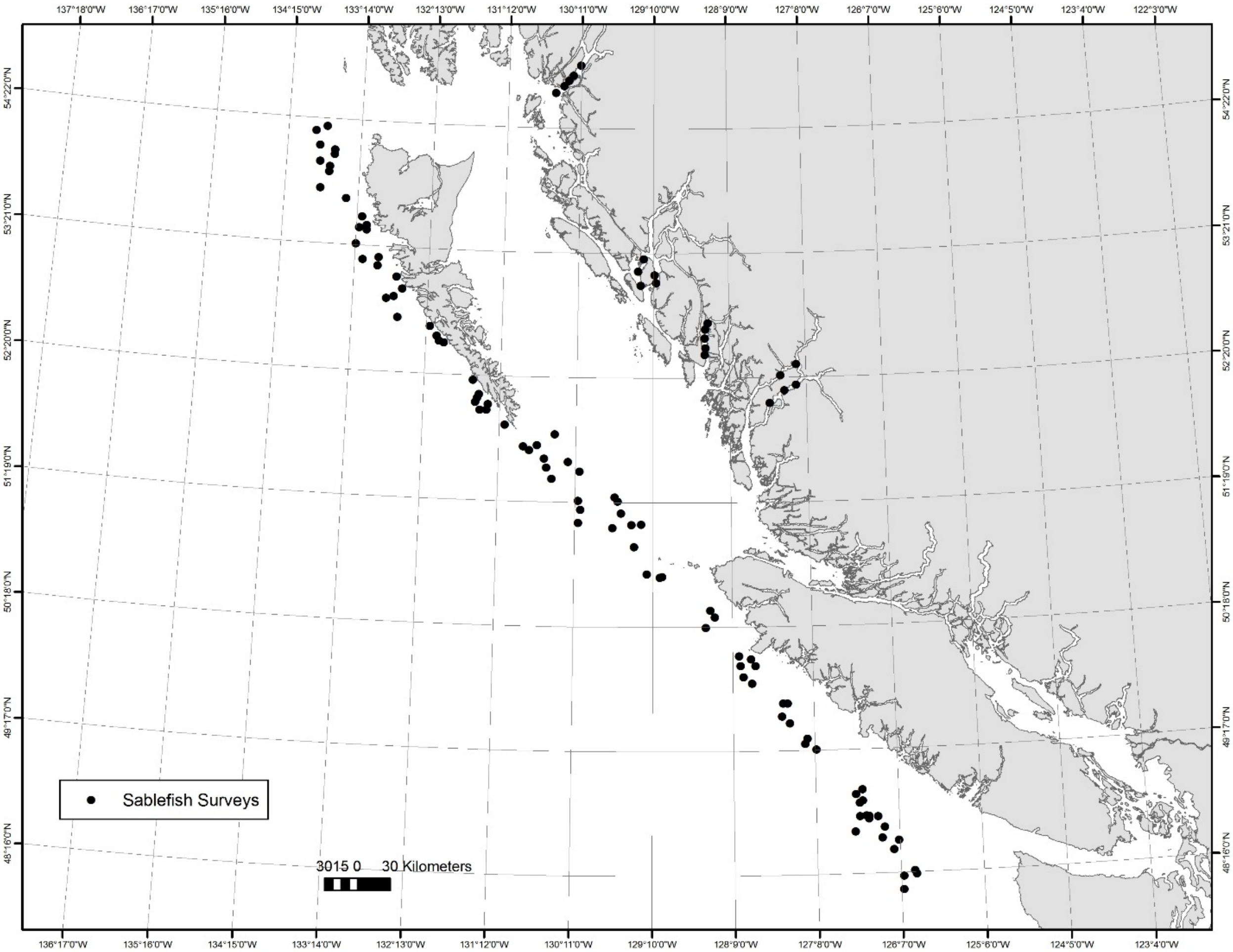


Figure 8. Set locations of the 2018 Sablefish Research and Assessment Survey.

Table 36. Total catch for the top 35 species (by weight) captured during the 2018 Sablefish Research and Assessment Survey.

Species	**Scientific Name**	**Total Catch (count)**	**Total Catch (kg)**
Sablefish	*Anoplopoma fimbria*	58415	119154
Pacific Halibut	*Hippoglossus stenolepis*	387	2986
North Pacific Spiny Dogfish	*Squalus suckleyi*	964	2973
Lingcod	*Ophiodon elongatus*	192	1912
Yelloweye Rockfish	*Sebastes ruberrimus*	311	1157
Arrowtooth Flounder	*Atheresthes stomias*	354	711
Redbanded Rockfish	*Sebastes babcocki*	219	389
Giant Grenadier	*Albatrossia pectoralis*	106	376
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	180	346
Pacific Grenadier	*Coryphaenoides acrolepis*	346	331
Grooved Tanner Crab	*Chionoecetes tanneri*	342	118
Shortraker Rockfish	*Sebastes borealis*	25	86
Shortspine Thornyhead	*Sebastolobus alascanus*	51	62
Canary Rockfish	*Sebastes pinniger*	7	17
	Lithodes couesi	27	13
Pacific Cod	*Gadus macrocephalus*	3	11
Pink Snailfish	*Paraliparis rosaceus*	26	10
	Paralomis multispina	25	9
Pacific Flatnose	*Antimora microlepis*	7	8
Dover Sole	*Microstomus pacificus*	8	8
Fragile Urchin	*Allocentrotus fragilis*	58	8
Brown Box Crab	*Lopholithodes foraminatus*	5	4
Oregontriton	*Fusitriton oregonensis*	109	3
	Neptuneidae	58	2
Rosethorn Rockfish	*Sebastes helvomaculatus*	5	1
Silvergray Rockfish	*Sebastes brevispinis*	1	1
Aurora Rockfish	*Sebastes aurora*	2	1
Fish-eating Star	*Stylasterias forreri*	7	1
Black Hagfish	*Eptatretus deani*	3	1
Golden King Crab	*Lithodes aequispinus*	1	1
Spotted Ratfish	*Hydrolagus colliei*	1	0
	Neptunea	40	0
Pacific Ocean Perch	*Sebastes alutus*	1	0
Sharpchin Rockfish	*Sebastes zacentrus*	2	0
Rockfishes	*Sebastes*	1	0

Table 37. Number of sets where the species was captured, total catch count, proportion of the total catch, and a breakdown by area for the 25 most abundant species (by weight) captured during the 2018 Sablefish Research and Assessment Survey Randomized Tagging Program sets.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)	4B	3C	3D	5A	5B	5C	5D	5E
Sablefish	*Anoplopoma fimbria*	110	58415	94.80	0	11591	7680	3946	7764	6407	3616	17411
North Pacific Spiny Dogfish	*Squalus suckleyi*	33	964	1.56	0	44	156	171	140	0	0	453
Pacific Halibut	*Hippoglossus stenolepis*	49	387	0.63	0	21	120	46	31	15	44	110
Arrowtooth Flounder	*Atheresthes stomias*	46	354	0.57	0	130	15	32	44	9	1	123
Pacific Grenadier	*Coryphaenoides acrolepis*	17	346	0.56	0	19	48	0	163	0	0	116
Yelloweye Rockfish	*Sebastes ruberrimus*	12	311	0.50	0	3	3	27	126	0	0	152
Redbanded Rockfish	*Sebastes babcocki*	29	219	0.36	0	16	23	53	52	0	0	75
Lingcod	*Ophiodon elongatus*	25	192	0.31	0	1	80	22	27	0	0	62
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/ melanostictus* complex	19	180	0.29	0	16	1	30	4	0	3	126
Giant Grenadier	*Albatrossia pectoralis*	27	106	0.17	0	20	23	3	16	0	0	44
Shortspine Thornyhead	*Sebastolobus alascanus*	34	51	0.08	0	8	17	5	5	0	1	15
Pink Snailfish	*Paraliparis rosaceus*	7	26	0.04	0	7	13	1	5	0	0	0
Shortraker Rockfish	*Sebastes borealis*	12	25	0.04	0	1	7	8	5	1	0	3
Dover Sole	*Microstomus pacificus*	8	8	0.01	0	4	0	2	0	0	0	2
Canary Rockfish	*Sebastes pinniger*	2	7	0.01	0	1	6	0	0	0	0	0
Pacific Flatnose	*Antimora microlepis*	4	7	0.01	0	2	0	0	1	0	0	4
Rosethorn Rockfish	*Sebastes helvomaculatus*	4	5	0.01	0	0	0	2	2	0	0	1
Pacific Cod	*Gadus macrocephalus*	3	3	0.00	0	1	1	0	0	0	0	1
Black Hagfish	*Eptatretus deani*	2	3	0.00	0	0	0	0	3	0	0	0
Longspine Thornyhead	*Sebastolobus altivelis*	2	2	0.00	0	0	1	0	0	0	0	1
Aurora Rockfish	*Sebastes aurora*	2	2	0.00	0	0	1	0	0	0	1	0
Sharpchin Rockfish	*Sebastes zacentrus*	1	2	0.00	0	0	0	0	2	0	0	0
Spotted Ratfish	*Hydrolagus colliei*	1	1	0.00	0	0	1	0	0	0	0	0
Silvergray Rockfish	*Sebastes brevispinis*	1	1	0.00	0	0	0	0	1	0	0	0
Pacific Ocean Perch	*Sebastes alutus*	1	1	0.00	0	0	0	0	1	0	0	0

Table 38. 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. Data from 2003 and 2004 have been omitted from this table.

Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Sablefish	17730	24105	18833	20326	15529	17375	22568	16845	18095	14266	25428	18073	36604	46808	350988
Arrowtooth Flounder	598	763	1655	1163	1787	553	1037	921	414	864	610	427	686	336	12831
Pacific Grenadier	399	313	880	608	829	676	742	715	254	534	686	627	276	346	8867
North Pacific Spiny Dogfish	465	317	437	162	565	414	868	966	386	287	365	699	158	964	8385
Rougheye/Blackspotted Rockfish complex	166	355	558	513	418	406	266	941	223	488	320	386	257	177	6059
Pacific Halibut	114	163	185	125	224	172	256	342	99	447	444	283	165	323	3489
Redbanded Rockfish	113	93	154	257	150	131	244	208	127	241	295	217	287	219	2948
Lingcod	128	108	201	109	93	97	165	71	88	92	121	154	106	192	1890
Giant Grenadier	97	67	162	146	179	118	105	195	80	87	206	72	67	106	1848
Yelloweye Rockfish	33	22	71	58	60	21	106	34	13	17	81	97	22	311	1005

Table 39. Annual summary of the total catch (piece count) for the top 10 species (by total piece count over all years) for the Sablefish Research and Assessment Survey Inlet Program sets. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	7066	5062	3453	2498	4339	7507	11034	6213	3271	3341	2708	5050	8110	11607	101156
Pacific Halibut	72	104	111	99	78	109	108	113	88	265	333	243	90	64	1979
Arrowtooth Flounder	23	46	101	108	49	25	11	20	11	49	30	24	14	18	553
North Pacific Spiny Dogfish	6	6	8	1	2	15	18	12	4	5	44	14	1	0	142
Dover Sole	4	4	4	23	1	0	0	1	2	5	1	1	2	0	49
Walleye Pollock	7	1	6	3	3	3	3	4	1	4	2	2	1	0	42
Pacific Sleeper Shark	1	5	5	4	2	0	1	0	0	2	0	2	0	0	29
Shortraker Rockfish	0	4	4	5	4	1	3	2	0	0	3	0	0	1	27
Pacific Cod	0	0	0	8	1	5	0	1	1	2	1	0	1	0	20
Rougheye/Blackspotted Rockfish complex	0	1	2	1	1	1	0	2	0	2	0	1	1	3	17

Table 40. Number of fish sampled for biological data during the 2018 Sablefish Research and Assessment Survey showing the number of tag releases, lengths, age structures, and DNA tissue samples that were collected by species.

Species	Scientific Name	Tags	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Pacific Halibut	*Hippoglossus stenolepis*	0	325	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus* complex	0	147	147	147
Sablefish	*Anoplopoma fimbria*	10965	16706	5492	0
Shortraker Rockfish	*Sebastes borealis*	0	25	25	0
Yelloweye Rockfish	*Sebastes ruberrimus*	0	150	144	102

Table 41. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Tagging Program sets. Data from 2003 and 2004 have been omitted from this table.

Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Sablefish	8999	12210	10385	11059	9331	10270	12463	10486	10118	8204	12094	9910	15841	13094	184318
Rougheye/Blackspotted Rockfish complex	0	56	0	282	289	266	240	393	179	373	270	270	183	144	2945
Pacific Grenadier	0	0	0	461	562	378	471	380	188	0	0	0	0	0	2440
Arrowtooth Flounder	0	0	0	441	379	245	400	656	140	0	0	0	0	0	2261
North Pacific Spiny Dogfish	0	0	0	0	219	326	440	674	207	0	0	0	0	0	1866
Redbanded Rockfish	0	0	0	224	145	131	243	204	113	0	0	0	29	0	1089
Giant Grenadier	0	0	0	129	141	111	99	195	79	0	0	0	0	0	754
Yelloweye Rockfish	0	0	0	55	60	21	106	32	12	0	75	58	21	150	590
Pacific Halibut	0	0	0	0	2	60	5	15	0	0	0	0	158	261	501
Shortraker Rockfish	0	0	0	53	65	73	18	59	18	13	10	59	26	24	426
Pacific Flatnose	0	0	0	18	39	27	17	24	11	0	0	10	0	0	146
Shortspine Thornyhead	0	0	0	1	9	26	22	53	34	0	0	0	0	0	145
Lingcod	0	0	0	0	27	36	1	3	1	0	0	0	0	0	68
Rosethorn Rockfish	0	0	0	8	6	2	23	7	3	0	0	0	0	0	49
Dover Sole	0	0	0	3	1	3	13	18	3	0	0	0	0	0	41
Pink Snailfish	0	0	0	30	0	0	1	0	0	0	0	0	0	0	31

Table 42. Annual summary of the number of common fish species sampled for biological data during the Sablefish Research and Assessment Survey Randomized Inlet Program sets. Data from 2003 and 2004 have been omitted from this table.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Sablefish	4394	3506	2554	1993	3070	5064	5984	3900	2503	2379	2234	3272	4693	3582	60647
Pacific Halibut	0	0	0	0	0	0	0	4	0	0	0	0	90	63	157
North Pacific Spiny Dogfish	6	0	0	0	0	0	8	11	0	0	0	0	0	0	25
Arrowtooth Flounder	0	0	0	0	0	0	3	18	0	0	0	0	0	0	21
Shortraker Rockfish	0	0	0	0	3	1	2	2	0	0	3	0	0	1	12
Rougheye/Blackspotted Rockfish complex	0	0	0	0	0	1	0	2	0	2	0	1	1	3	10
Walleye Pollock	7	0	0	0	0	0	1	1	0	0	0	0	0	0	9

Multi-species Small-mesh Bottom Trawl Survey

An annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island was initiated in 1973. In 1998, areas in Eastern Queen Charlotte Sound were added to the survey. Given that the survey is conducted using a shrimp bottom trawl without an excluder device, groundfish can make up a significant portion of the catch in many of the tows. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Although catch rates are useful indicators of stock status, additional information such as the size and age composition of the catch improves the usefulness of the indices. Consequently, a program was initiated in 2003 to collect biological samples from all groundfish species caught during the survey. Groundfish staff 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 Canadian Coast Guard Ship 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, 2017, and 2018 due to staffing limitations.

The 2018 survey was conducted onboard the F/V Nordic Pearl and ran from May 2 to May 17. A total of 126 tows were completed, of which 122 were usable (Figure 11). 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 50,850 kg. The mean catch per tow was 416 kg, averaging 39 different species of fish and invertebrates in each. Over all tows over the entire survey, the most abundant fish species encountered were Rex Sole (Glyptocephalus zachirus), Dover Sole (Microstomus pacificus), Flathead Sole (Hippoglossoides elassodon), Slender Sole (Lyopsetta exilis), Spotted Ratfish (Hydrolagus colliei), and Pacific Hake (Merluccius productus). 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 21 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 10,377 individual fish from 17 different species (Table 22). Most biological samples included fish length and sex but age structures were also collected for Bocaccio (Sebastes paucispsinis) and Lingcod (Ophiodon elongatus) 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).

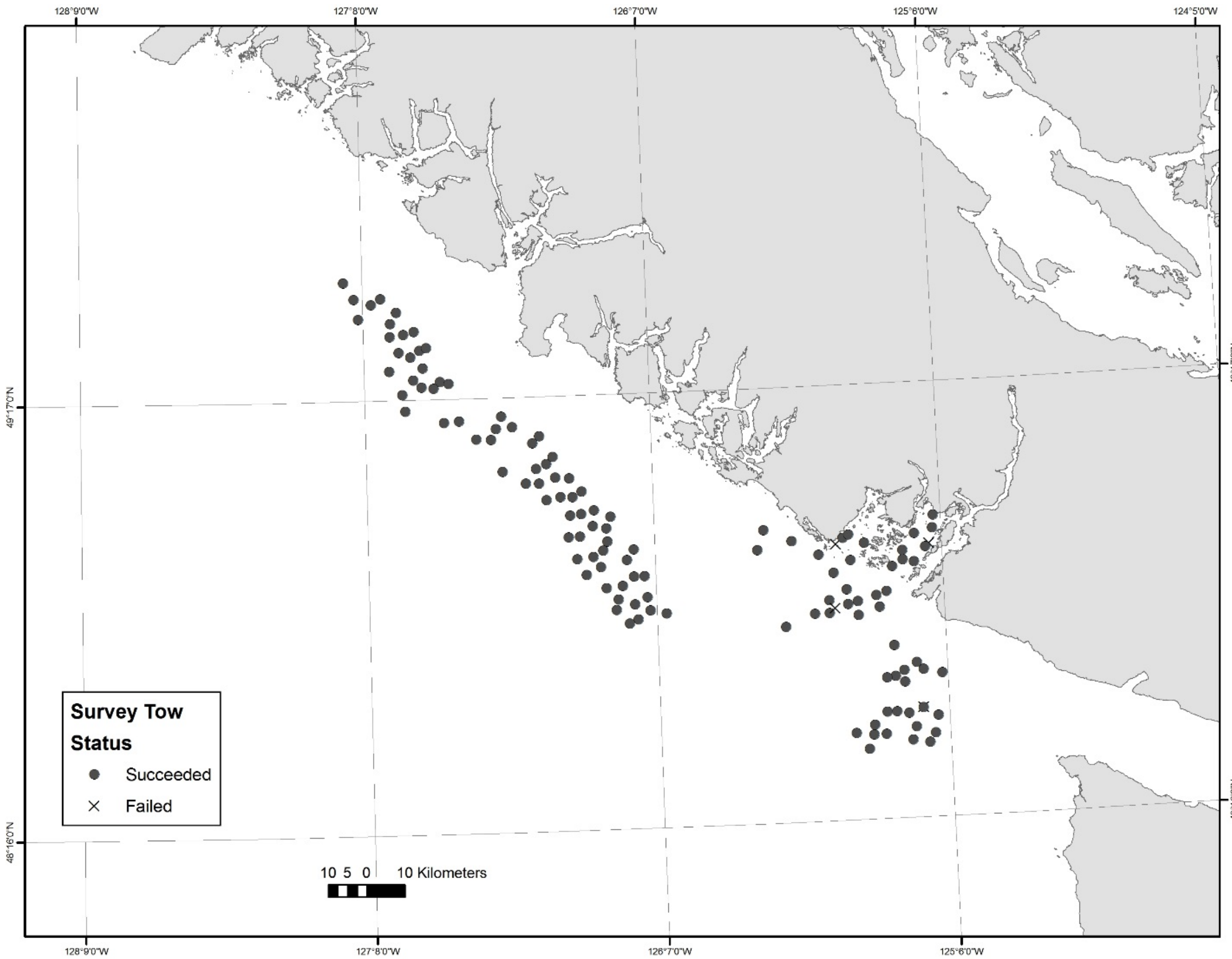


Figure 9. Tow locations of the 2018 Multi-species Small-mesh Bottom Trawl Survey.

Table 43. 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 2018 Multi-species Small-mesh Bottom Trawl Survey.

Species	**Scientific Name**	**Number of Tows**	**Catch (kg)**	**Biomass (t)**	**Relative Error**
Rex Sole	*Glyptocephalus zachirus*	72	4635	3864	0.05
Dover Sole	*Microstomus pacificus*	71	4427	3759	0.09
Flathead Sole	*Hippoglossoides elassodon*	71	2733	2500	0.16
Pacific Hake	*Merluccius productus*	61	2158	1676	0.24
Slender Sole	*Lyopsetta exilis*	71	1946	1694	0.1
Pacific Sanddab	*Citharichthys sordidus*	46	980	788	0.19
Arrowtooth Flounder	*Atheresthes stomias*	69	908	819	0.15
Spotted Ratfish	*Hydrolagus colliei*	69	749	604	0.12
English Sole	*Parophrys vetulus*	65	632	518	0.17
Sablefish	*Anoplopoma fimbria*	69	561	468	0.39
North Pacific Spiny Dogfish	*Squalus suckleyi*	39	497	370	0.2
Pacific Cod	*Gadus macrocephalus*	39	452	391	0.24
Longnose Skate	*Raja rhina*	69	440	354	0.08
Petrale Sole	*Eopsetta jordani*	60	439	380	0.14
Greenstriped Rockfish	*Sebastes elongatus*	62	281	221	0.19
Lingcod	*Ophiodon elongatus*	49	262	220	0.15
Yellowtail Rockfish	*Sebastes flavidus*	35	241	212	0.25
Walleye Pollock	*Gadus chalcogrammus*	61	220	179	0.17
Eulachon	*Thaleichthys pacificus*	61	146	123	0.16
Pacific Halibut	*Hippoglossus stenolepis*	27	143	124	0.19
Darkblotched Rockfish	*Sebastes crameri*	56	124	100	0.19
Blackbelly Eelpout	*Lycodes pacificus*	62	117	96	0.13
Pacific Ocean Perch	*Sebastes alutus*	15	102	70	0.9
Big Skate	*Beringraja binoculata*	11	78	61	0.37
Pacific Herring	*Clupea pallasii*	38	68	69	0.77

Table 44. Number of fish sampled for biological data during the 2018 Multi-species 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**	**DNA Tissue Collected**
American Shad	*Alosa sapidissima*	78	0	0
Arrowtooth Flounder	*Atheresthes stomias*	195	0	0
Big Skate	*Beringraja binoculata*	55	0	0
Bocaccio	*Sebastes paucispinis*	35	35	0
Dover Sole	*Microstomus pacificus*	1167	0	0
English Sole	*Parophrys vetulus*	377	0	0
Eulachon	*Thaleichthys pacificus*	4680	0	424
Lingcod	*Ophiodon elongatus*	170	127	0
Longnose Skate	*Raja rhina*	870	0	0
Pacific Cod	*Gadus macrocephalus*	80	0	0
Pacific Halibut	*Hippoglossus stenolepis*	40	0	0
Petrale Sole	*Eopsetta jordani*	359	0	0
Rex Sole	*Glyptocephalus zachirus*	1467	0	0
Rougheye/Blackspotted Rockfish complex	*Sebastes aleutianus/melanostictus complex*	42	42	42
Sablefish	*Anoplopoma fimbria*	134	0	0
Sandpaper Skate	*Bathyraja interrupta*	99	0	0
Walleye Pollock	*Gadus chalcogrammus*	529	0	0

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 hook 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 has 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.

At the time of writing, the 2018 IPHC survey data are not yet finalized and so have not been included in this report.

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TSC Agency Reports – IPHC 2019

Contents

Agency Overview

Management of the Pacific halibut resource and fishery has been the responsibility of the International Pacific Halibut Commission (IPHC) since its creation in 1923. Assessing, forecasting, and managing the resource and fishery requires accurate assessments, continuous monitoring, and research responsive to the needs of managers and stakeholders. The fishery for Pacific halibut (*Hippoglossus stenolepis*) is one of the most valuable and geographically largest in the northeast Pacific Ocean. Industry participants from Canada and the United States of America 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 the field (port and sea sampling) seasonal positions, the following transitions occurred in 2018 and early 2019:

Name	Position	Start Date	End Date
Jamie Goen	Fisheries Statistics and Services Branch Manager		April 2018
Lara Erikson	Fisheries Statistics and Services Branch Manager	August 2018	
Caroline Robinson	Fisheries Data Specialist (2A, Recreational, Subsistence, & Data Entry)	June 2018	
Ed Henry	Fisheries Data Specialist (Bycatch)	July 2018	
Huyen Tran	Fisheries Data Manager	November 2018	
Colin Jones	Setline Survey Specialist (Gear and Bait)	January 2019	

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 FISS (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 FISS 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 the FISS in selected areas during most years since 1963 (with a break from 1987 to 1992). Historical information regarding previous FISS operations has been presented in IPHC Annual Reports and FISS 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 2018 FISS chartered 13 commercial longline vessels (four (4) Canadian and nine (9) USA) during a combined 88 trips and 806 charter days. 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. All 1,496 stations planned for the 2018 FISS season were either scouted or completed. Of these stations, 1,458 (97%) were effectively completed. A total of 13,290 otoliths were collected coastwide. Approximately 818,246 pounds (371 t) of Pacific halibut, 85,716 pounds (39 t) of Pacific cod, and 51,337 pounds (23 t) of rockfish were landed from the FISS stations.

Design

The IPHC's FISS design encompasses nearshore and offshore waters of the IPHC Convention Area (Figure 1a). The current FISS 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. FISS 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.

Eight (8) skates were set in IPHC Regulatory Area 2A and in IPHC Regulatory Area 4CDE. IPHC Regulatory Areas 2B, 2C, 4A and 4B had seven (7) skates of baited gear set at each FISS station in all charter regions. FISS specifications for gear, setting schedule, and soak time have been consistent since 1998. FISS 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 IPHC Regulatory Area).

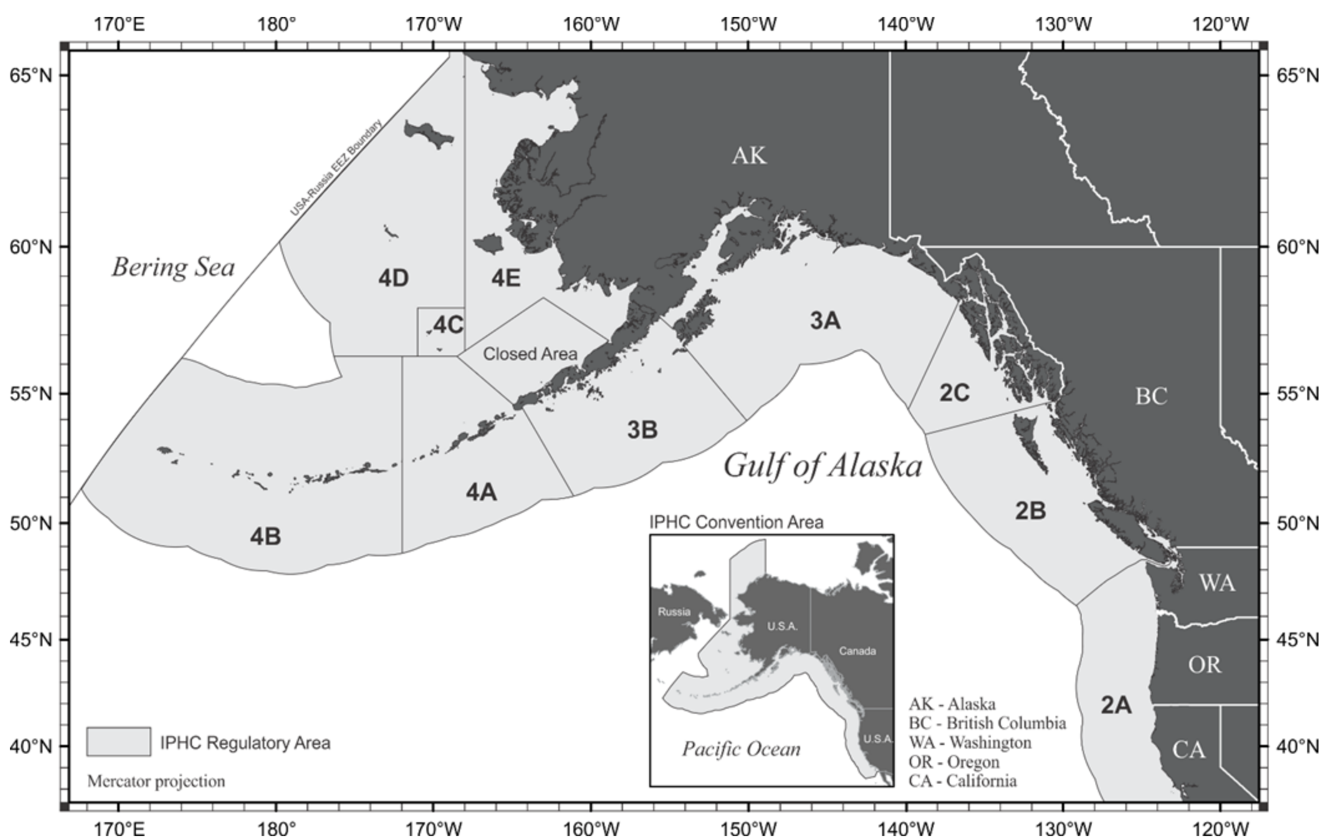

Figure 1a. Map of the IPHC Convention Area and IPHC Regulatory Areas.

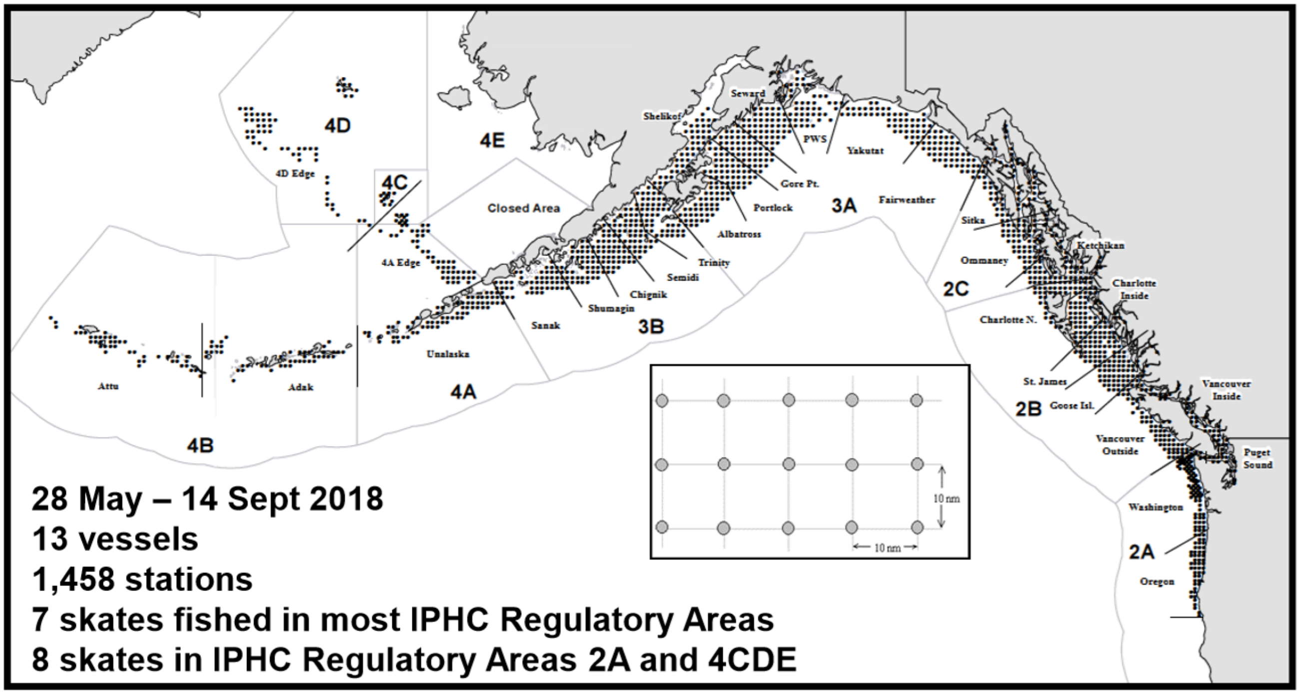

Figure 1b. 2018 IPHC fishery-independent setline survey station positions, charter region divisions, and IPHC Regulatory Areas.

FISHERY-INDEPENDENT SETLINE SURVEY (FISS) EXPANSION STATIONS

Since 2014, the IPHC has been sampling expansion FISS 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 FISS 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 FISS stations added to the standard grid to cover habitat not previously sampled.

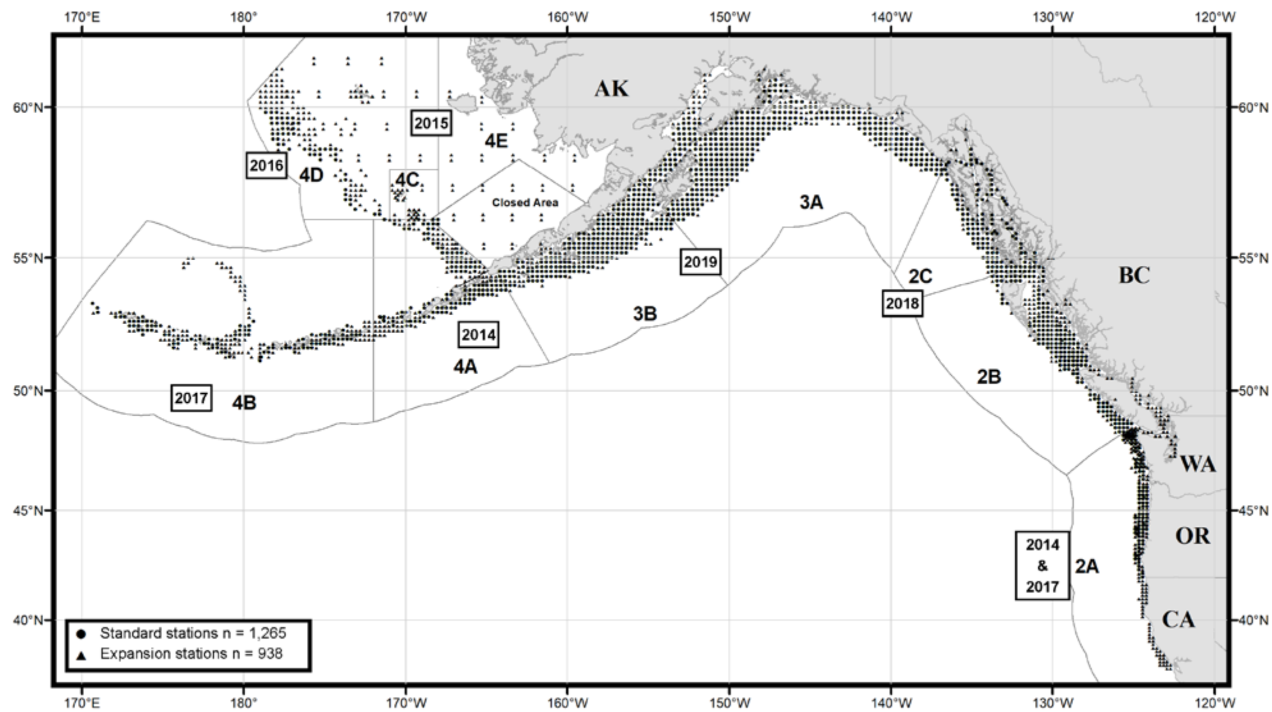

Figure 2. IPHC fishery-independent setline survey (FISS) and expansion stations planned (2014-19).

2018 FISS Expansion in IPHC Regulatory Area 2A

The expansion stations in the Puget Sound charter region were fished to allow for a contiguous survey in the Salish Sea in conjunction with expansion work in IPHC Regulatory Area 2B. In addition, an ad-hoc densified grid off the north Washington coast was fished for the second time. A total of 144 stations were surveyed, of which 14 were expansion stations and 26 were the ad-hoc densified grid stations off the north Washington coast (Figure 3).

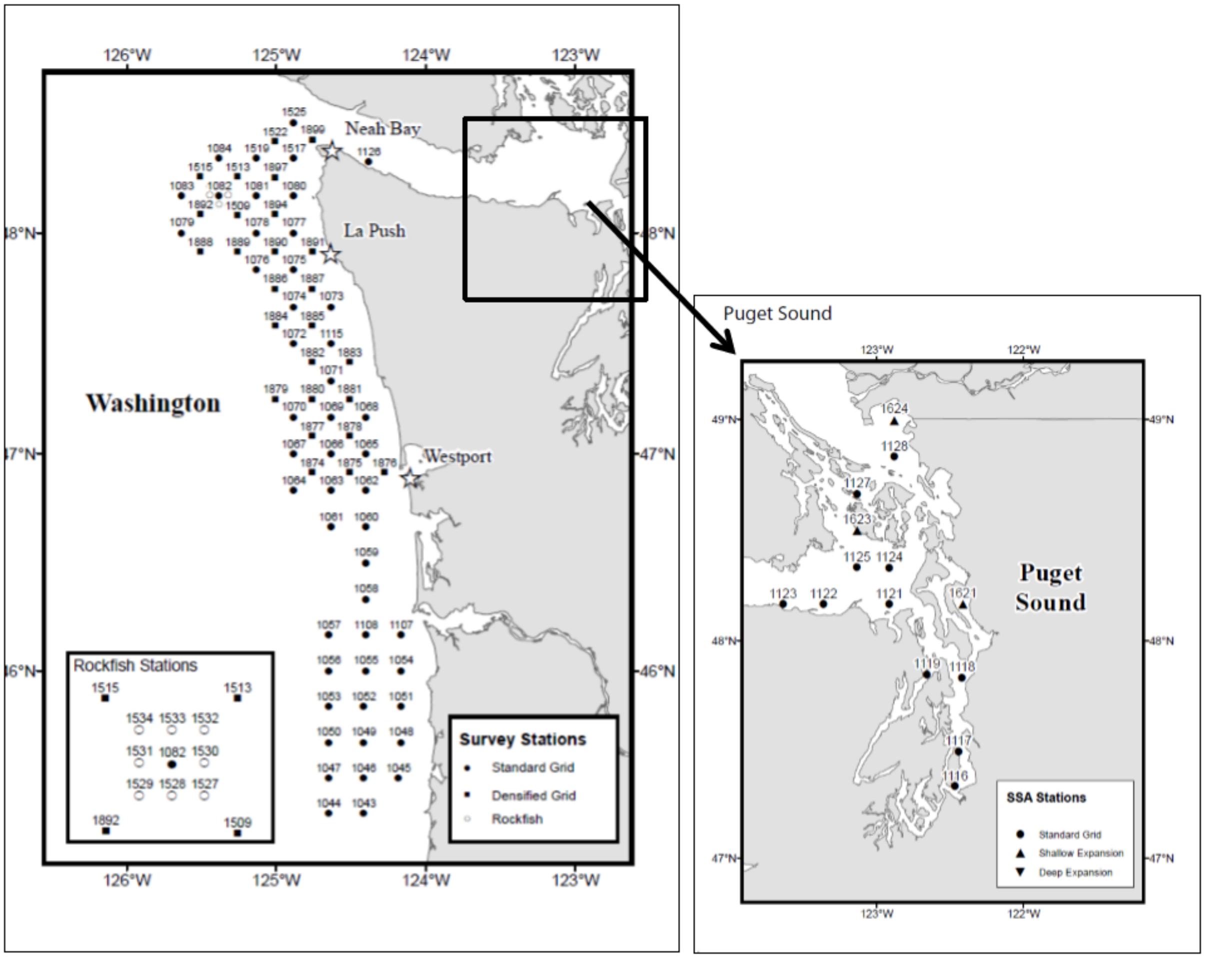

Figure 3. 2018 IPHC fishery-independent setline survey stations in IPHC Regulatory Area 2A with charter regions.

2018 FISS Expansion in IPHC Regulatory Area 2B

The expansion in IPHC Regulatory Area 2B included an additional 136 new stations (129 expansion and seven extra) that were added to the existing 166 FISS stations (standard) in IPHC Regulatory Area 2B. These included stations as shallow as 17 m (9 fm) and as deep as 732 m (399 fathoms (732 m) (Figure 4). To help manage this expansion, the historical Charlotte and Vancouver charter regions were divided into four new regions identified as Charlotte Inside, Charlotte North, Vancouver Inside and Vancouver Outside (Table 1).

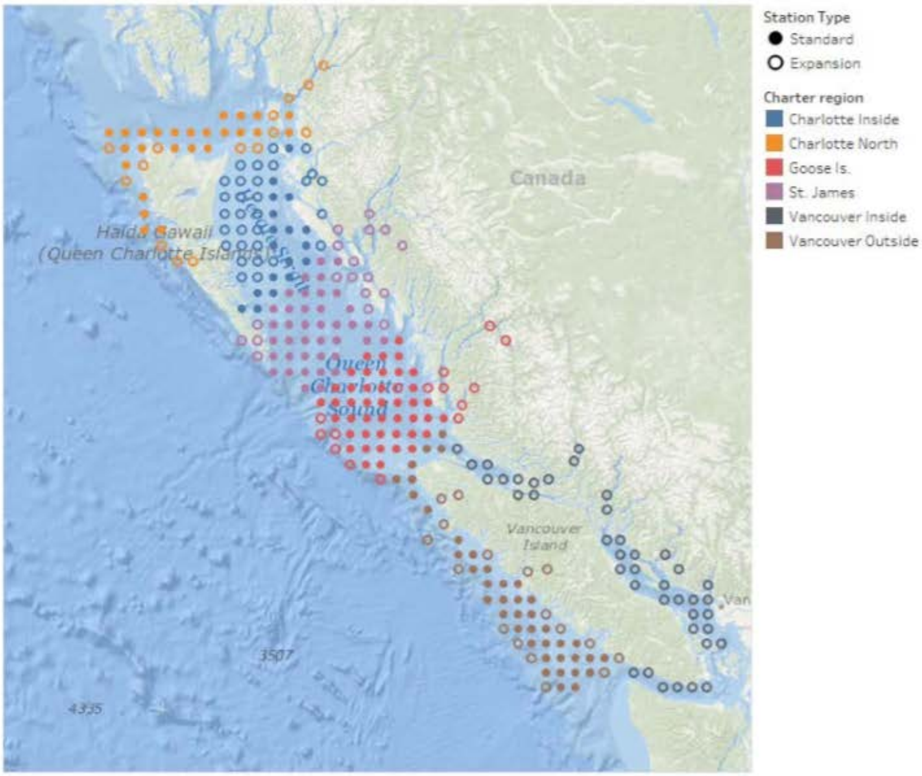

Figure 4. 2018 IPHC FISS stations in IPHC Regulatory Area 2B with charter regions.

Table 1. IPHC Regulatory Area 2B FISS charter regions and count by station type.

Charter Region	Total Stations	Expansion	Extra[2]	Standard
Charlotte Inside	48	29	1	18
Charlotte North	40	14	1	25
Goose Islands	58	14	1	43
St. James	57	18	0	39
Vancouver Inside	41	39	2	0
Vancouver Outside	58	15	2	41
Total	302[1]	129	7	166

[1] six stations were not permitted because of habitat closures.
[2] extra stations are added between grid stations that are far apart from each other, typically up fjords and channels.

2018 FISS Expansion in IPHC Regulatory Area 2C

The expansion in IPHC Regulatory Area 2C included 121 of the existing FISS stations (standard) with an additional 44 new stations (40 expansion and four extra), including stations as shallow as 17 m (9 fm) and as deep as 797 m (436 fm) (Figure 5). The expansion stations were divided into the existing FISS charter regions (Table 2).

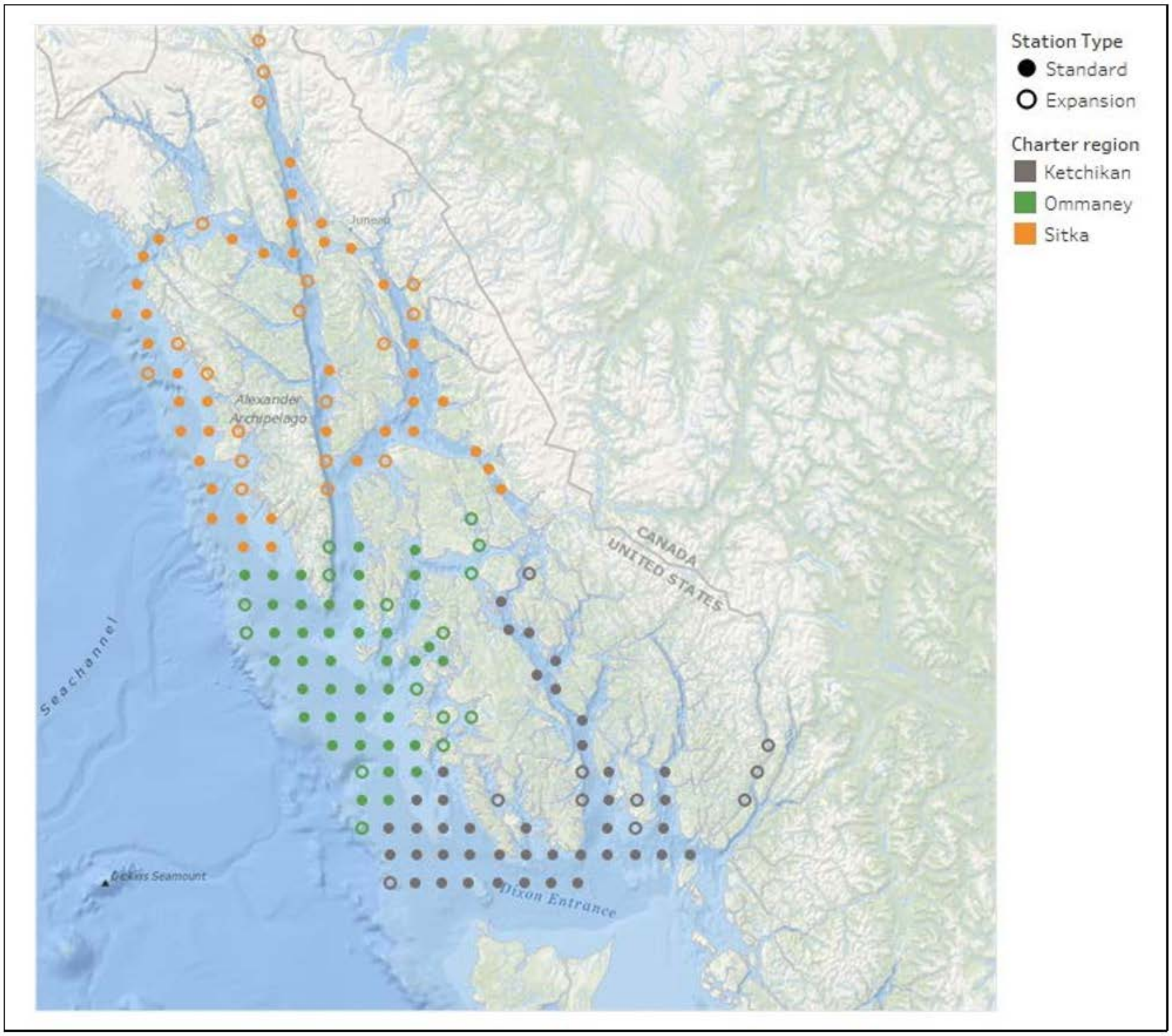

Figure 5. 2018 FISS stations in IPHC Regulatory Area 2C by charter region.

Table 2. IPHC Regulatory Area 2C FISS charter regions and count by station type.

Charter Region	Total station count	Expansion	New extra stations [2]	Standard
Ketchikan	51	9	1	41
Ommaney	55	14	1	40
Sitka	59	17	2	40
Total	165[1]	40	4	121

[1] three stations in Glacier Bay were not fished because of permitting
[2] extra stations are added between grid stations that are far apart from each other, typically up fjords and channels.

Pacific halibut catch-per unit effort in weight (WPUE) and numbers (NPUE)
The FISS covers commercial as well as non-commercial fishing grounds, so the average WPUE and NPUE for all IPHC Regulatory Areas surveyed was below that of the commercial fleet. Detailed information such as catch by station within the IPHC Regulatory Area(s) as well as over a time series is available here:

https://iphc.int/data/setline-survey-catch-per-unit-effort

A record of hook status, either as a 20% subsample or a full census, is collected for each set. Hook status, which is either the organism captured, a bait returned, an empty hook, or a missing hook, is used to calculate the hook competition adjustment factor. The impact of the hook competition adjustment can also be observed through the above link.

Pacific halibut biological data
FISS Sea Samplers record fork lengths of all Pacific halibut caught, with the corresponding location details. All O32 Pacific halibut, as well as sublegal-sized (U32) Pacific halibut randomly selected for otolith collection are assessed for sex, maturity, prior-hooking injury severity, and evidence of depredation. Otoliths, used to determine age, are collected from a randomized subsample. Male Pacific halibut are assessed as either mature or immature, and females as immature, mature, spawning or resting. All U32 Pacific halibut not selected for otolith collection were measured and released alive, a subsample of which were tagged prior to release. Details of the biological data collected on the FISS are available here:

https://iphc.int/data/fiss-biologicals-maps-and-plots

Prior hooking injury results
A prior hooking injury (PHI) is defined an injury that appears to have occurred when the fish was being released during a previous capture by hook-and-line gear. A PHI code was assigned using predefined criteria for every Pacific halibut captured (e.g. no injury, minor injury, moderate injury, severe injury, or unknown). The PHI results are also available at the above link.

Biological data for other species
Over 100 other species of fish or other organisms are consistently observed on the IPHC FISS. To explore the bycatch species observed by IPHC Regulatory Area since 1998 check out the interactive web pages here:

https://iphc.int/static/56/fiss-bycatch

FUTURE WORK

2019 expansions

As shown in Figure 6, one more year remains to complete the FISS expansions for each IPHC Regulatory Area. The IPHC will be continuing with the FISS expansion into IPHC Regulatory Areas 3A and 3B, as approved by the Commission in 2014. The IPHC has begun vetting the proposed FISS stations with the respective State and Federal agencies. In some cases, this also involves special permitting requirements. There are 89 expansion stations planned for IPHC Regulatory Area 3A and 67 for IPHC Regulatory Area 3B.

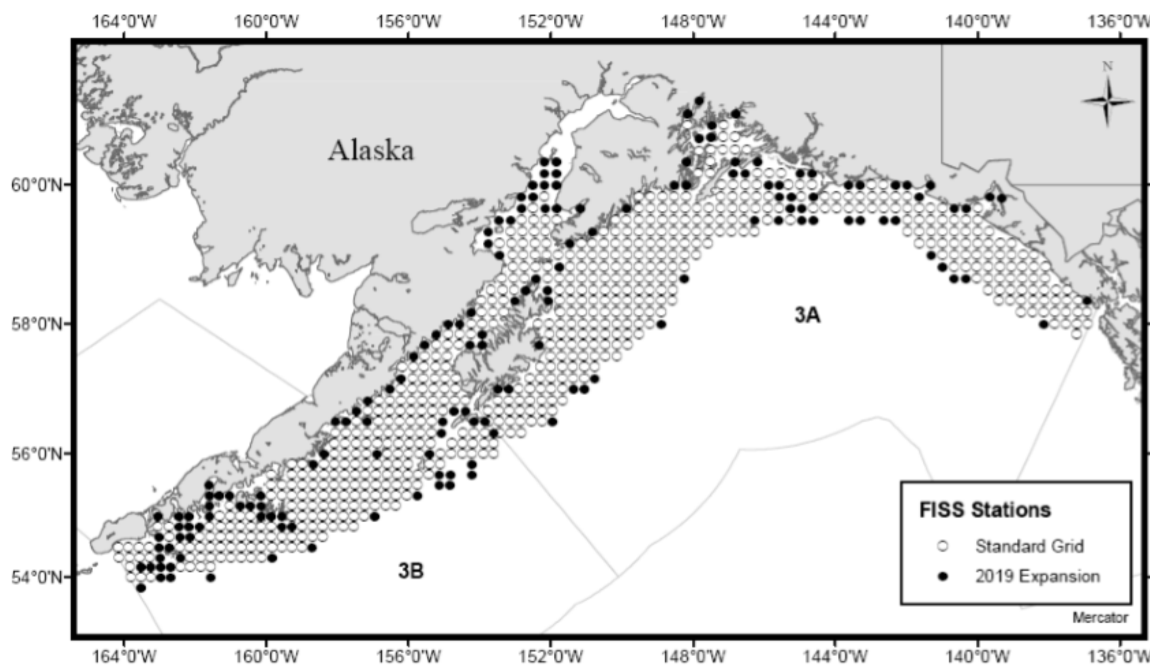

Figure 6. 2019 IPHC Regulatory Areas 3A and 3B FISS stations.

Gear comparison

The IPHC is conducting a gear comparison during the 2019 FISS to compare fixed-hook and snap gear. The comparison will evaluate whether data from both gear types can be used in the IPHC stock assessment process and how FISS work compares to the gear and results of the commercial fishery. All stations in IPHC Regulatory Area 2C will be fished twice, once by the FISS standard of fixed-hook gear and once by snap gear. To accomplish this work, IPHC Regulatory Area 2C has been divided into early and late charter regions instead of by the traditional three charter regions of Ketchikan, Sitka and Ommaney. Vessels using snap or fixed-hook gear interested in bidding on IPHC Regulatory Area 2C should refer to the 2019 FISS Bid Specifications for the bidding options (https://iphc.int/the-commission/opportunities). Vessels using any single gear type will not be able to fish more than half the stations in IPHC Regulatory Area 2C in 2019 i.e. 65 stations. The stations for each charter region by gear type are shown in Figures 7 and 8.

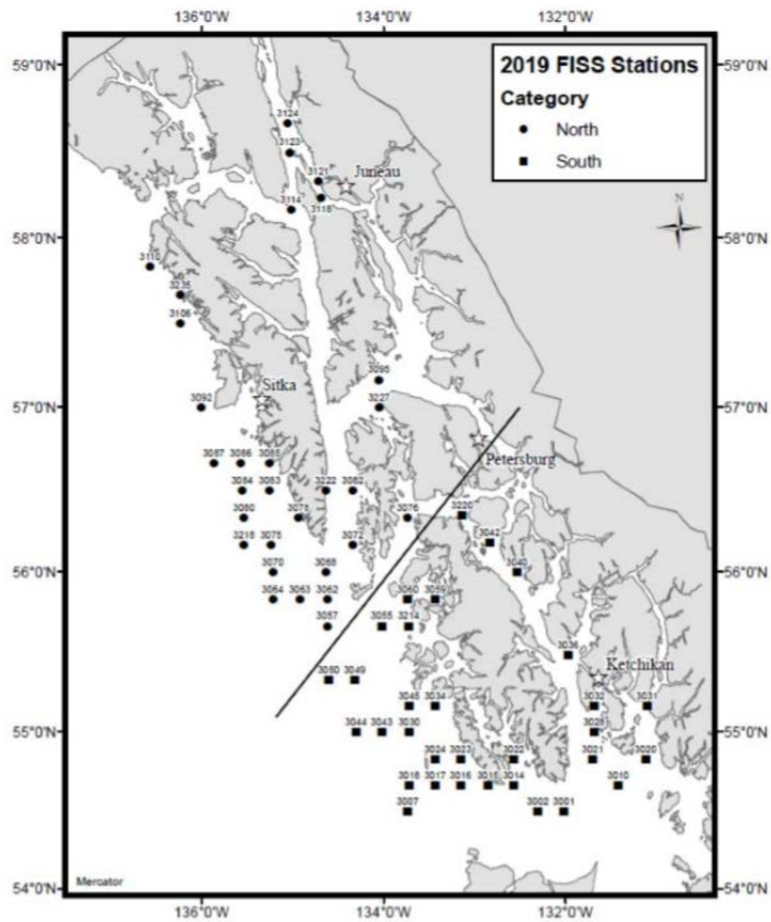

Figure 7. IPHC Regulatory Area 2C fixed-hook gear early (26 May to 15 July) charter region or snap gear late (16 July to 31 August) charter region.

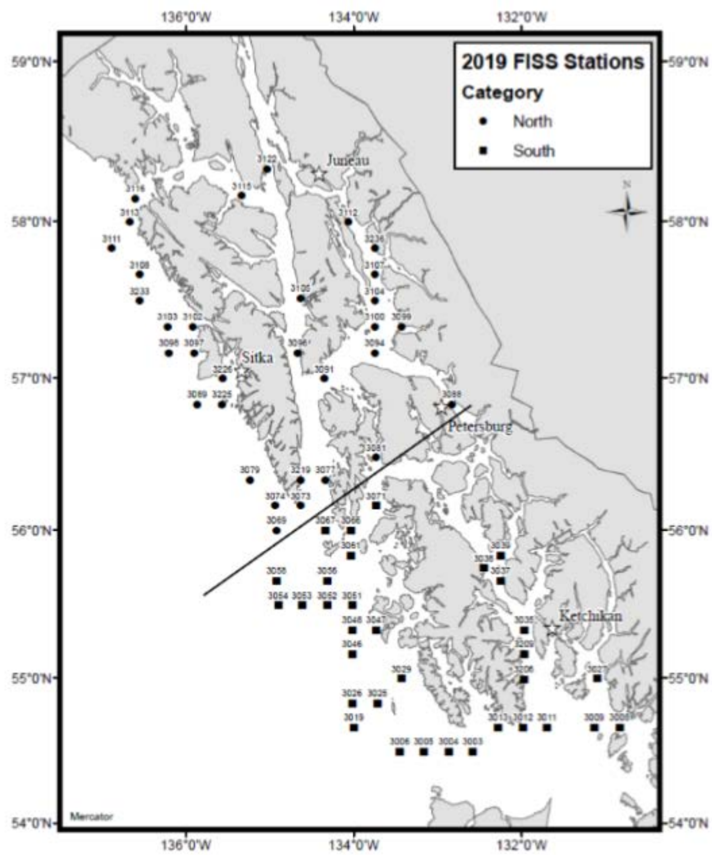

Figure 8. IPHC Regulatory Area 2C fixed-hook gear late (16 July to 31 August) charter region or snap gear early (26 May to 15 July) charter region.

Pacific halibut weights

Beginning in 2019, weights of all Pacific halibut are to be collected on the FISS.

Reserves – N/A

Review of Agency Groundfish Research, Assessment, and Management

Pacific halibut and IPHC activities

Research

Abstract

Since its inception, the IPHC has had a long history of research activities devoted to 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 Secretariat 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) Migration
2) Reproduction
3) Growth and Physiological Condition
4) Discard Mortality Rates (DMRs) and Survival
5) Genetics and Genomics

These research areas have been selected for their important management implications. The studies conducted on Migration are aimed at further understanding reproductive migration and identification of spawning times and locations as well as larval and juvenile dispersal, 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 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 2019

In 2019, the IPHC will be continuing research activities related to twelve continuing projects. These include the following:

- projects aimed at the development of tools for sex identification (621.16) and at producing accurate reproductive maturity estimations (674.11),
- project monitoring the Pacific halibut population for heavy metal and persistent organic pollutants (642.00),
- projects conducting migration-related research involving the use of satellite and wire tagging, estimating larval abundance and distribution over time and in relation to oceanographic and environmental conditions, and tail imaging recognition (650.21, 650.22, 670.11, 675.11),
- projects dealing with the identification of markers for growth-related studies (673.14) and on the relationship between temperature history and growth (673.15).
- projects investigating condition factor indices in wire-tagged fish (672.12) and characterizing the discard mortality rates in the longline fishery (672.13) and,
- project conducting work related to the sequencing of the Pacific halibut genome (673.13).

Project 621.16 ("*Development of genetic sexing techniques*") has as its main objective the identification of molecular markers for sex in order to provide a genetic method for sex identification in settings in which direct observations of sex cannot be obtained (i.e. fish at commercial offloads). In addition, this project was designed to provide genetic validation of the physical marking of sex at sea (Project 621.15, IPHC-2017-WM2017-10). Three single nucleotide polymorphisms (SNPs) were identified to be associated with sex and molecular assays were developed for two of the identified SNPs. These assays were estimated to have an accuracy of 97.5% in a comparison between assayed sex and visually-determined sex in a sample of 199 fish, based on an assumption that no process or recording errors existed within the visually-determined data (Drinan et al., 2018). The assay was subsequently used to evaluate the accuracy of commercial sex-marking at sea and is now being applied to provide sex information from biological samples (i.e. fin clips) collected from sampled fish from the 2017 commercial catch.

Project 642.00 ("*Assessment of mercury and other contaminants*") is the continuation of a project monitoring the prevalence of heavy metal and persistent organic pollutant contamination in the Pacific halibut population. Tissue samples for monitoring have been collected in IPHC's FISS since 2002.

A total of four projects are continuing migration-related studies, two of which involve tagging. First, **Project 650.21**: ("*Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting (PAT) tags*") involved a study of the migratory behavior of O32 Pacific halibut residing in summer on Bowers Ridge in IPHC Regulatory Area 4B, at both seasonal and interannual time scales. The primary goal of the project is to evaluate relative connectivity between Bowers Ridge, the western Aleutian Islands, and the broader eastern Pacific Ocean. Results will be placed in the context of data obtained from prior satellite-tagging experiments in which more than 200 O32 Pacific halibut have been tagged in the eastern Bering Sea and Aleutian Islands region. A total of 22 fish (13 female; 8 male; 1 of unknown sex) were tagged during July of 2017 with pop-up archival transmitting (PAT) tags: 16 with tags programmed to detach and report in mid-January (i.e., during the spawning season) and 6 with tags programmed report in July (i.e., after 365 days at liberty) of 2018. Final locations were obtained for 18 of these fish (14 during winter and 4 in July). Seventeen of the reporting locations were on Bower's Ridge, with one tag reporting in winter from the eastern Bering Sea shelf break near St. Matthew Canyon. Analysis of the archived environmental data and generation of at-liberty position estimates is ongoing. Second, **Project 650.22** ("*Larval connectivity*") is aimed at investigating the movement and connectivity of Pacific halibut larvae primarily between the Gulf of Alaska and the Bering Sea, and also within each basin. Larval abundance and distribution, as well as that of 2-year old fish from the same cohort, are being modeled over time and over oceanographic and environmental conditions. Third, **Project 670.11**: "*Wire tagging of Pacific halibut on NMFS trawl and IPHC setline surveys*" involves the tagging of U32 Pacific halibut in order to further understand coastwide migratory and growth patterns of young Pacific halibut. In 2018, 916 Pacific halibut were tagged during the NOAA Fisheries trawl survey (768 fish tagged in the Bering Sea and 148 fish tagged in the Aleutian Islands) and 1,747 Pacific halibut were wire-tagged on the IPHC's FISS. Finally, **Project 675.11** ("*Tail pattern recognition*") is the continuation of a pilot study conducted in 2017 that investigated the identification of individual fish to complement migratory studies by way of photographic recognition of tail patterns. Various pattern-recognition software packages have been used to examine uniqueness and longevity of patterns in tail coloration on both the blind and eyed side of the fish, showing relative promise for identifying the same individuals over time. Cameras were deployed on several vessels during the FISS in 2018 and over 744 tail images of wire tagged U32 fish were collected and are being used to create a database of tail images.

Project 672.12 ("*Condition Factors for Tagged U32 Fish*") continues the study of the relationship between the physiological condition of fish and migratory performance as assessed by tagging in U32 fish in order to better understand the potential use of quantitative physiological indicators in predicting migratory performance. Fat level determinations, blood parameters and biometrical measures are being evaluated for a subset of tagged U32 fish.

Project 672.13 ("*Discard mortality rates and injury classification profile by release method*") is continuing to investigate the relationship between three hook release methods (careful shake, gangion cut and hook stripper) 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. Furthermore, this project is also conducting investigations on the applicability and accuracy of electronic monitoring in capturing release methods and fish condition in vessels without observer coverage. This project has received funding from a grant from the Saltonstall-Kennedy NOAA grant program under project number NA17NMF4270240.

Project 673.13 ("*Sequencing the Pacific halibut genome*") aims at characterizing for the first time the genome of the Pacific halibut to support studies on population genetics, to assist in the identification of genomic regions and genes responsible for temporal and spatial adaptive phenotypic and behavioral characteristics in response to environmental and anthropogenic influences and to provide genomic resolution to genetic markers for sex, reproduction and growth that are currently being investigated. Sequencing efforts are currently under way.

Project 673.14 (*"Identification and validation of markers for growth in Pacific halibut"*) has continued efforts to identify and validate molecular and biochemical markers 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 trajectories. Initial studies have involved evaluating molecular responses of white skeletal muscle to temperature- and density-induced growth manipulations in juvenile Pacific halibut in captivity. Potential applicable molecular (gene and/or protein) markers for growth are currently being validated for their use in detecting growth trajectories using muscle samples from adult Pacific halibut. The results of this study will contribute to our understanding of the possible role of somatic growth variation in the observed changes in size-at-age in the Pacific halibut population. This project has received funding from a grant from the North Pacific Research Board under project number 1704.

Project 673.15 ("*Influence of thermal history on growth*") is designed to study the thermal profile experienced by fish at sea as assessed by electronic archival tagging and otolith microchemistry in order to investigate the relationship between growth patterns (or productivity) and spatial and temporal variability in environmental conditions for growth. This study will allow us to relate temperature histories that are experienced by individual fish to the growth patterns that they display, to examine spatial and temporal trends in rearing conditions and growth, and to extend thermal analyses to untagged Pacific halibut via otolith microchemical analyses. In addition, the data are expected to provide information regarding dispersal of U32 Pacific halibut, both seasonally and ontogenetically. During the 2018 FISS a total of 255 externally-attached electronic archival tags were deployed coast wide and 13 fish were tagged with PAT tags in the western Aleutian Islands. Additional tag releases are anticipated in 2019. Given that these fish are relatively small when tagged, and therefore only weakly selected to the target longline fishery, recapture rates are expected to be modest over their first 2-3 years post-release. One fish was recovered during 2018; the PAT tags are programmed to report during the summers of 2019 and 2020.

Project 674.11 ("*Full characterization of the annual reproductive cycle in adult female Pacific halibut*") aims at fully characterizing the annual reproductive cycle of female and male Pacific halibut in order to advance our understanding of sexual maturation in this species and to improve maturity assessments and maturity-at-age estimates. Sample collection in the Portlock area in the central Gulf of Alaska began as a pilot study in June 2017 and subsequently initiated fully in September 2017 and continued on a monthly basis through its successful completion in August 2018, for a . A variety of biological measures and samples were collected from thirty females and thirty males at each month for physiological analyses of reproductive parameters throughout an entire annual reproductive cycle. The results of this project will greatly assist in improving our estimates of the actual spawning biomass. In June 2019, additional samples from female and male Pacific halibut will be collected from the Portlock area in order to conduct a temporal analysis of maturity during three consecutive years from 2017 until 2019.

In addition to the continuing research projects described above, the IPHC will begin work in 2019 on five new projects that will cover specific research needs:

Project 2019-01 ("*Integrating migration and genetics research to refine Pacific halibut population structure, distribution and movement*") proposes performing studies to improve our understanding of spawning site contributions to nursery areas in relation to year-class and recruit survival and strength, as well as of the relationship between nursery origin and adult distribution and abundance over temporal and spatial scales through the application of genetic, approaches to address management-relevant questions on population structure, distribution and movement.

Project 2019-02 ("*Whale detection methods relevant for Pacific halibut*") proposes testing electronic monitoring-based methods to detect whale presence in the directed longline Pacific halibut fishery. This study will be performed in the framework a Bycatch Reduction Engineering Program (BREP-NOAA)-funded study led by the Alaska Longline Fishing Association in which IPHC is a collaborating partner.

Project 2019-03 ("*Adult Pacific halibut captive holding studies*") proposes performing studies on captive adult Pacific halibut to establish or validate measures or protocols required for other ongoing projects, such as (1) determining the permanence of individual tail markings for tracking individual movement rates, (2) calibrating measures of fat content for condition factor determinations and of stable isotope (C^{13} and N^{15}) ratios for inferring growth and dietary information, (3) calibrating O^{18} otolith signatures with environmental temperature and (4) producing larvae for behavioral studies.

Project 2019-04 ("*Use of LEDs to reduce Pacific halibut catches before trawl entrainment*") proposes evaluating if artificial illumination (e.g. LEDs) in trawl gear can reduce Pacific halibut bycatch before trawl entrainment in relation to the physiological condition of the fish. This study will be performed in the framework of a Bycatch Reduction Engineering Program (BREP-NOAA)-funded study led by Pacific States Marine Fisheries Commission in which IPHC is a collaborating partner.

Project 2019-05 ("*Improving the characterization of discard mortality of Pacific halibut in the recreational fisheries*") proposes determining mortality rates of discarded Pacific halibut in the Pacific halibut recreational fisheries. This study will be conducted with partial funding from a grant from the National Fish and Wildlife Foundation awarded to IPHC in collaboration with academic and industry partners.

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 FISS or as part of the commercial fishery data collection program. Ongoing data collections projects that are continuing in 2019 include the following:

IPHC FISS

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 FISS (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 FISS 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 the FISS in selected areas during most years since 1963. The majority of the current FISS station design and sampling protocols have been consistent since 1998.

Environmental data collection aboard the IPHC FISS using water column profilers

PIs: Lauri Sadorus, Jay Walker

The IPHC collects oceanographic data using water column profilers during the IPHC FISS. 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 Oceanic and Atmospheric Administration (NOAA) Fisheries 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 NOAA Fisheries Aleutian Islands trawl survey, which takes place every two years, since 2012. Alternating year by year with the Aleutian Islands trawl survey is the NOAA Fisheries Gulf of Alaska trawl survey, which IPHC has participated in since 1996. The IPHC uses the NOAA Fisheries trawl surveys to collect information on Pacific halibut that are not yet vulnerable to the gear used for the IPHC FISS 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

The IPHC positions field staff to sample the commercial landings for Pacific halibut in Alaska, British Columbia, Washington, and Oregon. Sampling of commercial landings 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.

Assessment

The 2018 stock assessment produced the following scientific advice regarding the Pacific halibut stock:

1. Fishing intensity: The IPHC does not have an explicit coastwide fishing intensity target or limit reference point, making it difficult to determine if current levels of fishing intensity are consistent with the interim harvest strategy policy objectives. However, given the healthy female spawning biomass and the TAC set for 2018 only being marginally higher than the levels estimated to maintain biomass at or near current levels of 43%, on the weight-of-evidence, the stock is classified as **not subject to overfishing**.
2. Spawning biomass: Female spawning stock biomass of Pacific halibut at the beginning of 2018 was estimated to be 43% (27–63%) of the SB_0 (unfished levels) defined by the interim harvest strategy policy. The probability that the stock is below the SB_{30} level (IPHC trigger) is estimated to be 11%, with less than a 1% chance that the stock is below SB_{20} (IPHC limit reference point). Thus, on the weight of evidence available, the Pacific halibut stock is determined to be **not overfished** (SB_{2019} > SB20%).
3. Outlook: The stock is projected to decrease over the period from 2019-22 for all TCEYs greater than 20 million pounds (~9,070 t), corresponding to a Spawning Potential Ratio (SPR) of 64%. At the reference level (SPR of 46% and a TCEY of 40 Mlbs or 18,140 t) the probability of at least a 5% decrease in stock size increases over time from 37% (2020) to 86% (2022). There is a one third chance (<34/100) that the stock will decline below the threshold reference point (SB30%) in projections for all the levels of fishing intensity up to an SPR of 40% evaluated over three years.

For more information on the 2018 stock assessment and the fishery status, as well as the harvest decision table indicating levels of risk associated with various levels of removals, please refer to papers IPHC-2019-AM095-09 and IPHC-2019-AM095-10 (https://iphc.int/uploads/pdf/am/2019am/iphc-2019-am095-09.pdf and https://iphc.int/uploads/pdf/am/2019am/iphc-2019-am095-10.pdf), which can be found on the meeting page at the IPHC website.

Management

The International Pacific Halibut Commission (IPHC) completed its 95th Annual Meeting (AM095) in Victoria, British Columbia, Canada, on 1 February 2019, with Mr. Paul Ryall of Canada presiding as Chairperson. More than 200 Pacific halibut industry stakeholders attended the meeting, with over 140 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://www.iphc.int/venues/details/95th-session-of-the-iphc-annual-meeting-am095.

Regulatory Changes: Fishery Limits and Fishing Periods

The fishery regulations approved by the IPHC, including fishery limits and fishing periods, will be recommended to the Contracting Parties for implementation according to their domestic law and regulation, in accordance with the Convention[1].

Fishery Limits

The Commission adopted distributed mortality (TCEY) values for each IPHC Regulatory Area as shown in **Table 3**.

Table 3. Distributed mortality (TCEY) by IPHC Regulatory Area

IPHC Regulatory Area	***Distributed mortality limits (TCEY) (net weight*)***	
	Metric tons (t)	**Pounds (lb)**
Area 2A (California, Oregon, and Washington)	748.43	1.65M
Area 2B (British Columbia)	3,098.04	6.83M
Area 2C (southeastern Alaska)	2,875.78	6.34M
Area 3A (central Gulf of Alaska)	6,123.50	13.50M
Area 3B (western Gulf of Alaska)	1,315.42	2.90M
Area 4A (eastern Aleutians)	879.97	1.94M
Area 4B (central/western Aleutians)	657.71	1.45M

[1] *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*.

Areas 4CDE (Bering Sea)	1,814.37	4.00M
Total	**17,513.20**	**38.61M**

*"net weight" of a Pacific halibut means the weight of Pacific halibut that is without gills and entrails, head-off, washed (without ice and slime). If a Pacific halibut is weighed with the head on or with ice and slime, the required conversion factors for calculating net weight are a 2 percent deduction for ice and slime and a 10 percent deduction for the head.

The Commission adopted the mortality limits for each Contracting Party, by IPHC Regulatory Area and sector, as shown in Table 4.

Table 4. Mortality table projected for the 2019 mortality limits by IPHC Regulatory Area, in millions of pounds

Sector	**IPHC Regulatory Area**								
	2A	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**4CDE**	**Total**
Commercial discard mortality	0.02	0.13	NA	NA	0.19	0.09	0.02	0.04	**0.50**
O26 Bycatch	0.13	0.27	0.03	1.28	0.36	0.18	0.22	1.87	**4.33**
Non-CSP Recreational (+ discards)	NA	0.08	1.38	1.74	0.00	0.01	0.00	0.00	**3.21**
Subsistence	NA	0.41	0.44	0.22	0.01	0.01	0.00	0.06	**1.14**
Total Non-FCEY	0.15	0.88	1.85	3.24	0.57	0.29	0.24	1.96	**9.18**
Commercial discard mortality	NA	NA	0.06	0.31	NA	NA	NA	NA	**0.37**
CSP Recreational (+ discards)	0.60	0.84	0.82	1.89	NA	NA	NA	NA	**4.16**
Subsistence	0.03	NA	NA	NA	NA	NA	NA	NA	**0.03**
Commercial Landings	0.86	5.10	3.61	8.06	2.33	1.65	1.21	2.04	**24.88**
Total FCEY	**1.50**	**5.95**	**4.49**	**10.26**	**2.33**	**1.65**	**1.21**	**2.04**	**29.43**
TCEY	**1.65**	**6.83**	**6.34**	**13.50**	**2.90**	**1.94**	**1.45**	**4.00**	**38.61**
U26 Bycatch	0.00	0.02	0.00	0.37	0.11	0.10	0.01	1.12	**1.73**
Total Mortality	**1.65**	**6.85**	**6.34**	**13.87**	**3.01**	**2.04**	**1.46**	**5.12**	**40.34**

Fishing Periods (season dates)

The Commission adopted an overall fishing period (season) of 15 March – 14 November 2019 for all commercial Pacific fisheries in Canada and the USA. In IPHC Regulatory Area 2A, the tribal commercial fisheries and the incidental Pacific halibut fisheries will occur within these dates, and the non-tribal directed commercial fishery will consist of 10-hour derby fishing periods, including 26 June, 10 July, 24 July, 7 August, 21 August, 4 September, and 18 September, with other possible dates to be determined by the IPHC Secretariat.

Other Actions

Harvest Strategy Policy

The Commission provided direction to the IPHC Secretariat and the Management Strategy Advisory Board (MSAB) for further work on harvest strategy policy development, noting that scale and distribution components will be evaluated and presented no later than at the 97th Annual Meeting (AM097) in 2021, for potential adoption and subsequent implementation as a harvest strategy.

Expanded fishery-independent setline survey (FISS)

The IPHC approved the last in a series of expansions to its annual FISS. The purpose of the expansion series is to provide more accurate and precise estimates among regulatory areas and to encompass all depths over which the stock is distributed. In 2019, the FISS in IPHC Regulatory Areas 3A and 3B will be expanded beyond the standard grid of FISS stations fished each year.

Upcoming Meetings

The IPHC's 95th Interim Meeting will be held 25-26 November 2019, in Seattle, Washington. The IPHC's 96th Annual Meeting (AM096) is planned for 3-7 February 2020 in Anchorage, Alaska, and the 97th Annual Meeting (AM097) is planned for 25-29 January 2021 in Victoria, British Columbia.

Commission Membership

United States Government Commissioner Mr. Chris Oliver was elected Chairperson for the coming year. Canadian Government Commissioner Mr. Paul Ryall was elected Vice-Chairperson. The other Canadian Commissioners are Mr. Neil Davis and Mr. Peter DeGreef. The other US Commissioners are Mr. Robert Alverson and Mr. Richard Yamada.

Meeting Report

The Report of the 95th Session of the IPHC Annual Meeting (AM095) has been published and posted at the Annual Meeting page of the IPHC website: https://www.iphc.int/uploads/pdf/am/2019am/iphc-2019-am095-r.pdf. The Report includes details on all the decisions, recommendations, and requests made by the Commission during the Annual Meeting.

Ecosystem Studies

[See the description of "Environmental data collection aboard the IPHC FISS using water column profilers" in the Research section on ongoing IPHC data collection projects above.]

Publications

International Pacific Halibut Commission. 2018. Annual Report 2018. https://www.iphc.int/uploads/pdf/ar/iphc-2018-annual-report.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 2019

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 2018, 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 Acting Division Director, Dr. Jim Hastie at Jim.Hastie@noaa.gov, (206) 860 – 3412.

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 twenty-first annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2018 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 2018, we continued to utilize 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) collection of DNA and/or whole specimens of rougheye rockfish (*Sebastes aleutianus*), blackspotted rockfish (*Sebastes melanostictus*), darkblotched rockfish (*Sebastes crameri*) and

blackgill rockfish (*Sebastes melanostomus*) to reduce uncertainty in the assessment of morphologically-similar west coast rockfish – Northwest Fisheries Science Center;
3) Collect fin clips and other tissues from all Pacific sharks (*Somniosus pacificus*) to examine genetics – NOAA, NWFSC – Cindy Tribuzio

4) Collect all specimens of sharpnose sculpin (*Clinocottus acuticeps*) for species confirmation – Dan Kamikawa

5) Request for photographs of lamprey scars and specimens for Pacific lamprey (*Lampetra tridentata)* and river lamprey (*Lampetra ayresii* – Laurie Weitkamp, NWFSC, Conservation Division, Newport;

6) Identify to species all Pacific Lamprey (*Lampetra tridentata*) then collect and freeze each specimen individually – Laurie Weitkamp, NWFSC, Conservation Division, Newport;

7) Identify to species all river Lamprey (*Lampetra ayresii*) then collect and freeze each specimen individually – Laurie Weitkamp, NWFSC, Conservation Division, Newport;

8) Collection of all biological data and specimens of deepsea skate (*Bathyraja abyssicola*) and broad skate (*Amblyraja badia*) - Moss Landing Marine Laboratories;

9) Collect and freeze all specimens of Pacific black dogfish (*Centroscyllium nigrum*), velvet dog shark (*Zameus squamulosus*) and cookiecutter shark (*Isistius brasiliensis*). – Moss Landing Marine Laboratories;

10) 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;

11) Collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* and velvet dog shark (*Zameus squamulosus*) – Moss Landing Marine Laboratories;

12) Collection of any chimaera that is not a spotted ratfish (*Hydrolagus colliei*), including: *Harriotta raleighana*, *Hydrolagus* spp. and *Hydrolagus trolli* – Moss Landing Marine Laboratories;

13) Collection of voucher specimens for multiple fish species – Oregon State University;

14) Coral population genetics - Collect whole specimens of *Desmophyllum dianthus* - in 95% ETOH – Cheryl Morrison;

15) 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;

16) Retain whole specimens of big skate (*Beringraja binoculata*), California skate (*Raja inornata*) and starry skate (*Raja stellulata*) captured at depths greater than 500 m

17) 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 2018 West Coast Groundfish Trawl Survey;

8) Collection of ovaries and finclips from bank rockfis, brown rockfish, copper rockfish, lingcod, shortspine thornyhead, Pacific hake, cowcod, vermilion/sunset rockfish, and Pacific cod, Dover sole, sablefish, yelloweye rockfish,

9) Collection of ovaries from cowcod and yelloweye rockfish species, thornyheads and other species to assess maturity;

10) Collection of prey items for multiple species for stable isotope analysis

11) Collection of stomachs for non-rockfish species (arrowtooth flounder, Pacific sanddab, petrale sole, sablefish, and lingcod;

12) Collection of voucher specimens for teaching purpose;

13) Photograph, tag, bag and freeze deep water species such as arbiter snailfish (*Careproctus kamikawi*) and other rare or unidentified deep water species;

14) macroscopic analysis of maturity of big skate and longnose skate.

For more information please contact Aimee Keller at Aimee.Keller@noaa.gov

B. Southern California shelf rockfish hook-and-line survey

In early Fall 2018, FRAM personnel conducted the 15th 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*), bank rockfish (*S. rufus*), copper rockfish (*S. caurinus*), greenspotted rockfish (*S. chlorostictus*), cowcod (*S. levis*) blue rockfish (*S. mystinus*), speckled rockfish (*S. ovalis*), the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) and lingcod (*Ophiodon elongatus*) within the SCB.

The F/V Aggressor (Newport Beach, CA), F/V Mirage (Port Hueneme, CA), and F/V Toronado (Long Beach, CA) were each chartered for 14 days of at-sea research, with 14 biologists participating during the course of the survey. The three vessels sampled a total of 201 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 201. It is anticipated that monitoring at these sites will continue during subsequent surveys.
Some experimental resampling (7 sites)

47 species

8480 lengths

5280 oties

7100 finclips

279 Tagged fish

483 ovary specimens from 11 species

Including supplementary experimental sampling at 7 sites, the survey encountered 8,567 individual fish representing 47 species. Data collected included 8,480 sexed lengths and weights, 5,280 otolith pairs, 7,100 finclips. Approximately 483 ovaries were collected from 11 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 third consecutive year, the survey encountered whitespeckled rockfish (S. moseri) - a species rarely captured with fishing gear. There are fewer than 12 documented captures of S. moseri, and several of the individuals caught on the hook and line survey were submitted to the University of Washington’s Burke Museum. The survey captured two specimens not encountered on previous surveys: a Pacific round herring (Etrumeus acuminatus) and a Pelagic stingray (Pteroplatytrygon violacea). In most years, researchers also deploy an underwater video sled to capture visual observations for habitat analysis, species composition, and fish behavior studies, however the video sled was not available for this year’s survey. The survey continued to descend or release and tag all individuals captured at 6 sites located inside federal marine reserves. To date, just under 900 individuals have been tagged. 2018 was the third year following implementation of the HookLogger wireless electronic data collection system on board survey vessels. This system networks two mobile tablet workstations on the back deck with a desktop computer inside the galley with each machine writing to a common database using customized UI and networking software. HookLogger has eliminated the need for post-survey manual data entry and has improved data quality by integrating real-time validations and other error checking.

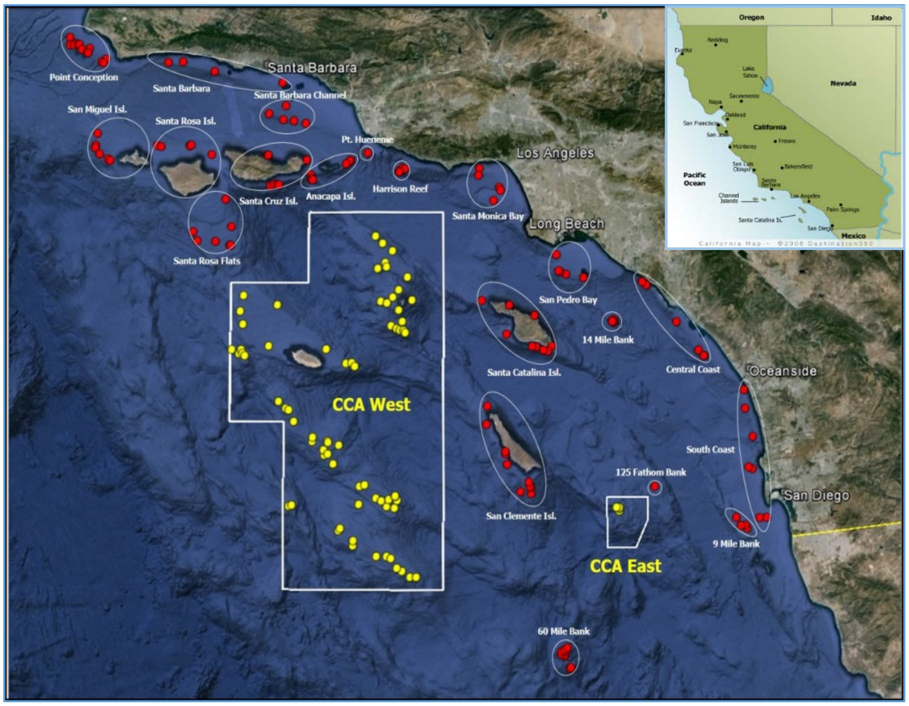

Figure 1. Sampling locations for the 2018 Hook and Line Survey located inside (yellow dots) and outside (red dots) the Cowcod Conservation Areas (CCAs).

For more information, please contact John Harms at John.Harms@noaa.gov

C. 2018 California Current Ecosystem (CCE18): Investigations of hake ecology, survey methods, and the California Current ecosystem

The summer 2018 research cruise (CCE18) was conducted in U.S. and Canadian waters by scientists from the Northwest Fisheries Science Center, FRAM Division on the NOAA Ship *Bell M. Shimada* from 19 August 2018 to 14 September 2018. The operating area was from roughly 42.5°N (Cape Blanco, Oregon) to 48.6°N (southern Vancouver Island, British Columbia). The *Shimada* headed north from Newport, Oregon along Oregon and Washington to Vancouver Island on Leg 1; on Leg 2, the *Shimada* wert south from Seattle along the Washington and Oregon coasts. Acoustic transects were oriented east-west and were run during daylight hours only. Scouting for hake off acoustic transects was also conducted. Acoustic data were collected day and night with Simrad EK60 narrowband and EK80 broadband scientific echosounders operating at frequencies of 18, 38, 70, 120, and 200 kHz. The *Shimada* conducted 22 successful midwater trawls targeting hake, resulting in a combined total hake catch of 3,776 kg. Hake accounted for 21% of the total catch; widow rockfish accounted for 62%. Of the 22 trawls, six paired trawls compared codend liners of different mesh sizes (32 mm vs. 7 mm). Initial results show no significant difference between nets with regards to opening height and scope. Hake length frequencies displayed no obviously big or small cutoff. For catch composition, key fish and invertebrates were present in both nets; no pattern was observed in species proportions. Data for comparisons of the EK60 with the EK80 were collected in a wide variety of settings and conditions. In general, the comparison looked reasonable.

For more information, please contact Sandy Parker-Stetter at sandy.parker-stetter@noaa.gov.

D. Trig-cam Pilot Study

Investigators: Victor Simon, Peter Frey, John Harms and Aimee Keller

The Northwest Fishery Science Center's Fishery Research Survey team conducted a 2-day pilot study (July 22-23, 2018) using a stationary camera system, developed by the Alaska Fishery Science Center, to test its suitability for surveying rockfish abundance in untrawlable habitats along the U.S. west coast. The study involved 2 vessel days aboard the chartered west coast fishing vessel the F/ V Excalibur, following completion of the first half of our annual trawl survey in July 2018. A total of 79 camera drops occurred using six camera units equipped with environmental sensors, at depths of 48 to 146 m on or near Stonewall Bank off the Oregon coast (Figure 2). A total of 40 to 200 photographs were taken per site with yellowtail, yelloweye, canary, greenstriped, and other rockfishes the dominant species observed. Additionally, some flatfishes were present and some sites had no fish photographed. We determined that chartered commercial boats with extensive crabbing experience make excellent platforms for efficient deployment and retrieval of these systems and that the effort requires the same number of scientist and vessel crew as standard trawl survey operations (3 scientists, 1 captain, and 3 deckhands) to maintain operational efficiency over time. Scientists needed time during deployments to optimize the camera system by adjusting sinker weight, height off seafloor, camera angle and light in response to changing environmental conditions such as cloud cover, water clarity, and currents. Following deployment cameras remained in place for 10 to 50 minutes with many images of fish captured (canary, yelloweye, yellowtail, greenstriped and other rockfishes as well as some flatfish) but other images with no fish present. A wireless approach for downloading images proved effective; however, network and onboard hardware should be improved to increase downloading speed. The system could be readily adapted to incorporate additional environmental sensors to provide ecosystem data. Overall, the system holds promise for certain applications – particularly if a project does not require accompanying biological data. The value of the data for managing fisheries will be evaluate after we review images and attempt to use existing software to calculate lengths. We believe this camera system offers exciting potential for sampling untrawlable or sensitive habitats where bottom trawls cannot or should not be used, however additional rigorous testing and comparisons are needed to clearly identify pros and cons relative to other new and existing technologies. We are exceedingly grateful to our colleagues at the Alaska Fishery Science Center for both lending the cameras to us as well as providing guidance and support on their use.

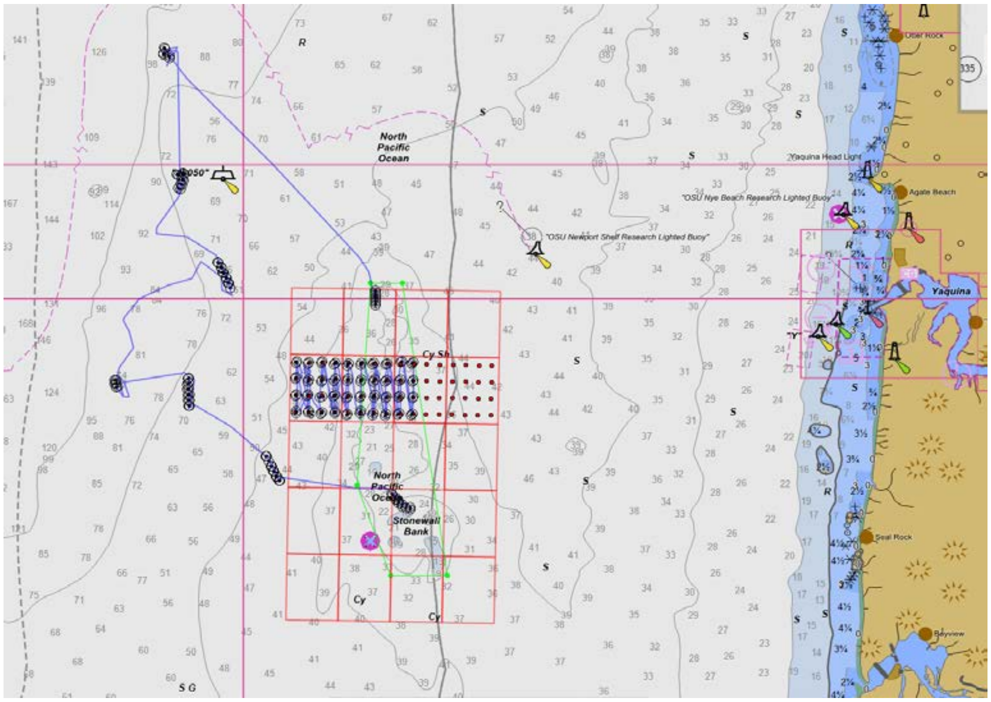

Figure 2. Locations where drop camera was deployed during 2018 pilot study.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

III. Reserves

A. Size and catch of demersal fish within the Southern California Bight in relation to Cowcod Conservation Areas (2014 – 2016)

Investigators: Aimee A. Keller, John H. Harms, John R. Wallace, Colin Jones, Jim A. Benante, and Aaron Chappell

In 2001, the Pacific Fishery Management Council established two large (10878 km2 and 260 km2) Southern California Bight marine reserves called the Cowcod Conservation Areas (CCAs) in response to declining abundance of west coast rockfishes, particularly overfished cowcod. Following closure, no fishery independent monitoring took place for groundfishes within the CCAs through 2013. To assess the impact of the closures, we sampled multiple sites inside versus outside CCAs from 2014 to 2016 via the Northwest Fisheries Science Center's Hook and Line Survey. We investigated variations in catch per unit effort (CPUE), size, length frequency and percent of sites with positive catch for 14 abundant groundfish (bank, bocaccio, chilipepper, copper, cowcod, greenspotted, lingcod, olive, rosy, speckled, squarespot, starry, swordspine and the vermilion-sunset complex). General Linear Models (GLMs) that included area, year, depth and distance from port revealed significantly greater CPUE inside CCAs for 11 species and significantly lower CPUE ($P < 0.04$) for copper, lingcod, and the vermilion complex. For 11 species and the vermilion complex, we saw significant differences ($P < 0.05$) in size and length frequency with larger fish present inside CCAs. The percentage of sites positive for individual species tended to be greater inside CCAs for 11 species. We also observed significantly elevated species richness (species per site) and total CPUE inside the CCAs. Results indicated that establishment of the CCAs proved an effective management tool leading to larger individuals and greater CPUE for multiple rockfishes.

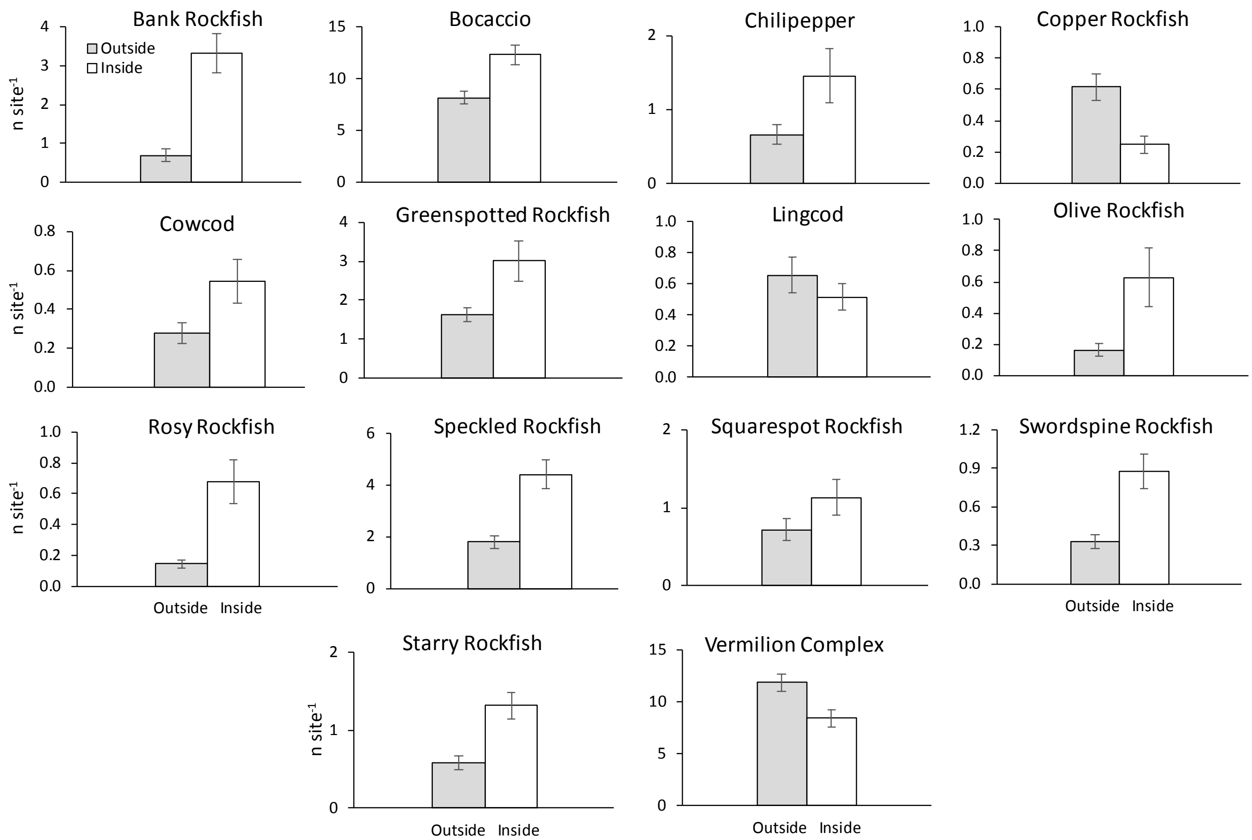

Figure 3. Species-specific standardized CPUE (n site^{-1}) for bank rockfish, bocaccio, chilipepper rockfish, copper rockfish, cowcod, greenspotted rockfish, lingcod, olive rockfish, rosy rockfish, speckled rockfish, squarespot rockfish, starry rockfish, swordspine rockfish, and the vermilion-sunset complex collected during the 2014 – 2016 Hook and Line Surveys. Means and standard errors (+ SE) are shown for each species inside (grey bars) and outside (white bars) the CCAs.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

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

A. Hagfish

1. No reported research occurred in 2018

2. No assessment occurred in 2018

B. Dogfish and other sharks

1. No reported research occurred in 2018

2. No assessment occurred in 2018

C. **Skates**
   1. **No reported research occurred in 2018**
   2. **No assessment occurred in 2018**

D. **Pacific cod**
   1. **No reported research occurred in 2018**
   2. **No assessment occurred in 2018**

E. **Walleye Pollock**
   1. **No reported research occurred in 2018**
   2. **No assessment occurred in 2018**

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 - 2018. 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 – 2017, 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% (L50, A50) maturity were estimated at 33.4 cm and 2.3 years. However, L50 results north and south of Pt. Conception varied substantially, with corresponding L50 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.

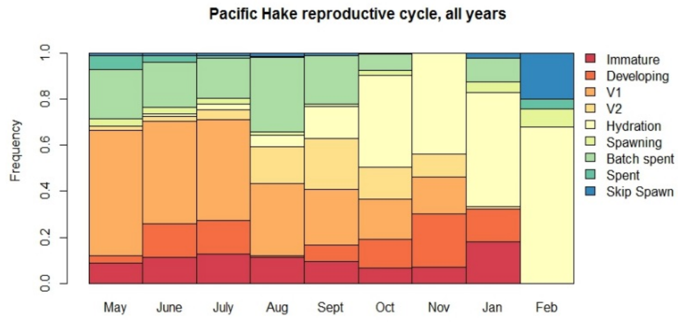

Figure 4. Temporal trends in Pacific hake reproductive cycle – coastwide with all years combined.

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

Authors: A. Berger, C. Grandin, I. Taylor, A. Edwards, S. Cox

This stock assessment reported the collaborative efforts of the official U.S. and Canadian JTC members in accordance with the Agreement between the government of the United States and the government of Canada on Pacific hake/whiting. The assessment reported the status of the coastal Pacific Hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the United States and Canada for 2017. Coast-wide fishery landings of Pacific hake averaged 226 thousand mt from 1966 to 2016, with a low of 90 thousand mt in 1980 and a peak of 363 thousand mt in 2005. Prior to 1966 the total removals were negligible relative to the modern fishery. Recent coast-wide landings from 2007–2016 have been above the long term average, at 262 thousand mt. Landings between 2013 and 2013 were predominantly comprised of fish from the very large 2010-year class, comprising around 70% of the total removals. In 2016, U.S. fisheries caught mostly 2- and 6-year old fish from the 2010 and 2014 year classes, while the Canadian fisheries encountered mostly 6-year old fish from the 2010 year-class. The Agreement between the United States and Canada establishes U.S. and Canadian shares of the coast-wide TAC at 73.88% and 26.12%.

Data were updated for the 2017 assessment with the addition of fishery catch and age compositions from 2016, reanalyzed acoustic survey biomass and age compositions for 1995 (completing the reanalyzed acoustic survey time series initiated in the 2016 model), and other minor refinements such as catch estimates from earlier years. The assessment used Bayesian methods to incorporate prior information on two key parameters (natural mortality, *M*, and steepness of the stock-recruit relationship, *h*) and integrated over parameter uncertainty to provide results that can be probabilistically interpreted. The exploration of uncertainty was not limited to parameter uncertainty as structural uncertainty was investigated through sensitivity analyses. Pacific Hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts resulting in time-varying selectivity, and little data to inform incoming recruitment until the cohort is age-2 or greater, will, in most circumstances, continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Uncertainty in this assessment is largely a function of the potentially large 2014 year-class, which has been observed twice by the fishery but has yet to be observed by the acoustic survey, and uncertain selectivity. However, with recruitment being a main source of uncertainty in the projections and the survey not able to monitor the 2014 year-class until they are 3 years old (i.e., summer 2017), short term forecasts are very uncertain.

The base model estimates indicate that since the 1960s, Pacific hake female spawning biomass has ranged from well below to near unfished equilibrium biomass. The model estimates that the stock was below the unfished equilibrium in the 1960s and 1970s, increased toward the unfished equilibrium after two or more large recruitments occurred in the early 1980s, and then declined steadily through the 1990s to a low in 2000. This long period of decline was followed by a brief peak in 2003 as the large 1999-year class matured and subsequently supported the fishery for several years. Estimated female spawning biomass declined to an all-time low of 0.565 million mt in 2009 because of low recruitment between 2000 and 2007, along with a declining 1999-year class. Spawning biomass estimates have increased since 2009 on the strength of large 2010 and 2014 cohorts and an above average 2008 cohort. The 2017 female spawning biomass is estimated to be 89.2% of the unfished equilibrium level (B_0) with a 95% posterior credibility interval ranging from 37% to 271%. The median estimated 2017 female spawning biomass is 2.13 million mt.

Estimates of historical Pacific hake recruitment indicate very large year classes in 1980, 1984, 1999, and 2010. The U.S. fishery shows that the 2014 year-class comprised a very large proportion of the observations in 2016. Uncertainty in estimated recruitments is substantial, especially for 2014, as indicated by broad posterior intervals. The fishing intensity on the Pacific Hake stock is estimated to have been below the $F_{40\%}$ target except for 1999 when the median estimated fishing intensity was slightly above target. Fishing intensity has been substantially below the $F_{40\%}$ target since 2012. Although the official catch targets adopted by the U.S. and Canada have been exceeded only once in the last decade (2002), fishing intensity is estimated to have not exceeded the target rate in the last 10 years. Recent catch and levels of depletion are presented in Figure 5.

Management strategy evaluation tools will be further developed to evaluate major sources of uncertainty relating to data, model structure and the harvest policy for this fishery and compare potential methods to address them. A spatially explicit operating model is needed, so forthcoming research will focus on how best to model these dynamics, including the possible incorporation of seasonal effects and potential climate forcing influences in the simulations.

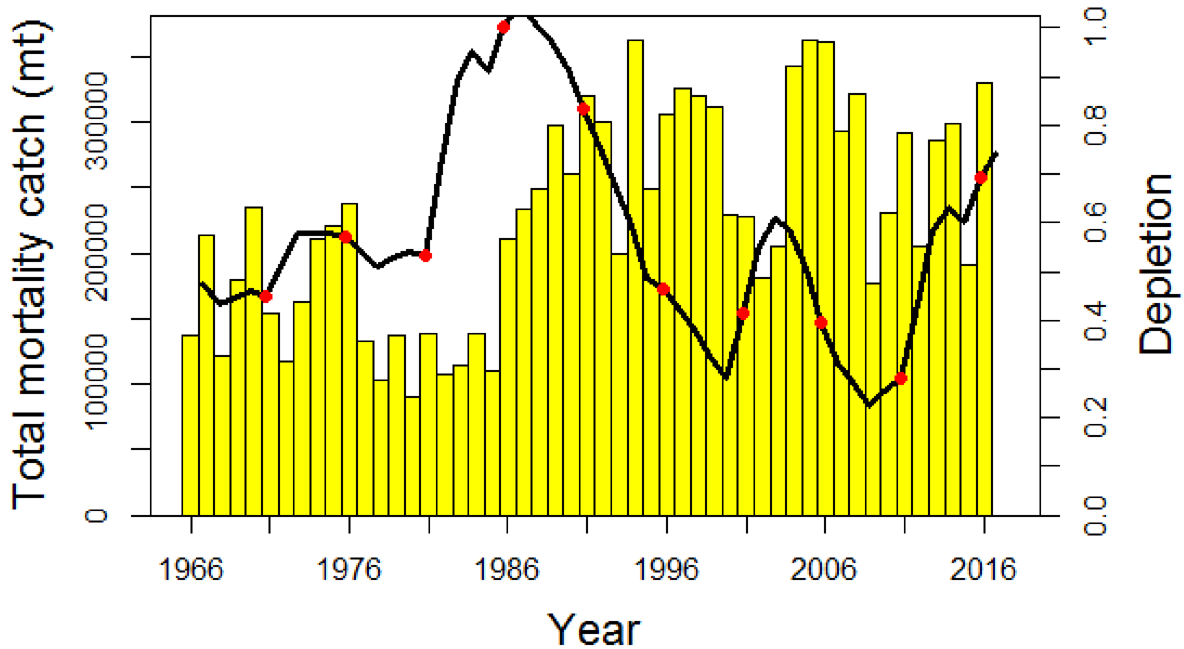

Figure 5. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2016.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov.

H. Rockfish

1. Research

A. Investigating spatial and temporal variation in reproductive trends in aurora rockfish (*Sebastes aurora*)

Investigators: Melissa A. Head, Jason M. Cope and Sophie H. Wulfing

The authors outline a new method for estimating maturity that incorporates skip or abortive spawning events leading to potentially non-asymptotic behavior in the population maturity schedule. They also introduce a flexible model that captures these functional reproductive changes, including fish that have spawned before but may not in a given year. This new approach aids fisheries managers who seek to understand marine species' responses to different oceanographic regimes over time and space. In an effort to assess shifts in maturity and spawning behavior of West Coast groundfish, this new method was used to evaluate spatial and temporal trends in length at maturity, the annual reproductive cycle, and spawning behavior of aurora rockfish (*Sebastes aurora*). Ovaries (n = 538) were collected by the Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey from 2012 – 2016. The authors estimated biological (presence of physiological maturity markers) and functional (potential spawners in a given year) maturity using a standard logistic and the new flexible spline model. The range in estimated lengths at 50% maturity (biological and functional) varied only slightly between the two modelling methods (23.62 – 23.93 and 25.46 – 25.57 cm). They also investigated geographic trends in length at maturity and found ~2 cm difference in functional maturity between fish sampled north (GLM = 26.48 ± 0.82) and south of Cape Mendocino, CA (GLM = 24.74 ± 0.62). Model sensitivity was examined by changing the maturity estimates in the 2013 aurora rockfish stock assessment using these updated data, and resultant maturity estimates from the logistic and spline models at different spatial scales. The new flexible spline model described in this research has the ability to account for skip spawning in adults, and thus is a better method for estimating potential spawners in a given year. Spawning output, but not relative stock status, was sensitive to model choice, spatial resolution, and the updated data.

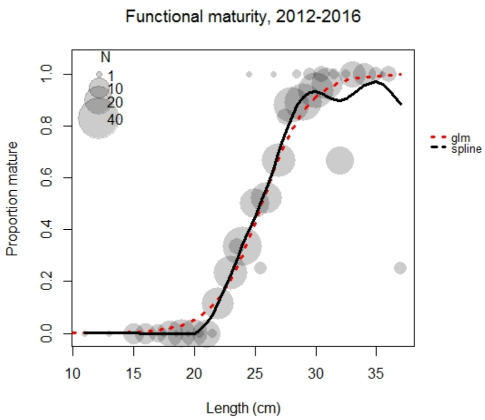

Figure 6. Length (cm) at maturity estimates for aurora rockfishes showing the coast-wide GLM (red dashed line) and spline (black solid line) fit for functional maturity (i.e. incorporating skip or abortive spawning events)

V. Ecosystem Studies

A. Identification of pelagic and demersal fish predators on gelatinous zooplankton in the Northeast Pacific Ocean

Investigators: Richard D. Brodeur, Troy W. Buckley, Richard E. Hibpshman, John C. Buchanan, and Douglas L. Draper

Pelagic coelenterates (Cnidaria and Ctenophora) and urochordates (salps and appendicularians) have been considered important consumers or predators in marine food webs for many years but have only more recently been recognized as important prey for many marine species. We summarize data obtained from > 100 Northeast Pacific fish predators based on extensive food habits analyses (~350,000 stomachs examined) from broad-scale surveys of pelagic and demersal fishes ranging from the Bering Sea to the Southern California Current. In the Bering Sea, we identified 16 predators on coelenterates and 14 on thaliaceans. In the Aleutian Islands, 16 and 18 predators were identified for the two jellyfish groups and a total of 15 and 24 predators, respectively, were found in the Gulf of Alaska. In the California Current, we identified 12 coelenterate predators and 4 thaliacean predators. We identified several hitherto unknown predators of jellyfish and examined factors related to predation on jellyfish. Dominant pelagic consumers of coelenterates include dogfish, rockfish, hake, medusafish, and saury and consumers of thaliacians included salmon, walleye pollock, and sablefish. We also show that the occurrence of coelenterate prey is generally much higher in stomachs of several fish species examined fresh at sea compared with that found in stomachs of the same species examined in the laboratory following preservation. Differences were less pronounced with the more durable salp prey. We suggest that many existing estimates of predation on readily digested gelatinous prey may underestimate the true predation rate and their importance in marine food webs.

B. Assessment Science

1. Modeling

a) Incorporating fishing time from the Southern California Bight Hook and Line Survey in model outputs to improve abundance indices used in stock assessments

Investigator: Danni Shi (Varanasi Scholar from the University of Washington)

This research focused on using survival analysis as a tool to analyze time series of rockfish catch to improve estimates of catch rate and abundance indices for use in stock assessments. In general, survival regression models can indicate the effects from different variables (i.e. continuous variables such as sea surface temperature or categorical variables such as sampling site) upon the survival rate. The author compared a parametric survival regression model (e.g. Weibull-distribution-based model) and a semi-parametric approach (Cox models with no assumption of the baseline function) using both categorical and continuous variables. For example, to determine if different levels of categorical variables affected survival rate, the survival rate was plotted against fishing time (catch rate) for each level of a factor (Figure 7, A-I). The resulting plots clearly indicated differences in survival rate by area (B), vessel (C) and location (inside versus outside the cowcod conservation area, I) with lesser or no influence by year (A), moon phase (D), drop number (E) , angler (F) , hook number (G) or tide phase (H). The results indicated a steeper decline in survival rate inside the cowcod area (either grouped by area of collectively) and by the Aggressor as indicated by shorter fishing time. Results varied by species and model but indicated that incorporating fishing time in model outputs via survival regressions has the potential to improve abundance estimates used in stock assessments

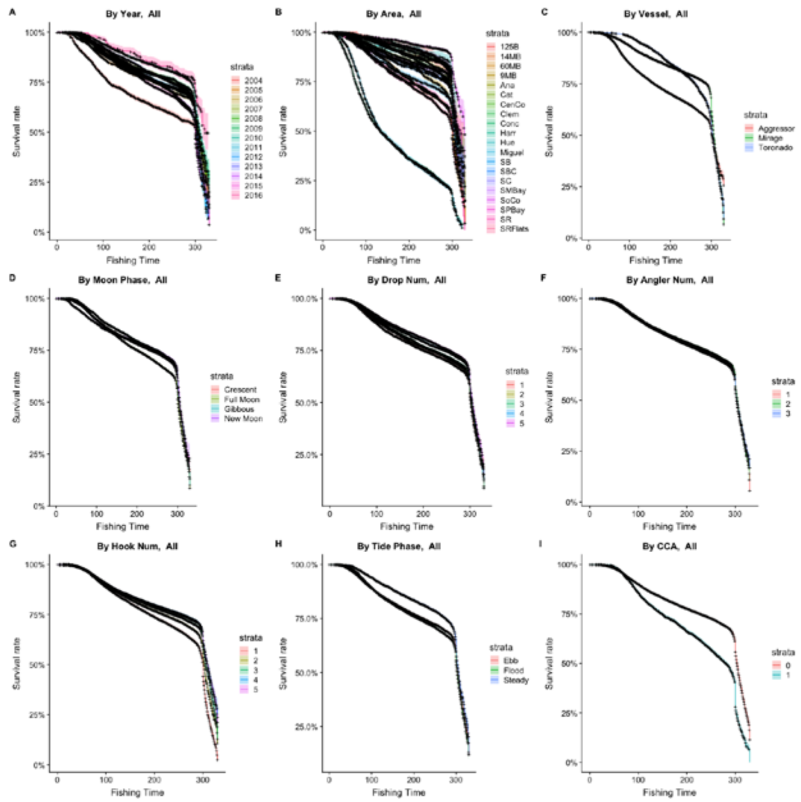

Figure 7.

b) The effect of survey frequency and intensity on U.S. West Coast stock assessment estimates

Investigators: Owen S. Hamel, Ian G. Taylor, Jason M. Cope, Vladlena Gertseva, Melissa A. Haltuch, Aimee Keller, Andi Stephens, James T. Thorson, John R. Wallace, Chantel R. Wetzel

Fisheries management systems rely on stock assessments to inform management. Stock assessments, in turn, rely on well-designed and comprehensive surveys to provide data necessary to estimate scale and trends in fish populations. Given limited budgets and the financial demands of conducting surveys and the concomitant laboratory and analytical requirements, it is important to consider tradeoffs in designing our surveys, and evaluate alternative ways to reduce survey effort if required. We conducted a retrospective analysis of the impact of reducing the intensity or frequency of the U.S. West Coast Groundfish Bottom Trawl survey across eleven recently assessed species. We considered reducing the survey by approximately half through either an every-other year survey or reducing the number of charted vessels from four to two in each year. The influence of the survey reductions on assessment outputs and catch limits depend upon species life-history, frequency of occurrence in the current survey, and the data-richness of each assessment. All approaches to reducing survey sampling led to increased uncertainty in stock assessment results, while variability in assessment results among survey configurations was greatest for rockfish species, which are less commonly encountered in the survey, and for data-moderate assessments which rely more heavily on survey data.

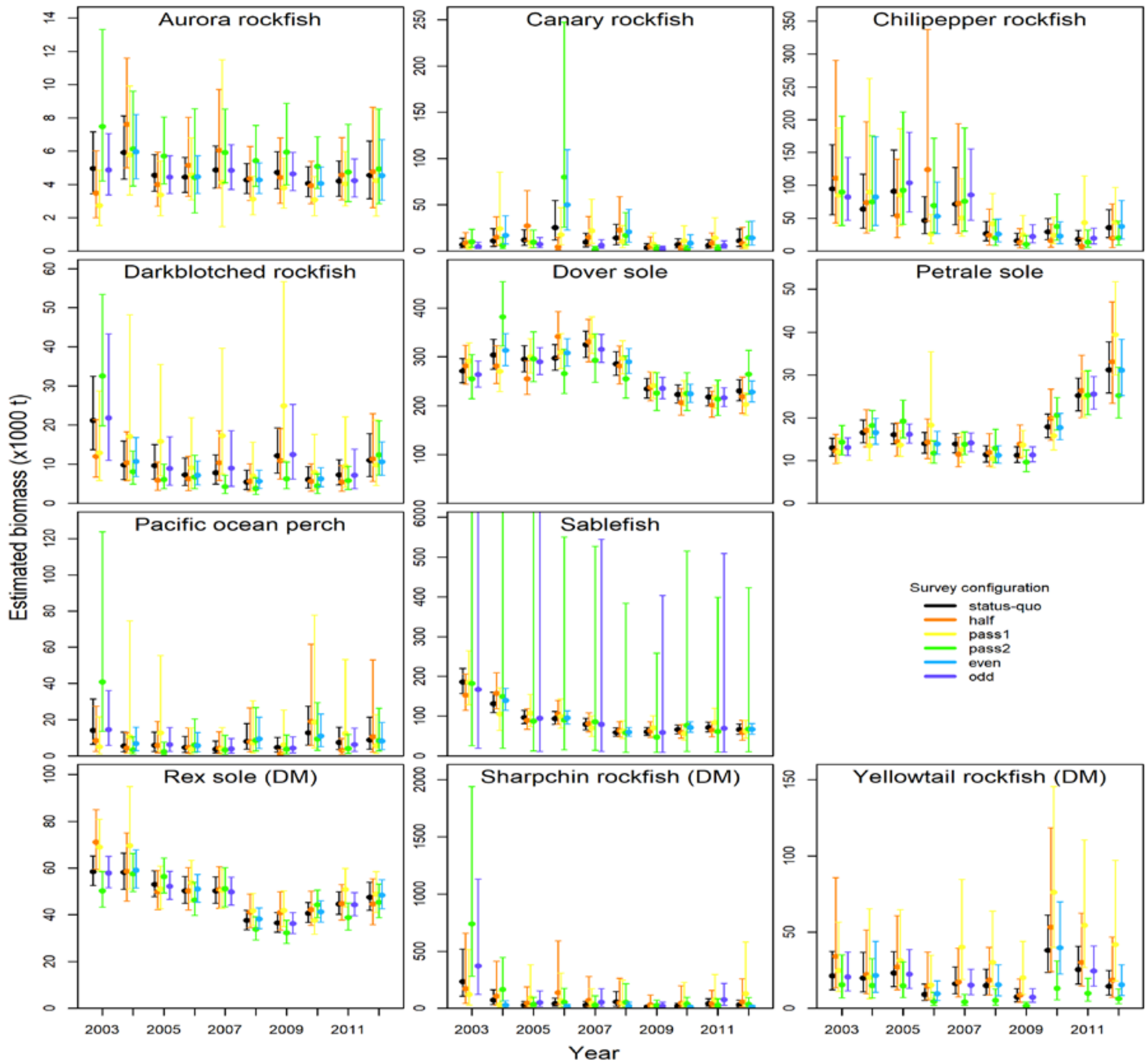

Figure 8. GLMM-derived indices of abundance and 75% lognormal confidence intervals for each survey configuration for each species. "DM" indicates species with Data Moderate stock assessments. The upper limit of the confidence intervals for sablefish that extend beyond the range of the figure are 1,451,000 t and 777,000 t for "odd" in 2003 and 2005, and 1,314,000 t, 1,131,000 t, and 616,000 t for "pass2" in 2003-2005.

2. Survey Science and Observer Science

a) Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator (*Pycnopodia helianthoides*)

Investigators: C. D. Harvell, D. Montecino-Latorre, J. M. Caldwell, J.M. Burt, K. Bosley, A. Keller, S.F. Heron, A.K. Salomon, L. Lee, O. Pontier, C. Pattengill-Semmens, J.K. Gaydos

Multihost infectious disease outbreaks have endangered wildlife, causing extinction of frogs and endemic birds, and widespread declines of bats, corals, and abalone. Since 2013, a sea star wasting disease has affected >20 sea star species from Mexico to Alaska. The common, predatory sunflower star (*Pycnopodia helianthoides*), shown to be highly susceptible to sea star wasting disease, has been extirpated across most of its range. Diver surveys conducted in shallow nearshore waters (n = 10,956; 2006–2017) from California to Alaska and deep offshore (55 to 1280 m) trawl surveys from California to Washington (n = 8968; 2004–2016) reveal 80 to 100% declines across a ~3000-km range. Furthermore, timing of peak declines in nearshore waters coincided with anomalously warm sea surface temperatures. The rapid, widespread decline of this pivotal subtidal predator threatens its persistence and may have large ecosystem-level consequences.

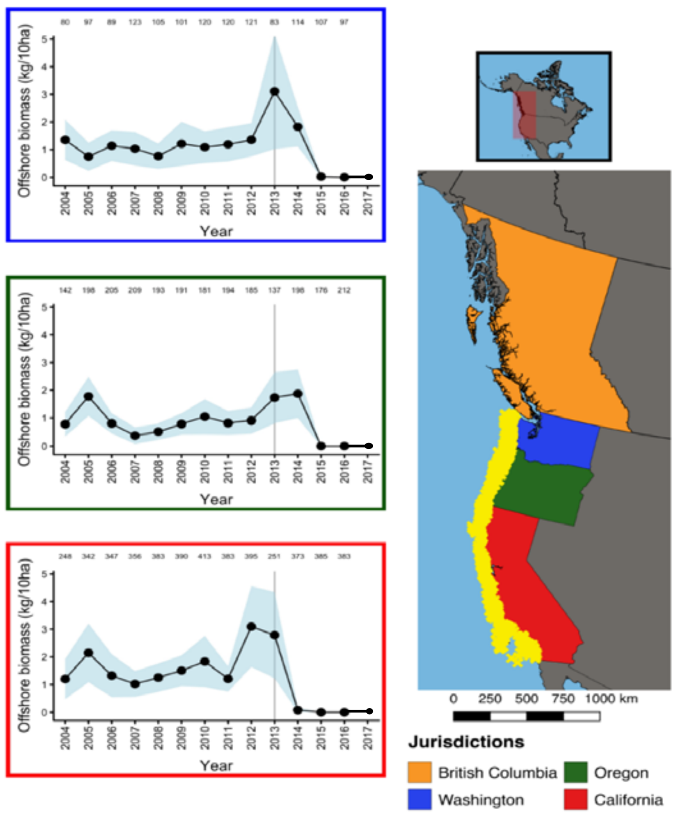

Figure 9. Collapse of *Pycnopodia* in WA, OR and CA in 2014-2018: yellow dots show trawl survey locations. Decline associate with warming and began earlier in CA. This sea star is a pivotal predator on sea urchins with depletion producing cascading ecosystem effects (Harvell et al., 2019: Science Advances)

b) West Coast Observer Program

The FRAM West Coast Groundfish Observer Program (WCGOP) continued collecting fishery-dependent data during 2018 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.

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.

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

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 vessels ranging in size from skiffs to larger fixed gear vessels and depths ranging from less than 20 ft. to more than 300 ft. 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.

For more information, please contact Jon McVeigh at Jon.McVeigh@noaa.gov

c) Fisheries Observation Science Program Coverage Rates, 2002–17. U.S. Department of Commerce, NWFSC Processed Report 2018-02

Investigators: Somers, K.A., J.E. Jannot, K. Richerson, V. Tuttle, and J. McVeigh.
NWFSC Processed Report 2018-02 (https://doi.org/10.25923/e2pz-0w11)

The Fisheries Observation Science (FOS) Program at the Northwest Fishery Science Center consists of two programs, the At-Sea Hake Observer Program (A-SHOP) and the West Coast Groundfish Observer Program (WCGOP). The A-SHOP observes the hake fleet that processes catch at sea, while the WCGOP observers a number of fleets that deliver catch shoreside for processing, including sectors that target and incidentally impact groundfish. Both programs place trained scientists on board commercial fishing vessels to observe and sample all catch; the WCGOP specifically focuses on at-sea discard estimates. This report also includes fish ticket landings data from the Pacific Fishery Information Network (PacFIN). This processed report describes the level of observer coverage, as the proportion of targeted landings associated with observed trips to the total targeted landings across all trips in the fleet, for 2002 to 2017. The species targeted are defined based on the fishery and described in the header of each table. The total targeted landings by each fleet are reported even in years when the FOS did not observe any trips. In some cases, fewer than three active vessels in a stratum result in confidential data, which are masked using asterisks. The level of observer coverage and sampling can vary greatly between fisheries, years, and spatial strata. This report quantifies the magnitude of expansions required to use observer data to estimate fleetwide levels of discard and can highlight areas where estimates are less certain. Every year this report is updated to include the newest year of data, the most current data from the FOS and PacFIN for previous years, and the most recent data processing procedures. This report includes the three new sectors which WCGOP observed for the first time in 2017: Sea Cucumber Trawl, Pacific Halibut Derby, and Ridgeback Prawn. All updates are described in the Groundfish Mortality report, which is available in draft form annually in the Pacific Fishery Management Council September Briefing Book and later in the year in final form via a Technical Memorandum. The tables in this processed report are also available as spreadsheets.

For more information, please contact Jon McVeigh at Jon.McVeigh@noaa.gov

d) The utility of spatial model-based estimators of unobserved bycatch

Investigators: B.C. Stock, E.J. Ward, J.T. Thorson, J.E. Janot, B.X. Semmens

ICES Journal of Marine Science, Volume 76, Issue 1, 1 January 2019, Pages 255–267, https://doi.org/10.1093/icesjms/fsy153

Quantifying effects of fishing on non-targeted (bycatch) species is an important management and conservation issue. Bycatch estimates are typically calculated using data collected by on-board observers, but observer programs are costly and therefore often only cover a small percentage of the fishery. The challenge is then to estimate bycatch for the unobserved fishing activity. The *status quo* for most fisheries is to assume the ratio of bycatch to effort is constant and multiply this ratio by the effort in the unobserved activity (ratio estimator). We used a dataset with 100% observer coverage, 35,440 hauls from the US west coast groundfish trawl fishery, to evaluate the ratio estimator against methods that utilize fine-scale spatial information: generalized additive models (GAMs) and random forests. Applied to 15 species representing a range of bycatch rates, including spatial locations improved model predictive ability, whereas including effort-associated covariates generally did not. Random forests performed best for all species (lower root mean square error), but were slightly biased (overpredicting total bycatch). Thus, the choice of bycatch estimation method involves a tradeoff between bias and precision, and which method is optimal may depend on the species bycatch rate and how the estimates are to be used.

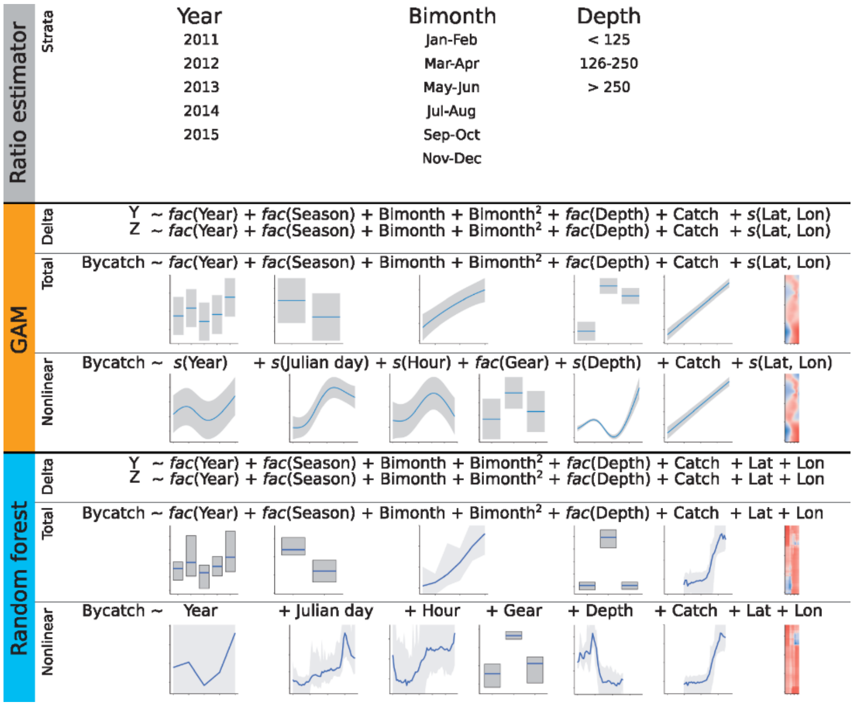

Figure 10. Summary of models fit to the West Coast Groundfish Observer Program bycatch dataset. The ratio estimator was stratified by year, bimonthly period, and depth (fathoms). The Delta and Total models were fit to the same covariates, meant to mimic the stratified ratio estimator. Covariates treated as factors are indicated by fac(). The Delta models split the bycatch data into presence/absence (Y) and positive catches (Z), then calculated bycatch as Y × Z. The Nonlinear models incorporate all available covariates using nonlinear terms, e.g. spline terms in GAMs, s(). Covariate effect plots are shown for models fit to Pacific hake. The following R packages were used in analyses: “mgcv” to fit GAMs, “visreg” to visualize GAM covariate effects, “randomForest” to fit RFs, and “forestFloor” to visualize RF covariate effects.
For more information, please contact Jason Janot at Jason.Janot@noaa.gov

e) Towards stewardship: beyond the basics and how do we go further

Investigators: Vanessa J. Tuttle, Jason Jannot, Tom Good

Well-established observer programs have been turning the crank collecting haul and catch data for decades. Observer programs and data collections evolve and change over time, but how do we take data collection the next step and encourage greater stewardship in the industry? Can we smooth the path and identify conservation needs through careful examination of existing data? Can we encourage and guide fisheries towards sustainability by co-leading the way? The At-Sea Hake Observer Program is leading the charge by monitoring seabird trawl cable strikes. We are assessing injury and mortality from these interactions in the Pacific hake processing fleet off the U.S. West Coast. The challenge with cable strikes is they were only infrequently and opportunistically observed in the past, meaning this mortality was both cryptic in nature and under-reported. Taking a collaborative approach with industry, we hope to reduce seabird injury and mortality through the

development of successful bycatch mitigation strategies. We began with a new, randomized data collection aimed at monitoring trawl cables and recording seabird strikes to document the interactions. This helped reveal the scope of the problem and indicated which species are most vulnerable to cable strikes. We then convened a workshop bringing fishers, scientists and managers together to brainstorm potential mitigation strategies. Feasible and practical mitigation strategies are at the heart of success for this project. The workshop group identified and agreed upon five distinct strategies, keeping in mind that there must be real potential to field test these strategies. Finally, we hope to push towards sea trials of the most promising strategies. Ultimately, the goal is to develop a catalog of best practices that will result in reduced injury and mortality of seabirds in trawl fisheries. We hope that a strong, transparent, collaborative process will move us towards improved stewardship, with relative ease.
For more information, please contact Vanessa Tuttle at Vanessa.Tuttle@noaa.gov

f) Migration to OPTECS Introduces Positive Changes in Sampling Flow and Observer Life

Investigator: Eric Brasseur
West Coast Groundfish Observer Program, Pacific States Marine Fisheries Commission, Newport, Oregon, USA

The North West Fisheries Science Center's Fisheries Observation Science (FOS) program is in the process of migrating from paper data collection on trawl vessels to direct tablet data entry. Initial introduction of tablet-based sampling indicates that observers will spend more time on deck at first, until they become conditioned to the new process, and will in turn see a significant reduction in time spent with post data collection duties such as cleaning and drying forms, performing calculations and transcribing data. When not engaged in sampling, observers will be able to undertake additional program duties, devote more time to computer maintenance and data security, and have more time to rest, resulting in a safer work experience. The Observer Program Technology Enhanced Collection System (OPTECS) software was designed to complement and direct observer sampling rather than rely on mirroring a paper form. The software is divided into sections based on how the observer encounters the data. This natural flow allows the observer to sample quickly and move from task to task fluidly. During testing one observer noted that entering paper collected data, with the app on a tablet, was simpler than entering the same data via the web portal, attesting to its usability. Future enhancements to the software flow will incorporate user experience based improvements in a second version.

Complementing the technological changes, we developed a stand that attaches to a Marel M-1100 scale that can be adjusted to various heights and angles to allow the observer to work hands free. This helps minimize the risk of damage to the tablet and potential data loss, while freeing up the observers hands. Upon return, data are transmitted to shore along with a copy of the database for debriefer analysis. The observer then enters forms not currently available in the OPTECS software. Due to the data collection methods and built in validations, corrections to the data are minimal. The program results in quick and efficient data availability as electronic data collection expands and the debriefing process is finalized.

For more information, please contact Eric Brasseur at Eric.Brasseur@noaa.gov

g) Uniting electronic monitoring and observer data to improve management of the US West Coast groundfish fishery

Investigators: K.A. Somers, J. Jannot, J. McVeigh
NOAA – NWFSC – West Coast Groundfish Observer Program, USA

In 2015, to explore the potential for reducing the financial burden of monitoring costs borne by industry, electronic monitoring (EM) systems were adopted in-lieu of observers by some vessels. This subset of the fleet is no longer required to maintain 100% observer coverage and is instead randomly selected to achieve ~30% observer coverage, which is focused on biological and supplementary data collection. Rather than viewing observer and EM programs as opposing forces, we presented three specific ways that we have integrated these two programs and datasets to continue to provide total catch estimates for all species and essential biological data.

First, we assessed the strengths of both EM and observer data to identify the most appropriate source to utilize in calculating discard estimates for each species impacted by the fishery. EM provides excellent estimates of at-sea discards of a subset of IFQ species that are identifiable on video, as well as total weight estimates of unsampled, operational discharge (Figure 11). However, quota species account for only ~75 of the more than 300 species encountered by the bottom trawl fleet, which include both actively managed groundfish species and currently unmanaged nongroundfish species. Much of the non-quota groundfish species discards consist of Ecosystem Component Species (ECS) and other groupings that the Pacific Fishery Management Council (PFMC) has identified as likely to be increasingly targeted in the future. Observer data remains the only source of discard rates for these components of the ocean ecosystem, which are essential to estimating fleetwide at-sea discard amounts and understanding overall fishery impacts.

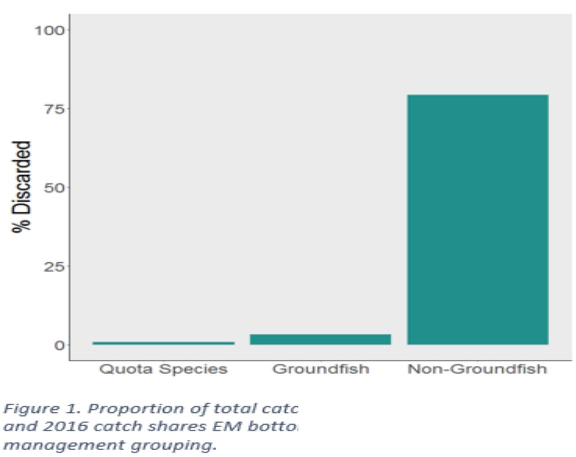

Figure 11. Proportion of the total catch discarded at sea in the 2015 and 2016 catch shares EM bottom trawl fishery by management group.

Second, we recognized that differing rules in the EM fleet require new sampling protocols for observers. Prohibitions on which species can be discarded while using EM resulted in the regular landing of unmarketable species, which are frequently undocumented on landings receipts.

Without the deployment of observers, the catch of these "shoreside discards" would be under-estimated and unknowable.

Finally, observers continue to collect valuable biological and genetic data necessary to meet the needs of stock assessments and inform legally-mandated biological opinions. These data are often either completely unavailable from EM and shoreside monitoring or not associated with specific temporal and spatial attributes. For quota, non-quota groundfish, and non-groundfish species, WCGOP observers collect length-frequency data. Since 2015, the WCGOP and the EM program have worked together to collect and synthesize datasets that can be used to inform management while helping fishers navigate a new world of monitoring.

h) Green Sturgeon Research with the California Halibut Trawl Fishermen of the San Francisco Bay Area

Investigator: Kevin Stockmann

NOAA Fisheries West Coast Groundfish Observer, San Francisco, USA

According to the International Union for Conservation of Nature, sturgeons are more critically endangered than any other group of species. Green sturgeon (*Acipsenser medirostris*) are anadromous fish occurring along the West Coast of North America. In 2006, the Southern Distinct Population Segment (DPS) of green sturgeon was listed as threatened under the Endangered Species Act. The most recent 5-Year Review: Summary and Evaluation affirmed the green sturgeon's status as threatened. A recovery plan is under development. Green sturgeon are encountered as bycatch in the California halibut trawl fishery centered outside San Francisco Bay. Observers provide important contributions to the science and management of this species. Biological data collected by observers provide critical information for the analysis and continued monitoring of bycatch effects, supporting catch and mortality estimates by life stage, and clarifying the proportion of Southern DPS fish encountered versus the non-listed Northern DPS. Observer data also play an important role in addressing uncertainties regarding catch estimates and post-release impacts. Observers applied over 315 Passive Integrated Transponder (PIT) tags to determine a recapture rate. Observer data from the halibut trawl fishery represent valuable monitoring of the sub-adult population.

To assess post release impacts, NOAA Fisheries led a collaborative study with halibut fishermen, observers and the California Department of Fish and Wildlife. Observers and fishermen applied satellite tags to 76 randomly selected bycaught green sturgeon to estimate post release survival and to learn more about green sturgeon movement patterns. Tags were programmed to stay on the fish 3-4 weeks before popping off and transmitting depth, temperature and acceleration data. Of the 49 satellite tags that transmitted sufficient data, analysis suggested 81.5% of released sturgeon survived to three weeks, post release. This is the first study in the United States to quantify a post trawl interaction survivorship rate for any sturgeon species.

i) Observer Contributions to a U.S. West Coast Success Story

Investigator: Ryan Shama

NOAA Fisheries Northwest Fisheries Science Center, Fisheries Resource Analysis & Monitoring Division, West Coast Groundfish Observer Program

Due to overcapitalization, the U.S. Secretary of Commerce declared the West Coast groundfish fishery a failure in 2000. To meet sustainability mandates, NOAA Fisheries adopted a strategy that would further limit access to the fishery, reduce catch of sensitive species, and significantly improve the quality and availability of fishery-dependent data for West Coast groundfish stocks. The U.S. West Coast groundfish fishery is now in the midst of a truly remarkable success story. Of the 10 species deemed overfished between 1999 and 2010, all but two have been declared rebuilt, as of 2017. Observers played a crucial role in this recovery by providing accurate accounts of at-sea discards, a major piece of the puzzle previously unavailable to fishery managers. Along with at-sea discard estimates, biological sampling provided valuable fishery-dependent data for stock assessments.

Prior to the deployment of fishery observers on West Coast groundfish vessels, fishery managers were missing data for at-sea discards. From 2002-2017, WCGOP observers accounted for 2,974,384.96 lbs. of discards (expanded) from nine species : lingcod, widow rockfish, petrale sole, canary rockfish, Pacific ocean perch, darkblotched rockfish, bocaccio, cowcod and yelloweye rockfish. WCGOP observers also provided the primary component of fishery-dependent biological data, used for West Coast groundfish stock assessments. During their 82,830 sea days, WCGOP observers have collected biological data from 105,446 individuals from the nine species noted previously. Biological data collected varied by species but included length, sex, otoliths (age), and fin clips (genetics). The observer component became even more instrumental in the recovery of overfished species, when the Catch Share program was implemented on January 1, 2011. With catch shares, came the requirement for 100% observer coverage in the trawl sector. While controversial, this management strategy provided an immediate and significant reduction in the catch of overfished species from ~250 mt yr^{-1} to <25 mt yr^{-1}.

j) Observer Program Annual Reports

Jannot, J.E., K. Somers, K. Richerson, N.B. Riley, J. McVeigh. 2018. Pacific halibut bycatch in US West Coast Fisheries (2002-17). FOS Observer Program, NWFSC. National Marine Fisheries Service, NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112.

Somers, K.A., J. Jannot, K. Richerson, N. Riley, V. Tuttle, and J. McVeigh. 2018. Estimated discard and catch of groundfish species in the 2017 U.S. west coast fisheries. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

Somers, K.A., J. Jannot, V. Tuttle, N.B. Riley, and J. McVeigh. 2018. Groundfish Expanded Mortality Multiyear for 2002-2017 US west coast fisheries. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112. https://www.nwfsc.noaa.gov/data/map

Somers, K.A., J.E. Jannot, V. Tuttle, J. McVeigh. 2018. Observed and estimated total bycatch of salmon in the 2002-2016 U.S. west coast fisheries. West Coast Groundfish Observer Program. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

Somers, K.A., J.E. Jannot, V. Tuttle, & J. McVeigh. 2018. FOS coverage rates, 2002-2017. Last updated: May 2018. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

k) Involving Industry in the Collection of Needed West Coast Groundfish Data

Investigators: Jim Benante1, John Lafargue
Pacific States Marine Fisheries Commission, USA
Groundfish species on the West Coast of the United States were declared a federal disaster in 2000. Observer programs had seen dramatic growth in the United States from 1995-2000 in response to the need to better manage commercial fisheries. The fishery dependent data observer programs collected was helping to fill in some of the data gaps, but Southern California did not have much commercial fishing activity so there were very few data collection opportunities. Commercial sport fishing opportunities in Southern California were being severely limited due to several important species being declared overfished and harvest limits being greatly reduced. In response fishers began to ask tough questions about the data being used to manage their fisheries. In 2003 after meetings and discussions with a variety of active commercial and sport fishers in the Southern California Bight region, a study was developed with the help of the local fishers to survey shelf rockfish resources in untrawlable habitats in Southern California using commercial sportfishing vessels as the research platforms. 14 years later a substantial data set has been compiled on the relative abundance of a large number of shelf rockfish in untrawlable areas of the Southern California Bight. In addition a variety of biological samples and oceanographic data has been collected. The survey has supplied annual abundance indices and/or biological data or samples for a variety of species and made available for use in stock assessments for the following species: Blue Rockfish (2017); Bocaccio (2009, 2011, 2013, 2015, 2017); Cowcod (2013); Greenspotted Rockfish (2011); Lingcod: (2017); Yelloweye Rockfish (2009); Vermilion Rockfish (2005). The cooperative approach employed by this survey has been effective in efficiently generating fishery-independent abundance indices and biological data collection for multiple groundfish species in untrawlable habitats. Industry vessels provide effective and relatively inexpensive research platforms that are reliable. The local fishers can provide valuable insight into the gear selection, fish behavior, location of viable habitats, local weather conditions, moorages, etc.

l) Everything the same is different: bycatch trends in the At-Sea Pacific hake fishery

Investigator: Vanessa Tuttle

NOAA Fisheries Northwest Fisheries Science Center, Fisheries Resource Analysis & Monitoring Division, West Coast Groundfish Observer Program

A review of the bycatch trends in the at-sea Pacific hake (*Merluccius productus*) fishery seems timely given the interesting set of recent ocean conditions (warm blob), change in the status of several formerly-overfished rockfish species, and the record-breaking size of recent hake quotas. Rockfish, spiny dogfish, salmon, squid and several roundfish species make up the vast majority of bycatch in the at-sea hake fishery. An inspection of rockfish bycatch trends, under recent fishery-constraining hard caps, reveals the challenges imposed by these constraints (including temporary fishery closures). Chinook salmon bycatch, which is closely monitored by the West Coast Region to ensure the fishery does not exceed the take threshold outlined in the Biological Opinion, shows high inter-annual variation. Bycatch of various round fish, including sablefish, lingcod, jack and Pacific mackerel, show interesting cyclical patterns with sometimes-extreme variability. Finally, we have seen some incredibly rare swordfish and bluefin tuna bycatch, two species who seemed to have had temporary range extensions due to the warm blob. The NWFSC's At-Sea Hake

Observer Program deploys fisheries observers in the at-sea hake fleet to collect data essential to the management of this largest-by-volume fishery off the U.S. West Coast.

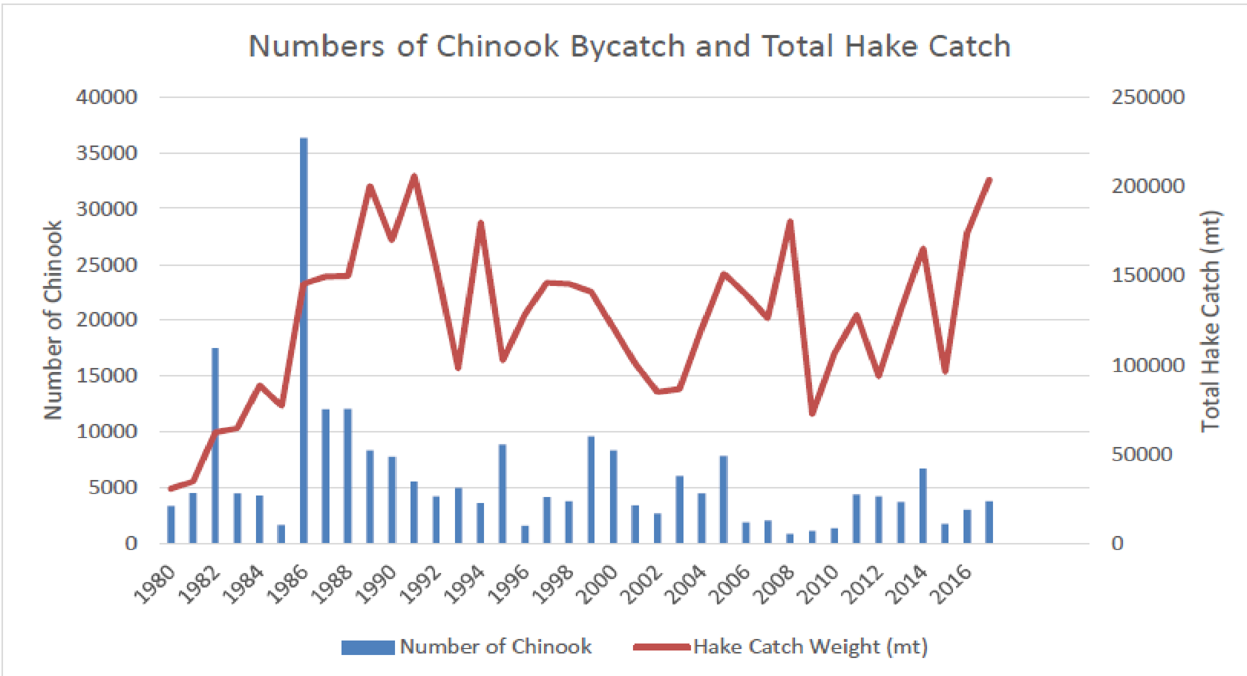

Figure 12. Chinook salmon bycatch in the at-sea hake fishery shows strong inter-annual variability. Vigorous efforts to avoid Chinook bycatch have been relatively successful in the last decade, with a mean catch rate of 3107 individual fish per year, a decline from the previous decade with a mean catch rate of 5011 individual fish per year. Bycatch of other salmonids in the at-sea hake fishery are nominal.

B. Ecosystem Research

1. Habitat

a) Relating groundfish diversity and biomass to structure-forming invertebrates in the Northeast Pacific Ocean: exploring fishery-independent trawl survey catch data

Investigators: K.L. Bosley, K.M. Bosley, A.A. Keller and C.E. Whitmire

Structure-forming invertebrates (SFIs: corals, sea pens and sponges) inhabit the world's oceans and are often associated with high numbers of fish. But the precise nature and extent of any association is difficult to quantify and poorly understood. We investigated the associations between SFIs and demersal fish using 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 non-linear relationships between species richness and sponge density across all geographic regions we examined. Finfish biomass was also related to SFIs and environmental variables but those relationships varied geographically. Multivariate analyses were used to examine relationships among 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. Indicator species analysis 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 Anoplopoma fimbria exhibited opposite trends. These results provide information about broad-scale associations between SFIs and demersal fish that may be useful for developing studies focused on the function of SFIs as essential fish habitat and the role they play in the life-history of demersal fishes.

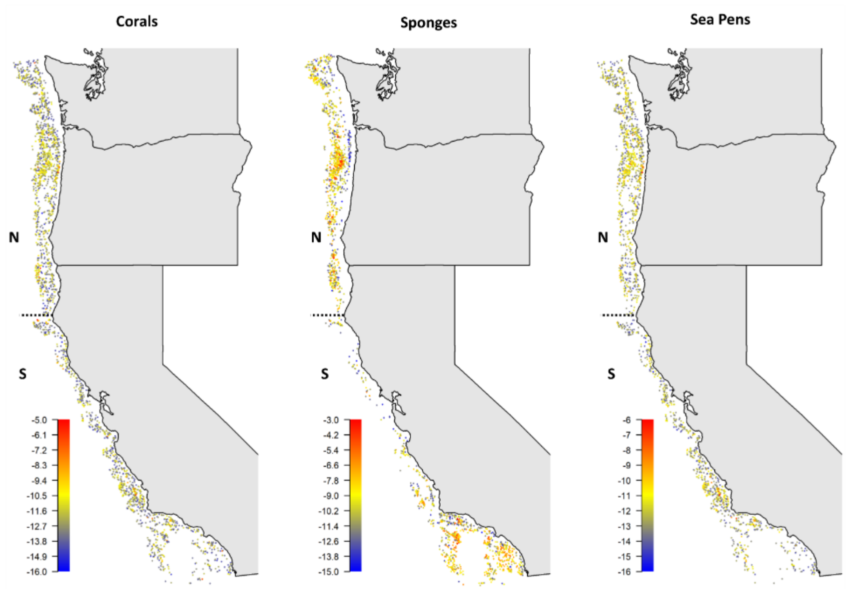

Figure 13. Location of trawls containing corals, sponges and sea pens during the bottom trawl survey 2003 to 2015. Density is on a log scale to better represent low CPUE (ka ha^{-1}). dashed lines indicate Cape Mendocino, CA.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

b) Return of the dead zone: severe hypoxia observed off Oregon and Washington during the 2017 West Coast Groundfish Bottom Trawl Survey

Investigators: Aimee A. Keller, Peter Frey, Victor Simon, Lorenzo Ciannelli, and Stephen D. Pierce

Seasonal hypoxia has occurred in near-bottom waters off the Oregon continental shelf since 2002. Potentially linked to shifts in climate and upwelling, the severity of these hypoxic events has varied considerably over time. In 2017, the West Coast Groundfish Bottom Trawl Survey encountered severe hypoxia in shelf tows with depths ranging from 62 to 160 m off the coasts of Oregon and Washington. Near-bottom dissolved oxygen levels (DO) as low as 0.10 ml l^{-1} correlated strongly with reductions in catch and species richness. Large quantities of decomposing Dungeness crabs encountered in other areas suggested that these hypoxic conditions may have been widespread and resulted in local die-offs of benthic invertebrates. We examine the extent and intensity of near-bottom hypoxia observed in 2017, analyze catches of groundfish and invertebrates from oxygen-poor locations, and explore environmental factors that may have contributed to the severity of this phenomenon in 2017. Our prior research revealed significant positive relationships between catch and DO for 19 of 34 groundfish species within hypoxic bottom waters using generalized additive models. We utilize an expanded time series (2008 to 2017) to examine similarities and differences in the response of various subgroups of groundfish species to low DO levels, information of value to future ecosystem-based management in the face of changing oceanographic conditions.

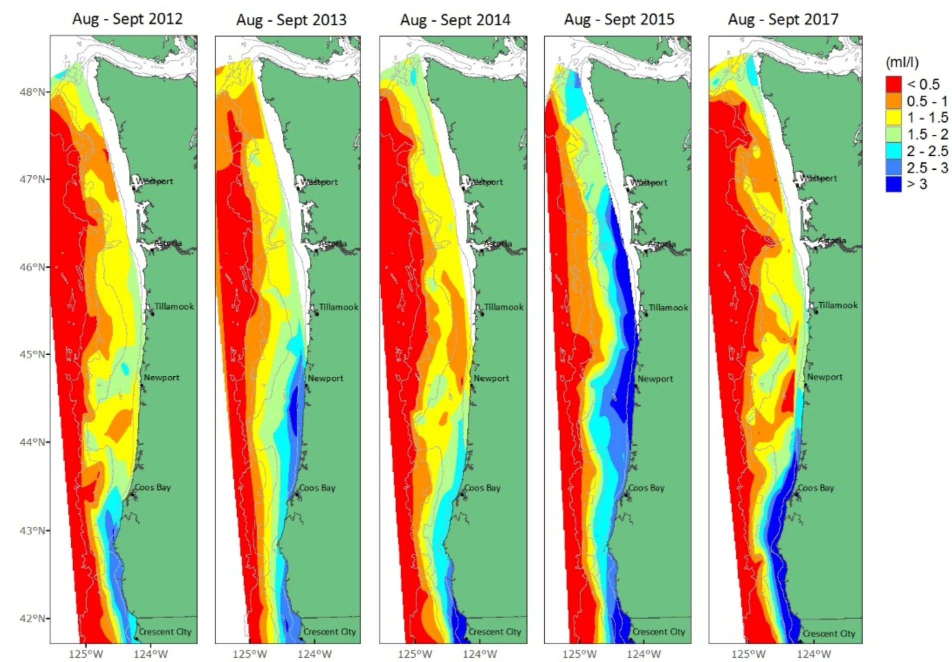

Figure 14. Near bottom dissolved oxygen concentrations (ml l^{-1}) north of Crescent City 2012 – 2017 – demonstrating the return to hypoxic conditions after 2015.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

c) Sub-regional differences in groundfish distributional responses to anomalous ocean temperatures in the northeast Pacific

Investigators: Lingbo Li, Anne Hollowed, Edward Cokelet, Steve Barbeaux, Nicholas Bond, Aimee Keller, Jackie King, Michelle McClure, Wayne Palsson, Phyllis Stabeno, and Qiong Yang

Although climate-induced shifts in fish distribution have been widely reported at the population level, studies that account for ontogenetic shifts and sub-regional differences when assessing responses are rare. In this study, species-specific changes in groundfish distributions were assessed at different size classes within sub-regions based on shifts in depth, latitude, and longitude. The authors examined large, quality-controlled datasets from depth-stratified, random bottom trawl surveys conducted during summer in the Gulf of Alaska, along the west coast of Canada and the U.S. from 1996 to 2015, a period punctuated by a marine "heat wave". Temporal biases in bottom temperature were minimized by partitioning each survey into three sub-regions. Near-bottom temperatures, weighted by stratum area, were unsynchronized and exhibited varying interannual variability across sub-regions. The sub-regions also varied by weighted bottom depth from the shallowest in the western Gulf of Alaska and Hecate Strait (100 m) to the deepest in southern west coast of the U.S. (300 m). The centroids (centres of gravity) of groundfish distribution were weighted by catch per unit effort (CPUE) and stratum area for ten important species subdivided by sub-region and size classes. Multivariate analyses showed significant differences in aggregate fish movements in response to temperature across sub-regions but not among species or size class. Groundfish demonstrated poleward responses to warming temperatures in relatively few sub-regions but tended to move vertically (either upward or downward) to seek colder waters within sub-regions. Within sub-region, the temperature responses of groundfish varied between species but not by size class. Shallower species exhibited highly varied distributional responses to temperature changes across sub-regions while deeper-water species tended to have similar temperature responses. Choosing an appropriate spatial scale is highly recommended for future climate change studies.

2. Ecosystems

C. By-catch Reduction Engineering

a) Illuminating the headrope of a selective flatfish trawl: effect on catches of groundfishes, including Pacific halibut

Investigators: Mark Lomeli, W. Waldo Wakefield and Bent Herrmann

This study evaluated how illuminating the headrope of a selective flatfish trawl can affect catches of groundfishes, including Pacific halibut *Hippoglossus stenolepis,* in the U.S. West Coast limited-entry (LE) groundfish bottom trawl fishery. Over the continental shelf, fishermen engaged in the LE bottom trawl fishery target a variety of flatfishes, roundfishes, and skates. Green LED fishing lights (Lindgren-Pitman Electralume) were used to illuminate the headrope. The lights were grouped into clusters of three, with each cluster attached ~1.3 m apart along the 40.3-m-long headrope. Catch comparisons and ratios of mean fish length classes were compared between tows conducted with (treatment) and without (control) LEDs attached along the trawl headrope. Fewer Rex sole *Glyptocephalus zaphirus,* arrowtooth flounder *Atheresthes stomias,* and lingcod *Ophiodon elongatus* were caught in the treatment than in the control trawl, though not at a significant level. Pacific halibut catches differed between the two trawls, with the treatment trawl catching an average of 57% less Pacific halibut. However, this outcome was not significant due to a small sample size. For Dover sole *Microstomus pacificus* 31–44 cm in length and sablefish *Anoplopoma fimbria* 43–61 cm in length, significantly fewer fish were caught in the treatment than in the control trawl. On average, the treatment trawl caught more rockfishes *Sebastes* spp., English sole *Parophrys vetulus*, and petrale sole *Eopsetta jordani*, but not at a significant level. These findings show that illuminating the headrope of a selective flatfish trawl can affect the catch comparisons and ratios of groundfishes, and depending on fish length and species, the effect can be positive or negative.

Figure 15. Images of an LED cluster attached (Left) near the center of the trawl headrope on the starboard side and (Right) along the wing tip on the port side, and their orientations.

b) Effects on the bycatch of eulachon and juvenile groundfish by altering the level of artificial illumination along an ocean shrimp trawl fishing line

Investigators: Mark Lomeli, Scott D. Groth, Matthew T. O. Blume, Bent Herrmann, and W. Waldo Wakefield (ICES Journal of Marine Science, 75:2224–2234)

The authors examined how catches of ocean shrimp (*Pandalus jordani*), eulachon (*Thaleichthys pacificus*), and juvenile groundfish could be affected by altering the level of artificial illumination along the fishing line of an ocean shrimp trawl. In the ocean shrimp trawl fishery, catches of eulachon are of special concern, as the species' southern Distinct Population Segment is listed as "threatened" under the US Endangered Species Act. Using a double-rigged trawl vessel, with one trawl illuminated and the other unilluminated, catch efficiencies for ocean shrimp, eulachon, and juvenile groundfish were compared between an unilluminated trawl and trawls illuminated with 5, 10, and 20 LED fishing lights along their fishing line. The addition of artificial illumination along the trawl fishing line significantly affected the average catch efficiency for eulachon, rockfish (*Sebastes* spp.), and flatfish, with the three LED configurations each catching significantly fewer individuals than the unilluminated trawl without impacting ocean shrimp catches. For Pacific hake (*Merluccius productus*), the ten LED-configured trawl caught significantly more fish than the unilluminated trawl. For the five and 20 LED configurations, mean Pacific hake catches did not differ from the unilluminated trawl. This study contributes new data on how artificial illumination can affect eulachon catches (and other fish) and contribute to their conservation.

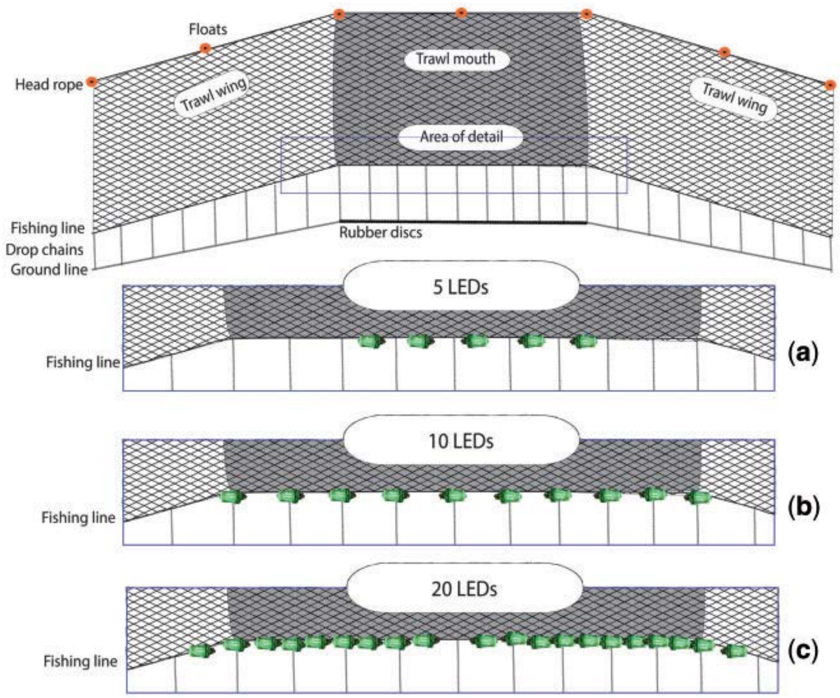

Figure 14. Schematic of an ocean shrimp trawl viewed from the front (top image) and diagrams depicting the placement and orientation of the LEDs along the trawl fishing line for the 5- (a), 10- (b), and 20-LED (c) configurations. Note: diagram not to scale.

c) Evaluating off-bottom sweeps of a U.S. West Coast groundfish bottom trawl: Effects on catch efficiency and seafloor interactions

Investigators: Mark Lomeli, W. Waldo Wakefield and Bent Herrmann

In the U.S. West Coast groundfish bottom trawl fishery, lengthy sweeps (>85 m) that maintain seafloor contact are traditionally used. While these sweeps are effective at herding groundfishes, their bottom tending characteristics increase the potential to cause seafloor disturbances, and injury and unobserved mortality to benthic organisms. In this study, we examined if changing from conventional to modified sweeps (with sections elevated 6.5 cm off bottom) would affect catch efficiency of target groundfishes and seafloor interactions. We used a DIDSON imaging sonar to observe how each sweep configuration interacted with the seafloor. An altimeter was periodically placed on the modified sweep to measure height off bottom. Results detected no significant catch efficiency effect of changing from conventional to modified sweeps. The DIDSON and altimeter data showed the modified sweeps exhibit elevated sections where infaunal and lower-profile epifaunal organisms can pass under without disturbance. Results demonstrate that seafloor interactions can be substantially reduced using elevated sweeps in this fishery without impacting catch efficiency. Further, findings from this research could be potentially applicable to other fisheries nationally and internationally.

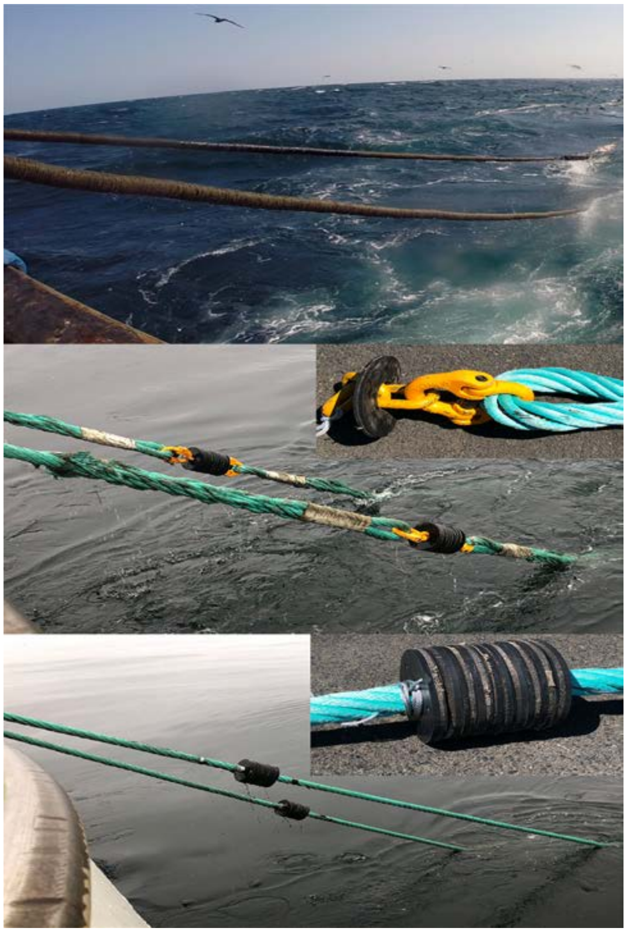

Fig. 15. Images of the conventional sweeps (top image) and the mechanisms used to attach the disc clusters to the modified sweeps (middle and bottom images).

d) Influencing the behavior and escapement of Chinook salmon out of a midwater trawl using artificial illumination

Investigators Mark J.M. Lomeli and W. Waldo Wakefield

The Pacific hake (*Merluccius productus*) midwater trawl fishery is the largest groundfish fishery off the U.S. west coast by volume. Catches comprise mainly Pacific hake, however, bycatch of Chinook salmon (*Oncorhynchus tshawytscha*) can be an issue affecting the fishery as individuals belonging to Endangered Species Act (ESA) listed Evolutionarily Significant Units 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 whether Chinook salmon could be attracted 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 of the BRD between tows conducted with and without artificial illumination on the BRD to determine if illumination can enhance their escapement. Our results show that artificial illumination can influence where Chinook salmon exit out of the BRD we tested, but also demonstrate that illumination can be used to enhance their escapement overall. As conservation of ESA-listed Chinook salmon is an ongoing management priority, our research contributes new information on how artificial illumination can minimize adverse interactions between Pacific hake trawls and Chinook salmon.

e) The efficacy of illumination to reduce bycatch of eulachon and groundfishes before trawl capture in the Eastern North Pacific Ocean shrimp fishery

Investigators: Mark Lomeli, Scott Groth, Matt Blume, Bent Herrmann, and W. Waldo Wakefield

This study examined the extent that eulachon (*Thaleichthys pacificus*) and groundfishes escape trawl entrainment in response to artificial illumination along an ocean shrimp (*Pandalus jordani*) trawl fishing line. Using a double-rigged trawler, we compared the catch efficiencies for ocean shrimp, eulachon, and groundfishes between an unilluminated trawl and a trawl illuminated with 5 green LEDs along its fishing line. Results showed a significant reduction in the bycatch of eulachon and yellowtail rockfish (*Sebastes flavidus*) in the presence of LED illumination. As eulachon are an Endangered Species Act listed species, this finding provides valuable information for fishery managers implementing recovery plans and evaluating potential fishery impacts on their recovery and conservation. For other rockfishes (*Sebastes* spp.) and flatfishes, however, we did not see the same effect as the illuminated trawl caught similarly or significantly more fishes than the unilluminated trawl. Prior to this research, the extent that eulachon and groundfishes escape trawl capture in response to illumination along an ocean shrimp trawl fishing line was unclear. Our study has provided results to fill that data gap.

VI. Publications

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NMFS Southwest Fisheries Science Center

Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2019

Edited by Melissa Monk

With contributions from John Field, Tom Laidig, Nick Wegner, and William Watson

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 focuses on early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. The Habitat Ecology 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 Fisheries Resource Division in La Jolla currently represents the SWFSC on the Pacific Council's Groundfish Management Team, and several scientists from the Fisheries Ecology Division in Santa Cruz currently serve on the Pacific Council's Scientific and Statistical Committee.

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).

Moving into the next year we are going to expand on the rockfish genetic identification by similarly identifying rockfish larvae from the Trinidad Head Line, northern California and the Newport Line, central Oregon in collaboration with Eric Bjorkstedt and Ric Brodeur, respectively. This project should enable us to understand rockfish spawning dynamics at the California Current scale.

We continued a project to extract otoliths from the genetically-identified rockfish larva and measure otolith band widths and core size. We have removed otoliths from six rockfish species annually between 1998 and 2013. We are in the process of measuring otolith core width and the width of the 3 outer bands. 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 postdoctoral 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 extracted DNA from the sample in two ways. First, we conducted DNA extraction using as template the ethanol in which each sample was stored. Second, we masticated the entire sample and extracted DNA from this mush. After extracting DNA 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. Because reference sequences were not available for some species we constructed a 12S reference library using tissue from fishes of known identity. We have completed the Mi-seq runs and are currently running bioinformatics analyses to determine which species were found in each sample. 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 January 1962 through 2014, and by the end of this year expect to have completed analysis of samples collected in winter and spring of 2015-2018. This will provide a 56-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. macdonaldi, S. paucispinis*).

B.2 Research on Juvenile Rockfish at the SWFSC

The Rockfish Recruitment and Ecosystem Assessment survey completed its 36th survey year in June of 2018. The abundance of most young-of-the-year (YOY) pelagic juvenile rockfish was lower than recent years, following a series of very high abundance years that started in 2013 and persisted through the 2014-2016 large marine heatwave. The exception was fairly high YOY rockfish abundance within the southern California Bight. A manuscript detailing the relationship between pelagic juvenile rockfish abundance and oceanographic conditions was completed in 2018 (Schroeder et al., in press). This study built upon earlier studies of environmental drivers of rockfish recruitment variability, in which it was hypothesized that transport and source waters in the California Current Ecosystem were key factors driving the density independent processes that lead to variable recruitment in adult rockfish populations.

Previous studies focused on relative sea level as a proxy for the transport of Pacific Subarctic Water (PSUW) into the California Current from the Gulf of Alaska region. Most shelf break and slope water in the California Current is composed of a mix of PSUW, which tends to be cooler, lower salinity, and higher in oxygen and nutrients, and Pacific Equatorial Water (PEW), which reflects the poleward reach of the more subtropical waters of the California undercurrent and tends to be warmer, more saline, low oxygen, nutrient poor (spicy). By evaluating a more robust set of data to represent subsurface and offshore environmental conditions, particularly water mass characteristics using the results of a data-assimilative Regional Ocean Model System (ROMS) as well as in-situ data from ARGO array (an observing system of free-drifting profiling floats that measure the temperature and salinity of the upper 2000 m of the world's oceans).

The study demonstrated clearly that high YOY rockfish abundances tend to correspond to greater contributions of Subarctic water, while years of low rockfish abundance are associated with subtropical waters (Figure 1). The analysis was of particularly utility in interpreting observations during the large marine heatwave, which was characterized by warm surface waters and elevated sea levels, but cool, subarctic waters in the subsurface environment. The results are key to understanding mechanisms and drivers of recruitment variability, which in turn are key to understanding productivity of rockfish (and other) populations, and will help to better understand likely consequences of future climate variability and change. Several additional publications (Ainley et al. 2018, Warzybok et al. 2018) were also completed in 2018 that were based on part on the rockfish recruitment survey data and the interactions between pelagic juvenile rockfish and higher trophic level predators.

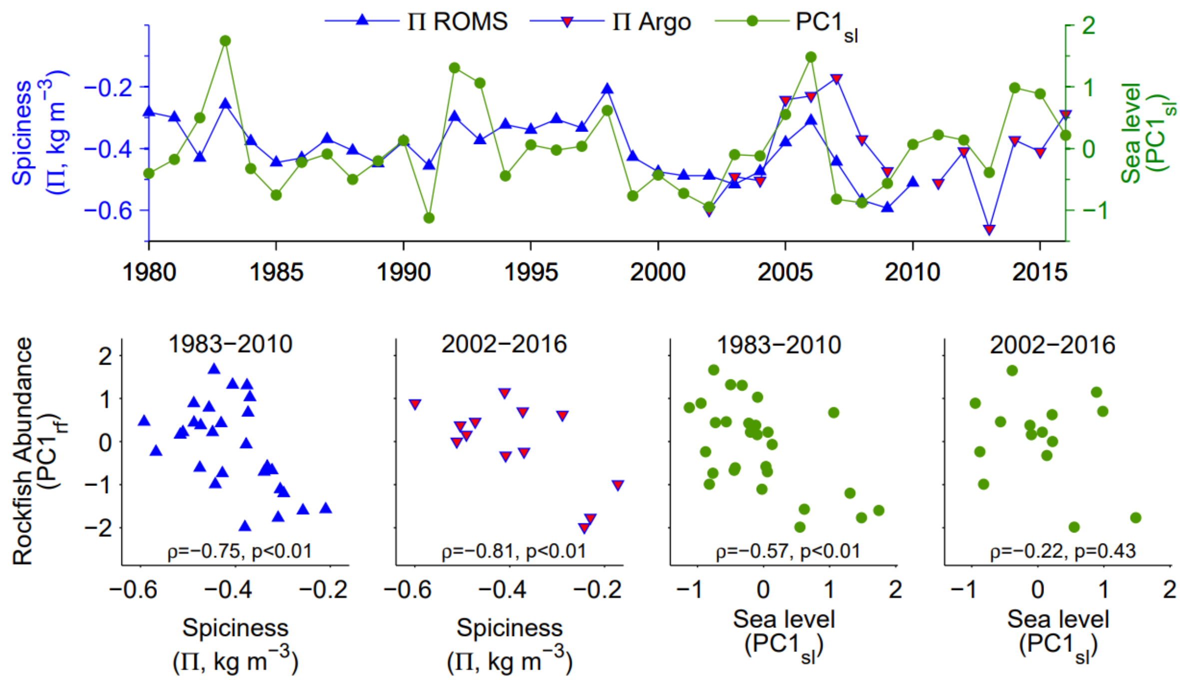

Figure 1: (Top) Time series of April-May averages of spiciness on the 26.0 isopycnal (Π) from ROMS models and Argo profiles and relative sea level anomalies (PC1sl; derived from tide gauge measurements along the California coast). (Bottom) Relationships between rockfish abundance (PC1rf) and the time series displayed in the top plot for two different time periods: 1983-2010 and 2002-2016 (from Schroeder et al., in press).

C. BY SPECIES, BY AGENCY

C2. Shelf Rockfish

C2.a. 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 our groups has 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*). Our recent analyses suggest that hypoxia at depth is a major determinate of post release mortality, with lower levels of dissolved oxygen associated with increased mortality. We hope to continue to assess rockfish movements and behavior in relation to hypoxia to determine rockfish sensitivity pre and post capture. Better understanding how low levels of dissolved oxygen contribute to mortality will allow for refinement of the catch-and-release process and the implementation of release guidelines that maximize survival.

In addition to tagging studies, we have worked with the recreational fishing community in California to measure the effectiveness and angler preference for different types of commercially available release devices. While there were some significant differences between device types, all devices were effective for releasing rockfishes back to depth. Initial post-release mortality (defined as all mortality events observable from the vessel while fishing) across all devices was relatively low (7.5%) in capture depths less than 100 m. Our results suggest that rockfishes should be released at least half-way to the bottom (preferably directly to the bottom) for the device to be effective in minimizing post-release mortality. Although all descending devices work, at-sea conditions, vessel type, and fish size tend to influence effectiveness and user preference of different device types (Bellquist et al. 2019).

D. OTHER RELATED STUDIES

D1. SWFSC FED Habitat Ecology Team 2017-18 Research on California 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. Expanding Pacific Research and Exploration of Submerged Systems Campaign

Contact: Tom Laidig (tom.laidig@noaa.gov)

In 2018, a team of federal and non-federal partners initiated a new phase of collaborative ocean science off the western United States. The **EX**panding **P**acific **R**esearch and **E**xploration of **S**ubmerged **S**ystems (EXPRESS) campaign targets deepwater areas off California, Oregon, and

Washington. The core focus of campaign activities is the collection of spatially explicit deepwater habitat information including multibeam, backscatter, and visual data on continental shelf, shelf edge, and slope habitats. This goal will be attained through partnerships between NOAA (NOS and NMFS), BOEM, USGS, and MBARI. From initial successes, this nascent interagency effort quickly evolved into a major field program engaging and exciting scientists and marine resource managers spanning numerous disciplines and organizations. EXPRESS members were involved in several research expeditions in 2018 including the 30-day deep sea coral cruise aboard the NOAA ship *Bell M. Shimada* (See D3 below) and multiple west coast mapping surveys aboard the NOAA ship *Rainier*. Six EXPRESS expeditions are currently planned for 2019.

D3. FY19 NMFS Deep-sea coral EXPRESS expedition, 9 Oct-8Nov 2018
Contact: Tom Laidig (tom.laidig@noaa.gov)

A 30-day deep sea coral expedition was conducted 9 Oct - 8 Nov, 2018 off the coast of Oregon and California. The expedition was supported by NMFS' Deep Sea Coral Research and Technology Program and was jointly planned and staffed by NOAA (CINMS, NWFSC, SWFSC), BOEM, and USGS under the EXPRESS campaign (See D2 above). Research conducted during this cruise is part of the four year West Coast Deep Sea Coral Initiative. The Goals of the expedition were to 1) Collect Essential Fish Habitat baseline information at 12 sites proposed for modification the Pacific Fishery Management Council, 2) Revisit previously surveyed sites to document if changes have occurred over time, 3) Collect information to validate BOEM supported cross-shelf habitat suitability models, and 4) Collect samples to help in identifying west coast corals and sponges and expand use of new technologies.
The expedition began off Newport, OR and worked its way south to the southern California Bight. Two underwater survey vehicles were used; the NWFSC and PIFSC's autonomous underwater vehicle (AUV) and the Mare remotely operated vehicle (ROV). Benthic habitats were surveyed for the presence of deep-sea corals (DSC), sponges, and fishes. Water chemistry, DSC, sponge, and geologic samples were collected for a variety of researchers along the west coast.

Eighteen unique areas were sampled along the coast at depths from 50 - 650 m. A total of 37 ROV and 24 AUV dives were completed along with 123 water samples. Forty one DSC, 54 sponge, and 10 geologic samples were collected. Over 110 fish, 35 coral, and 34 sponge taxa were identified including some potential new species of DSC and sponges (Fig. X, XX). At least 3 DSC species had southern range extensions. A newly discovered, yet undescribed species of yellow-colored *Swiftia* previously found only around the Farallon Islands was observed as far south as Anacapa Island in southern California.

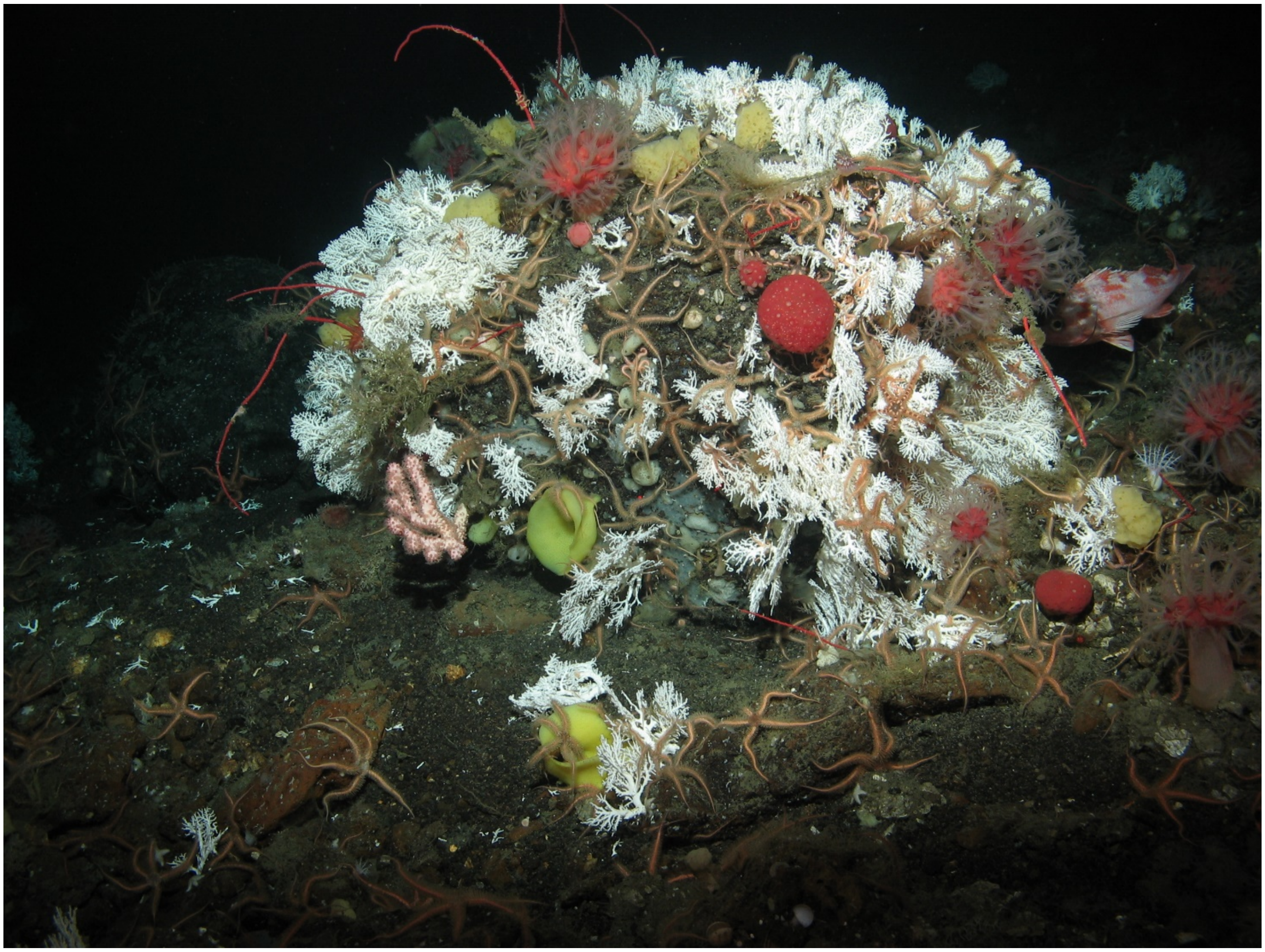

Figure X. A boulder covered in corals of at least 4 different species (white *Stylaster* spp. [possibly *S. parageus*], pink *Paragorgia* spp., red mushroom corals [*Heteropolypus ritteri*], and red stick corals (*Swiftia* spp.). Image taken on Mendocino Ridge at ~430 m.

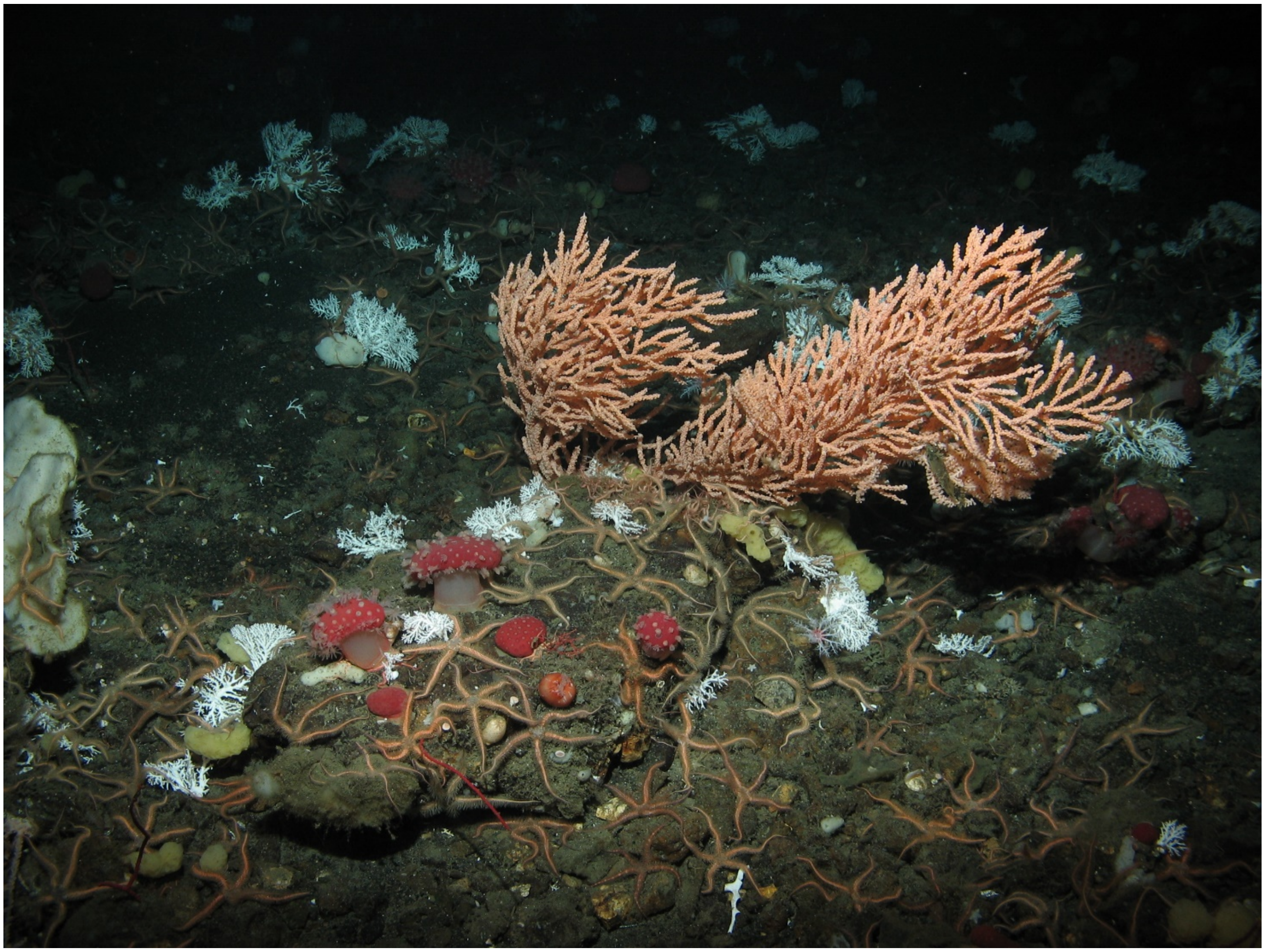

Figure XX. A red tree coral, *Primnoa pacifica*, observed on Mendocino Ridge at ~350 m. This is a southern range extension for this species.

D4. Anthropogenic noise generated by mobile survey vehicles
Contact: Tom Laidig (tom.laidig@noaa.gov)

During our UHSI cruise in southern California in 2017, 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 calls from *Sebastes paucispinis*.

D5. Revise Habitat Use Database (HUD) for 5-Year Essential Fish Habitat Review
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

During 2017, a final draft of the HUD was completed for all 117 species of groundfish identified in the current PFMC Groundfish Fishery Management Plan (FMP). The updated draft version of the HUD was then reviewed by West Coast EFH Coordinator, John Stadler, and retired NWFSC-FRAM fisheries research biologist, Waldo Wakefield. At their requests, several additions and modifications were made during 2018. A final, updated version of the HUD will be completed in mid-May (2019) and made publicly available through the NWFSC/FRAM Data Warehouse (https://www.nwfsc.noaa.gov/data/map) soon thereafter.

D6. Conduct Habitat Suitability Probability Modeling for 5-Year Essential Fish Habitat Review
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

Support was provided to Waldo Wakefield (NWFSC, retired) and Bran Black (Oregon State University) to inform Habitat Suitability Modeling efforts for adult life stages of the 92 groundfish species that are directly managed under the PFMC Groundfish Fishery Management Plan. Using information contained in the updated HUD (see D5 above), input data were provided for latitude, depth, and habitat association inputs for Bayesian analysis. Model outputs were then displayed graphically in GIS on a scale of 0-1 that estimates the probability that any particular location (i.e., 25 m x 25 m pixel in the output map) is suitable habitat for a particular species. Modeling efforts continued throughout 2018, with a target completion date of May 2019.

D7. Complete Data Quality layer for Cross-Shelf Benthic Habitat Suitability Modeling Project
Contact: Joseph J. 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 is ongoing. During 2017, a coastwide substrate map, initially created for the 2005 PFMC review of EFH for West Coast groundfishes, 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. During 2018, a data quality layer was compiled to improve the utility of the map for modeling purposes by weighing the reliability of various seafloor induration data. This updated substrate map and companion data quality layer were then used as an environmental input in coral and infauna modeling efforts. Metadata are now being created for the GIS products, and appropriate sections of the final report will be written and submitted during the spring of 2019.

D8. Organize and Host West Coast Groundfish Food Habits Workshop
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

With support from the West Coast Region office and Office of Sustainable Fisheries, a Groundfish Food Habits Workshop was conducted at NMFS-FED in Santa Cruz during September 24-25, 2018 with over 20 participants from 4 different NMFS Science Centers, academics, CDFW biologists, and NGOs. The main goals of the Workshop were to 1) become informed of past and current research on groundfishes, as well as pelagic fishes, sea birds, and marine mammals, 2) learn how to initiate a focused food habits program from Centers that have established programs (i.e., AFSC, NEFSC), and 3) bring together SWFSC and NWFSC scientists to plan and coordinate future work. This Workshop was highly effective in achieving its goals and helped to inform the development of the SWFSC's Center for Ecosystem Science Committee. A final report from the Workshop is currently being prepared and will be submitted to all Workshop participants, the West Coast Region and Office of Sustainable Fisheries, and SWFSC-CESC.

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. The review panel provided several recommendations for additional work, and indicated that subsequent to a future review, it would be feasible to recommend that this approach for estimating the species composition of California rockfish landings be recommended as the best available science to inform stock assessments in the 2021 stock assessment cycle.

D10. Plasticity in reproductive output in the chilipepper rockfish
Contact: Lyndsey Lefebvre (Lyndsey.Lefebvre@noaa.gov)

An understanding of the reproductive biology of a species is fundamental to successful management of fish stocks. Rockfish (*Sebastes* spp.) have complex reproduction, being viviparous and generally late to mature, often with extended adolescent periods characterized by abortive maturation events. Furthermore, whereas the majority of *Sebastes* species in the California Current region produce one brood of larvae annually, several are known to produce more than one, though no stock assessments have yet considered the impact multiple brooding may have on population spawning potential for these species. We documented abortive maturation and examined the prevalence and size-dependent and regional patterns of multiple brooding using macroscopic evaluation and detailed histological analysis of ovaries from a model species, chilipepper (*S. goodei*), collected off Central and Southern California (Lefebvre et al. 2018). We modeled the size-related maternal effect on the probability of multiple brooding, and quantified size-dependent fecundity relationships. Our results indicate that the most robust estimation of reproductive output, as a function of the fecundity-length relationship, is improved for chilipepper when multiple brooding is incorporated, due to the greater probability of additional broods, and thus greater spawning potential, in larger females.

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: 407-418.

Baetscher, D. S., E. C. Anderson, E.A. Gilbert-Horvath, D.P. Malone, E.T. Saarman, M.H. Carr, and J.C. Garza. In press. Dispersal of a nearshore marine fish connects marine reserves and adjacent fished areas along an open coast. Molecular Ecology. DOI: https://doi.org/10.1111/mec.15044

Bellquist, L., Beyer, S. Arrington, M., Maeding, J., Siddall, A., Fischer, P., Hyde, J., Wegner, N.C. (2019). Effectiveness of descending devices to mitigate the effects of barotrauma among rockfishes (*Sebastes* spp.) in California recreational fisheries. Fisheries Research 215:44-52.

Bizzarro, J.J., E.A. Gilbert-Horvath, E.J. Dick, A.M. Berger, K. Schmidt, D. Pearson, C. Petersen, L.A. Katutzi, R.R. Miller, J.C. Field, and J.C. Garza. In review. Addressing cryptic species issues in stock assessments as exemplified by blue rockfish (*Sebastes mystinus*) and deacon rockfish (*S. diaconus*).

Haskell, N., A. Mamula, and T. Collier. In press. Competition or cooperation? Peer effects in the Pacific Coast groundfish fishery. Land Economics.

He, X., and J.C. Field. In press. Effects of recruitment variability and fishing history on estimation of stock-recruitment relationships: Two case studies from U.S. West Coast fisheries. Fisheries Research.

Lefebvre, L., C. Friedlander, and J.C. Field. In press. Reproductive ecology and size-dependent fecundity in the petrale sole, *Eopsetta jordani*, in California, Oregon and Washington waters. Fishery Bulletin.

Lefebvre, L. S., S.G. Beyer, D.M. Stafford, N.S. Kashef, E.J. Dick, S.M. Sogard, and J.C. Field. 2018. Double or nothing: Plasticity in reproductive output in the chilipepper rockfish (*Sebastes goodei*). Fisheries Research 204:258-268.

Schroeder, I., J. Santora, S. Bograd, E. Hazen, K. Sakuma, A. Moore, C. Edwards, B. Wells, and J.C. Field. In press. Source water variability as a driver of rockfish recruitment in the California Current Ecosystem: implications for climate change and fisheries management. Canadian Journal of Fisheries and Aquatic Sciences.

Sogard, S. M., and S.A. Berkeley. 2017. Patterns of movement, growth, and survival of adult sablefish (*Anoplopoma fimbria*) at contrasting depths in slope waters off Oregon. Fishery Bulletin 115(2):233-251.

Warzybok, P., Santora, J.A., Ainley, D.G., Bradley, R.W., Field, J.C., Capitolo, P.J., Carle, R.D., Elliott, M., Beck, J.N., McChesney, G.J. and M.M. Hester. 2018. Prey switching and consumption by seabirds in the central California Current upwelling ecosystem: Implications for forage fish management. Journal of Marine Systems 185: 25-39.

Watters, D. L., and E.J. Dick. 2018. A comparison of length distributions of rockfishes (*Sebastes* spp.) from submersible and trawl surveys off central California. Fishery Bulletin 116(3):291-301.

E2. Other Publications

Baetscher, D. S. 2019. Larval dispersal of nearshore rockfishes. Ph.D. dissertation, University of California, Santa Cruz. 173 p.

Dick, E.J., A. Berger, J. Bizzarro, K. Bosley, J. Cope, J. Field, L Gilbert-Horvath, N. Grunloh, M. Ivens-Duran, R. Miller, K. Privitera-Johnson, and B. T. Rodomsky. 2018. The combined status of blue and deacon rockfishes in U.S. waters off California and Oregon in 2017. Pacific Fishery Management Council, Portland, Oregon. 377 p.

Field, J.C., and X. He. 2018. Stock assessment update of blackgill rockfish, *Sebastes melanostomus*, in the Conception and Monterey INPFC areas for 2017. Pacific Fishery Management Council, Portland, Oregon. 96 p.

He, X., and J. C. Field. 2018. Stock assessment update: Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas for 2017. Pacific Fishery Management Council, Portland, Oregon. 224 p.

Monk, M. H., X. He, and J. Budrick. 2018. Status of California scorpionfish (*Scorpaena guttata*) off southern California in 2017. Pacific Fishery Management Council, Portland, Oregon. 217 p.
Sakuma, K.. 2018. Cruise report, NOAA Ship Reuben Lasker RL-18-02, May 8 - June 21, 2018: Rockfish recruitment and ecosystem assessment. NOAA National Marine Fisheries Service, SWFSC Fisheries Ecology Division, Santa Cruz, California. 18 p.

STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2018

Prepared for the Sixtieth Annual Meeting of the Technical Subcommittee
of the Canada-United States Groundfish Committee

With contributions from:
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April 2019

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 2018. 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 2018.

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/shellfish 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 fisheries biologist serves as a groundfish sampler and general support and is located in Cordova, and a seasonal groundfish/shellfish sampler is located 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 and the groundfish/shellfish research biologist serves on the Council's Scallop Plan Team. 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, dark 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 2018, ADF&G AKFIN personnel processed 10,902 groundfish fish tickets, collected 22,906 groundfish biological samples and measured 10,244 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 2018

ADF&G Region	
1 - Southeast	3,376
2 - Central	2,403
4 - Westward; Kodiak, Chignik, AK Pen.	4,139
4 - Westward; BSAI	4,360
Total	10,902

Groundfish Biological Data Collection - Calendar Year 2018

ADF&G Region	AWL Samples Collected	Age Estimates Produced by Regional Personnel	Age Estimates Produced by the Age Determination Unit
1 - Southeast	6,508	none	4,174
2 - Central	9,412	1,779	1,217
4 - Westward	6,986	3,074	n/a
Total	22,906	4,853	5,391

b. Interagency Electronic Reporting System - eLandings (Contact Elaine Brewer).

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 1.1 million landing reports have been submitted to the eLandings repository database. More than 99% of all groundfish landings are submitted electronically.

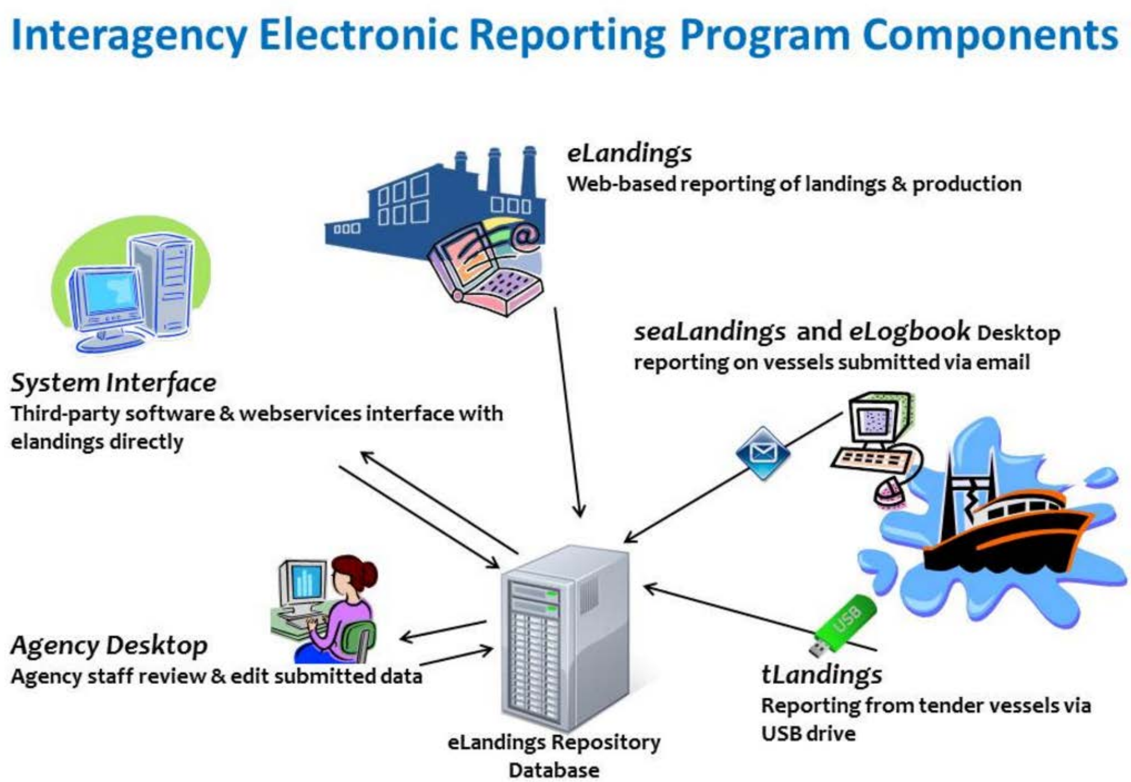


Figure 10. Data are reported by the seafood industry using eLandings web, seaLandings and tLandings. Agency staff review, edit and verify landing and production reports within the eLandings agency desktop tool. Industry can pull harvest data for their company from the database using the eLandings system interface tools.

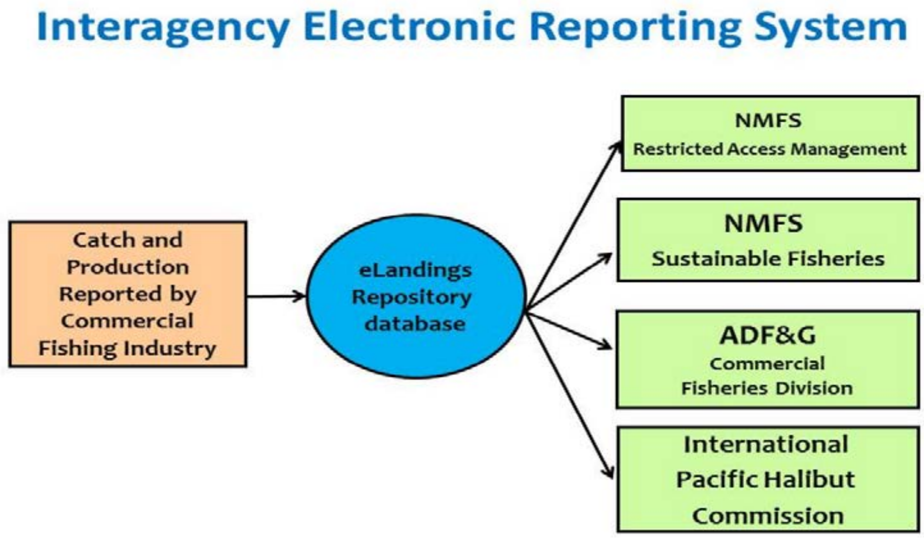


Figure 11. Interagency staff have established methods to pull data from the repository database into their databases of record. The ADF&G fish ticket records are pulled into the commercial fisheries fish ticket database once data verification has occurred.

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 2018 salmon season, 82.3% percent of all salmon landings were submitted electronically.

While implementation of statewide electronic reporting of shellfish and herring fisheries was planned to be addressed in 2018, this ambitious undertaking had to be put on hold due the eLandings Program Coordinator II, Gail Smith, unexpectedly being out on medical leave for an extended period of time and eventually retiring in July 2018. Additionally, the two main ADF&G eLandings programmer positions had an average vacancy rate of 22.9% during 2018. Due to the complexity of the eLandings system, training a new programmer requires up to two years before he/she can act without review.

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 2018, the IERS recorded 201,268 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 yelloweye, 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 2018, the ADU received 10,939 otolith sets from central and southeast Alaska commercial and survey sampling (representing 12 groundfish species). The ADU produced 9,907 ages and distributed 8,900 ages to region managers, including data from samples received in previous years but processed in 2018. 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 2018, quality control procedures resulted in an additional 6,660 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 2,038 age estimates. Given production, quality control, and training procedures, the ADU recorded 18,605 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 (18,086 otoliths in 2018, representing 14 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 2018, ADU personnel participated in age structure exchanges to address agency and TSC concerns, prepared and presented CARE documents at the TSC meeting, and organized the 2019 CARE meeting. The ADU participated in four yelloweye rockfish age structure exchanges with Washington Department of Fish and Wildlife (WDFW), Northwest Fisheries Science Center in Newport, OR (NWFSC), Fisheries and Oceans Canada (DFO), and ADF&G in Homer to address TSC recommendations from 2017 and 2018. The ADU also participated in four sablefish exchanges with the Alaska Fisheries Science Center in Seattle, WA (AFSC), NWFSC, and DFO; one Pacific cod exchange with AFSC for training; and one lingcod exchange with WDFW to support an otolith/fin ray comparison study. During the 2018 TSC meeting, Kevin McNeel presented a CARE summary and recommendations to the subcommittee and, as the Chair of CARE, distributed TSC recommendations to CARE participants. McNeel also worked with AFSC personnel to organize the 2019 CARE meeting held in April at the AFSC Sandpoint facility in Seattle, WA. .

2. The ADU is funded by State of Alaska, AKFIN, and special project support. In fiscal year 2018 and 2019, approximately 48% of funding was provided by the State of Alaska, 30% by AKFIN, and 22% from research grants. During 2018, the ADU employed seven people (approximately 60 man months) to age, process samples, enter data, maintain sample archives, measure samples, and complete other support tasks for both groundfish and invertebrates.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 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.

a. 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. Southeast Region

The Southeast Region extends from the EEZ boundary in Dixon Entrance north and westward to Cape Suckling, at approximately 144o W. longitude. Regional staff in Juneau coordinate a data collection program for halibut and groundfish in conjunction with a regionwide 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 and age 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 landed at Sitka for estimation of age composition in 2016 - 2018. 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 BOF. 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. Seasonal technicians collected data from the sport harvest at seven major ports in the region. 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 non-halibut age reading was done in Homer, and the staff members are active participants in CARE. 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.

III. Marine Reserves

Nothing to report for 2018.

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).

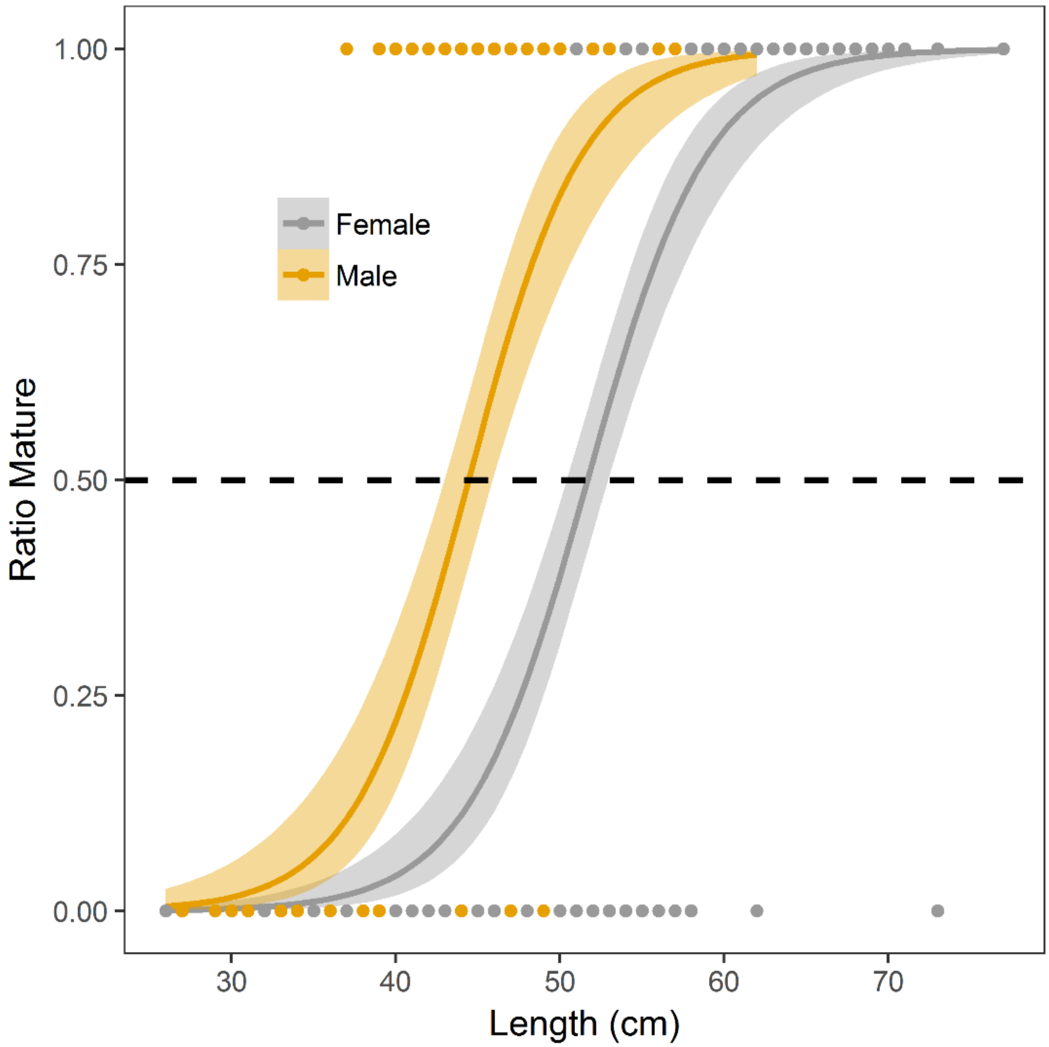


Figure 12. Preliminary size at 50% maturity with 95% confidence intervals for male (44.4 cm, n=182) and female (51.6 mm, n=269) *E. deani* in southern Southeast Alaska.

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 2018 six hagfish management areas were created within the Southeast Region. In 2018, 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 120,000 lbs. The primary species caught is *E. deani* and a market has been developing for Alaskan hagfish where they are sold for food. 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

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 2,645 boat-trips and 12,472 angler-days of effort targeting all species in 2018. Interviewed anglers caught 8 salmon sharks but kept only one and caught 2,002 spiny dogfish and kept 3. Length measurements were obtained from one sleeper shark (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 2018, 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 2018.

d. Fisheries

No applications for commissioner's permits were received in 2018, and no permits have been issued in Central Region since 2006. During 2018, harvest of spiny dogfish was low in both Cook Inlet Area (.005 mt) and PWS (0.242 mt). Estimates of the 2018 sport harvest of sharks are not yet available, but harvest in 2017 was estimated at 50 sharks of all species in Southeast Alaska and 105 sharks in Southcentral Alaska. The precision of these estimates was relatively low; the Southeast estimate had a CV of 44% and the Southcentral estimate had a CV of 30%. 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.

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 Wyatt Rhea-Fournier).

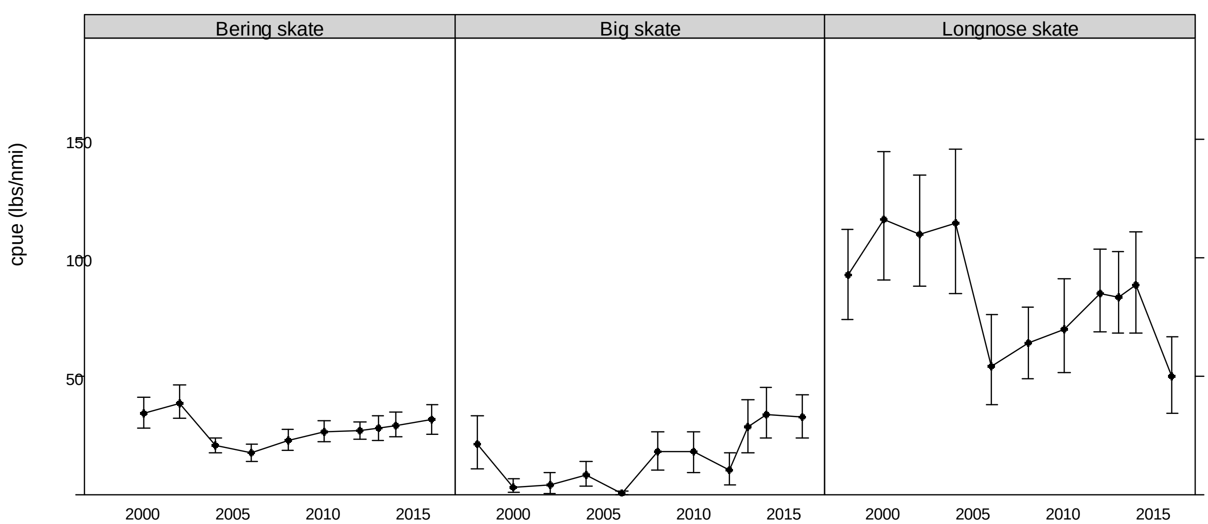


Figure 4. Trawl survey CPUE estimates of skates with 90% confidence intervals in Eastern PWS.

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 up to 5% of target species to align with the National Marine Fisheries Service (NMFS) maximum retainable allowance (MRA) 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 5.3 mt in 2018, less than half the 2017 harvest, and continuing a steady decline since 2015. In PWS, skate harvest was 14.2 mt in 2018, similar to the 2017 harvest. 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 2018 of 17.9 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.

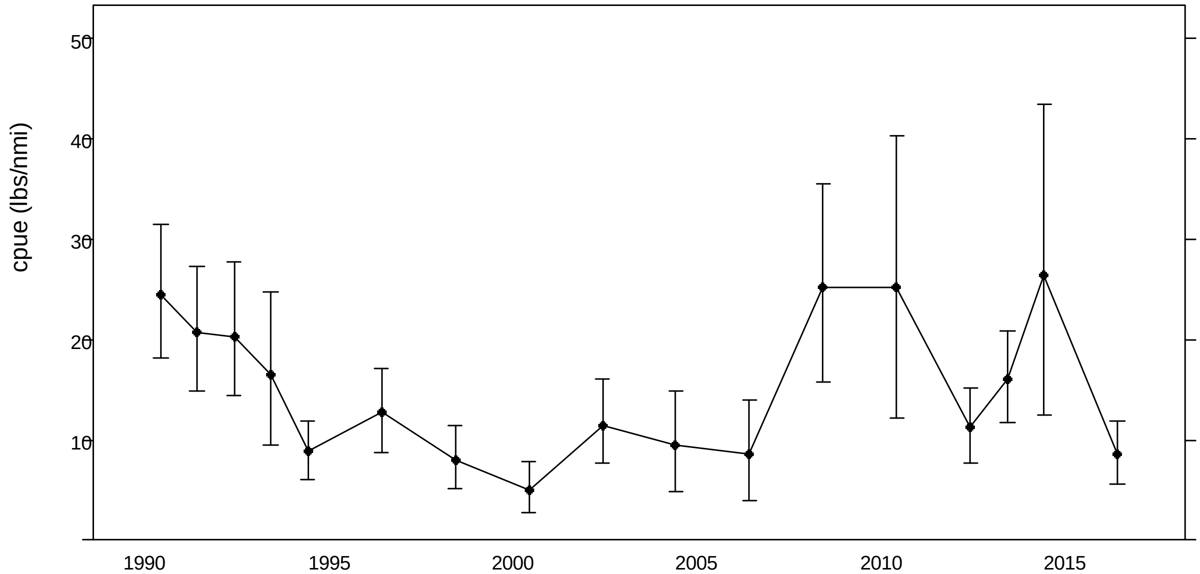


Figure 5. Trawl survey CPUE estimates of Pacific cod with 90% CIs in Eastern PWS.

In the **Central Region**, skipper interviews and biological sampling of commercial Pacific cod deliveries from Cook Inlet and PWS areas during 2018 occurred in Homer, Seward, Whittier, and Cordova. 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 2018.

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.

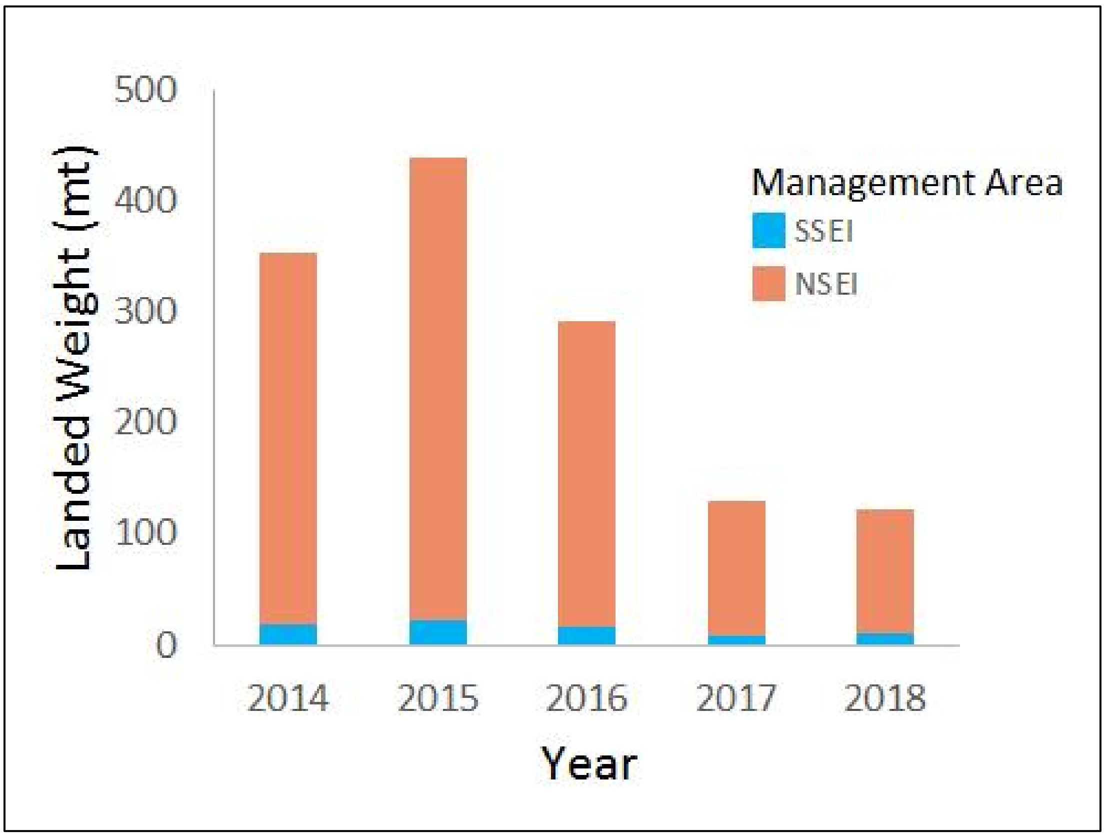
A state-waters Pacific cod fishery management plan has also been adopted in waters of the Bering Sea near Dutch Harbor. The **Dutch Harbor Subdistrict** Pacific cod season is open to vessels 58 feet or less OAL using pot gear, with a limit of 60 pots. The fishery GHL is set at 6.4 percent of the Bering 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 the Kodiak, Chignik, and South Alaska Peninsula 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 2018 catch in the state-waters Pacific cod fisheries. In the Bering Sea -Aleutian Islands Area, trawl gear took 8%, longline gear took 52%, and pot gear took 39% of the harvest in the parallel Pacific cod fisheries. Pot gear is the only legal gear type for the Dutch Harbor Subdistrict state-waters fishery. For the Aleutian Islands Subdistrict state-waters fishery, trawl, jig, longline, and pot are all legal gear types; both pot and trawl vessels participated in 2018 however harvest is confidential due to the number of processors.

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 121 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2018 with 96 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 2014–2018 for the direct and bycatch fisheries.

The 2018 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and PWS areas of the **Central** Region were 450 mt and 304 mt, respectively. The Cook Inlet Area GHL was down 82% from 2017 while the PWS GHL decreased 77%. Pacific cod harvest from the state-waters seasons was 254 mt from Cook Inlet Area and 159 mt from PWS. Pacific cod harvest during the 2018 parallel seasons was 338 mt from Cook Inlet and 109 mt from PWS, both down significantly from 2017. In Central Region in 2018, the parallel jig season was not opened and therefore the state-waters season opened on January 1 in PWS and Cook Inlet Area; the harvest by this sector was minimal and was open until December 31. In Cook Inlet Area and PWS, parallel longline and pot fisheries were open concurrently with federal "A" and "B" seasons. The state-waters pot GHL was achieved for the >58 foot vessels although the <58 foot vessels harvested just below the GHL. For PWS, the state-waters longline fishery only harvested 35% of the GHL.

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 2018 Pacific cod GHLs were 1,015 mt in the Kodiak Area, 710 mt in the Chignik Area and 2,424 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik and South Alaska Peninsula was 529 mt, 641 mt and 2,423 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 2018 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 2018, the total state-waters catch for the Dutch Harbor Subdistrict was 13,180 mt.

Estimates of the 2018 sport harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2017 estimates were 6,679 fish in **Southeast** and 13,158 fish in **Southcentral Alaska**. The estimated annual harvests for the recent five-year period (2013-2017) averaged about 14,176 fish in **Southeast** Alaska and 29,832 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 2018 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 500 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.

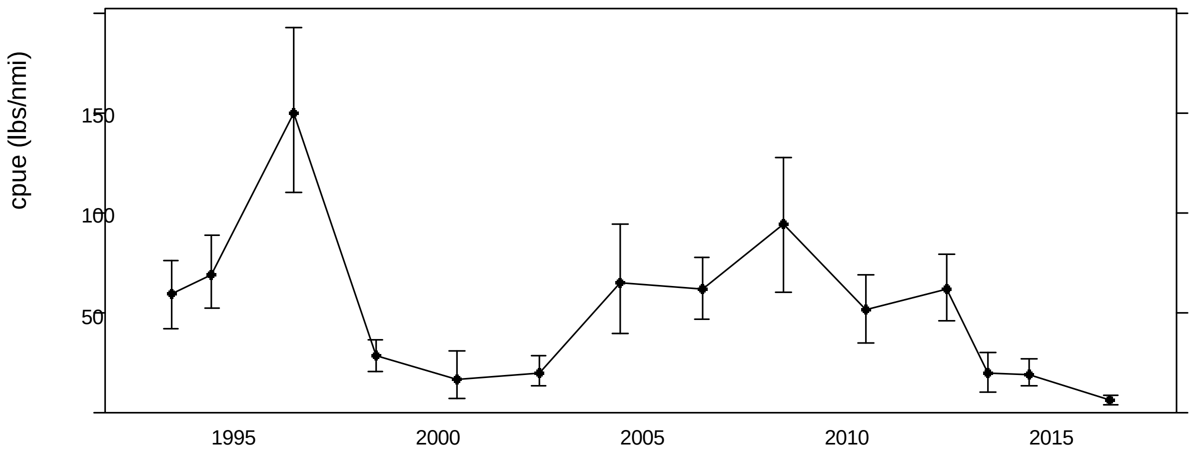


Figure 7. Trawl survey CPUE estimates of Walleye pollock with 90% confidence intervals in Eastern PWS.

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 addition, the Rockfish Management Plan allows 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 2018 PWS pollock pelagic trawl fishery opened January 20 and closed on March 2, after the GHL had been achieved. There were 28 landings made by 16 vessels with a total harvest of 3,507 mt, 96% of the 3,629 mt GHL; interest in the fishery was high because of low Pacific cod abundance and corresponding harvest levels. Rockfish bycatch during the fishery totaled 1.6 mt well below the 16 mt allowed as bycatch to the pollock harvested. In the Cook Inlet Area, no seine pollock commissioner's permits were issued in 2018. Pollock was harvested in Central Region as bycatch to other groundfish fisheries at low levels; in 2018, 0.8 mt was harvested in Cook Inlet Area and 1.1 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 2018. 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 2018, length, weight and age structures were collected from 1,789 yelloweye rockfish caught in the directed and halibut commercial longline fisheries. Skipper interviews and port sampling of commercial rockfish deliveries in Central Region during 2018 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 Area black rockfish being met 2014-2018. Additional rockfish samples were collected from bycatch fisheries in Cook Inlet Area 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 determine 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. In 2018, a new project was initiated to study genetic variation between outside waters of North Gulf, outside waters of PWS, and inside waters of PWS for both yelloweye and black rockfish; collection of fin clips began in 2018 and will continue into 2019 followed by genetic analysis. 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).

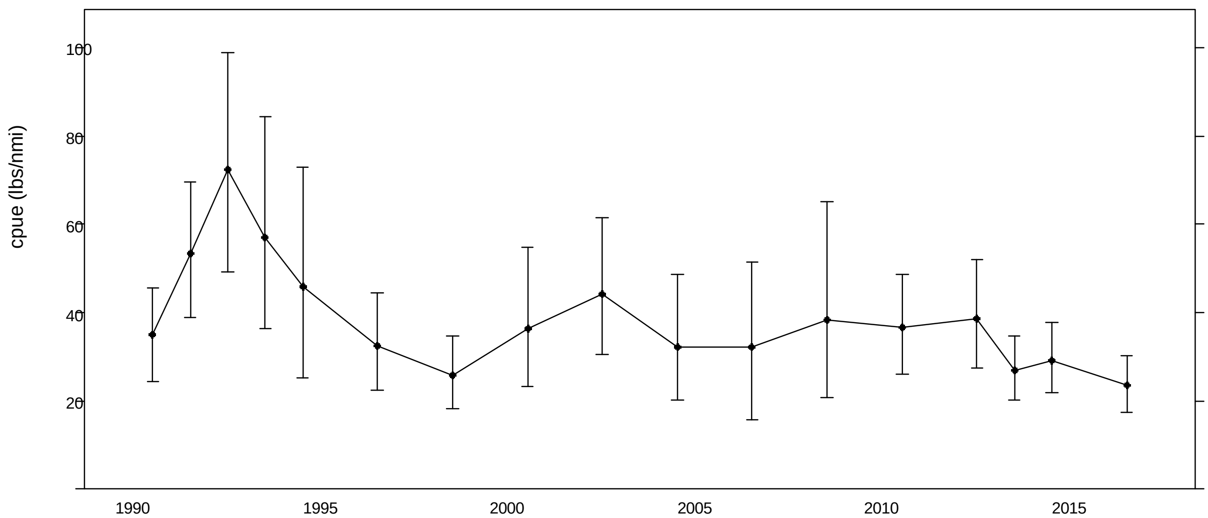


Figure 8. Trawl survey CPUE estimates of rougheye/blackspotted rockfish with 90% confidence intervals in Eastern PWS.

The **Westward Region** continued port sampling of several commercial rockfish species and Pacific cod in 2018. 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 2017 season.

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 2018 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 2019 (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 10,950 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 rockfish harvest and groundfish effort by port. The 2018 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, Central Cook Inlet, and Homer was 4,363 rockfish (Contact Martin Schuster).

The Division of Sport Fish conducted research in PWS on the ability of 6 species of rockfish to resubmerge unassisted when released at the surface. This study is ongoing. Results will be published as an ADF&G Fishery Data Series report towards the end of 2020 (Contact Brittany Blain-Roth or Jay Baumer).

The **Age Determination Unit** initiated the North Pacific Research Board funded project 1803: Reconstructing reproductive histories of yelloweye rockfish through opercular hormone profiles in 2018. 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, cortisol, and ecdysteroids 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 (Contact Dion Oxman).

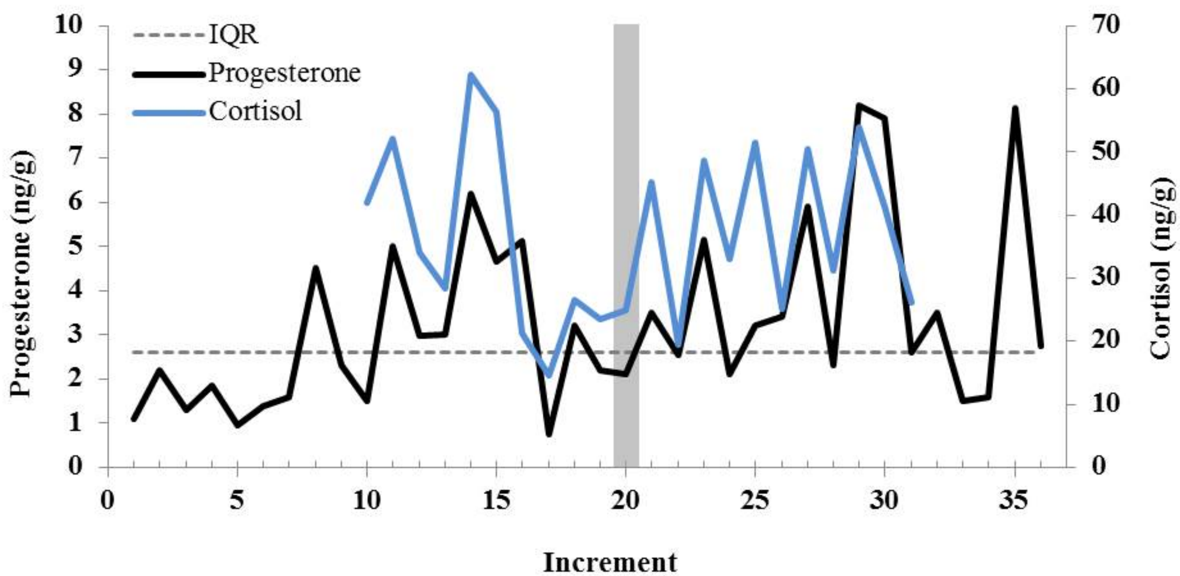


Figure 9. Progesterone (black) and cortisol (blue) concentrations recovered from annual growth increments within the operculum of a 36-year old female yelloweye rockfish via immunoassay extraction. Peak

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 manned submersible. After 2012, 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 km2 with CV estimates of 12–33%. The ROV surveys were most recently performed in collaboration with Central Region staff in 2017 in EYKT and in 2018 in SSEO, NSEO and CSEO (Figure 10). The most recent density estimates for EYKT in 2017 was 1,072 yelloweye per km2 (CV=21%) and for SSEO in 2018 was 1,624 yelloweye per km2 (CV = 25%). Density estimates for the most recent survey year (2018) for NSEO and CSEO are in progress, however the estimate for these two survey areas in 2016 yielded density estimates of 701 yelloweye per km2 (CV=20%) for NSEO and 1,101 yelloweye per km2 (CV=14 %) for CSEO. In addition, from ROV video data, we can measure fish lengths for yelloweye rockfish, lingcod, and halibut using stereo camera imaging software (SeaGIS, Ltd) (Contact Andrew Olson).

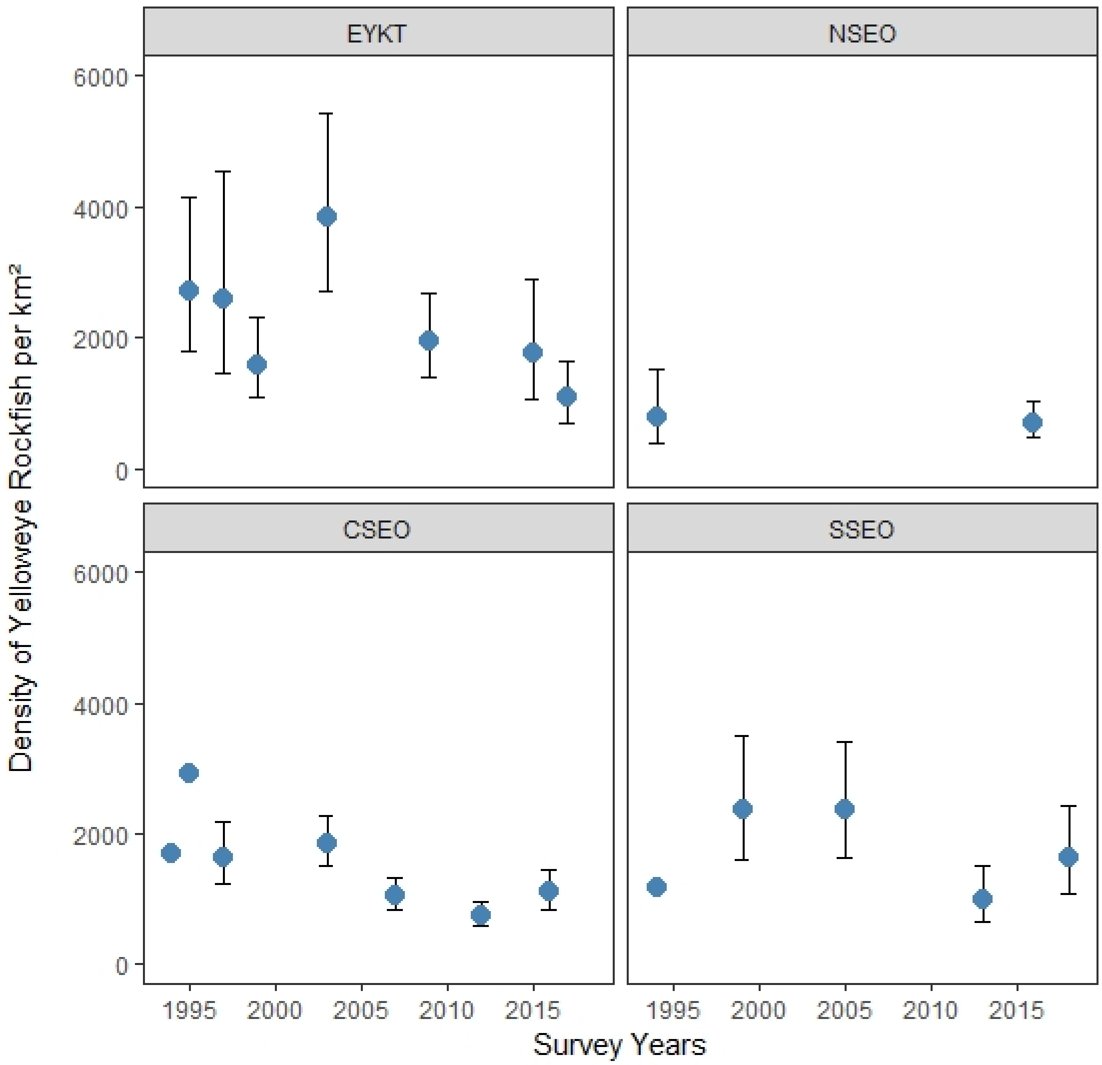


Figure 10. Density estimates of yelloweye rockfish with 90% confidence intervals in the Eastern Gulf of Alaska management areas. Management areas include: Eastern Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (CSEO).

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 Wyatt Rhea-Fournier).

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 total allowable catch (TAC), guideline harvest range (GHR), seasons, gear restrictions, and trip and bycatch limits.

Directed commercial harvest of DSR is restricted to hook-and-line gear. Directed fishing quotas are set for Southeast Outside 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 included logbook requirements and 5-day trip limits of 6,000 pounds sold per vessel in all areas except EYKT where the trip limit was 12,000 pounds. New regulations adopted in 2018 further restricted trip limit rules by prohibiting additional fish to taken or allowed on board a vessel until the trip limit period expired. The EYKT trip limit amount was also reduced to 8,000 pounds.

The directed DSR fishery season in SEO occurs only in the winter, prior before the start of the commercial halibut IFQ season. The SEO TAC for DSR is set after decrementing estimated subsistence harvest, the remainder is allocated 84% to the commercial sector and 16% to the sport sector. The 2018 ABC for DSR was 235 mt, which resulted in a TAC of 228 mt with allocations of 192 mt to commercial fisheries and 36 mt to sport fisheries. The 2019 ABC is set at 261 mt, resulting in a TAC of 254 mt of which 213 mt is allocated to commercial fisheries and 41 mt to sport fisheries. Estimated subsistence harvest for 2018 and 2019 was 7 mt. A significant portion of the total commercial harvest is taken as bycatch during the halibut fishery; each year DSR bycatch is estimated and decremented from the commercial TAC prior to the determining whether an area has enough quota remaining to prosecute a directed fishery.

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 the Eastern Gulf of Alaska Area. 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 district fishery at a time. Registration requirements also exist for the Chignik and South Alaska Peninsula areas. In the Kodiak Area, fishers may retain up to 20% of black rockfish by weight caught incidentally during other fisheries, and in the Chignik and South Alaska Peninsula Area black rockfish may be retained up to 5% by weight. In the Aleutian Islands District of the Bering-Sea Aleutian Islands Area, fishers may retain up to 20% of black rockfish and 20% for dark rockfish caught in the Bering Sea – Aleutian Islands area incidentally during other fisheries. 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).

In 2018, the Kodiak Area black rockfish GHL was 55 mt allocated across five districts. GHLs were attained in four sections of the Kodiak Area for a total harvest of 49 mt. The Chignik and South Alaska Peninsula area GHLs were 45 mt and 34 mt respectively. In the South Alaska Peninsula Area, the 2018 black rockfish harvest was 11 mt and no black rockfish harvest occurred in the Chignik Area. The Aleutian Islands GHL for black rockfish was 41 mt allocated across three sections. No vessels made directed black rockfish landings in the Aleutian Islands Area; all harvest was incidental retention. Harvest for black rockfish is confidential due to the number of participants and 24.7 mt of dark rockfish were harvested incidental to other groundfish species.

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 (Contact Natura Richardson).

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 was four rockfish per day, with a total possession limit of eight rockfish of those caught no more than one of those could be a non-pelagic species. The bag limit in the North Gulf Coast area was four rockfish per day, and a possession limit of eight rockfish of which only one per day and two in possession can be a non-pelagic rockfish species. The bag limit for Chiniak and Marmot Bay areas off Kodiak was three rockfish, no more than one of which could be a yelloweye. The bag limit in the remainder of Kodiak 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. The bag limit in the Alaska Peninsula and Aleutian Islands was 10 rockfish per day.

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. 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, 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 2018. The directed fishery for DSR in SEO opened in Central Southeast Outside (CSEO) only; East Yakutat (EYKT), Northern Southeast Outside (NSEO), and Southern Southeast Outside (SSEO) sections did not open to directed fishing, because the portion of the TAC allocated to those areas was not large enough to support manageable fisheries. Directed fishing for DSR was also opened in internal waters. The 2018 harvest of DSR by directed fisheries in CSEO was 51.1 mt and internal waters harvest was 28.3 mt. In addition, DSR was taken as bycatch with 80.5 mt harvested in SEO and 21.8 mt in internal waters. Harvest in the directed black rockfish fishery in Southeast Outside District (SEO) was 1.7 mt and black rockfish bycatch harvest in all groundfish, halibut, and salmon troll fisheries in SEO was 6.3 mt. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 58.2 mt harvested in 2018. 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 2018, the total rockfish harvest, including the directed PSR jig fishery and bycatch, was 26.8 mt. PSR harvest comprised 63% of the total harvest, with the majority of harvest coming from the directed PSR fishery. In PWS, rockfish are only harvested as bycatch, as there is no directed fishery. The harvest of 25.6 mt in 2018 was similar to 2017 and much reduced from 2014 through 2016 levels when the harvest exceeded the GHL. The majority of rockfish bycatch in PWS was caught by longline gear (92%) followed by trawl gear (8%) 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 2018 harvest are not yet available from the SWHS, but the 2017 estimates for all species combined were 149,927 fish in Southeast and 128,708 fish in Southcentral Alaska. The average annual harvest estimates for the recent five-year period (2013-2017) were 168,719 rockfish in Southeast Alaska and 141,028 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 2018. In **Central Region** thornyheads are retained as bycatch up to 10% in aggregate with other rockfish 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 2018, 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 2018 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 2018, 9,679 fish were marked and released in NSEI over the course of the tagging survey. In addition to marking, a total of 2,124 genetic samples were collected along the entire length of Chatham Strait. Over the 21-day survey, 24 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 2019 (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 Wyatt Rhea-Fournier).

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 2018 recommended ABC of 438 mt for the NSEI fishery was calculated by applying the 2017 fishery mortality at age (based on a harvest rate of 6.4% using the F50% biological reference point (BRP)) to the 2018 forecast of total biomass at age and summing across all ages. The 2018 ABC was a 13.6% increase from the 2017 ABC (385 mt), which was also based on the F50% BRP (the harvest rate was 6.4% for 2017). Since 2009 BRPs have become more conservative, i.e. F45% in 2009 and F50% 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. In 2018 there were 78 eligible permit holders in NSEI and 23 permit holders in SSEI.

In 2017, the CFEC approved a public petition for SSEI longline permit holders to fish pot gear due to whale depredation and rockfish bycatch issues, thus making the permit a longline/pot permit. SSEI has 20 longline/pot permits and 3 pot permits; the NSEI fishery is restricted to longline gear only. In 2018, the BOF amended SSEI sablefish longline and pot seasons to a concurrent season occurring from June 1 to November 15, adopted new regulations to require commercial sablefish pots to have two 4-inch circular escape rings and allowed for the possession of live sablefish for delivery as a live product.

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 sablefish household fishing permits. Bag (50 fish per permit), vessel (200 fish per vessel) and hook (350 per permit) limits were adopted for personal use sablefish fishing at the 2015 BOF meeting. In 2018, the BOF approved the use of pots in the personal use sablefish fishery with a limit of two pots per person, 8 pots per vessel.

The NSEI quota was set at 388 mt and the SSEI quota was set at 263 mt for 2018.

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 2018. 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 2018 were four fish of any size per day, four in possession, with an annual limit of eight fish applied to nonresidents. Creel surveys in Southeast Alaska in 2018 sampled 651 sablefish, reflecting the relatively small harvest relative to other species. The sablefish sport fishery in Southcentral Alaska has no bag, possession, or size limits. Port samplers in Southcentral Alaska measured only one sablefish from the sport harvest, again reflecting the relatively small harvests.

d. Fisheries

In the Southeast Region the 2018 NSEI sablefish fishery opened August 15 and closed November 15. The 78 permit holders landed a total of 388 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 5.0 mt. The 2018 SSEI sablefish fishery season was amended this year to allow for longline/pot gear permits to fish from June 1–November 15. In SSEI, 20 permits were designated to be fished with longline/pot gear and 3 permits for pot gear only. Twenty-three permit holders landed a total of 261 mt of sablefish, each with an equal quota share of 11.4 mt (Contact Andrew Olson). In the **Central Region,** the 2018 Cook Inlet Area sablefish fishery opened at noon July 15 with a GHL of 28.1 mt and closed by regulation on December 31. Seven vessels participated in CI and harvested just under 40% of the GHL. One vessel used pots in the fishery, with limited success, and the rest of the vessels fished with longline gear. The 2018 PWS sablefish fishery opened April 15 with a GHL of 60.3 mt and closed by regulation on August 31. PWS sablefish harvest totaled 40 mt, steadily increasing since the 7.7 mt historical low in 2015, although still not achieving the GHL. Longline gear was used to harvest 76% of the total and 23% was harvested with pot gear (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 2018 Aleutian Island fishery opened concurrent with the IFQ season, on March 24 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 2018 Aleutian Islands sablefish fishery was 14 mt. The season remained open until the November 7 closure date (Contact Asia Beder).

The most recent sablefish sport harvest estimates from the SWHS are for 2017. The estimated harvest was 14,564 fish in Southeast Alaska and 7,529 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 2017 (Contact Bob Chadwick, Dan Bosch).

K. Lingcod

a. Research

Dockside sampling of lingcod caught in the commercial fishery continued in 2018 in Sitka with 1,206 fish sampled for biological data. 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 2018 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,862 lingcod in 2018, 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 575 lingcod from the sport harvest at Seward, Valdez, Whittier, Kodiak, Central Cook Inlet, and Homer in 2018. These ports accounted for most of the sport lingcod harvest in Southcentral Alaska (Contact Martin Schuster).

b. Assessment

There is no stock assessment for lingcod in the Southeast Region.

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 2018 (Contact Mike Byerly or Wyatt Rhea-Fournier).

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 2018 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 BOF:

(1) In the Northern Southeast area, nonresidents were allowed one fish daily or in possession, the fish must be 30-35 inches in length or at least 55 inches or greater 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;

(2) In the Southern Southeast area, nonresidents were allowed one fish daily or 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 fish, of which one must be 30-45 inches in length and one must be 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 2018 were two fish in Cook Inlet and Kachemak Bay, and one fish in North Gulf Coast and Prince William Sound areas. 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 2018 totaled 22.4 mt in Cook Inlet Area, similar to the harvest in 2017. In PWS, lingcod harvest in 2018 was 13.4 mt in PWS, more than twice the harvest in 2017, 9 more longline vessels made lingcod landings in 2018 compared to 2017. Approximately 88% of the lingcod harvest from Cook Inlet Area resulted from participation in the directed lingcod jig fishery. Cook Inlet Area harvest increased more than seven-fold from 2015 to 2017 and remained steady in 2018; vessels fishing in the directed lingcod fishery typically participated concurrently in the directed rockfish fishery, which also had an increase in harvest and effort in recent years. In PWS, 61% of lingcod harvest was from longline effort and 38% of the total lingcod was harvested with jig gear, with 8.5 mt harvested in the directed fishery. In both areas, the remaining harvest resulted from bycatch to other directed (primarily halibut) longline fisheries. PWS area fisheries remained open through December 31 however, in Cook Inlet Area, the fishery closed November 11 when the GHL was achieved, the first time since 2006 (Contact Jan Rumble).

In the **Westward Region**, no directed lingcod effort occurred during 2018. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2018 harvest totaled 20 mt in the Kodiak Area and <1 mt in the Chignik, South Alaska Peninsula, and Aleutian Islands – Bering Sea areas combined.

Sport lingcod harvest estimates from the SWHS for 2017 (the most recent year available) were 11,427 lingcod in Southeast Alaska and 10,831 lingcod in Southcentral Alaska. The average estimated annual harvest for the recent five-year period (2013-2017) was 12,792 fish in Southeast Alaska and 15,618 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 (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 Sarah Webster).

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

Beder, A. 2018. Fishery management plan for the Aleutian Islands Subdistrict state-waters and parallel Pacific cod seasons, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 18-34, Anchorage.

Beder, A. 2018. Fishery management plan for the Dutch Harbor Subdistrict state-waters and parallel Pacific cod seasons, 2018. Alaska Department of Fish and Game, Fishery Management Report No. 18-05, Anchorage.

Beder, A. 2018. Fishery management plan for the Dutch Harbor Subdistrict state-waters and parallel Pacific cod seasons, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 18-35, Anchorage.

Beder, A., and J. Shaishnikoff. 2018. Annual management report for groundfish fisheries in the Bering Sea-Aleutian Islands Management Area, 2016. Alaska Department of Fish and Game, Fishery Management Report No. 18-06, Anchorage.

Beder, A., and J. Shaishnikoff. 2018. Annual management report for groundfish fisheries in the Bering Sea-Aleutian Islands Management Area, 2017. Alaska Department of Fish and Game, Fishery Management Report No. 18-18, Anchorage

Blain-Roth, B. 2018. Operational Plan: Submergence success of rockfish in Prince William Sound, 2018–2019. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.2A.2018.15, Anchorage.

Howard, K. G., C. Habicht, E. Russ, A. Olson, J. Nichols, and M. Schuster. 2019. Operational Plan: Genetic sampling of yelloweye and black rockfish from inside and outside waters of

Prince William Sound, North Gulf of Alaska, and Southeast Alaska. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.4A.2019.01, Anchorage.

Olson, A., and A. Baldwin. 2018. Eptatretus spp. (Hagfish) occurrence in Southern Southeast Alaska. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.1J.2018.02, Douglas.

Polum, T. B., and C. Worton. 2018. Northeast District Kodiak rockfish sampling operational Plan: collaborative Commercial and Sport Fisheries divisions project. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.2A.2018.18, Anchorage.

Richardson, N., and N. Nichols. 2018. Fishery management plan for the Kodiak Area state-waters Pacific cod season, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 18-36, Anchorage.

Richardson, N. 2018. Fishery management plan for the Kodiak Area commercial black rockfish fishery, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 18-12, Anchorage.

Tschersich, P. 2018. Hydroacoustic survey of black rockfish abundance and distribution operational plan for the Kodiak Management Area, 2017-2019. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Operational Plan ROP.CF.4K.18.02, Kodiak.

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 4/9/2019)

COMMERCIAL FISHERIES DIVISION

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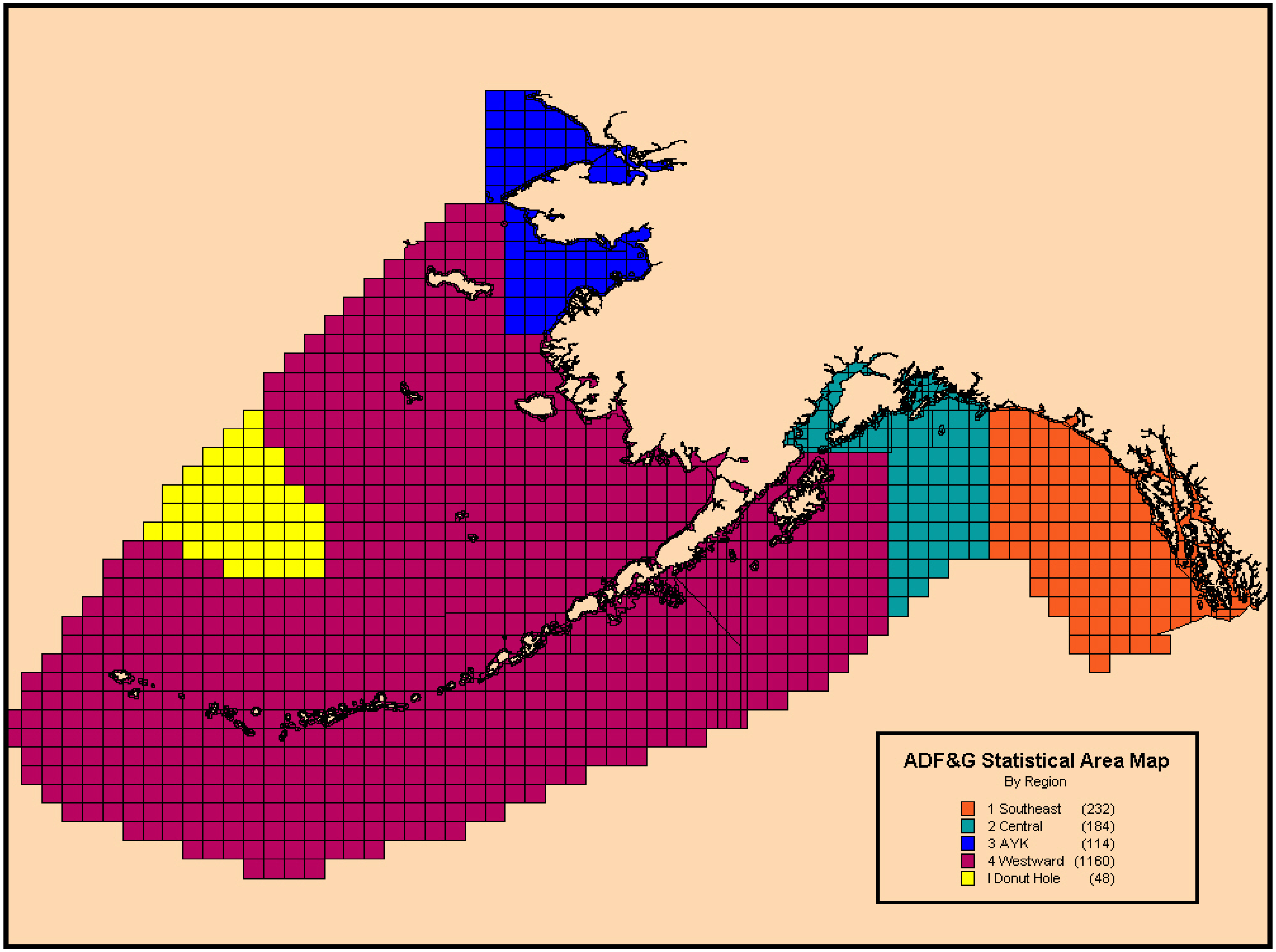
Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions.



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 2019

Prepared by

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Michael Prall
Travis Tanaka
Amanda VanDiggelen

Contents

I. Agency Overview

Within the California Department of Fish and Wildlife (CDFW), the Marine Region is responsible for protecting and managing California's marine resources under the authority of laws and regulations created by the State Legislature, the California Fish and Game Commission (CFGC) and the Pacific Fishery Management Council (PFMC). The Marine Region is unique in the CDFW because of its dual responsibility for both policy and operational issues within the State's marine jurisdiction (0 – 3 miles). It was created to improve marine resources management by incorporating fisheries and habitat programs, environmental review and water quality monitoring into a single organizational unit. In addition, it was specifically designed to be more effective, inclusive, comprehensive and collaborative in marine management activities.

The Marine Region has adopted a management approach that takes a broad perspective relative to resource issues and problems. This ecosystem approach considers the values of entire biological communities and habitats, as well as the needs of the public, while ensuring a healthy marine environment. The Marine Region employs approximately 140 permanent and 100 seasonal staff that provide technical expertise and policy recommendations to the CDFW, CFGC, PFMC, and other agencies or entities involved with the management, protection, and utilization of finfish, shellfish, invertebrates, and plants in California's ocean waters. 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 (PSMFC) staff sample the state's commercial groundfish fishery. The Marine Region's annual Year in Review provides summary of all its programs, including groundfish.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

II. Surveys

ROV Visual Survey and Analysis for MPA and Fishery Data Needs

From 2014 to 2016, CDFW's Marine Protected Area (MPA) Management Project collaborated with Marine Applied Research and Exploration to complete a statewide visual survey using a remotely operated vehicle (ROV) (see 2015, 2016, and 2017 TSC reports for description of the program). 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, completed an 18-month fellowship in September 2018. Manuscripts on the analysis of ROV data using spatial point process models and sampling effort simulations for long term MPA monitoring will be submitted for publication in 2019. Findings from this work are being utilized to inform ongoing visual surveys of deep water habitats (20-600 meters) of California's MPA network.

In 2018, scientists from CDFW's Groundfish Management Project and MPA Management Project developed methods for estimating fish density as an index of abundance and total biomass from expansions for select species using design and model-based approaches. In 2019, these methods will be evaluated by PFMC's Scientific and Statistical Committee. The survey methodology will be evaluated for use in stock assessments for: 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.

Preliminary results of modeling Gopher Rockfish indicate that depth, latitude and seafloor terrain attributes provide a suitable model fit. With these models, courser resolution seafloor mapping data can then be used as a basis for expansion of abundance and biomass. The estimates from the modeling are comparable to design-based estimates that validate the models. The resulting biomass estimates may be used to inform the upcoming stock assessments of Rockfish (Brown, Copper and Vermilion) in 2021. The projected estimates of density and biomass may also be used to measure MPA performance. Future surveys may provide a time series to examine long term trends in abundance to inform fishery and MPA management.

Contributed by Michael Prall (michael.prall@wildlife.ca.gov) and John Budrick

III. Reserves

Marine Protected Areas Research and Monitoring

California Legislature passed the Marine Life Protection Act (MLPA) in 1999, requiring California to redesign its then existing system of marine protected areas (MPAs) into a more coherent network. Completed in 2012, California's MPA Network is comprised of 124 MPAs along the entire California Coast and protects approximately 16 percent of state waters.

The Network is adaptively managed through the MPA Management Program, which is comprised of four focal areas: outreach and education, research and monitoring, enforcement and compliance, and policy and permitting. A key component of the research and monitoring focal area is the Statewide MPA Monitoring Program. The Statewide MPA Monitoring Program takes a two-phased approach to monitoring: Phase 1, regional baseline monitoring, which concluded in early 2018, and Phase 2, statewide long-term monitoring, which began in 2016 and is ongoing.

To guide Phase 2 implementation the State developed a MPA Monitoring Action Plan (Action Plan). Approved by both the Ocean Protection Council and CFGC in October 2018, the Action Plan informs next steps for long-term

MPA monitoring by compiling work to date, as well as incorporating novel, quantitative, and expert informed approaches to monitoring. Additionally, the Action Plan prioritizes key measures and metrics, habitats, sites, species, human uses, and management questions to target for long-term monitoring.

Guided by the Action Plan the state released a solicitation for qualifications and proposals request in November 2018. Projects funded through this solicitation will encompass a range of ecosystems onshore and offshore, including human uses. Data collection will begin in May 2019 and continue into 2021. This Phase 2 monitoring data will then be combined with Phase 1 monitoring data, as well as historical data preceding the Network redesign to aid in the evaluation of MPA Network performance at meeting the six goals of the MLPA and to informing adaptive management. The first comprehensive evaluation will take place in 2012.

For those interested, you can sign up for the MPA Management Program mailing list to receive updates about the program; archived newsletters are available here.

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 primarily export-only fishery. Using traps, fishermen land hagfish in live condition. The hagfish are usually stored dockside until packaged for live export to South Korea where they are sold live for human food. Considered scavengers, hagfish are found over deep, muddy habitat.

1. Assessment
Little is known about the status or biomass of Pacific Hagfish stocks. Since 2007, 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 weight 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 2017, fluctuating between 360 and 952 metric tons (0.8 and 2.1 million pounds) annually with an ex-vessel value of $565,000 to $1.80 million. In 2018 there were 976 metric tons landed for an ex-vessel value of $1.84 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 Oregon hagfish fishermen.

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. Fishermen must choose one trap type and may not combine hagfish trap types or have other non-hagfish traps onboard when fishing with a chosen hagfish trap. There is no limit on the number of groundlines for bucket or Korean traps; however, barrel traps may be attached to no more than three groundlines. All traps must have a CDFW approved destructive device and all holes, except for the entrance, in any hagfish trap must have a minimum diameter of 14.2 millimeters (9/16 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 2018, Marine Region staff reviewed 56 Scientific Collecting Permits requesting to take groundfish species; a slight decrease 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 2018, 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 coordination with the California Recreational Fisheries Survey Program (CRFS) CDFW collected 69 Yelloweye Rockfish from the recreational fishing sector in 2018. Length, weight, sex, and otoliths were collected from specimens. Fish ranged in length from 228-604 mm in total length, and were approximately 42 percent male, 25 percent female, and 33 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. This effort continued in 2018 and expanded to include statewide collection of carcasses of several recreationally important species of rockfish to inform upcoming stock assessments for those species. Carcasses were primarily collected from Commercial Passenger Fishing Vessels (CPFVs) after the fish had been filleted by deckhands. The carcasses were returned to CDFW offices where length, sex and otoliths were collected. Over 100 lingcod carcasses and 1,000 rockfish carcasses were collected in 2018. Collection activities will continue in 2019.

   Contributed by Melanie Parker (Melanie.Parker@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. In 2019, the PFMC recommended this item be considered for future regulation implementation.

Contributed by Caroline Mcknight (Caroline.Mcknight@wildlife.ca.gov)

4. Assessment
The CDFW did not conduct any stock assessments in 2018 for groundfish species.

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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
CDFW has collected commercial fisheries statistics since 1916 using paper fish tickets. Beginning July 1 2018, CDFW began accepting electronic fish tickets via PSMFC's E-Tix system instead of the paper fish tickets. Electronic reporting for most species is voluntary until July 1, 2019 when it becomes mandatory for all species. Once landed an electronic fish ticket needs to be completed immediately. If that is not possible, a paper dock ticket must be completed and the electronic fish ticket submitted within 3 business days. Federal electronic reporting requirements for various fisheries, including 24-hour submission, still apply.

   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.

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 2018 were much the same as in 2017, except for an increase to the Canary Rockfish bag limit from one to two fish, effective April 14, 2018.

   Catches of Yelloweye Rockfish were higher than anticipated, prompting the need to implement more restrictive fishing depths north of Point Conception on August 25, 2018. 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). During 2018 CDFW staff conducted biological field sampling of commercial fishery catches on behalf of the IPHC.

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.

   In 2018, new regulations allowed for CDFW to conform state regulations to federal regulations for the recreational fishery by notifying constituents within 10 days of publication of the regulations in the Federal Register. Notification is done via press release and the CFGC is notified of the action at their next scheduled meeting.

Previously, a full CFGC rulemaking was required to conform state regulations to federal.

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 27 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 in 2018 with four vessels participating in the fishery and 2,457 dressed pounds (1,114 dressed kilograms).

4. Recreational Fishery Monitoring
   The recreational Pacific halibut 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 the same scheduled season dates as in 2017.

   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 21, 2018. Final season catch estimates were 31,156 net pounds (14,136 net kilograms), 101 percent of the 30,580 net pound (13,871 net kilogram) quota.

   Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

V. Publications

CDFW. 2019. 2018 California Department of Fish and Wildlife (CDFW) report to the International Pacific Halibut Commission. 15 p. Available at: https://iphc.int/uploads/pdf/am/2019am/iphc-2019-am095-ar08.pdf.

OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2018

OREGON DEPARTMENT OF FISH AND WILDLIFE
2019 AGENCY REPORT

PREPARED FOR THE 23 -24 APRIL 2018 MEETING OF THE TECHNICAL SUB-COMMITTEE OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE

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1) AGENCY OVERVIEW

MRP Program Manager: Dr. Caren Braby
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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 in Newport, OR and 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.

2) SURVEYS
   a) RECREATIONAL FISHERIES MONITORING AND SAMPLING

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2018. Starting in November 2005, major ports were sampled year-round and minor ports for peak summer-fall season. Catch during un-sampled time periods in minor ports continues to be estimated 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 2018. Since 2003, as part of a related marine fish ageing research project, lingcod fin rays and otoliths from several species of nearshore groundfish, including rockfish species, kelp greenling and cabezon, were gathered. Starting in 2001, a portion of sport charter vessels were sampled using ride-along observers for species composition, discard rates and sizes, location, depth and catch per angler. Beginning in 2003, the recreational harvest of several groundfish species is monitored inseason for catch limit tracking purposes.

Other ODFW recreational management activities in 2018 include participation in the U.S. West Coast Recreational Fish International Network (RecFIN) process, data analysis, public outreach and education, and public input processes to discuss changes to the management of groundfish and Pacific halibut fisheries for 2019

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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 federal stock assessment. In 2018, preparations continued to add fixed gear fishery logbooks to the PacFIN database. Species composition sampling of rockfish and biological sampling of commercially landed groundfish continued in 2018 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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3) 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 (no fishing) and marine protected areas (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 2018. More information is available on the Oregon Marine Reserves website at OregonMarineReserves.com

a) MANAGEMENT

Data contribution to upcoming Cabezon Assessment (2019)
Juvenile fish surveys are conducted with Oregon State University as part of marine reserves monitoring are providing important data for the upcoming cabezon stock assessment in 2019. Cabezon are popular in both the nearshore sport and commercial fisheries in Oregon. Data from Marine Reserve sampling are being used to help stock assessors understand how quickly young cabezon grow and to inform assessments of recruitment patterns. These types of data are often difficult for stock assessors to come by because collecting and aging these very small (< 2 in) juvenile fish is challenging. ODFW is the only nearshore monitoring program currently collecting these data in Oregon. Fisheries managers are also exploring how data from marine reserves monitoring hook-and-line surveys might be used by stock assessors, to understand how relative abundance of cabezon can change from year to year.

Data in Response to Low Oxygen (Hypoxia)
In mid-August 2018, reports of dead fish and crab washing up on beaches prompted researchers and ODFW to believe there were low oxygen conditions along the coast, but little to no data were available to confirm these conditions. The ODFW Marine Reserves team responded by working with Dr. Francis Chan at OSU to deploy oxygen sensors on crab pots from mid-August through mid-September during Hook and Line Surveys. These sensors provided immediate information about oxygen levels in the nearshore while increasing the spatial understanding of when and where these conditions occur along the coast.

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b) MONITORING

Ecological monitoring was conducted at four marine reserve sites this past year. Monitoring included sampling with core tools (ODFW-led) and through collaborative activities. Sampling was conducted both in the reserves and in comparison areas outside of the reserves still open to fishing. Sampling with core survey tools conducted this year as part of our ongoing monitoring included:

- Hook and Line surveys
- SCUBA surveys
- Video lander surveys
- ROV surveys

Sampling through collaborative activities included:

- Oceanographic surveys (PISCO – Oregon State University and ODFW)
- 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, The Nature Conservancy, and Oregon State University)

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c) RESEARCH

The Marine Reserve program collaborated on four new ecological research projects this year. The first explored the presence of microplastics in nearshore rockfish species with researchers at Oregon State University. The second explored variations in canary rockfish growth and reproduction with a graduate student at Moss Landing Marine Laboratories in California. The third collaborative project was through a class project at the Oregon Institute for Marine Biology (OIMB) analyzing invertebrate biodiversity data from ROV surveys. The final new collaborative project explored crab movement related to habitat and oceanography with Oregon State University and the National Oceanographic and Atmospheric Administration (NOAA).

In addition, two new human dimensions research studies occurred in 2018 to understand 1) effort shift among Oregon nearshore fisheries and 2) Oregon coastal residents overall life satisfaction and stated preferences in relation to forest and marine protected areas. The effort shift study helps to understand the impact of marine reserve implementation, family successional planning, and the drivers of fishing behavior. The coastal resident's study pioneered new methods in the human dimensions field while also exploring non-market values of marine reserves, a first for Oregon.

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4) REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENT AND MANAGEMENT
   a) HAGFISH
      i) RESEARCH
      ii) ASSESSMENT

In 2018, two separate data-limited methods were applied to Oregon's hagfish fishery data to explore their utility for assessing the stock. The first method was an attempt to develop a delta-glmm CPUE index from fishery logbook data as a measure of relative abundance of hagfish through time. The second method used fishery length and maturity (visual) measurements in combination with an estimate of the ratio of hagfish natural mortality over growth (Thorson 2017) to conduct a length-based spawning potential ratio assessment. During analysis it was learned that for each method, data sample sizes were too variable from year-to-year to precisely characterize error through time rendering the assessment results too uncertain to be recommended for management use. ODFW is increasing fishery sampling effort and working to improve logbook information to reduce uncertainty and increase the utility of these assessment methods.

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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 2018 were 1,453,391 pounds, or 90.8% of state harvest guideline of 1.6 million pounds. No major management actions were taken in 2018 by ODFW.

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b) DOGFISH AND OTHER SHARKS
c) SKATES
   i) RESEARCH
   ii) ASSESSMENT

ODFW contributed data to two upcoming skate federal stock assessments in 2018. The primary effort included a commercial catch reconstruction of species-specific skate landings from 1978 – 2018, where gear-specific species compositions were applied to complex-level landings. Historically, skate landings were recorded at the complex level and it is only in recent years that species-specific landings have been required for commercial landings. This reconstruction is to be used in the Big Skate and Longnose Skate stock assessments in 2019. Additional commercial data was also provided to the assessments.

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   iii) MANAGEMENT
d) PACIFIC COD
e) WALLEYE POLLOCK
f) PACIFIC WHITING

Pacific whiting (hake) are the highest volume West Coast fishery by far. For example, 2018 landings of 695 million pounds constitute 71% of the 976 million pound total for all species combined. Preliminary stock assessment results (i.e., 1.6 billion lbs for US/Canada) could result in record high quotas for 2019, which are the result of exceptionally strong recent recruitment events. Recent management focus has been to develop new tools to reduce salmon bycatch, and to reduce constraints of bycaught rockfish stocks that have recovered from being overfished.

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g) GRENADIERS
h) ROCKFISH
   i) RESEARCH - Depth-associated variability of Deacon Rockfish (*Sebastes diaconus*) age, growth and maturity parameters in Oregon waters and their effect on stock status

The goals of this study were to understand how age, growth and maturity parameters vary with sex and depth in the Deacon Rockfish. As efforts were made to sample a variety of size classes, from both the nearshore and offshore, we also assessed how age composition differed between the two areas and determined what the implications of these differences would be on the reproductive output of the population. Finally, we incorporated the results of this study into the most recent Deacon Rockfish stock assessment and evaluated how altering life history parameters influenced the stock status.

Deacon rockfish were collected nearly monthly at offshore and nearshore sites during favorable weather periods out of Newport, Oregon. Samples were collected periodically from December 2016 to November 2017. The offshore study area was Stonewall Bank and the surrounding area out to 146 m of water depth. The nearshore study areas included Seal Rock and Siletz reefs. Recreational hook and line gear was 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 ~8 cm, helping to offset gear-related bias in size-selectivity of typical hook and line fishing gear. Approximately 50 Deacon Rockfish were collected per reef area per sampling day. Fish were measured (cm, fork length) and sexed and otoliths collected for age determination. Ovaries and testes were examined and assigned a maturity stage. For females, a small section of ovary from fish in stages 1, 2, 3, 6 and 7 were collected and placed in cassettes for histological preparation and microscopic evaluation of maturity. Ovary samples were preserved in 10% buffered formalin and later transferred to 70% ethanol for storage. Ages were determined using the break and burn technique applied to sagittal otoliths 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 or shorter, a caudal fin snip was taken and stored in 100% ethanol (molecular grade) for DNA analysis to confirm species identification.

Our primary goal was to better understand how age, growth and maturity parameters differed between Deacon Rockfish that resided in nearshore and offshore waters off central Oregon. Our study suggests that age and growth parameters do differ by both area and sex but, not surprisingly, sex was a more influential factor than area. We were unable to compare nearshore and offshore age and length at 50% maturity due to the small number of immature females collected offshore. We did find that age and length at 50% maturity values were similar between the nearshore and when the nearshore and offshore samples were combined. However, based on larger lengths of offshore females, our work suggests that a significant component of the total reproductive output in Oregon may come from offshore. It is worth noting that this is based on the assumption that the number of females in the nearshore and offshore are equal.

Although our best fit von Bertalanffy model included both sex and area, the effect of area on the parameter estimates was relatively minimal. Primarily, growth rate (k) differed with males in the nearshore growing faster than males in the offshore whereas females in the offshore grew faster than females in the nearshore. Regardless of area, male growth rate was faster than for females. The larger offshore individuals (both male and female) had a more diverse distribution of ages than individuals of the same size class in the nearshore. The offshore individuals we sampled stopped experiencing fishing pressure in 2007 due to the establishment of the Stonewall Yelloweye Rockfish Conservation Area. In the 10 years since its closure, the offshore fish have experienced essentially no fishing pressure allowing larger individuals to obtain older ages than normally occurs for populations experiencing fishing pressure. However, the >10 year age difference suggests that while the complexity of offshore age structure has increased due to the lack of fishing pressure, there were, prior to closure, likely more, older fish offshore. It is worth noting when the offshore area re-opens to fishing these larger older individuals are likely to be removed from the population. Although most of the offshore individuals were large mature females, we did capture young-of-the-year individuals. This finding is important because regional knowledge suggests Deacon Rockfish only settle in the nearshore and exhibit an ontogenetic migration from the nearshore to the offshore. Our findings may indicate that there is less movement of individuals between the nearshore and offshore than previously hypothesized.

Re-running the most recent stock assessment and forcing it to use some of the different growth and maturity parameters influences the spawning stock biomass trajectory and estimates of stock status, but all of the estimates were within the range of uncertainty estimated with the base Oregon Blue/Deacon stock assessment model. Although all of these runs were within the range of uncertainty, the stock trends were effectively the same regardless of where the parameter estimates were obtained from, except for the estimates from California, which caused dramatic differences in the stock trend. Incorporating spatiotemporal variability of growth data into stock assessments is increasingly being shown to have profound impacts of stock trajectory and status. As such, for nearshore stocks that are relatively data poor and rely on each individual state to collect their own data, it is important that growth function parameters be estimated (at a minimal) for each state (using locally obtained data) and the relative effect of spatial dynamics are considered. Further, although spatial variation on growth function parameter estimates are often shown to vary with latitude, few studies consider the effects of cross-shelf variability in growth functions. We argue that cross-shelf variability is important to consider as circulation changes dramatically as you move across the shelf and ultimately these differences may affect both growth rates of adults and the dispersal of their larvae.

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ii) RESEARCH - Otolith shape and population genetic variation in Deacon Rockfish (*Sebastes diaconus*)

Little is known about intraspecific variation within the Deacon Rockfish (*Sebastes diaconus*), a recently described species found off the West Coast of North America. We used an interdisciplinary approach to test for population structure among fish sampled at two nearshore reefs (Siletz Reef and Seal Rock) and one offshore area (Stonewall Bank) off the Oregon coast. We found that fish sampled from the three sample sites are differentiable based on otolith shape and genetic variation whether analyzed independently or classified into nearshore and offshore groups. We also identified 92 outlier loci that distinguish males and females, potentially representing sex-linked, putatively adaptive variation. Although sex-linked genetic variation did not appear to affect geographic comparisons, males and females were readily distinguished. Morphometric results indicated that there was significant secondary sexual dimorphism in otolith shape, but further sampling is required to disentangle potential confounding influence of age-structure. We found small but statistically significant otolith shape and genetic differences among Deacon Rockfish sampled off the Oregon coast, regardless of whether the three sample sites were analyzed independently or organized into nearshore (Siletz Reef, Seal Rock) and offshore groups (Stonewall Bank). Although differentiation was low, the fact that we detected statistically significant otolith shape and genotypic differences over such a small geographic scale (<50 km^2) is remarkable in itself. Furthermore, both morphometric and genetic results were comparable to findings from other marine fishes sampled over larger geographic distances.

Sex mattered in our otolith shape and genetic analyses. We found evidence for secondary sexual dimorphism in otolith shape. This result may reflect differences in the growth and lifespan of males and females, and further research is required to disentangle these potential effects among the sample sites. We identified 92 outlier loci that are likely sex-linked sites in Deacon Rockfish, and males and females exhibited statistically significant neutral and putatively adaptive genetic differences. Our otolith shape and genetic results do not provide strong evidence for two potential fish stocks of Deacon Rockfish in the nearshore and offshore. Although morphological and genetic differences were statistically significant, values were low and there was considerable overlap among specimens, and comparisons analyzing the three sample sites independently demonstrated similar results. Stock assessments using similar methods have relied upon stronger patterns in results in order to delineate a stock boundary.

This study provides a first step towards the investigation of intraspecific variation in the recently described Deacon Rockfish species. This study demonstrates the potential of RAD sequencing studies to provide substantial population genetic information for species that have not been previously investigated. Much work is still required to study how the species differs from Blue Rockfish (and other relatives) in biology and management requirements. If future genetic analyses of *Sebastes* want to include the Deacon Rockfish, the sequence data presented here should be compatible with reads from the previous RADseq studies of other rockfish species that also used the *SbfI* restriction enzyme. The shaper otolith digitization method easily allows datasets to be combined as well, and therefore both geometric morphometric and genetic data from this study should permit genus-wide studies of rockfish diversity.

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iii) RESEARCH – Habitat use and activity patterns of Deacon Rockfish (*Sebastes diaconus*) at seasonal scales and in response to episodic hypoxia

Knowledge of fish movements and residency are key to design and interpretation of results from bioacoustic sonar and visual survey methods, which are being developed as tools for use in nearshore rocky reef surveys to estimate biomass and species composition. Fishers in Oregon report that an important component of the nearshore catch, Deacon Rockfish (*Sebastes diaconus*), becomes unavailable to harvest seasonally, and suggest periodic migration away from nearshore reef areas. Seasonal and spatial variation in landings data potentially support this theory. We used a high-resolution acoustic telemetry array and a combination of presence/absence receiver arrays, to study the daily and seasonal movements and the activity patterns of 11 acoustically tagged Deacon Rockfish on a nearshore rocky reef off Seal Rock, Oregon. Over the 11-month study period, most fish (n=6) exhibited high site fidelity. For the duration of the high-resolution array (5 months), these fish had small home ranges (mean 95% kernel density estimation=4,907 m^2) and consistent activity patterns, except during seasonal hypoxia (defined as dissolved oxygen concentration [DO] < 2 mg l^{-1}). During the summer months, resident fish were strongly diurnal with high levels of daytime activity above the bottom in relatively rugose habitat, followed by nighttime rest periods in deeper water in habitat of relatively less rugosity. During hypoxia, fish exhibited moderate activity levels with no rest periods and moved well away from their core activity areas on long, erratic forays. Wintertime activity levels were moderate with less defined daily patterns, but fish continued to remain within the array area.

Overall, resident Deacon Rockfish displayed high site fidelity and coherence in both seasonal and daily movement patterns, but those consistent patterns were completely altered during extended hypoxia. High long-term survival and consistently high detection of resident fish over 11 months indicates that at least some Deacon Rockfish do not exhibit a seasonal migration away from nearshore reefs. Food items ingested by sampled Deacon Rockfish during this study included gelatinous zooplankton and small planktonic crustaceans: the colonial tunicate *Pyrosoma atlanticum*, hydrozoan *Velella vellela*, ctenophore *Pleurobrachia bachei*, brachyuran zoeae/megalopae, and pelagic amphipods. We suggest Deacon Rockfish may be resistant to standard fishing techniques due to these strong prey preferences, hook size, and potentially eye and visual abilities which allow both Blue and Deacon Rockfish to see and feed upon very small and/or transparent prey items such as gelatinous zooplankton.

Although our sample size was necessarily small, detection and position data for tagged fish was excellent, a trade-off due to using a high density of receivers and co-located sync tags. Mid-water schooling behavior of this species benefits detection rates, which can be problematic for more benthic rockfish in high relief habitat. The high-resolution inner VPS array, combined with the perimeter fence, and accelerometer/depth sensors in the tags, provided additional certainty about the fate of fish that remained inside or left the array. A larger study in southern Oregon, using similar methods but tagging both Deacon and Blue Rockfish inhabiting the same area, could shed light on differences in the two species' movements in various habitats including offshore reefs, which may act as refuges for older, more fecund fish in Oregon, in unfished rockfish conservation areas.

Contact: Leif Rasmuson (leif.k.rasmuson @state.or.us)

iv) ONGOING RESEARCH

1. Black rockfish ageing error

The past Black Rockfish federal stock assessment has noted that ODFWs Black Rockfish ages have a positive correlation between the age of the fish and the age reading CV. We will be working this year to determine the cause of this trend in CVs and attempt to reduce it.

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2. Yelloweye rockfish habitat modeling

Using the >1,000 video lander drops conducted by ODFW Marine Fisheries Research Project since 2009, we are developing habitat models and comparing the findings generated by VAST and R-INLA.

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3. Sex linked genetics of rockfish

Sex had an observable effect in the genetic data for Deacon Rockfish, and 92 outlier loci (sites with strong differentiation) were identified between males and females. Future research is required to determine the genomic identity of these outlier loci (as rockfish currently lack an annotated reference genome), but the outliers did not map to the same region identified as a Y sex chromosome in Black-and-Yellow and Gopher rockfish by a previous study.

Contact: Leif Rasmuson (leif.k.rasmuson@state.or.us)

4. Discard mortality of Yelloweye Rockfish associated with nearshore live fish longline fishery

In partnership with ODFWs marine reserves program we will examine the delayed mortality of Yelloweye rockfish caught in the nearshore live fish longline fishery that are released by venting.

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v) ASSESSMENT

vi) MANAGEMENT – Fixed Gear 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 rapid development of the open access nearshore fishery in the late 1990's. The commercial nearshore fishery exclusively targets groundfish with separate management groups for Black Rockfish, Blue and 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. 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. The fishery supplies mainly live fish markets, but also provides product for fresh fish markets. Landings are regulated through bimonthly trip limits, minimum size limits, and annual Harvest Guidelines (HGs). Weekly updates on landings allow MRP staff to effectively manage the fishery in-season. Landings from 2017 commercial nearshore fishing, logbook compliance, economic data, and biological data were published in the 2017 Commercial Nearshore Fishery Summary (Rodomsky et al. 2018).

In 2018, in-season adjustments were made to trip limits for all rockfish species management groups. For Black Rockfish, early season projections indicated risk of exceeding the harvest guideline under adopted trip limits. Therefore, the period 3 trip limit was reduced from 1,800 pounds to 1,500 pounds. As the season progressed and the rate of effort in the fishery declined, projected HG attainment fell behind and ODFW raised the trip limit for Black Rockfish from 1,500 pounds to 1,800 pounds in periods 5 and 6. For Blue, Deacon and Other Nearshore Rockfish mid-year projections indicated landings were relatively high and bimonthly trip limits needed to be reduced to maximize chances of keeping these fisheries open through the year. Effective 7/5/2018, the Blue and Deacon Rockfish trip limit was dropped from 300 pounds to 100 pounds and the Other Nearshore Rockfish trip limit was dropped from 450 pounds to 200 pounds for periods 4 – 6. These reductions resulted in 96.5% attainment of the combined Blue, Deacon and Other Nearshore Rockfish commercial HG.

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vii) MANAGEMENT – Mid-water Rockfish Trawl fishery

The reemergence of the mid-water trawl rockfish fishery has been one of the greatest success stories for US West Coast Fisheries. The fishery had been dormant since the 1990's due to widow and canary rockfishes being overfished. These stocks have now recovered, as has the fishery in 2017 and 2018. The ex-vessel value of the fisheries in both those years combined was $14 million.

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viii) MANAGEMENT – Recreational Fishery

Black rockfish (*Sebastes melanops*) remains the dominant species caught in the recreational ocean boat fishery; however the black rockfish harvest limit continues to decrease by 2-5% annually and will continue to decrease for the next several years. 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. Black rockfish has become as much of a limiting factor as yelloweye rockfish. The fishery season structure and regulations, such as bag limits (with 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. Even with pre-season adjustments, the recreational bottomfish fishery daily bag limit had to be reduced beginning on July 1 from five to four fish per angler per day. Effort and catches were much lower in June than projected. Additionally, the catches in July and early August were lower than anticipated with the reduced bag limit, this allowed the bag limit to return to five fish per day in mid-September. Even with the decreased bag limit for the peak summer months, 2018 had the highest bottomfish effort on record, with over 109,000 angler trips.

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ix) MANAGEMENT – Recreational Fishery Outreach Activities

To reduce bycatch mortality of overfished rockfish species in the sport fisheries, ODFW began an outreach campaign in 2013 with the goal of increasing descending device usage among sport anglers. The effort, branded “No Floaters: Release At-Depth”, has distributed over 16,000 descending devices to date, to all charter vessel owners and to the majority of sport boat owners who had previously targeted groundfish or halibut. ODFW staff have also participated in a number of angler education workshops, meetings, and shows to educate anglers and distribute devices. In addition, several thousand stickers and a few hundred hats bearing an emblem of the brand have been distributed with the goal of making rockfish conservation an innate aspect of fishing culture.

This outreach and education campaign appears to be successful. Prior to the beginning of the campaign, fewer than 40 percent of anglers used descending devices. After the campaign, the percentage of users increased to greater than 80 percent. 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 and 95 percent in 2018. 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. Based on a slowdown in requests for descending devices it is believed that the majority of anglers have them. Additionally, the funding that has provided devices has been fully used. Therefore, ODFW will no longer be distributing devices, but will continue with the outreach and education efforts.

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. entomales*), 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 float 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
j) SABLEFISH

Sablefish is considered the most important stock for West Coast groundfish fisheries excluding whiting. It supports large-scale pot and longline fisheries in Oregon, and is of high value for bottom trawlers in the DTS multi-species strategy (dover sole/thornyheads/sablefish). A new full stock assessment will be conducted in 2019, of which many are optimistic due to large bycatch events of juvenile sablefish in the past few years. ODFW contributed substantial support to the upcoming sablefish assessment in 2018. There has also been recent focus on reconsideration of sablefish allocations, which has been highly contentious. This includes proposals to limit or freeze the amount of IFQ allocation that can be taken by longlines and pots so that more can be available for trawlers. It also includes proposals to allow the transfer or sale of unused southern area sablefish IFQ to move to the northern area that has high attainments.

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k) LINGCOD

Lingcod is one of the most valuable, but underutilized species on the West Coast. For longline fisheries, the primary shelf habitats of lingcod are closed to a Rockfish Conservation Area that is used to minimize impacts to overfished yelloweye rockfish. For bottom trawl, the shelf habitat is open, but they have been constrained by low IFQs of yelloweye rockfish. There is however optimism that lingcod attainments could increase by large degrees for both longline and trawl fisheries due to faster than expected rebuilding progress of yelloweye rockfish, which has resulted in higher bycatch limits and reduce fishery constraints. ODFW contributed data and support to the most recent lingcod stock assessment and continues to collect data for future assessments.

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l) ATKA MACKEREL
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 considerations. In 2018, the recommended an annual catch limit for Area 2A (Oregon, Washington, and California) was 1.19 million pounds. The recreational fishery for Pacific halibut is managed under three subareas with a combination of all-depth and nearshore quotas. In 2018, the Columbia River subarea quota was 11,682 pounds, the Central coast subarea quota was 215,463 pounds, and the Southern coast subarea quota, was 8,982 pounds. Landings in the sport Pacific halibut fisheries are monitored weekly to track landings in relation to 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 2018 recreational landings in the Central coast subarea was 204,408 pounds, 95 percent of the adjusted sub-area quota. Landings in the Southern subarea were 6,043 pounds (67% of the sub-area quota) and in the Columbia River subarea, landings were 15,834 pounds (135 %). The Columbia River Subarea all-depth fishery opened a week prior to any other halibut fishery in either Washington or Oregon. That opening weekend also had the nicest weather of the summer, leading to a large shift in effort and an unanticipated increase in landings. This was the primary cause of the overage in that sub-area.

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n) OTHER
   i) KELP GREENLING

The 2015 Kelp Greenling stock assessment found that the Oregon stock biomass is far larger than is being exploited in fisheries. This resulted in a Greenling commercial Harvest Guideline (HG) far larger than can reasonably be attained under current effort levels (2018: 144.3 metric tons). After two-thirds of the 2018 season, over 90% of the harvest allocation was still available. On 9/1/2018, ODFW staff raised the bimonthly trip limit from 800 pounds to 1,000 pounds for periods 5 and 6 to increase Kelp Greenling opportunity for fishers while considering markets and local depletion concerns. With in-season adjustments final commercial fishery attainment was 12.4% of the annual HG.

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ii) CABEZON

(1) RESEARCH - Age reading of Cabezon (*Scorpaenichthys marmoratus*): 1) comparison of thin-section and break-and-burn methods and 2) comparison of growth curve fits

Previous ageing work on Cabezon by the Oregon Department of Fish and Wildlife was completed using the thin-section method because of the small otolith size and a perceived increase in pattern clarity. Recently however, the ODFW marine age reading team elected to try to decrease the amount of time spent on sample preparation while maintaining pattern clarity. A few common methods of otolith preparation were tested, but ultimately the best clarity came from soaking the otoliths in a 50% ethanol solution for at least a week and applying the break-and-burn method. Thus, one of the goals of this study was to 1) determine how much bias there was between the break-and-burn and thin sectioning and 2) assess bias and precision between current and previous ODFW age readers. In addition to examining how methodological differences in age and growth affect bias and precision of age estimates, we also wanted to examine how these differences ultimately impact parameter estimates obtained when fitting growth functions. Further, previous growth function parameter estimates in Oregon were generated solely from the recreational fishery and with a temporally restricted dataset. Therefore, we reanalyzed the data, examining the effect of port and fishery on the larger dataset while accounting for differences between readers. Finally, in the most recent Cabezon stock assessment, the assessors note a significant difference between Oregon and California male growth function parameters. Therefore, we reassessed parameter estimates for male Cabezon in Oregon to determine whether increasing the size of our dataset affected the growth function parameter estimates. In recent assessments (e.g. kelp greenling), the lack of young and small fish has been shown to have a profound impact on the ability of the model to establish the scale of the stock. Therefore, we also tested the effect of adding size data for young and small fish by: 1) assessing different techniques for anchoring the growth function at or near the origin and 2) testing how these different anchors affect the estimated growth function parameters.

Cabezon sagittal otoliths are small, opaque structures measuring approximately 5 mm in length. The first year is not always easy to distinguish from surrounding growth checks, but it frequently occurs between approximately 1.2 and 1.5 mm. The second year is more prominent and is typically seen at about 1.9 mm. Splitting of the annuli during years 1-3 also occurs, making it easy to over age young fish. The best method of otolith preparation for production ageing of Cabezon appears to be a combination of soaking the structure in 50% ethanol then burning one half or more for ageing. The average coefficient of variation and percent error were both very high between readers and methods while the average percent agreement between methods was very low. Comparison of the age bias plots show that there is clear evidence of age bias between all of the different reader and method combinations. All three tests of symmetry (McNemar, Evans-Hoenig, and Bowker) indicate that the different method/reader combinations are not symmetrical around the 1:1 axis; in other words there is strong evidence of age reading bias.

Our best-fit hierarchical model for the recreational data included sex as a fixed effect and reader as a random effect. Our best-fit hierarchical model for the fishery model only included sex as a fixed effect. A potential concern with these fishery analyses is that the commercial fishery data were only obtained from the non-live fish fishery. Inherent in the differences between the dead fish and live fish fishery is a selectivity for smaller "dinner plate-sized" individuals. Thus, the live-fish fishery is likely selecting not only smaller fish but also fish that grow more slowly. Therefore, during the stock assessment process when back calculating ages using the length at age key for the live fish fishery, we suggest a sensitivity analysis using the lower confidence bound of our best-fit model as the length at age-key for this fishery. Unlike the commercial fisheries, in the recreational fishery it is likely the sizes and ages are representative of Oregon's Cabezon population. During bottomfish charters with fisheries observers, 91% of all Cabezon caught were retained. Of the 9% that were released, 86% of those were released because they were below the legal limit. In other words only 1.25% of the Cabezon caught were released due to potential high grading. The parameter estimates generated by anchoring the growth curve by forcing t_0=0 or including fish from the SMURFs as age 0 or 0.5 drastically altered the parameter estimates and overall shape of the best-fit line. Overall we see that the residuals from not including the SMURF fish and not forcing t_0=0 had the best overall fit. This is not surprisingly considering an inherent quality of the von Bertalanffy growth function is that it generally fits better when not anchored at zero. Although including the SMURF fish makes biological sense, the goodness of fit is reduced when forcing t_0=0.

In this study we find that ethanol-soaked otoliths read using the break-and-burn method provide a dramatic increase in the number of structures that can be aged each day. However, our work also demonstrates that there is a large amount of age reading bias and overall lack of precision between otolith preparation methods and readers. The large difference between the ages generated using either thin-sectioning or break-and-burn is a concern because ages from 2005-2008 were read using thin-sectioning and all other years were read using break-and-burn. This work highlights the difficulties of ageing Cabezon and strongly argues for the need to conduct age validation studies for future stock assessments.

Contact: Leif Rasmuson (leif.k.rasmuson @state.or.us)

(2) ONGOING RESEARCH

1. Examination of other structures for ageing Cabezon.

We will examine Cabezon vertebrae and spines to see if they will be a viable structures for ageing Cabezon in the future given the issues aging from otoliths.

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(3) ASSESSMENT

ODFW contributed substantial support and data to the federal stock assessment for Cabezon in 2018, in addition to participating in the stock assessment team. Major data products include a historical recreational catch reconstruction, multiple fishery dependent datasets for indices of abundance, all age composition data and a detailed associated analysis on aging bias and confidence, and finally, two new fishery-independent datasets.

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(4) MANAGEMENT

Cabezon catch rates in the 2018 commercial nearshore fixed gear fishery were very high. As early as March and based on projections, ODFW staff recognized the remaining bimonthly limits were likely too high to keep the fishery open all year. After consulting industry advisors, Cabezon trip limits were dropped from 2,500 pounds to 1,500 pounds for period 3; from 2,500 pounds to 500 pounds for periods 4-5; and from 2,000 to 500 pounds for period 6. As the season progressed into period 5 it became clear that additional restrictions were needed to maximize the chances the fishery remained open all year. On 10/5/2018, a daily limit of 15 pounds per day was implemented and the period 6 trip limit was dropped from 500 pounds to 45 pounds. Final commercial fishery attainment was 97.1% with in-season adjustments.

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5) ECOSYSTEM STUDIES
   a) OPERATIONALIZING A SURVEY OF OREGON’S NEARSHORE SEMI-PELAGIC ROCKFISH

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 was the goal of this proposed work. Acquiring drop-camera footage from as many different schools as possible, containing a diversity of species compositions and size distributions, informed us about the range of school structures and allowed us to evaluate the level of sampling effort needed for future broad-scale surveys.

In the fall of 2017, we established 50 transects off of Newport at Seal Rock reef. These transects were evenly spaced in areas 2 and 3 of the ODFW black rockfish pit tagging project. These transects were established as a test location for conducting a “mock” hydroacoustic survey for nearshore semi-pelagic rockfish. This location presented an ideal test location due to 1) its proximity to the ODFW main office and 2) the presence of robust population estimates for the reef’s black rockfish (*Sebastes melanops*) population. Over the course of four days, using a contracted local charter passenger fishing vessel, we collected hydroacoustic data using a Biosonics 200kHz split beam transducer. For each transect we deployed our suspended stereo camera system three times on locations with either large schools of rockfish or rocky reef habitat. For each video drop we collected a minimum of two minutes of on bottom time (based on preliminary examination of existing data). A total of 70 miles of acoustics data were collected and 140 video drops were conducted.

We determined that the best way to process our video data was to use a mean maximum number (MaxN) approach rather than the common MaxN approach. We also demonstrated that there was no effect on the size of the fish observed with each method. Finally, regardless of the method used, the distribution of fish size classes from the fishing fleet was similar to that observed with the camera. The only notable difference is the camera saw larger and smaller fish than those observed in the hook and line data. Our system also has downward facing camera that allows us to compare the fish counts in the acoustic deadzone to the counts from the forward camera system. Our work suggests that there was no statistical difference in the number of fish in the down camera for black rockfish and that there were significantly more Blue/Deacon rockfish in the forward camera than the down camera. These data provide an initial suggestion that that the acoustic deadzone will be a manageable concern in relation to our data.

To establish how the deployment and retrieval of the BASS camera affects the behavior of semi-demersal rockfish. We spent multiple days in the summer of 2018 deploying the camera system directly below the transducer that was ensonifying a school of fish. We then remained over the camera system while we ensonified the school and as we retrieved the camera system. Our analyses suggest that the deployment of the camera system on the schools of fish does not result in the attraction or repulsion of fish to the school. Finally, using the data we collected in September of 2017 we were able to generate population estimates for Black and Blue/Deacon rockfish at Seal Rock reef. Our work found similar orders of magnitude population sizes of Blacks as those estimated by the pit tagging project.

Our next step is to use these methods to implement a statewide survey. ODFW's Marine Fisheries Research Project will be conducting this survey over the course of 1-1.5 months from late August to early October 2019 over all of Oregon's nearshore rocky reefs. The hydroacoustic survey will be conducted using evenly spaced transects conducted over the rocky habitat as identified from available GIS layers of nearshore habitat. For each acoustic transect the suspended stereo camera system will be deployed to provide length and species composition estimates. Once collected these data will be used to generate population estimates for Black, Blue and Deacon Rockfish for the state of Oregon using standard acoustic and video analysis methodologies. This project will provide the first fisheries-independent regional population estimates for Black, Blue and Deacon Rockfish in the state of Oregon.

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b) EFFECTIVENESS OF QUANTITATIVE STEREO LANDERS DURING DAY AND NIGHT

The need to develop fisheries independent estimates of demersal fishes in Oregon remains an important need for ODFW. Remote underwater vehicles (i.e. video landers) are being used for this purpose in multiple countries throughout the world as well as providing stock assessment data to at least four of the regional fisheries management councils. A key benefit of their use is their simplicity in deployment and retrieval which ultimately makes them an economically strategic tool for monetarily limited agencies. However, there remain ways for us to increase their efficiency. Chartering vessels is inherently costly and time investment to either 1) have a boat not work at night or 2) make runs back and forth to port is not cost effective. Therefore, being able to operate a vessel both during the day and night allows a vessel to be run more efficiently. However, if the species and number of fish detected differ significantly between day and night, the results can have dramatic impacts on the development of an index.

Lander drops are being conducted at three regions: nearshore reef sites (Seal Rock or Siletz Reef), mid-shelf reef site (Stonewall Bank), and near-shelf break (Daisy Bank). At each region three grids of 100 drops were established over areas presumed to have a rocky substrate based on available multibeam data. Sample locations were selected that are >400 m apart. Beginning five hours before sunset the odd numbered drop locations were sampled until sunset. Following sunset sampling reversed back on the grid only sampling the even numbers. Two stereo lander systems are hop-scotched throughout the study area to increase efficiency. CTD casts equipped with a light meter are made haphazardly throughout the day to characterize the water column. Landers are left on the bottom for 15 minutes to record video. Videos are then scored for both MaxN and mean MaxN. Field work for this project is ongoing.

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c) SURVEYS OF SUBTIDAL ROCKY AREAS WITH THE VIDEO LANDER

In 2018, extensive work was done drafting a final report on video lander survey work conducted on an approximately 30.2 km2 area of subtidal nearshore rocky reefs in the marine waters from Cape Foulweather to Alsea Bay, Oregon. Much of the preliminary results of this work has already been reported to the TSC over the past several years. The final report is anticipated to be published as an ODFW Informational Report in 2019.

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d) AGING ACTIVITIES

During 2018, 4,920 age estimates were produced from recreational and commercial sampling for research and assessment purposes. With the primary goal of preparing for the 2019 Cabezon federal stock assessment, 1,315 recreation structures were aged, and 269 tested to provide estimates of aging error. An additional 233 Cabezon were aged as part of an agency report (See Publications section) comparing the use of thin sectioning versus break and burn ageing methods and the comparison of growth curve fits. Outside of assessment and project work, Black Rockfish ageing continued as a priority with 1,498 commercial (295 tested) and 1,089 recreation (221 tested) aged.

Contact: Lisa Kautzi (Lisa.A.Kautzi@state.or.us)

6) PUBLICATIONS

1) Rasmuson, L.K., Kautzi, L.A., Aylesworth, L., Wilson, M.N., Grorud-Colvert, K., 2019. Age reading of Cabezon (Scorpaenichthys marmoratus): 1) comparison of thin-section and break-and-burn methods and 2) comparison of growth curve fits (No. 2019– 04), ODFW Informational Report. Oregon Department of Fish and Wildlife.

2) Depth-associated variability of Deacon Rockfish (*Sebastes diaconus*) age, growth and maturity parameters in Oregon waters and their effect on stock status. In review. Contact: Leif Rasmuson (leif.k.rasmuson @state.or.us)

3) Otolith shape and population genetic variation in Deacon Rockfish (*Sebastes diaconus*). In review. Contact: Leif Rasmuson (leif.k.rasmuson @state.or.us)

4) Habitat use and activity patterns of Deacon Rockfish (*Sebastes diaconus*) at seasonal scales and in response to episodic hypoxia. In review. Contact: Leif Rasmuson (leif.k.rasmuson @state.or.us)

Washington Department of Fish and Wildlife Contribution to the 2019 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2018-April 2019

April 23rd-24th, 2019

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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 & Financial 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 (until recently) supported by Phil Weyland (programming and data systems). Lisa Hillier oversees the Unit budget, participates in various fieldwork projects, and has recently been modeling stocks both on the coast and in Puget Sound. Phill Dionne oversees statewide marine forage fish research and management. Together with Phill, this Marine Forage Fish (MFF) Unit is composed of Dr. Todd Sandell, Adam Lindquist, Patrick Biondo, and Kate Olson. 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, Andrea Hennings, 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 (recently moved to King Co. DNR), 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 Assistant Director of the Fish Program, serves as a member of the NPFMC.

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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), Rob Davis, Donna Downs, Bob Le Goff (retired in 2018), Kristen Hinton, Jamie Fuller, Michael Sinclair, and Tim Zepplin. In early 2019 a cohort of non-permanent survey staff were also hired to conduct nearshore hook-and-line surveys, including Janna Goulding, Bryce Blumenthal, Douglas Howe, Gordon Verbos, Glen Beck, Thomas Hargrove, Mark Dailey, Walter Smith, 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. In the last two years 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 Intergovernmental Ocean Policy Unit, which consists of Michele Culver (lead), Corey Niles, Heather Hall, and Jessi Doerpinghaus. Both Heather and Jessi serve on the PFMC's Groundfish Management Team (GMT).

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For complete staff contact information see section VIII of this report.

Surveys

Puget Sound Bottom Trawl – Since 1987, the Washington Department of Fish and Wildlife (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 long-term, fisheries-independent indicator of population abundance for benthic fishes living on low-relief, unconsolidated habitats. These surveys have been conducted at irregular intervals and at different geographic scales since their initiation (Quinnell et al. 1991; Quinnell et al. 1993; Palsson et al. 1998; Palsson et al. 2002; Palsson et al. 2003). Surveys in 1987, 1989, and 1991 were semi-stratified random surveys of the majority of Puget Sound. From 1994-1997 and 2000-2007, surveys were annual, stratified random surveys focusing on individual sub-basins (WDFW unpublished data; Palsson et al. 1998; Blaine et al., in prep). Starting in 2008, surveys became synoptic again, sampling annually at fixed index sites throughout Puget Sound (Blaine et al., in prep).

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 Hake, English Sole, North Pacific Spiny Dogfish, and all species of skates; however, all species of fishes and invertebrates are identified to the lowest taxonomic level practicable, weighed, 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 fixed index stations throughout the study area are sampled each spring (late April-early June) (Figure 1).

Index stations were originally selected from trawl stations sampled during previous 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, middle, east, west), and the final letter designating the depth stratum. The index stations have remained relatively consistent since 2008, with a few exceptions: starting in 2009, 5 stations were added to make the current 51-station design; in 2012 and 2013, stations in the shallowest stratum (S) were not surveyed because of concerns from NOAA about impacts to juvenile salmonids; and in 2014 and 2015, stations JEWU and CSNV, respectively, were moved slightly to accommodate concerns raised by fiber-optic cable companies.

The trawling procedure of the survey has remained largely consistent and complete details can be found in Blaine et al. (2016). 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 with the net, which is based on a mensuration study conducted in 1994 (WDFW unpublished data). A small portion of the catch is retained for biological sampling, either when fresh on deck or after being preserved (freezing, ethyl alcohol, or formalin) for processing in the laboratory. Samples collected may include: fin clips (genetics); scales, spines, and otoliths (ageing); stomachs and intestines (gut contents); and muscle tissue (stable isotopes). When necessary, whole specimens may also be retained for positive identification or special projects being conducted by the WDFW or its collaborators.

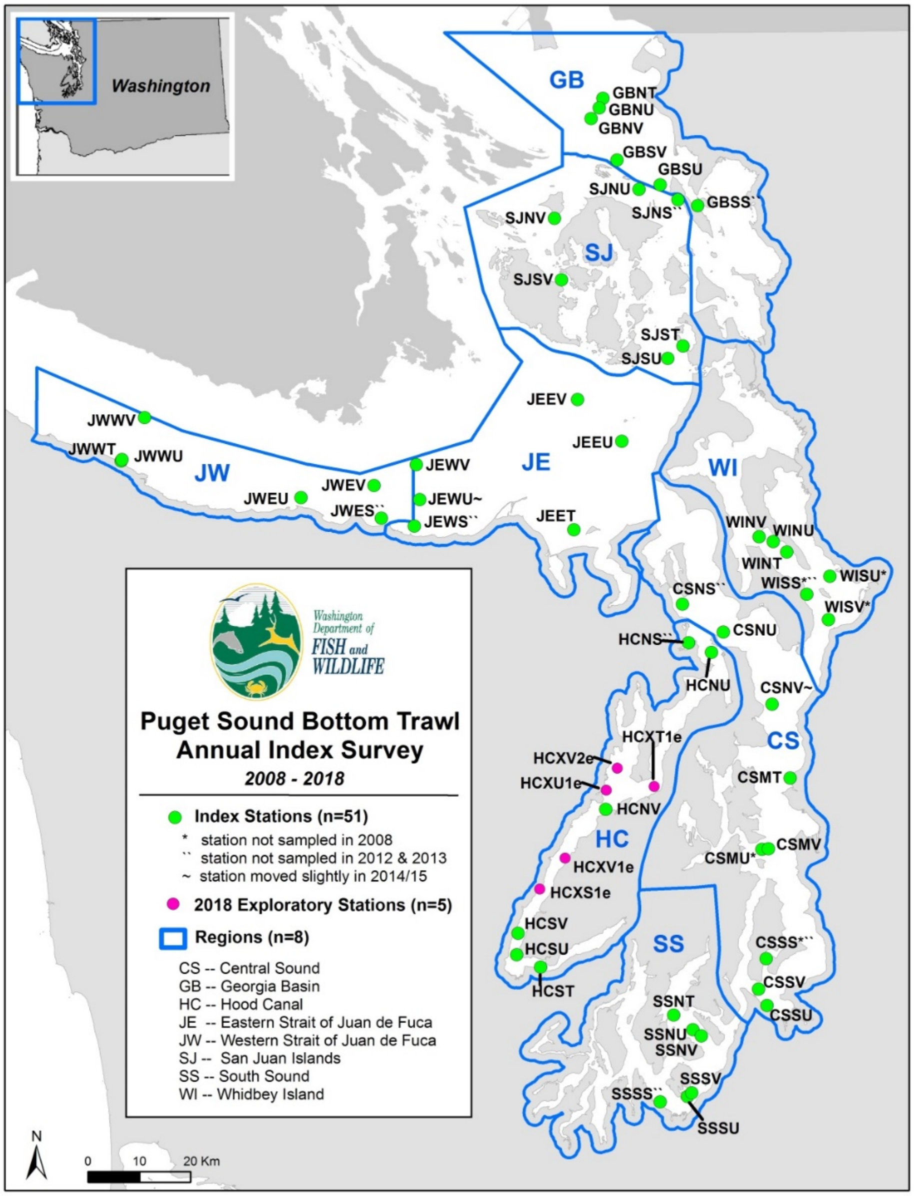


Figure 1. Trawl site locations for the index survey, sampled 2008-2018. Stations CSNV and JEWU were moved several hundred yards in 2014/15 to reduce the potential for interactions of trawl gear with previously unknown submarine cables. Five exploratory stations were conducted in 2018 to compare with index stations (see section "Exploratory Tows").

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, the protocol was altered 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 catch fall within the previous years' average (+/- standard deviation), no second tow is conducted at that station. If it is determined that the species composition was substantially different than expected, a second tow is conducted. This greatly improves the efficiency of the survey, as an average of only 4 stations have required a second tow each year. This newly gained efficiency has allowed institution of a new sampling program, conducting vertical plankton tows, to assess primary prey availability. In 2014 bottom-contact sensors were also added to the footrope to improve understanding of net performance and increase the accuracy of density estimates from the trawl, and a mini-CTD was deployed on the headrope to collect water quality data at each station and provide more accurate depth readings. In 2017, a Marport unit was also attached to the headrope to provide real-time data regarding the net's depth, bottom status, and opening height.

2018 At-A-Glance

In 2018, WDFW conducted the 11th Index trawl survey of Puget Sound from April 30 through May 24. During the 16 survey days, all 51 index stations were occupied, and a total of 54 index bottom trawls were conducted as 3 stations required a second tow. An estimated 63,855 individual fish belonging to 92 species/taxa and weighing 9.8 mt were collected (2017: 55,183 fish; 76 species; 9.4 mt). Similar to previous years, Spotted Ratfish constituted 57% of the total fish catch by weight and 22% of the total number of individual fish, followed by English Sole at 18% and 21%, respectively. The remaining fish species contributed 4% or less to the total fish catch weight and 11% or less to the total number of individual fish. For invertebrates, an estimated 57,078 individual invertebrates (those species catchable in the bottom trawl) from 89 different species/taxa weighing 2.0 mt were caught in the 2018 survey. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 35% and 31% of the total invertebrate catch weight. By number of individuals, Alaskan Pink Shrimp and Dock Shrimp comprised 39% and 24%, respectively, of the invertebrate catch. The remaining species contributed 8% or less to the total invertebrate catch by weight or by number.

ESA-Listed Species

Pacific Eulachon was, as per usual, the most abundant ESA-listed species encountered during the 2018 survey; 19 individuals were caught (29 in 2017) in regions CS, GB, JE, SJ, and WI. Two juvenile Chinook Salmon, both wild, were caught in Hood Canal; fin clips were taken for genetics samples and were sent to the WDFW Genetics Lab. Bocaccio (rockfish) were also encountered for the fourth time in the history of the bottom trawl survey (2012, 2016, 2017). One 22 cm subadult was found in JE, just west (i.e., outside) of the species' Puget Sound Distinct Population Segment (DPS) geographic boundary. The other two individuals caught, however, were found inside the DPS boundary and were both adults. One was a 33 cm male caught in SJ and the other a 35 cm female in GB. Both were weighed, measured, fin clipped (for genetics), and descended as quickly as possible after being recognized in the catch, and both are believed to have survived. NOAA officials were also contacted to ensure proper reporting of the take, and the captures were well within the limits of the survey's Section 10 collection permit.

Flatfish

English Sole, as previously mentioned, were the most prevalent species of flatfish, with estimates of 15,923 mt and 124 million individuals; these estimates are 16% and 33% higher than those in 2017, and are at their highest since 2010. Among regions, WI supported the highest population density of English Sole at 600 fish/ha while CS supported the highest biomass density at 64 kg/ha; the smallest population was found in JW at 1.6 kg/ha and 5 fish/ha. In terms of other flatfish species, Rock Sole, Starry Flounder, and Pacific Sanddab were once again the most dominant by weight with 4386 mt, 2167 mt, and 2034 mt, respectively. By abundance, Pacific Sanddab (24.7 million), Rock Sole (23.0 million), and Slender Sole (9.9 million) were the most dominant after English Sole.

While these estimates are for all of Puget Sound, each region supported its own composition of flatfish species, although English Sole accounted for over half of the flatfish biomass in 6 of the 8 regions. Dover Sole comprised the majority (33%) of flatfish biomass in JW while Starry Flounder (38%) did so in SS. Starry Flounder also made up 38% of flatfish biomass in HC, and Southern Rock Sole accounted for a quarter of it in WI. Otherwise, all other flatfish species comprised 20% or less of a region's flatfish biomass. Overall, Central Sound supported the highest biomass density of flatfish among the regions of 93.2 kg/ha, while WI supported the highest population density of 864.5 individuals/ha—25% higher than in 2017.

Codfishes (Gadiformes)

Pacific Cod catch increased for the first time since 2013; 17 were caught, weighing a total of 16 kg, in this 2018 survey from three regions. This catch rate resulted in an estimated population density of 1.4 ind/ha in JW, 0.95 ind/ha in GB, and 0.52 ind/ha in SJ (Figure 2). While the density in JW was similar to that from the 2017 estimates, the density in GB tripled, and it was also the first year that Pacific Cod were caught in SJ since 2014. Additionally, 14 of the 17 total individuals were 40 cm or less, which is the strongest showing of this size range since 2014, and could indicate the start of some recovery.

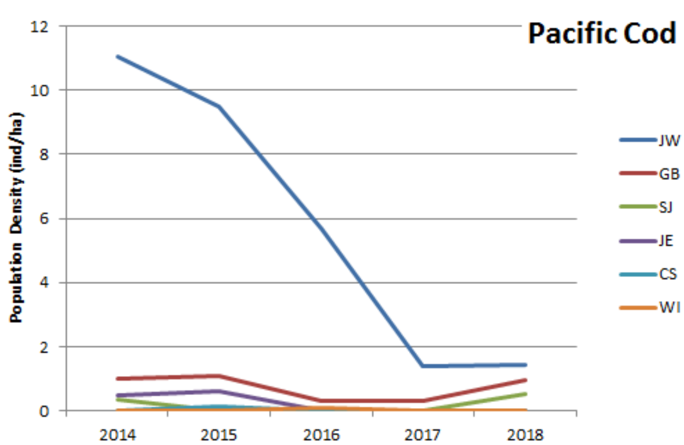


Figure 2: Population density (fish/hectare) of Pacific Cod caught in the 2014-2018 bottom trawl surveys, by region.

Pacific Hake biomass estimates more than doubled from 2017 (1404 mt) to 2018 (3290 mt) and abundance estimates increased from 23.6 million individuals to 40.3 million; hake were found in each of the eight regions except JW. Walleye Pollock also had a substantial increase and were found in all regions; biomass and abundance estimates increased 91% and 135%, respectively, from 2017 to 2704 mt and 55.6 million individuals.

Sharks and Skates (Elasmobranchs)

Compared to 2017, the 2018 North Pacific Spiny Dogfish catch was lower in terms of individuals, with 87 dogfish caught versus 123 in 2017, but higher in terms of weight, with 142 kg caught versus 131 kg. Dogfish populations can be migratory, however, and individuals are frequently in the water column rather than on the bottom, so their catchability in the bottom trawl is variable. Nevertheless, dogfish were found in seven of the eight regions, with 73% of the weight and 64% of the individuals being caught in GB; this was the first time in the trawl survey, however, that no dogfish were caught in JW. Brown catsharks were caught for the first time since 2014. Two females were found in GB and one male was found in HC; all were 40-50 cm and kept for researchers at WDFW and Moss Landing Marine Labs for further analysis.

Big Skate biomass and abundance estimates decreased 49% and 35%, respectively, to 2239 mt and 1.5 million individuals. Encounter rates of Big Skates were highest in SJ, which accounted for over 50% of the biomass and abundance. Longnose Skate biomass estimates also decreased 12% to 1255 mt, while abundance estimates increased 43% to 1.3 million individuals; estimates were highest in CS, JE, and GB. Nineteen Sandpaper Skates were caught in 2018, which is the highest catch in the bottom trawl survey since 2007. As in 2017, Sandpaper Skates were caught in JE, JW, and GB.

Other Fishes/Notable Finds

Because rockfish tend to exhibit preferences for rocky, untrawlable habitats, the bottom trawl survey is rarely used as an indicator of rockfish populations. With this in mind, however, there was a noticeably higher catch of rockfish in the 2018 survey compared to recent years; twice as many, in fact, as in 2017 (Table 1). Eleven different species were caught, including a Shortspine Thornyhead for the first time since 2010. Quillback Rockfish were, as usual, the most abundant species, followed by Copper and Yellowtail Rockfishes; these three species were actually caught in the highest densities found to date in the bottom trawl survey. While all but one of the Yellowtail were caught in just one tow in WI, the Coppers and Quillbacks were found in at least 5 of the regions.

Sablefish (*Anoplopoma fimbria*; aka “Black Cod”), which were caught last year in the survey for the first time since 2011, were again found in the survey this year but in fewer numbers. Only two Sablefish were caught, a 43-cm one in JW and a 46-cm one in GB. These are likely the same cohort found last year, as fish then ranged from 31 to 39 cm. Fin clips were taken for genetic analysis, and both individuals were released alive.

A few other less-frequently caught species found in the 2018 survey include Brown Irish Lord, Pacific Spiny Lumpsucker, and Red Brotula.

Table 45: Rockfish species counts caught in the bottom trawl survey from 2014-2018.

Species	2014	2015	2016	2017	2018
Black Rockfish	1	-	-	-	-
Bocaccio	-	-	11	7	3
Brown Rockfish	2	13	15	16	42
Canary Rockfish	-	1	-	2	3
Copper Rockfish	27	7	4	4	123
Greenstriped Rockfish	2	5	2	8	5
Puget Sound Rockfish	9	2	-	-	1
Quillback Rockfish	41	34	117	235	344
Redbanded Rockfish	-	-	1	-	-
Redstripe Rockfish	5	4	6	8	4
Shortspine Thornyhead	-	-	-	-	1
Splitnose Rockfish	-	-	2	-	3
Yellowtail Rockfish	-	7	-	13	59
Total	**87**	**73**	**158**	**293**	**588**

Exploratory Tows

In addition to the 51 index stations, we also conducted 5 exploratory tows in Hood Canal, the data from which are not included in the above summaries. When the index survey design was developed in 2008, stations were selected from tows of previous surveys that would, in theory, represent the species composition for a given region-depth stratum when averaged. Since the implementation of the index survey design, however, the stations have not been tested to determine whether they are still representative of their respective region-depth stratum; additionally, we are not sure how repeatedly towing in the same area can affect the site's environment and species composition over time. With a limited budget and survey timeline, we are not able to incorporate sufficient exploratory stations in each region each year, but we hope to implement some on a region-by-region basis as time and budget allow.

For the 2018 survey, we determined that we would be able to sample 5 exploratory stations in Hood Canal with minimal impact to the normal survey schedule and budget. This allotted one extra station for each of the four depth strata, and the additional station was attributed to the "V" (>60 fa) stratum as that constitutes the majority of the area in the region. The stations were chosen from tows of previous Hood Canal surveys (2002 & 2005), excluding those used to determine index stations and those on which the net had hung up in the past. The Hood Canal region is narrow east-to-west but long north-to-south, with the inlet on the north end; due to these features, the extra stations were selected to represent a different part of the region than their index counterparts. For example, the index "S" station (HCNS) is located north of the Hood Canal Bridge, so a previous "S" tow in the southern area of the Canal was selected as the exploratory station. Final station selections are included on the map in Figure 1.

A cluster analysis was used to compare the catch compositions from the exploratory stations with those from the index stations. On a whole, the stations clustered by each of the four depth strata, and the deeper two strata clustered separately from the shallower two strata, all with the exception of station HCNU. This index station was the only 'independent' station and had, at best, a ~45% similarity with other stations. Excluding HCNU, there was an average of 65% similarity between the exploratory and index stations. Each exploratory station was most similar to the index station(s) in the same depth stratum. The same analysis was conducted using biomass data, and the results were almost identical. The density data were further examined with a SIMPER analysis to look at the species contributing to the differences between stations; station comparisons were focused on the similarities/differences between each exploratory station and the index station(s) in the same depth stratum. Overall, with the exception of HCNU, the index stations and exploratory stations were reasonably similar within depth strata. The SIMPER comparisons showed that sometimes it was the smaller, more random species that contributed to a number of the dissimilarities among stations rather than the target species. Thus, the stations were likely more similar in terms of the fish species for which the survey was designed to sample. This effort seems to be a promising first step to assessing the long-standing index stations. Further efforts like this should be continued in other regions and to a greater degree to enable better comparisons.

Summary

The WDFW bottom trawl survey is the largest, and longest-running, fishery-independent survey of benthic organisms in Puget Sound. As such, this dataset provides an invaluable monitoring opportunity for populations of bottomfish and select benthic invertebrates, particularly given the inter-annual variation of many fish species. Continued collection of these data is important, as they can serve as a baseline for evaluating future population shifts due to fishery management actions, disease outbreaks, catastrophic events, and/or environmental shifts. Additionally, the data, samples, and estimates from the trawl survey are not only important for the WDFW's marine fish monitoring efforts, but are also used by other entities both within and outside the agency. The estimates of Dungeness Crab and Spot Prawns are presently being used by the WDFW's Shellfish Team to better inform fishery management decisions; a researcher and his students at the University of Puget Sound are analyzing the amount of microplastics ingested by multiple bottomfish species through our collected samples; and a University of Washington researcher is studying parasite loading in English Sole. These are just a few examples of how the bottom trawl survey includes such far-reaching applications that influence the knowledge and management of other species and supports other research efforts.

If you are interested in reading the full cruise report from the 2018 bottom trawl survey, please contact Jen Blaine (Jennifer.blaine@dfw.wa.gov). The 2019 Index bottom trawl survey is scheduled to occur from April 22 – May 31 and will be the biennial joint survey during which vessel time is shared between the Marine Fish Science Unit (this reporting group) and the Toxics-focused Biological Observation System Team.

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. From 2013-17 the PSMFS Unit surveyed Naval Base (NAVBASE) Kitsap Bangor, Bremerton, and Keyport; Naval Air Station (NAS) Whidbey Island Crescent

Harbor; Naval Magazine (NAVMAG) Indian Island; and Naval Station (NAVSTA) Everett using a combination of ROV, scuba, beach seine, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. A series of annual reports was submitted with the ultimate conclusions that: no ESA-listed rockfish were observed at any facility; no deep-water critical habitat (>30m) for adult rockfish is present within the secured areas of any of the facilities; and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish exist within the surveyed areas.

Though both natural and artificial habitats occurring within navigable waters were thoroughly surveyed from 2013-17, NAVBASE Bremerton also contains six extensive dry docks that are used to clean, inspect, and service ships ranging from small submarines to aircraft carriers (Figure 3). These dry docks are completely man-made and are episodically flooded to move ships in and out of them. Prior sampling for salmonids at NAVBASE Bangor has shown that a variety of groundfish may also entrained during these operations, though no ESA-listed rockfish were encountered. Fish that are entrained may be killed when passing through the inflow/outflow turbines, consumed by birds during dewatering, or left to die after dewatering is complete. While some salvage efforts do occur, they are infrequent and poorly documented.

Figure 3: Locations of the six service dry docks at Naval Base (NAVBASE) Bremerton on the Kitsap Peninsula in central Puget Sound.

During the reporting period members of the PSMFS Unit conducted two inspections of the dry dock facilities in order to formulate a sampling plan for surveys in 2019 and 2020. A variety of catch bags are being constructed that will sit atop, or hang below, various filter grates associated with inflow/outflow tunnels. Staff will observe bird predation during dewatering, retrieve fish from the catch bags for speciation and measurement, and also employ beach seining and kicknetting techniques to collect fish not captured in the bags. The goal will be to collect and identify all fish impacted by dry dock dewatering over 5-8 such events by the end of 2020. If no ESA-listed species are encountered during these efforts the provisions of the INRMP will be considered met and operations of the dry docks will continue as planned for another five years.

Annual Pacific Herring Assessment in Puget Sound – Annual herring spawning biomass was estimated in Washington in 2018 using spawn deposition surveys. 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 distinct genetic groupings (Cherry Point, Squaxin Pass, and the “all other stocks” complex). MFF Unit staff based in the Olympia, Mill Creek, and Port Townsend offices attempt to conduct spawn deposition surveys of all herring populations in Washington annually (acoustic-trawl surveys were discontinued in 2009 due to budget cuts; as a result, we are no longer able to estimate the age structure of the herring stocks). Locations sampled in 2018 are shown in Figure 4. Stock biomass assessment activities for the 2019 spawning season are in progress.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2018 was 10,279 metric tonnes, a 16.5% increase from 2017 (8,587 tonnes) (Table 2). The 2018 total is a 35% increase from the recent 2013 low point of 6,651 tonnes and is slightly above the previous ten year average (9,816 tonnes). The stability of the overall Puget Sound estimated biomass continues to be driven by significant gains in the Quilcene Bay stock (Hood Canal), which has increased over 209% between 2013 (1,880 tonnes) and 2018 (5,816 tonnes) and again comprises over half of the total herring biomass for the region (Table 2).

Table 2: Pacific Herring spawning biomass estimates (metric tonnes) in Puget Sound by stock and year

Stock and Region	Genetic grouping	PUGET SOUND HERRING SPAWNING BIOMASS ESTIMATES (Metric Tonnes), 2009-2018									
South/Central Puget Sound		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
	Squaxin Pass	748	463	513	534	503	357	294	236	271	381
Purdy		113	454	645	122	236	75	29	0	20	15
Wollochet Bay		327	10	19	28	9	35	0	0	5	0
Quartermaster Harbor		765	130	87	98	142	40	50	0	0	11
Elliot Bay		0	0	0	263	194	26	122	99	68	199
Port Orchard-Port Madison		1,604	318	112	197	167	82	83	0	0	13
South Hood Canal		142	194	142	239	181	102	256	226	90	58
Quilcene Bay		2,780	1,825	4,031	2,382	1,880	2,810	3,717	6,496	4,482	5,816
Port Gamble		965	393	1,328	367	248	154	313	163	164	451
Kilisut Harbor		0	0	0	0	0	5	0	0	0	0
Port Susan		229	138	125	55	26	62	64	55	103	67
Holmes Harbor		948	611	2,724	615	531	416	414	448	70	341
Skagit Bay		940	365	425	402	412	267	259	44	176	310
South/Central Puget Sound Total		9,559	4,899	10,150	5,303	4,528	4,431	5,600	7,767	5,450	7,662
North Puget Sound		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Fidalgo Bay		14	93	108	81	91	200	73	5	5	0
Samish/Portage Bay		290	589	351	390	629	706	507	929	451	379
Semiahmoo Bay		898	825	1,456	797	516	2,566	5,309	1,631	2,097	1,603
	Cherry Point	1,217	702	1,180	1,016	824	910	475	468	337	249
Interior San Juan Islands		0	22	0	5	0	5	34	0	0	61
NW San Juan Islands		0	0	0	0	0	0	0	0	0	0
North Puget Sound Total		2,419	2,231	3,095	2,289	2,059	4,386	6,398	3,033	2,890	2,292
Strait of Juan de Fuca		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Discovery Bay		186	24	0	95	0	5	11	221	93	232
Dungeness/Sequim Bay		42	68	94	39	64	65	7	40	153	93
Strait of Juan de Fuca Total		228	92	94	134	64	70	18	261	247	326
All Other Stocks total (excluding Cherry Pt. and Squaxin)		10,241	6,056	11,647	6,176	5,325	7,620	11,247	10,356	7,979	9,649
Puget Sound Total		12,205	7,221	13,340	7,726	6,651	8,888	12,017	11,060	8,587	10,279

The combined spawning biomass of South/Central Puget Sound herring stocks in 2018 was 7,662 metric tonnes, a 29% increase from the 2017 total of 5,450 tonnes and 15% above the ten year average (6,535 tonnes). The three Hood Canal stocks, of which Quilcene Bay is the major contributor (Table 2), made up 97% of the total for the South/Central Puget Sound region in 2018 (Figure 5). A number of stocks in this region that were previously abundant continue to hold at low levels, particularly the Purdy, Quartermaster Harbor, Port Orchard-Port Madison, and Port Susan stocks. The Wollochet Bay stock had no spawn detected in 2018 and has only had spawn once in the past 4 years, and the Kilisut Harbor stock is now considered a disappearance, with only one year of spawn detected in the past decade.

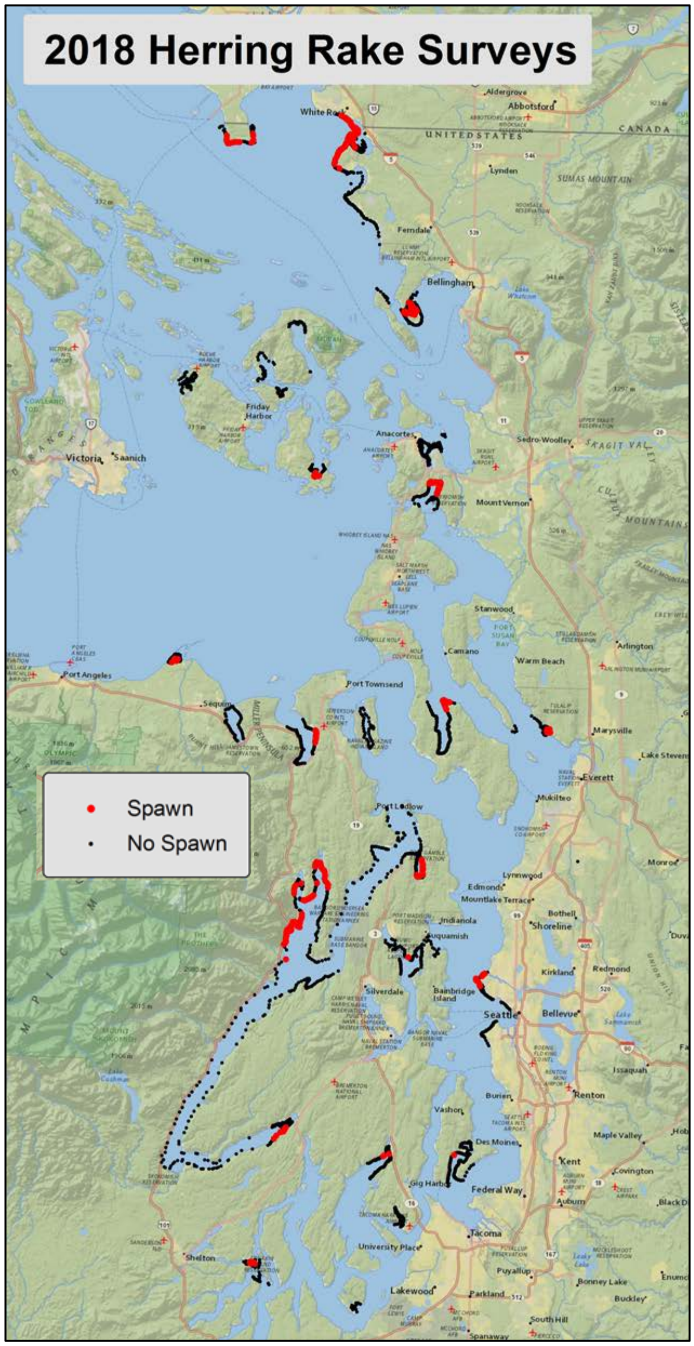


Figure 4: Locations of all rake surveys conducted in 2018, with red dots indicating detection of eggs.

The cumulative biomass of North Puget Sound stocks (2,292 tonnes) remained much lower than the recent peak in 2015 (6,398 tons), but remains close to the ten year average for this region (3,109 tonnes) (Table 2). This was primarily the result of a more normal year (1,603 tonnes in 2018) for the Semiahmoo Bay stock, which had a record year in 2015 (5,309 tonnes). However, the spawning biomass of the Cherry Point stock again declined in 2018 to 249 tonnes, a decrease of 26% from 2017 (337 tonnes) and only 66% of the ten year average for this site (738 tonnes). 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 (13,606 tonnes).

Estimated herring spawning biomass for the Strait of Juan de Fuca region remained higher (326 tonnes) than the ten year average (153 tonnes) and increased slightly from 2017 (247 tonnes) (Table 2). Spawning in Dungeness Bay (93 tonnes in 2018) declined from 2017 (153 tonnes), but was well above the ten year average (67 tonnes) for this site. In addition, the Discovery Bay stock increased dramatically in 2018 (232 tonnes), up 60% from 2017 (93 tonnes) and was also well above the 10 year average (87 tonnes).

Spawning activity was observed in Willapa Bay at one site in 2018; no spawn was detected at the other coastal site, Grays Harbor, although the number of surveys was again restricted by poor weather. In general, herring spawning biomass for these areas is relatively small compared to Puget Sound.

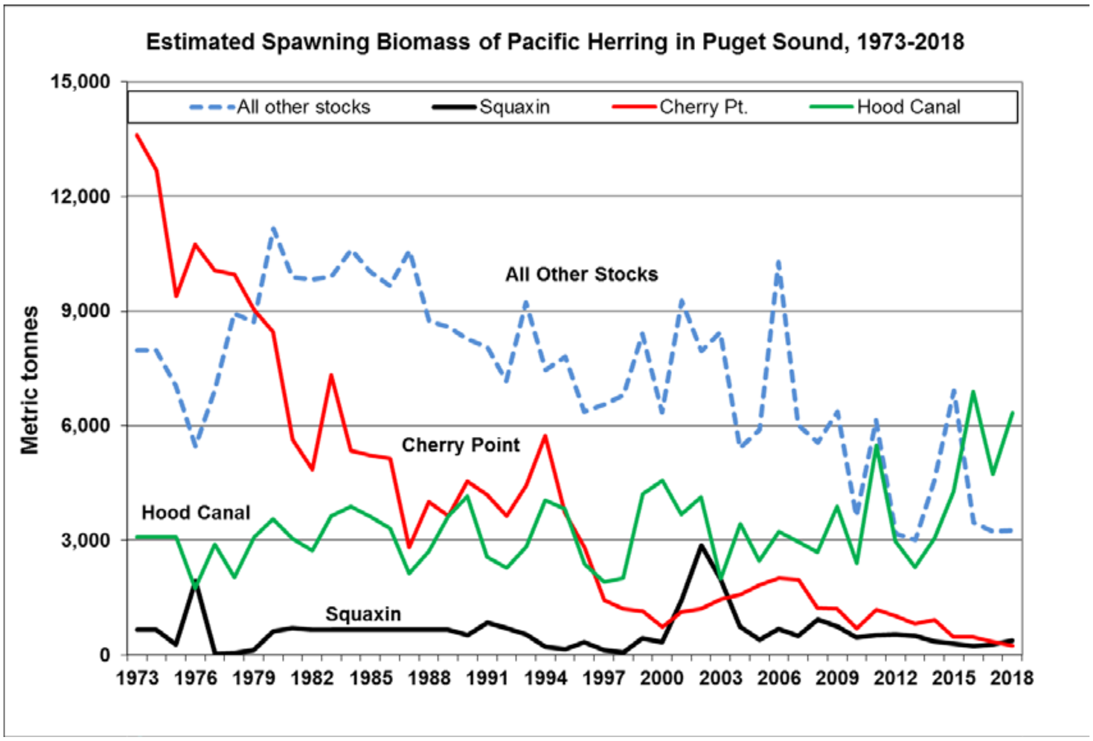


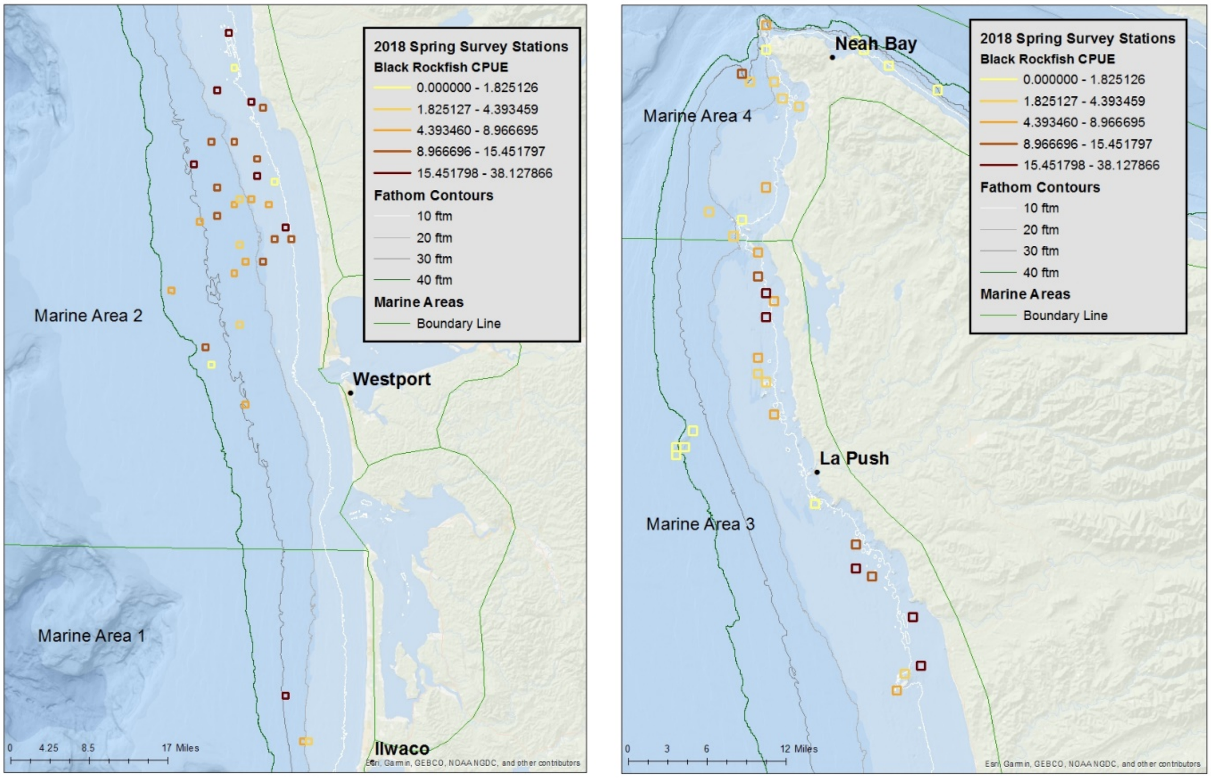
Figure 5: A comparison of Pacific Herring spawning biomass estimates for notable stocks in Puget Sound (note that only Squaxin Pass and Cherry Point are genetically distinct from the "Other stocks" complex)

Coastal Black Rockfish Rod and Reel Survey – The WDFW has conducted fishery independent rockfish surveys on the Washington coast since the 1980s. Historically, these surveys have primarily focused on Black Rockfish due to the predominance of this species in recreational fishery landings. Concerns over population sizes of other less dominant, but highly sought after, nearshore groundfish species has recently motivated survey design changes to address this data need. From 2014 through 2017, the WDFW conducted a series of experimental rod and reel surveys devoted to the development of a multispecies nearshore rockfish survey by evaluating nearshore rockfish distribution, life history, and fishing gear selectivity. This effort indicated that due to variable behaviors and terminal tackle selectivity among species, Washington's nearshore groundfish species would be best described with two separate coastal surveys: one targeting rockfish that typically school above rock piles and another targeting demersal groundfish species.

The primary focus of the 2018 rod and reel surveys was to implement standardized rod and reel surveys that can describe relative changes in population abundances of nearshore rockfish species and other associated groundfish species along the entire Washington Coast over time. Specifically, a "Black Rockfish Survey" was conducted in the spring to describe nearshore schooling species and a "Demersal Groundfish Survey" focusing on nearshore demersal rockfish and other associated groundfish species including Kelp Greenling and Cabezon was implemented in the fall.

The Black Rockfish rod and reel survey was conducted in the spring due to unsuitable ocean weather conditions in the winter, low charter vessel availability in the summer, and higher Black Rockfish catch rates in the spring when compared to fall WDFW rod and reel surveys. The survey began the day after the Washington coastal recreational groundfish season opened on March 10 to avoid any possible differences in catch rates due to varying recreational fishing pressure before and after the season opener.

Spring survey locations spanned the entire Washington Coast from the mouth of the Columbia River to the confluence of the Sekiu River with the Strait of Juan de Fuca and included all coastal marine areas. Location depths were limited to under 40 fathoms, which includes the typical depth range of Black Rockfish and all locations where the WDFW rod and reel surveys have encountered Black Rockfish in the past. Survey fishing effort was spatially distributed within the confines of the Washington Coast survey grid scheme developed by WDFW for the 2015 spring rod and reel survey. This grid is composed of 1-km squared cells superimposed over the entire Washington coast. Grid cells (stations) were chosen from this grid design for survey operations (Figure 6).



A) South Coast B) North Coast

Figure 6: 2018 spring selected survey stations (1 km grid cells) in Marine Area 1 and 2(A) and Marine Area 3 and 4 (B). Catch per unit effort (CPUE) is reported as the total number of Black Rockfish captured per rod hour (aggregated individual angler fishing time) at each station.

Targeted stations were chosen based on known rockfish habitat and observed catch rates of Black Rockfish from previous WDFW surveys. The presence of rockfish habitat within each grid cell was confirmed with rod and reel survey data spanning from 1998 to 2017. A grid cell was determined to have known rockfish habitat when at least one rockfish, Lingcod, Cabezon, or Kelp Greenling had been captured in it in a previous survey. Stations were then chosen along the Washington Coast roughly relative to the amount of known rockfish habitat by Marine Area and depth. Stations were selected to include both marginal and superior habitat locations based on catch rates from previous WDFW rod and reel surveys. All chosen cells had produced at least one groundfish in a previous hook and line survey and some effort was taken to evenly distribute stations spatially within each marine area and by depth.

Four recreational charter vessels were used to complete the 2018 spring survey. Each cruise was staffed with five hired anglers and three to four WDFW scientific staff. All contracted skippers had at least seven years of professional captain experience fishing for rockfish on the Washington Coast and each angler deployed had over 10 years of experience fishing for rockfish on the Washington Coast.

Fishing rods, reels, and terminal tackle were kept consistent across all stations surveyed. Terminal tackle consisted of two shrimp flies tied on a leader above a dropper weight and leaders were pre-tied at specified lengths before the charter day to ensure consistency. The weight of sinkers used for each drift was chosen by the vessel's captain after taking into consideration depth and weather conditions, but were kept consistent among anglers for each drift.

Stations were generally fished in a south to north order when ocean conditions allowed. Stations to be visited on any given charter day were chosen before leaving port by the lead biologist after consultation with the vessel's captain and taking into account ocean conditions. Two to four stations were surveyed each day dependent on their distance from port. Specific fishing locations within each station that would most likely provide high rockfish catch were determined by the vessel's captain. Before setting up each fishing event, captains took time to scout for fish aggregations or high relief areas, and to consider previous survey and personally known catch locations within each cell. The distance of each drift and number of drifts per station were determined by the captain to allow for repositioning on schools of fish or habitat, to remain within the cell, or to target other areas of potentially higher catch located within the station's boundaries. All fishing effort was conducted within each station's cell boundaries. Anchoring of the vessel was only permitted when drift speed was too fast to effectively fish while drifting (approximately 1.6 knots). For record and timekeeping purposes, each anchored fishing event was recorded as a drift.

All fishing effort was conducted during daylight hours and charter days ranged from 8-12 hours. Initially, 80 minutes of total fishing time was devoted to each station. However, after the first day, total fishing time per station was reduced to 60 minutes to allow for more stations to be fished in a single charter day. Total fishing time at each station was calculated as the total aggregated time of each drift within a station's cell. Total fishing time for each drift began when the first angler's hook entered the water and ended when the last angler's hook left the water for any reason.

Five anglers fished for the total fishing time in each station surveyed, and the same five anglers fished all stations each charter day. Individual anglers were randomly assigned a specific position on the vessel to fish for all drifts at a single station. Due to space limitations on one of our chartered vessels, the F/V Topnotch in Marine Area 3, the captain was used as an angler for all drifts. Because he needed access to a specific fishing position in order to set up drifts and fish effectively, we were not able to randomize his fishing position.

For each drift, anglers started and ended fishing at the same time but were allowed to retrieve their gear as many times as necessary during the drift to land catch or maintain gear. Individual angler fishing times per drift were recorded as total time each angler's hooks were in the water, which excludes any time that fishing gear was out of the water either to land a fish or work on the gear. Anglers were allowed to fish anywhere in the water column that they expected to catch the most fish and captains were encouraged to describe the depths of fish aggregations to them.

Catch and effort information collection included station number, GPS location of the start and end of each set, depth, disposition of vessel (anchored or drifting), drift speed and direction, number of anglers, total fishing time per station, and terminal tackle gear type. Individual angler's fishing time, catch by species, gear loss, and fishing depth (benthic or pelagic) were recorded for each angler. The intensity and direction of weather conditions including tide, wind, and swell were also recorded, and benthic habitat observations inferred from the vessel's sonar and captain's descriptions were noted for each station visited.

Catch was identified to species, measured (fork length), and scanned for previously implanted tags. Fish that were not chosen for age structure sampling were released at capture location with a descending device when needed. Released Yelloweye Rockfish were tagged with both an internal PIT tag and an external Floy tag. Released Cabezon, Kelp Greenling, China, Copper, Deacon, Quillback, Tiger, and Vermilion rockfish were tagged with a Floy tag and released.

Sixty-seven stations were successfully surveyed over 20 days in March, April and May. Aggregated individual angler rod hours at successfully surveyed stations ranged from 4.2 to 5.3, excluding the 80-minute total fishing time stations fished on the first survey day in Marine Area 1 (Figure 7). Unsuccessful survey stations included one station in Marine Area 4 where efforts were abandoned after a master time of only 46 minutes due to dramatic increase in drift speed and three stations in Marne Area 2 that were not sampled due to poor weather. Of the 67 stations surveyed, three were fished while at anchor and one had a mix of drift and anchor fishing due to an increase of current while fishing the station.

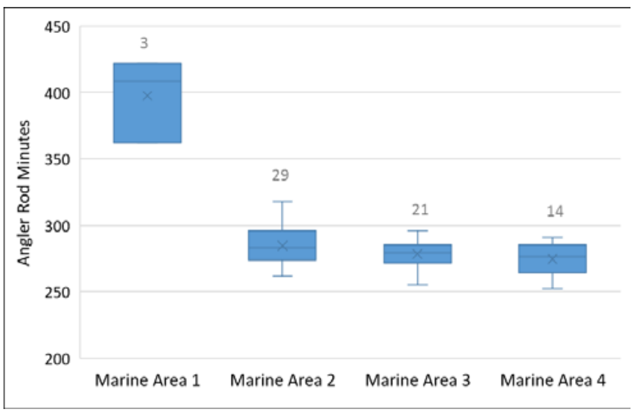


Figure 7: Box-whisker plot representing median, IQR, and minimum/maximum values of aggregated angler rod minutes spent at each station per Marine Area. Sample size (number of stations) is shown above the upper whisker.

Black Rockfish was by far the most dominant species captured across all marine areas and depth bins with the exception of 31-40 fathoms in Marine Area 3 (Table 3). Other high-catch species included Yellowtail Rockfish, Canary Rockfish, and to a lesser extent Lingcod and Deacon Rockfish. In general, species diversity was low; less than 17 individuals of all other species encountered were captured.

Table 3: Catch by number of all species per Marine Area and depth bin in the 2018 spring survey.

Species	Marine Area 1	Marine Area 2					Marine Area 3				Marine Area 4				Grand Total
	21-30 fathom	0-10 fathom	11-20 fathom	21-30 fathom	31-40 fathom	Total	0-10 fathom	11-20 fathom	31-40 fathom	Total	0-10 fathom	11-20 fathom	21-30 fathom	Total	
Black Rockfish	317	259	650	493	137	1539	492	374	2	868	30	106	89	225	2949
Buffalo Sculpin			1			1									1
Cabezon								2		2		1		1	3
Canary Rockfish			1	112	27	140	1		35	36	8	6	27	41	217
China Rockfish											1	3		4	4
Chinook Salmon									1	1		1	1	2	3
Coho Salmon									1	1					1
Copper Rockfish				1		1					1		3	4	5
Deacon Rockfish			1	5		6	32	8	15	55		9	1	10	71
Kelp Greenling							3	3		6		3		3	9
Lingcod		4	17	32	5	58	3	5	10	18	4	9	9	22	98
Pacific Halibut			1			1									1
Pacific Herring													1	1	1
Pacific Sandab					1	1									1
Quillback Rockfish				3	2	5			4	4	1	4	2	7	16
Tiger Rockfish									1	1					1
Unspecified flat fish												1		1	1
Vermilion Rockfish								1	1	2		1		1	3
Widow Rockfish									6	6					6
Yelloweye Rockfish				1	2	3			1	1					4
Yellowtail Rockfish	5			34	4	38	3	21	151	175	2	30	10	42	260
Grand Total	322	263	671	681	178	1793	534	414	228	1176	47	174	143	364	3655

The 2019 Black Rockfish Survey is currently in progress with minor method adjustments to reduce station size and further standardize survey effort.

Coastal Nearshore Demersal Groundfish Rod and Reel Survey – As part of the 2018 WDFW multispecies coastal nearshore rockfish survey efforts, a demersal rockfish rod and reel survey was implemented in the fall of 2018. The primary objective of fall survey efforts was to develop standardized gear, effort, and methods that could be utilized to describe relative changes in population abundances of a variety of nearshore demersal groundfish species along the entire Washington Coast over time. The species of interest included China, Copper, Quillback, Tiger, Vermilion, and Yelloweye rockfish, as well as Kelp Greenling and Cabezon. Survey methods in the fall of 2018 were identical to the methods described in the spring Black Rockfish Survey, with a few key changes to target demersal species.

The demersal survey was conducted in the fall due to unsuitable ocean weather conditions in the winter, low charter vessel availability in the summer, and limited staff and vessel time in the spring due to other survey priorities. Study locations spanned the Washington Coast Marine Areas 3 and 4, where most known target species' habitat exists, and depths from subtidal to 40 fathoms (Figure 8). While target species are marginally distributed in Marine Area 2, logistical issues prohibited the survey of this area in 2018. Marine Area 1 has little known habitat containing demersal species and was not included in the survey. Due to the smaller study area, only two recreational charter vessels were used to complete the 2018 fall survey over eight fishing days.

As with the spring survey, fishing effort was spatially distributed within the confines of the Washington Coast survey grid scheme developed by WDFW for the 2015 spring rod and reel survey. Within this schema, one kilometer squared grid cells (stations) were chosen for survey operations (Figure 8). Targeted stations in the fall survey were chosen based on known habitat of demersal rockfish species.

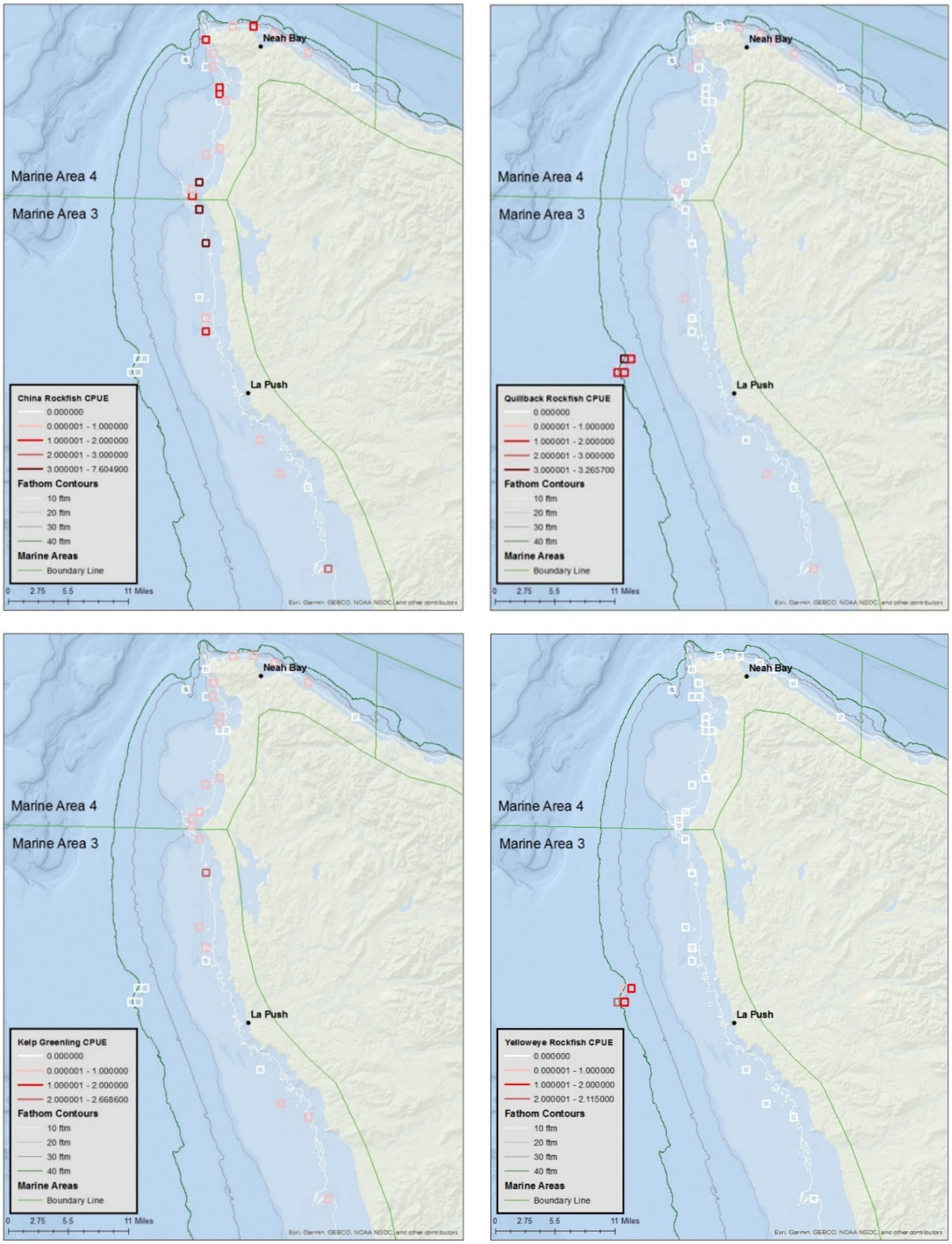


Figure 8: 2018 fall selected survey stations (1 km grid cells) and catch per unit effort (CPUE) of select target species. CPUE is reported as the total number of individuals captured per rod hour (aggregated individual angler fishing time) at each station.

Rod and reel survey data spanning from 1998 to the spring of 2018 was used to confirm the presence of demersal rockfish habitat within a grid cell. For each target species, a grid cell was determined to have known habitat when at least one target species individual had been captured in the cell in a previous survey. Stations were then chosen along the Washington Coast roughly relative to the amount of known habitat for each target species by Marine Area and depth. Care was taken to evenly distribute chosen stations spatially within each marine area and depth bin. Stations were selected to include both marginal and superior habitat locations for each target species based on catch rates from previous WDFW rod and reel surveys.

Other method changes from the 2018 Black Rockfish Survey included a terminal tackle change to a salmon mooching rig baited with a white worm and all angler fishing effort was done on or near the bottom; schools of fish in the water column were not targeted. Also, in order to address data gaps in age structure collections from the coastal recreational fishery, any rockfish, Kelp Greenling, Lingcod, or Cabezon on the extremes of the known size distribution was sacrificed and a length, sex, and age structure (otolith or Lingcod fin) were collected. All other data collection and fishing effort methods were kept consistent with the spring survey described above.

Thirty-two stations in Marine Area 3 and 4 were successfully surveyed in September. Sixty minutes of total fishing time was spent at all successful stations allowing for the completion of 4-5 stations per charter day. All fishing effort was conducted unanchored and drift speeds ranged from 0.1 to 1.1 knots. Total angler rod hours at surveyed stations ranged from 4.2 to 4.9 rod hours (Figure 9).

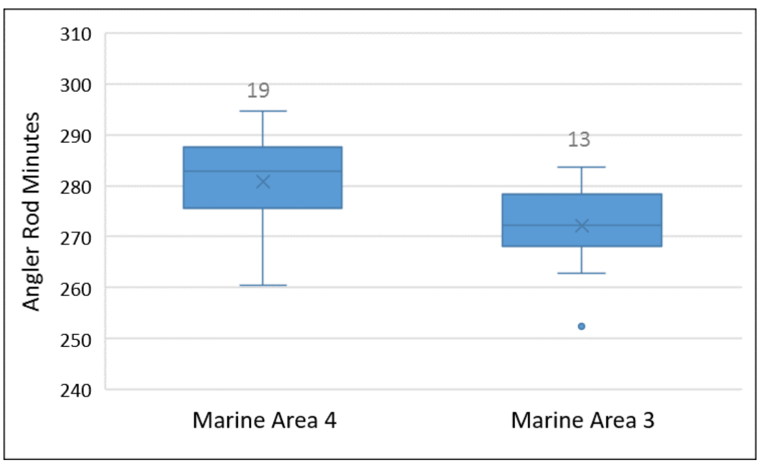


Figure 9: Box-whisker plot representing median, IQR, and minimum/maximum values of aggregated angler rod minutes spent at each station per Marine Area. Sample size (number of stations) is shown above the upper whisker.

China Rockfish was the predominant target species captured in less than 20 fathoms and in the survey overall, while Quillback Rockfish was the predominant target species captured in waters over 20 fathoms (Table 4). Catch was diverse, with eleven different rockfish species, Cabezon, Lingcod, and Kelp Greenling represented.

Table 4: Catch (number) of all species per Marine Area and depth bin in the 2018 fall survey.

Species	Marine Area 3 0-10 fathom	Marine Area 3 11-20 fathom	Marine Area 3 31-40 fathom	Marine Area 3 Total	Marine Area 4 0-10 fathom	Marine Area 4 11-20 fathom	Marine Area 4 21-30 fathom	Marine Area 4 Total	Grand Total
Black Rockfish	131	95		226	77	54	28	159	385
Cabezon	7	9		16	9	7		16	32
Canary Rockfish			29	29		15	36	51	80
China Rockfish	58	12		70	27	34	6	67	137
Chinook Salmon						1		1	1
Copper Rockfish	3	4		7	5	10	1	16	23
Deacon Rockfish	15	16	2	33	6	3	3	12	45
Kelp Greenling	18	9		27	12	13		25	52
Lingcod	7	5	1	13	2	10	2	14	27
Quillback Rockfish	1	2	38	41	1	11	2	14	55
Red Irish Lord					1	2		3	3
Tiger Rockfish	1	1	1	3					3
Rock Sole						3		3	3
Yellow Irish Lord			1	1					1
Vermilion Rockfish						2	1	3	3
Widow Rockfish			3	3					3
Yelloweye Rockfish			25	25					25
Yellowtail Rockfish	14	12	54	80		7	9	16	96
Grand Total	255	165	154	574	140	172	88	400	974

The 2019 Demersal Groundfish Survey is scheduled to occur in September and October. Marine Area 2 will be added and minor method adjustments to reduce station size and further standardize survey effort will be implemented.

Toward a Synoptic Reconstruction of 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, there is a need 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 two years. 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 since 2011, very little directed monitoring of marine protected areas and reserves has occurred in Puget Sound in recent years and no monitoring activities were conducted in 2018.

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. When only results from short-term monitoring programs are available it can be difficult for resource managers to gauge the effects of regulatory actions aimed at long-term resource conservation. This is particularly true for species that are long-lived, slow-growing, and late to mature. For these species, demographic changes in response to management actions may be slow to manifest and difficult, or impossible, to detect over time spans of fewer than two generations. Data obtained from long-term monitoring is more likely to capture changes over time in fish communities composed of a wide variety of life spans and other life history attributes. Members of the Puget Sound MFS Unit examined a sixteen year series of dive data for long-term changes or trends in abundance, size, and distribution of several key bottomfish species. Further, they made comparisons among and between those sites surveyed that fall within marine protected areas (MPAs) and those that do not. In order to gain added perspective, data were compared to those acquired from four different scuba-based studies conducted prior to the commencement of surveys at four of the sites (Figure 10).

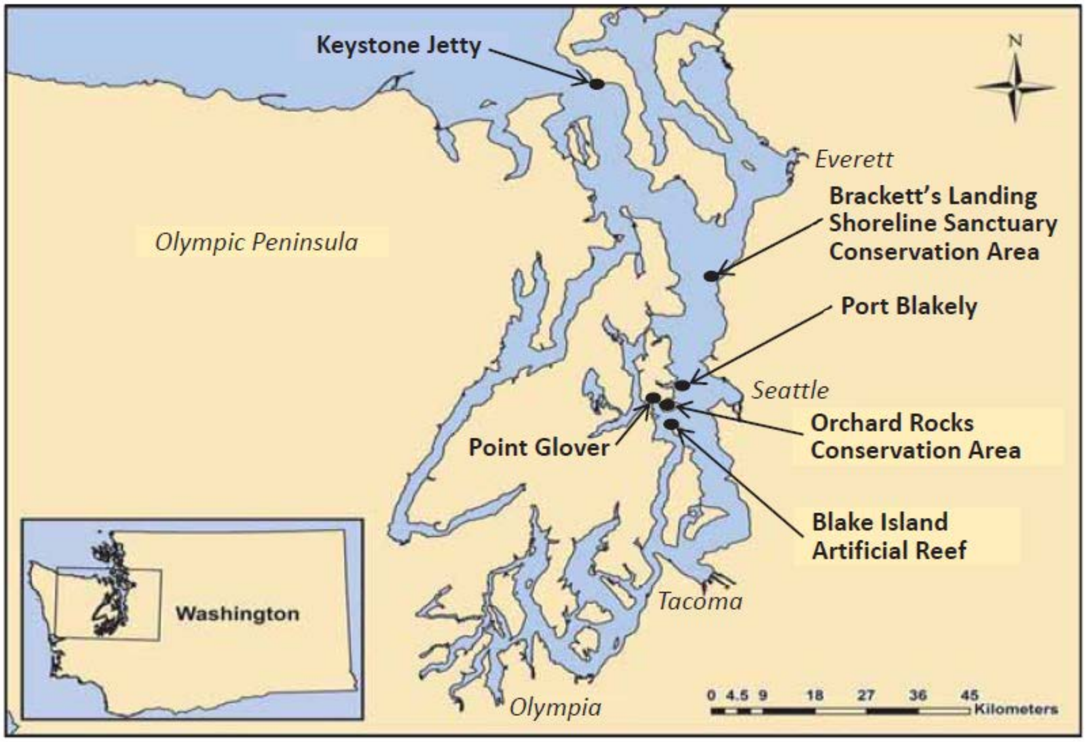


Figure 10: Locations systematically surveyed via scuba from 1995 through 2010.

At all six sites, species composition was dominated by just three taxonomic groups: rockfishes, surf perches, and greenlings, though the relative proportions of those groups varied among sites. Species richness also varied within and among groups, and within and among sties. Curiously, the greatest number of species observed was at the most heavily fished site, while the fewest number observed was at the most protected MPA. In pairwise comparisons of species composition by season (spring and fall), nearly all were significantly different both within and between sites. Though not confirmed, the data suggest that differences in species composition may occur along a latitudinal gradient. The species that contributed most to the differences between sites were Striped Seaperch, Puget Sound Rockfish, and Brown Rockfish.

At most sites, there was evidence of strong juvenile rockfish recruitment in 2006/07 for one or more of the following species: Black Rockfish, Quillback Rockfish, and Copper Rockfish. This event was made apparent by relatively high density "pulses" in length classes over time, whereby, unusually high numbers of juvenile fish enter a population and, with growth, sequentially moved from smaller to larger length-classes over time (i.e., a detectable "pulse" in length-class frequency was detected over time.)

Some have suggested that Lingcod, a high trophic-level feeder, may exert predatory top-down control over some rockfish species. We examined our data from the site where overall rockfish and Lingcod density was greatest, and where the highest density of Puget Sound Rockfish occurred. Puget Sound Rockfish rarely exceed 20 cm in length and bear fewer and less robust spines than many other rockfish species, thus they are more vulnerable to predation than larger rockfishes. We searched for inverse relationships between Lingcod and rockfish density and biomass (e.g., increasing trends in Lingcod density accompanied by decreasing trends in rockfish density). Such relationships could provide evidence that Lingcod predation is a factor in limiting rockfish population growth. A strong relationship between Lingcod and rockfish density and biomass was not apparent.

The frequencies of occurrence of Lingcod and rockfish in the largest length-classes were greatest at the Bracket's Landing Shoreline Conservation Area, the most longstanding MPA in Puget Sound (established in 1970). However, a substantial downward trend in the density of Copper and Quillback Rockfish in the largest length classes was apparent during the first seven years of the survey period. Several potential hypotheses were considered and it appears that senescence is the most likely explanation, though poaching may be a contributing factor. Some rockfish populations are known to be dominated by a small number of year classes. Given the age and long-term protection status of fish at Bracket's Landing, it is hypothesized that a strong cohort of Copper and Quillback Rockfish reached terminal age and perished over the course of several years. The occasional occurrence of large dead Lingcod and rockfish at Bracket's Landing lends some support to this hypothesis. No dead Lingcod or rockfish were encountered at any of the other surveyed sites.

Findings were compared to studies that were conducted at four of the surveyed sites during years prior to 1995. One of the most striking contrasts was the complete absence of Lingcod noted at Bracket's Landing during surveys conducted in 1975/76. From 1995-2010, Lingcod frequency of occurrence at Bracket's Landing was 100%. Furthermore, the annual mean lengths for Lingcod were greater at Bracket's Landing than at any other site surveyed. All four of the comparable studies indicate changes over time in rockfish species composition.

The informative perspective on the recent status of several key bottomfish species at six nearshore sites in central Puget Sound in this report will serve as an important benchmark for future surveys. However, the ability to identify and interpret trends over time, particularly for rockfishes, was confounded by factors such as high interannual variability in juvenile recruitment, poorly understood post recruitment inter- and intraspecific interactions, and, at some sites, discontinuous sampling and changes in protection statuses. *In comparing MPA sites to non-MPA sites, we were not able to discern any trends that could be unequivocally linked to harvest management actions, though at least two observations suggest evidence of a protection response.* First, at the Orchard Rocks Conservation Area, subsequent to the year (1998) that it was afforded MPA status, a persistent increase in rockfish density and biomass occurred. Second, the mean length, density, and biomass of Lingcod at the Keystone Conservation Area increased after the year (2002) that it was afforded MPA protection. Unlike rockfishes, which typically grow at substantially slower rates in Puget Sound, Lingcod grow rapidly, particularly during the first several years of their life. The rapid growth, and accompanying rapid increase in fecundity, of Lingcod makes it a potentially valuable first-response species for detecting positive effects of conservation efforts.

Based on the findings of this evaluation, the Puget Sound MFS Unit recommends that surveys be resumed at an interval coinciding approximately with two elapsed generations for key species and, this recommendation is currently under review by management.

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 2005. 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 homeports, 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. Fish ticket landing 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).

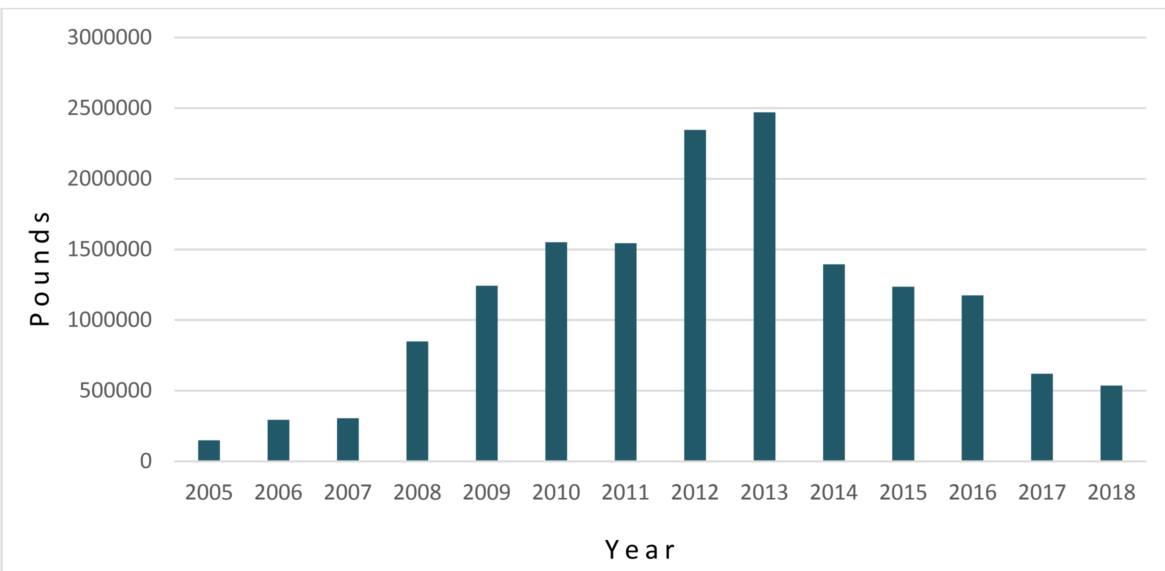


Figure 11: Hagfish Landings in pounds by Washington 2005-18.

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 78 cm male, the smallest a 25-cm female. Typically the largest specimens measure 67 to 70 cm, however, in recent years WDFW biologists have seen a couple of larger specimens, like the 78 cm female. 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.

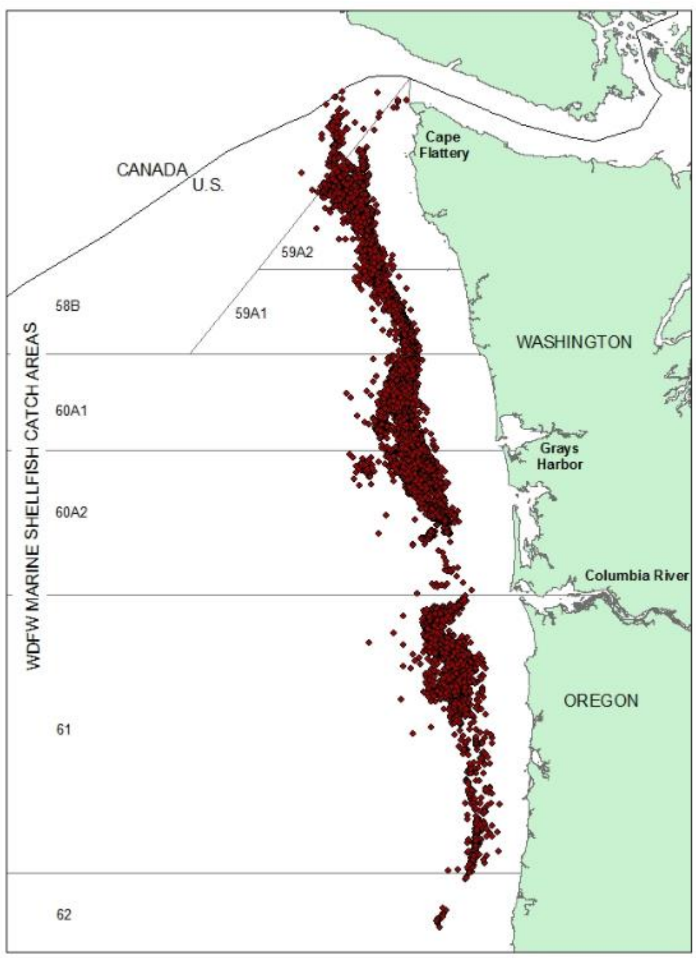


Figure 13: Distribution of Hagfish fishing trips off WA and OR, from Washington logbooks, 2005-18.

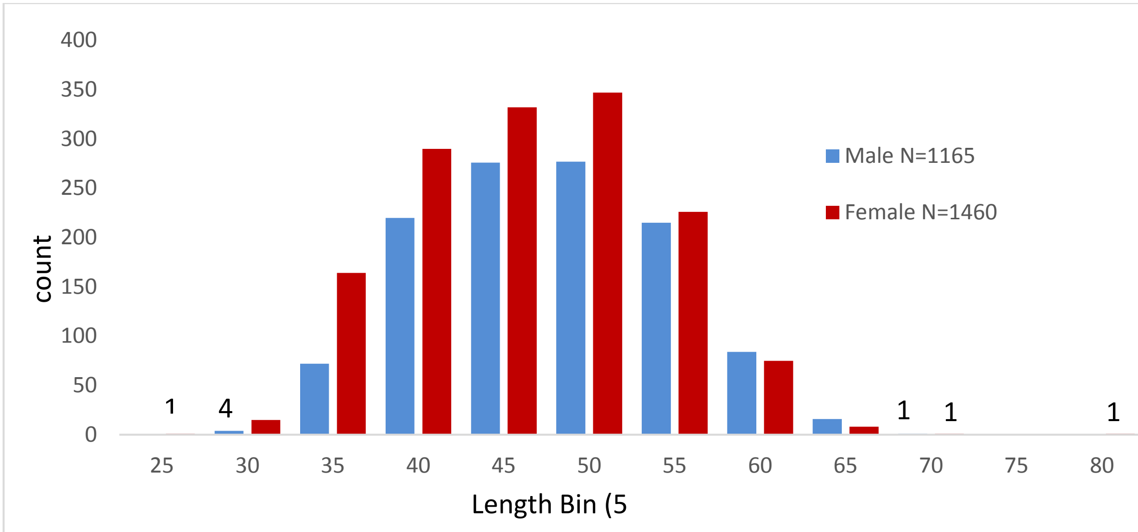


Figure 14: Length (cm), male and female Pacific Hagfish only, 2016-18.

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.

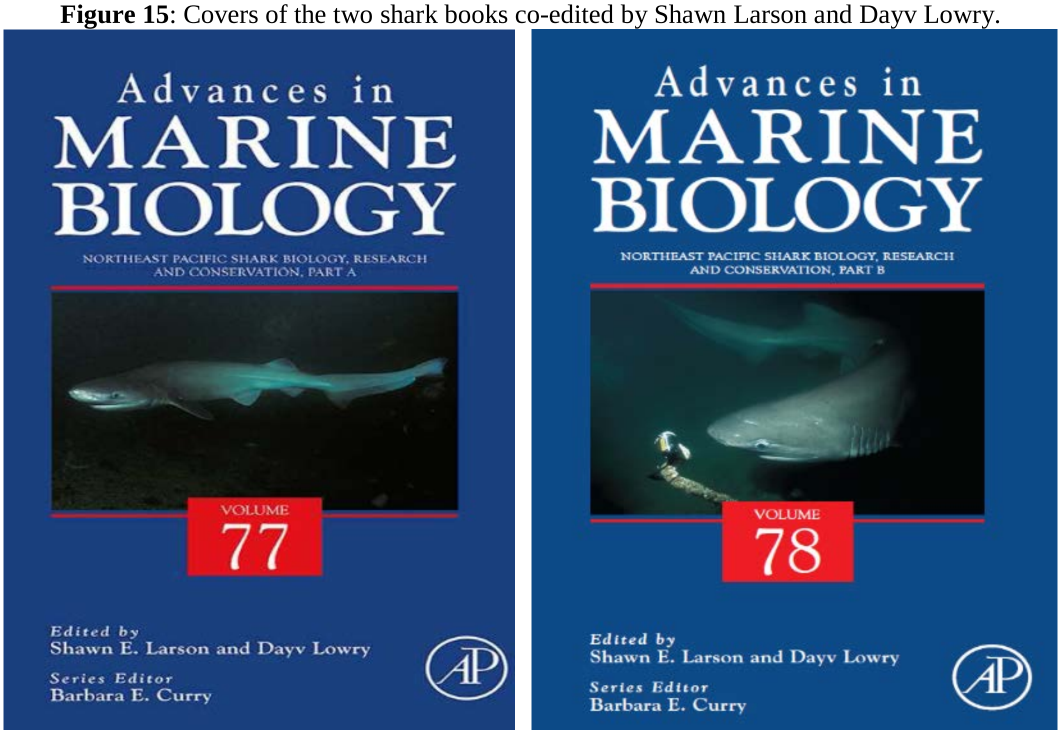
In 2014 the Lummi Nation initiated a directed drift- and set-gillnet fishery for dogfish in their Usual and Accustom Fishing Ground in northern Puget Sound (predominantly Birch Bay and Lummi Bay), which continue until 2017. The annual harvest quota for this fishery was set at 250k lbs for the entire period of operation, and harvest occurred predominantly from May-August, involved little to no reported bycatch, and closed each season as fishers transition to targeting salmon in the fall. Landings since 2014 are shown below (Table 5) and are typical of a short-term, opportunistic fishery. The fishery did not occur in 2018 as "catchers were having trouble finding markets," however a fishery may occur in 2019 again as product testing and marketing of a smoked fillet product is currently underway.

Table 5: Landings of Spiny Dogfish by the Lummi Nation since 2014.

Year	Landings (thousands of lbs)
2014	160
2015	219
2016	263
2017	87

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), which were published in late 2018. 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. 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 fourth of which will be held in La Paz, MX in March of 2020, is now the second largest international gathering of elasmophiles in North America, behind only the American Elasmobranch Society's annual meeting.

Figure 15: Covers of the two shark books co-edited by Shawn Larson and Dayv Lowry.



To date, chapters in the two volumes have been cited 42 times and downloaded over 2,500 times (Table 6). This citation rate is slightly low, but the download rate is well above normal and chapters have also been featured in blog postings and other social media.

Table 6: 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		121
Ebert, et al.	Biodiversity, Life History, and Conservation	77	3	287
Bizzarro, et al.	Diet Composition and Trophic Ecology	77	4	320
Reum, et al.	Stable Isotope Applications for Understanding Sharks	77	2	256
Matta, et al.	Age and Growth of Elasmobranchs	77	5	109
Larson, et al.	Review of Current Conservation Genetic Analyses	77	4	288
Larson+Lowry	Introduction to Volume 78	78	1	93
Kacev et al.	Modeling Abundance and Life History Parameters	78	3	99
Grassman et al.	Sharks is Captivity: Husbandry, Breeding, Education	78	6	279
King, et al.	Shark Interactions With Directed and Incidental Fisheries	78	7	242
Mieras et al.	Economy of Shark Tourism: Ecotourism and Citizen Science	78	4	327
Lowry	Conclusion: Future of Management and Conservation	78	3	111

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. Chapters for this volume are now complete and editorial review is underway. The volume will be finalized in June of 2019 and publication is expected by the end of the year.

Skates

West Coast Skate Stock Assessment Work – Stock assessments for Big and Longnose Skate will be completed in 2019 to support PFMC management. Three main challenges for this work are estimating historical catches by species, estimating historical discards, and establishing ageing techniques. The earliest coastal commercial skate landings in Washington were recorded in 1949, but landings were not recorded at the species level and landing conditions (wings or round) were not well documented either. Mandatory sorting requirements were not established until 2004 for Longnose Skate, and in 2009 for Big Skate. Dockside sampling for skates started in 2004. A large portion of skate caught were discarded or used for vitamin A production. However, we were not able to locate reports that can provide estimates of discards or prevalence of skates in the vitamin A fishery. Ageing for elasmobranchs can be challenging, with spines, vertebrae, and tag-based estimates often providing conflicting results. The NWFSC is investigating traditional methods vs. machine ageing in an effort to provide the necessary age data. WDFW staff are coordinating with NWFSC staff on data compilation and population modeling in Stock Synthesis.

Pacific Cod

No specific, directed research or management to report.

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
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 2018 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). Survey stations where Yelloweye Rockfish were observed were prioritized to enable a population estimate for the species to be made as soon as possible. No Bocaccio were encountered at any survey station, though four fish were noted during "exploratory" deployments. Video review of these transects is on-going, with the majority of the remaining videos containing few or no fish of interest.

In March and April of 2018, the WDFW conducted a three-week survey in a portion of the Yelloweye Rockfish and Bocaccio DPSs lying in Canadian waters of the Gulf Islands within the 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 Maximum Entropy (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). Funding for the survey was provided by NOAA (Dan Tonnes). A total of 64 transects were completed over 13 sampling days. Yelloweye rockfish were scarce in the southern portion of the survey area, but encounters increased as sampling moved northward. Preliminary review of the video identified at least 49 Yelloweye rockfish, but additional fish may be detected during the full video review process. No Bocaccio were observed during the survey. Initial review of the video transects is nearly complete but will require secondary reviews prior to data analysis.

In August 2018, the WDFW conducted a three-week survey of the San Juan Islands, which lies within the US portion of the DPSs for Bocaccio and Yelloweye Rockfish, with a total of 60 transects completed over 13 sampling days. This survey had the same goals and sampling design as the survey of the Canadian Gulf Islands and was meant to facilitate cross-border comparison of rockfish prevalence and size distribution. Consistent with previous ROV surveys of the San Juan Islands in 2008 and 2010, Yelloweye Rockfish were seldom encountered, with only 11 fish observed on eight transects. Canary rockfish were rarely encountered in the 2008 and 2010 surveys, but 33 fish were seen on eight transects in the most recent survey. No Bocaccio were seen in this survey. Initial review of the video transects is nearly complete but will require secondary reviews prior to data analysis.

In October 2018, the WDFW partnered with DFO Canada to conduct a 14-day survey of the southern and central Strait of Georgia. This survey utilized the WDFW-owned ROV deployed from the 40-m long Canadian Coast Guard Ship Vector. The primary goals of this survey were to 1) evaluate densities of "inshore rockfish", as defined by DFO, inside and outside established Rockfish Conservation Areas; and 2) use a stereo camera system to obtain length measurements of Yelloweye Rockfish that will be used in population recovery models. This survey was also designed based on the results of a MaxEnt habitat suitability model. The majority of stations were randomly assigned to High probability polygons inside and outside of selected RCAs, but is some cases it was necessary to hand-place stations due to a lack of matching habitat outside of an RCA. A total of 85 transects were completed in 14 survey days. The habitat in this survey was characterized by high densities of sponges, which provided a highly-complex and crevice-rich environment utilized by several rockfish species. In contrast to the previous two surveys, Yelloweye Rockfish were commonly encountered, with over 200 fish of all sizes observed during the survey. No Bocaccio were seen in this survey. Reviews of the transect videos have just started are being conducted jointly by WDFW and DFO, with the bulk of the effort provided by DFO.

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 held its last official meeting on February 27th, 2017 and then dedicated itself solely to finalization of a recovery plan. On March 24th, 2017 NOAA Fisheries finalized the removal of Canary Rockfish from the Federal List of Threatened and Endangered Species, (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. Research and educational outreach elements of this plan are presented elsewhere in this report.

As various kelp species may serve as habitat for ESA-listed rockfishes, NMFS, the Northwest Straits Initiative, the Puget Sound Restoration Fund, the WDFW, the Washington State

Department of Natural Resources, and various other regional partners have embarked on development of a kelp assessment and recovery plan for the Southern Salish Sea as a complement to the rockfish recovery plan. Information on historic and current kelp distribution and abundance have been compiled, stressors and threats identified, and an initial draft plan is under review. Completion of the plan is anticipated in 2019 and Puget Sound MFS Unit staff (Lowry, Pacunski) are serving on a research advisory committee to help with prioritization of proposed research to fill critical management gaps.

Completion of Report to Washington State Legislature Regarding Research Funded by the Rockfish Research Fund – In 2007 the Washington State Legislature approved House Bill 1476, creating a Rockfish Research Account (RRA) to increase monitoring of rockfish abundance and distribution in state waters. This bill was needed as a result of the significant decline in the past half century of many rockfish species residing in Washington marine waters. Progressively from 1999, seven rockfish species were federally designated as "overfished" on the West Coast, followed in 2010 by the listing of three species in Puget Sound and the southern Strait of Georgia under the federal Endangered Species Act (ESA).

Funded by surcharges on commercial and recreational fishing licenses, revenues from the Rockfish Research account have helped the WDFW to greatly expand its understanding of these vulnerable marine fish. The Department, in collaboration with diverse partners, has realized significant achievements that otherwise could not have been accomplished. These achievements include rebuilding of six federally declared overfished rockfish species on the coast, and delisting of an ESA listed species, Canary Rockfish, in Puget Sound.

Since 2008, WDFW has reported to the Legislature every other year on the status of rockfish stock assessment research and fishery management efforts. In March of 2019 the latest report in that series was finalized, providing an update on the current status of rockfish stock assessment capabilities, research projects conducted in FY 2016 - 2018, and future plans for research by the Department. Most of these projects and advancements have been included in past TSC reports. The periodic report was delivered to the Legislature and an offer was made to further discuss details of the report with any and all interested parties. Due to larger budget concerns and scheduling conflicts no briefing have yet been scheduled, but it is hoped that several one-on-one meetings with legislators will occur in the summer of 2019 once the Legislature adjourns. The full citation for the report is provided below and it is available digitally upon request from Theresa Tsou, Lisa Hillier, Dayv Lowry, and/or Lorna Wargo.

Education, Outreach, and Rule Changes Pertinent to Use of Descending Devices – From 2012 through 2017 the WDFW advocated the voluntary use of descending devices to return rockfish and other groundfish to the depth of capture, thus reducing deleterious effects of barotrauma. 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's State Waters have a descending device onboard, rigged, and ready for use. The Puget Sound Anglers and staff from NOAA's Northwest Fishery Science Center were strong partners in education and outreach efforts leading up to this rule change – 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. In total, over 9,500 descending devices (Shelton Fish Descenders and SeaQualizers), 55,000 laminated rockfish species identification cards, and 9,000 pocket rockfish identification keychain card sets have been distributed to charter boat captains and members of the public. A set of 4'x3' signs about rockfish conservation were also posted at prominent fishing ports in 2017. Members of the MFS have also presented at over three dozen meetings 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.

To continue to promote the responsible use of descending devices, the WDFW is always on the lookout for novel methods to reinforce messages about their conservation benefits. In February of 2019 the Department (Lowry and Hall) worked with PSMFC (Steve Williams) to design a L'il Sucker drink holder/stabilizer to keep messages about descending device use close at hand (Figure 16). In total, 2,500 units were ordered and are currently be distributed to anglers and users of marine waters at boat shows, sportsman's' shows, and elsewhere.

Figure 16: Design of L'il Sucker promoting descending device use to reduce the effects of barotrauma on rockfishes.

Thornyheads
No specific, directed research or management to report.

Sablefish
No specific, directed research or management to report.

Lingcod

Preparing for a Formal Stock Assessment in Puget Sound – Over the past 2-3 years concerns have been raised by the public about Lingcod populations within Puget Sound, especially in the San Juan Archipelago and Central Puget Sound off Edmonds. Specifically, some constituents are concerned that the current management regime is not protective enough, as legal-sized fish (26-36") are hard to find after only a few weeks into the six-week season (May 1 – June 15). Though declining trends in CPUE are apparent in some regions, the issue seems largely to be a result of increased fishing pressure/effort, especially near urban centers, since 2010. In addition to the slot limit and short season noted above, the daily bag limit is one fish per angler and fishing is not allowed deeper than 120' to reduce barotrauma impacts on rockfish. The WDFW considers this a highly conservative management regime.

The WDFW is taking steps to evaluate Lingcod populations using a Stock Synthesis model, which is a size and age-structured population assessment tool. This type of model is commonly used for coastal fisheries and is data intensive. The model structure for Puget Sound Lingcod utilizes commercial and recreational landings, length frequency data, age data, and catch-per-unit-effort data to evaluate historic and current trends in the population. When complete, managers will be able to use the output from the Stock Synthesis model to inform management decisions for Lingcod in Puget Sound. The recreational rule change cycle in Washington considers changes to marine fisheries only every third year, with 2019 being the next applicable annum.

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 has been Resolved – 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, MFS 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'. The 120' 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's Intergovernmental Ocean Policy Unit 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.

In March of 2019 the WDFW agreed to eliminate Lingcod retention in the Pacific Halibut fishery in Marine Catch Area 6, removing the threat of targeted fishing over rocky habitat. This decision was arrived at after considering the increased Pacific Halibut quota for 2019, and thus the potential for increased exposure duration of deep-water rockfish to fishing pressure during the targeted halibut fishery. 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 occurred as scheduled in 2018 and 2019. The process of permit renewal is now back on track and moving forward in a timely manner.

Participation in Puget Sound Leg of Annual IPHC Survey – Each year the IPHC performs a coast-wide, extensive longline survey of Pacific Halibut abundance. In most years, fishing is focused on the outer coast of Washington and does not occur east of the Bonilla-Tatoosh line. In some recent years, however, the IPHC, NOAA, and the WDFW have coordinated to sample stations inside Puget Sound, as far south as the waters off Tacoma.

In August of 2018 Dayv Lowry participated in the IPHC survey for four days as they fished stations from Port Townsend to Tacoma. Details on catch are provided in the IPHC report, with numerous halibut but zero rockfish caught. An event worth noting was the encounter of several dozen 200+ cm Sixgill Sharks at a station south of Maury Island, off Tacoma. This represented more sharks than observed by all other methods (trawl, scuba, public reports) over the last 8 years in Puget Sound. As a result of this high encounter rate, the WDFW is currently coordinating with the Monterey Bay Aquarium to put pop-up satellite archival tags on Sixgills Sharks in 2020. This is a fine example of inter-agency coordination prompting academic research that will enhance knowledge about fundamental aspects of marine fish biology and behavior.

Other groundfish (and forage fish) species

Pacific Sand Lance Genetic Research – Together with partners at the NWFSC, Shoreline Community College, Sea Doc Society, Washington State DNR, North Pacific Research Board, and UW's Friday Harbor Labs members of the PSMFS Unit and MFF unit are working to investigate regional variation in population structure of Pacific Sand Lance. Samples have been collected from the San Juan Archipelago, Eagle Harbor (Bainbridge Island), and Nisqually River delta thus far, and additional collections are planned. Fish have been obtained via beach seining and digging on mud flats during low tide. Thus far, amplification of the DNA has gone well, and is being overseen by the Shoreline Community College molecular genetics lab. Preliminary results are expected by early 2020.

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 (PSEMP) update – The Toxics-focused Biological Observation System (TBiOS) team at WDFW has been conducting regular status and trends (S&T) monitoring of toxic contaminants in a wide range of indicator species in Puget Sound, including assessments of health effects on biota, since 1989. TBiOS' most recent regular S&T monitoring includes assessments of English sole (a benthic indicator) in 2015, 2017, and 2019, and Pacific herring (a pelagic indicator) in 2014, 2016, and 2018. In addition, TBiOS recently conducted a large-scale assessment of contaminants in winter adult Chinook salmon (i.e. Blackmouth) from sport fisheries in seven marine areas of Puget Sound (winter 2016/17). Data from the Blackmouth study was used by the Washington Department of Health to set fish consumption advisories for this species in Puget Sound. Data from the English sole, Pacific herring, and Blackmouth studies are summarized online at the Puget Sound Partnership's Toxics in Fish Vital Sign website. The Toxics in Fish Vital Sign is a communication tool that helps distill TBiOS' complex contaminant monitoring information into usable metrics for ecosystem recovery managers.

In addition to benthic and pelagic indicator species, TBiOS has recently adopted two new indicators for assessment of contamination in the *nearshore* environments of Puget Sound. To ascertain the effects of contaminants on early the life-stages of salmon, TBiOS conducted two assessments (2016 and 2018) of juvenile Chinook salmon from 12 major rivers and deltas of Puget Sound. In addition, TBiOS recently adopted mussels as a nearshore indicator and has conducted three, Puget Sound-wide, assessments of contaminants using transplanted (i.e. caged) mussels over the winters of 2012/13, 2015/16, and 2017/18. TBiOS has secured long-term funding to conduct regular nearshore contaminant surveys with these species into the future.

TBiOS has also conducted a number of special studies in recent years. For instance, in 2012 they conducted a large-scale assessment of contaminants in Dungeness crab and spot prawn from nine marine areas and three urbanized bays of Puget Sound. This data was used by the Department of Health to set shellfish consumption advisories for these species. In addition, TBiOS has conducted several recent studies to track the effectiveness of large-scale removals of creosote-treated wooden pilings (Port Gamble Bay 2014 and 2015, and Quilcene Bay 2012-2015). In these studies, TBiOS used Pacific herring embryos, a particularly sensitive life-stage, to test for ecological impacts of chemicals leaching out of the pilings. Publications and reports for a number of these studies are available at the TBiOS list of publications website, as well as at the aforementioned Toxics in Fish Vital Sign website. For additional details on TBiOS research regarding toxic contaminants in Puget Sound biota contact Jim West at james.west@dfw.wa.gov or 360-902-2842.

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 27 free-floating nets, 31 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, at which time funding from the National Fish and Wildlife Foundation will provide support through 2021.

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Conferences and Workshops

In 2018-19 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.

Data Limited Stock Assessment Symposium and Class. Seattle, WA, May 2018. Seven MFS Unit staff attended.
Salish Sea Fish Assemblage Workshop. Seattle, WA, September 2018. MFS Unit staff were coauthors on nine talks over two days, and were the presenters of six of these talks.
South Sound Science Symposium. Shelton, WA, October 2018. Dayv Lowry served on the Steering Committee and presented results of regional ROV survey work in Puget Sound.
Seattle Aquarium Discover Science Days. Seattle, WA, November 2018. Bob Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, and Amanda Phillips attended and presented.

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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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2017-2019 CARE Chair

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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	E
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-
Groot	Joanne	CDFO	Nanaimo	Canada	joanne.groot@dfo-mpo.gc.ca
Wischniowski	Stephen	CDFO	Nanaimo	Canada	stephen.wischniowski@dfo-
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)

<u>Wednesday, April 5</u>

XI. Workshops, working groups, hands-on microscope work [8:30 – 5:00]

*schedule lunch as appropriate for respective groups

1. Rougheye rockfish workshop [9:00 – 10:30] Imaging Room 1110

2. Lingcod workshop [10:30 – 12:00] (Imaging Room 1110, Groundfish Lab 1125 for structure preparation)

3. Working Groups (Traynor Room and Room 2079 available all day)

4. Hands-on microscope work and calibration (Traynor Room)

XII. Scientific PowerPoint Presentation [1:00 – 1:45]

Tom Helser, *Fish tales: isotopes, trace elements and increments, and what they tell us*

XIII. Workshops, working groups, hands-on microscope work (continued)

5. Longnose skate workshop [2:00 – 5:00] (Imaging Room 1110)

--- Posters available for viewing during breaks from other tasks all day---

CARE Social at the Wedgwood Ale House and Café-see sign-up sheet and directions (5:30-9:00)

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.

Committee of Age Reading Experts

2019 Committee Report

and

Executive Summary of the

Twentieth Biennial Meeting April 9-12, 2019

Prepared for the Sixtieth Annual Meeting of the

Technical Subcommittee of the Canada-USA Groundfish Committee

April 23 – 24, 2019

Prepared by
Kevin McNeel
2017-2019 CARE Chair

Alaska Department of Fish & Game
Division of Commercial Fisheries
Age Determination Unit Supervisor
10107 Bentwood Pl
Juneau, Alaska
99801

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, 2018; however, to promote timely reporting of work and recommendations occurring during the recent CARE conference, an Executive Summary of the 20th CARE conference held April 9-12, 2019 is included here as part of the TSC report. Current officers through June 30, 2019 (elected at April CARE 2017 Meeting) are:
   - Chair – Kevin McNeel (ADF&G-Juneau)
   - Vice-Chair – Barbara Campbell (CDFO)
   - Secretary – Nikki Atkins (NWFSC)

   The Secretary will prepare a draft of the minutes from the recent CARE meeting to be distributed to CARE members for review and subsequent approval prior to the end of his term. Due to the proximity of the TSC meeting following the CARE meeting, it is necessary to for the Chair to prepare the report to TSC to include proceedings of the recent meeting as an executive summary. Finalized minutes will be included in the annual 2019 report.

3. **2018 Annual Report**
   - Initial CARE 2019 Meeting Announcement sent by CARE Chair to CARE members on July 2, 2018 to establish themes for CARE and the venue. On November 2, 2018 an overview of the 2019 meeting logistics, agenda, and workshops was given.
   - The CARE Vice Chair contacted CARE members to finalize all age structure exchanges. Ten exchanges were initiated in 2018: one big skate exchange initiated by NWFSC-PSMFC, two canary rockfish exchanges initiated by WDFW and NWFSC, one longnose skate initiated by AFSC, one Pacific cod exchange by ADF&G-Juneau, four sablefish exchanges initiated by NWFSC, AFSC, ADF&G-Juneau, and CDFO, and one yelloweye rockfish exchange initiated by ADF&G-Homer (Table 3).
   - Jon Short (AFSC) and Nikki Atkins (NWFSC) updated the CARE website for current info, CARE officers, and 2017 CARE Meeting minutes.

4. **CARE Conference – Executive Summary**
   CARE meets biennially for a conference that usually lasts three days. Conferences typically consist of one and a half "business" days and one and a half days for a hands-on calibration workshop at microscopes to review and standardize age reading criteria with any extra time scheduled for a specific focus group or workshop.

   c. **Overview:** The most recent biennial CARE Conference was held in Seattle, WA, April 9-11, 2019 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 36 CARE members (Table 1) from seven participating agencies: ADF&G (3), AFSC (17), CDFO (3), IPHC (3), NEFSC (1), NWFSC/PSMFC (4), ODFW (2), and WDFW (3). Following the CARE conferenced, AFSC hosted a two-day FT-NIRS workshop (Appendix II). The next CARE Conference in 2021 will be held prior to the TSC meeting in April in Newport, Oregon. The following officers were elected at the April 2019 meeting and will take office July 1, 2019:
   - Chair – Delsa Anderl (AFSC)
   - Vice-Chair – Andrew Claiborne (WDFW)

- Secretary – Nikki Atkins (NWFSC-PSMFC)

d. Business Session Highlights:

i. Scientific presentations:

An unofficial Call for Presentations and Posters for the 2019 CARE Conference was sent to members on November 2, 2018 (Appendix II). Submissions were requested to address current research and the 2018 TSC recommendations: yelloweye rockfish, differentiating cryptic species, and evaluating machine reading of otoliths.

Abstracts were due to the CARE Chair by March 8, 2019. There were two oral presentations submitted for the scientific presentation session. (Appendix III).

Two oral presentations in PowerPoint format were given during the CARE meeting:

1. Andrew Claiborne, Results of the yelloweye rockfish exchanges: comparison of age determinations from Alaska, British Columbia, and the coasts of Washington and Oregon

2. Chris Hinds, Importance of juvenile sablefish growth and methods of estimation

ii. Agency Reports:

AFSC (Thomas Helser), CDFO (Steve Wischniowski), IPHC (Joan Forsberg), ADF&G (Kevin McNeel), 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, CDFG, or ADF&G- Homer and Kodiak, but a report was sent from Kodiak. Details from agency reports will be available in the finalized CARE minutes, published to the CARE website by year's end.

iii. Working Groups:

a) Yelloweye rockfish:

Hands-on microscope work and calibration summary
Goal: Yelloweye rockfish ageing and reviewing exchange data
Tuesday, April 9, 2019

Participants:
Joanne Groot (CDFO)
Michele Mitchell (CDFO)
Chris Hinds (ADF&G)
Jodi Neil (ADF&G)
Sandra Rosenfield (WDFW)
Andrew Claiborne (WDFW)
Patrick McDonald (NWFSC-PSMFC)
Kevin McNeel (ADF&G)

Age readers from CDFO, WDFW, ADF&G-ADU, and PSMFC aged specimens from the radiocarbon sample using images. Specific features discussed were identification of the 1st, preferred aging axis, edge interpretation, splitting vs. banding of fine annuli in older specimens, and the importance of tracing annuli from the surface onto the reading surface to help interpret noise.

b) Pacific cod

Hands-on microscope work and calibration summary
Goal: Pacific cod ageing and calibration
Tuesday/Wednesday, April 9/10, 2019

Participants:
Kevin McNeel (ADF&G)
Jodi Neil (ADF&G)
Chris Hinds (ADF&G)
Delsa Anderl (AFSC)
John Brogan (AFSC)
Dustin Nadjkovic (AFSC)
Beth Matta (AFSC)
Kali Stone (AFSC)
Sandra Rosenfield (WDFW)

The group reviewed annotated images of Pacific cod otoliths from the 2019 age structure exchange to corroborate ages and resolve discrepancies. The group went over the spacing of the first two annuli, tracking annuli, edge growth and preferred reading axes. Also, the results of AFSC's ^{18}O study were reviewed and the group discussed the common check that occurs between the first and second annuli. Delsa Anderl also went over some of the work and collaboration that AFSC was doing with Korean age readers.

c) **Sablefish:**

Hands-on microscope work and calibration summary
Goal: Sablefish ageing and reviewing exchange data
Wednesday, April 10, 2019

Participants:
Kevin McNeel (ADF&G)
Jodi Neil (ADF&G)
Chris Hinds (ADF&G)
Delsa Anderl (AFSC)
John Brogan (AFSC)
Joanne Groot (CDFO)
Michele Mitchell (CDFO)
Patrick McDonald (NWFSC-PSMFC)
Jamie Hale (NWFSC-PSMFC)
Nikki Atkins (NWFSC-PSMFC)
Dustin Nadjkovic (AFSC)
Tyler Johnson (NWFSC-PSMFC)
Kali Stone (AFSC)

The group reviewed the results and annotated images of the four sablefish otolith age structure exchanges. All agencies confirmed that they use the surface of the otolith to age, but AFSC uses the unburned surface. ADF&G uses a 2mm measurement criteria for the first, which resulted in an additional year on some otolith ages. Everyone reviewed annotations and resolved some discrepancies from the age structure exchange.

Thirty known-age sablefish were presented at CARE. The sablefish working group decided that the unprocessed and broken and burned otoliths should be imaged and mixed into a larger sample to prevent ages from being biased. These will be sent to all participating agencies following CARE. Some members of the working group also reviewed images of known-age otoliths from the historic collections for calibration.

d) Longnose skate:

Hands-on microscope work and calibration summary
Goal: Big and longnose skate ageing
Wednesday, April 10, 2019, 4:00 pm to 5:00 pm
AFSC, Seattle, WA, Imaging Room 1110

Participants:
Morgan Arrington (AFSC, University of Washington)
Beth Matta (AFSC)
Patrick McDonald (NWFSC-PSMFC)
Tyler Johnson (NWFSC-PSMFC)
Chris Gburski (AFSC)

The group began the skate ageing session viewing thin section images from vertebral centra on the imaging PC monitor, prepared by Morgan. The US West Coast longnose skate *(Raja rhina*) specimen images were acquired with reflected light and image enhanced. We examined discrepancies between the AFSC and NWFSC from the CARE exchange conducted in winter 2018. Early growth years (0-1 years old) were viewed for consensus ageing. The intermedialia, corpus calcarea arms, edge, birthmark increment, translucent versus opaque growth zones, and total length were used for age determination. For West Coast collected longnose skate, it was surmised that the birthmark is closer in distance to the focus when compared to longnose skate collected from the Gulf of Alaska. To explain this difference, water temperature and timing for embryo development within the skate egg case may vary from these two regions with variances in life history events. Edge growth and seasonality (summer vs. fall collected) was discussed to estimate age and edge growth. One specimen was subsequently ranged due to the difficulty in age interpretation. Skate maturity stage (mature vs. immature) with respect to how it may affect appearance of growth zones was also discussed. Ontogenetic shift in diet may affect growth and maturity stage timing. Age 1-2 years old were also viewed. The ‘young skate’ section for ‘Longnose Skate Ageing Procedures’ from the CARE Ageing Manual was referenced to assist with ageing. Tyler showed West Coast collected big skate (*Beringraja binoculata*) unstained vertebral thin sections (n = 5) that we viewed with reflected light. Both age 1 or 2-year-old and age 3 or 4-year-old specimens were looked at for a consensus age. How to interpret growth patterns including splitting versus grouping, translucent growth zones, spacing, pre-annular checks, and thin section thickness were discussed. There were 5 participants from AFSC and NWFSC.

e) Shortspine thornyhead:

Hands-on microscope work and calibration summary
Goal: Discuss otolith structure exchange that between AFSC and ADU (initiated by AFSC) using unburned thin-sectioned specimens.
Thursday April 11, 2019 CARE

Participants:
Jodi Neil (ADF&G-Juneau)
Charles Hutchinson (AFSC)
Todd TenBrink (AFSC)

Both agencies annotated the images and we discussed these annotations as well as looked at a few additional unburned thin-sectioned specimens and aged and annotated them as a group. The results of the annotated structure exchange specimen suggested a slightly older pattern interpretation by AFSC age readers in comparison to the ADU age readers. During the working group we discussed the best counting pathway to use (e.g. sulcus vs edge) and how to interpret the early years. Shortspine thornyhead growth patterns are noisy and checky in the early years so all readers agreed that using the surface if possible and the sulcus was the best way to interpret this noise.
A concern brought up by the AFSC age readers was whether darker areas in older specimens were compressed zones or fast growth larger zones and how to interpret these zones. In unburned thin sections these zones appear as translucent bands that are very difficult to see individual annuli. We discussed the possibility that for these older specimens maybe the thin section was not thin enough to be able to clear up these translucent compressed areas.

We discussed the possibility of conducting a larger paired-structure exchange that would include both a broken and burned half and an unburned thin-sectioned half from the same specimens, with both agencies contributing otoliths for the exchange. At the end of the meeting, Charles proposed AFSC put together a list of questions and goals they would like to achieve in the next structure exchange as they were the agency that initiated the last exchange to address concerns they had.

f) Rougheye/Blackspotted/Shortraker Rockfish:

Review and hands on work summary
Goal: Discuss agency progress and compare shape analysis results
Thursday April 11, 2019 CARE

Participants:
Charles Hutchinson (AFSC)
Betty Goetz (AFSC)
Stephen Wischniowski (CDFO)
Kevin McNeel (ADF&G)

All agencies worked together to provide updates, collect morphometric and shape data, and compare model results at CARE. Steve Wischniowski provided a sample of rougheye and blackspotted otolith images and Charles Hutchinson created otolith measurements using ImagePro Plus and compared measurements with otolith weight and age to the current AFSC model output. Kevin McNeel created shape estimates and otolith measurements using R and looked for statistical groups and identification error. Each agency is currently working to address specific concerns for identifying these species and a summary was provided to the group (Appendix IV).

iv. **Hands-on Session Highlights and Demonstrations:**
A total of 21 readers reviewed 7 species during the hands-on workshops and, mainly for the purpose of calibration between age readers and agencies. Members aged yelloweye rockfish, Pacific cod, sablefish, longnose skate, and shortspine thornyhead. A demonstration for measuring rockfish otolith with image analysis was demonstrated by Charles Hutchinson (AFSC) and Kevin McNeel (ADF&G). See species aged, participating members, and agencies in Table 2.

v. **Exchanges:**
Kevin McNeel (ADF&G) presented Barb Campbell's (CDFO) updates on CARE exchanges. She reported that there were 13 exchanges in 2017, 10 exchanges in 2018, and four exchanges in 2019. Three of the 2017 and one of the 2018 exchanges were outstanding and needed data to be finalized. Barb also commented that maybe statistical results on invoices was not necessary, that agencies should resolve ages and submit on agency age

B. CARE Subcommittee (Working Group) Reports – Executive Summary

There were five active working groups that reported at the 2018 CARE Conference:

5. **TSC Meeting 2018:** Kevin McNeel (ADF&G) gave an overview of the 2018 meeting in San Jose, California. In the report given to the TSC McNeel gave an update on changes in CARE personnel and our activity and included the 13 age structure exchanges in 2018. He commented that CARE initiated 5 yelloweye exchanges, which directly addresses the 2017 TSC to CARE recommendation to review yelloweye rockfish age pattern criteria. The TSC was interested in near infrared methods to age otoliths and commented on using tag-recapture, known-age sablefish. It was reported that AFSC has been working on evaluating the method for Walleye pollock, Pacific cod, sablefish and sole, that the method may have more potential for some species, and that AFSC is the only center on the west coast with NIR machine.
McNeel reviewed recommendations: the 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, to compare criteria. TSC members proposed to add yelloweye rockfish criteria as a research priority to make it easier to study.

6. **CARE Website:** Jon Short (AFSC) gave updates on the CARE website. Jon Short showed the new WordPress webpage that is supported by the PSMFC. There new website is missing a lot of content that needs to be moved forward and CARE is looking for people that have time to update the websites. Jon Short is missing some 2015/2016 agency production number summaries and has been waiting to update the website until he has all updates. Jon and Kevin asked CARE members to turn those in as soon as possible
7. **CARE Forum**: Nikki Atkins (NWFSC) gave an update on the CARE website forum. Nothing has happened on the forum for quite some time. However, with the new host for the website the forum seems like it might be more user friendly. Old posts from the form will be copied and moved into the new forum as "archived" posts so the content won't be lost. Nikki will contact all current users of the forum with the new address and reminders of their usernames so they can log in to the new version.

J. CARE & TSC Recommendations

4. 2019 CARE to CARE

   a. Recommends the CARE Manual working group (Elisa Russ, Betty Goetz, Jodi Neil) finalize and add the following sections before the 2021 CARE meeting:

      i. Lingcod Otolith Ageing Procedures section (is written, needs to be added)

      ii. Sablefish Ageing Procedures section (is written, needs to be added)

      iii. Thin Sectioning Method section – add a section under the General Ageing Procedures (is written, needs to be added)

      iv. Add section on baking otoliths under General Otolith Ageing Procedures; to be written and finalized

      v. Ergonomics section including equipment checklist as appendix (is written, needs to be added)

   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 for review and addition of edits to the manual by the 2021 CARE meeting:

      vi. Walleye Pollock Ageing Procedures section (use AFSC manual as starting point); not written

      vii. Spiny Dogfish Ageing Procedures section – summary of spiny dogfish age determination paper by Dr. Cindy Tribuzio; not reviewed

      viii. Rockfish Ageing Procedures section; not reviewed

         1. Edit to avoid redundancy with Thin Sectioning section;

         2. Revise/move some information to General Otolith Ageing Procedures section where appropriate;

      ix. Remove documentation sections regarding changes to CARE Manual

         1. See Recommendation C to post archived editions.

         2. 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. Most archived material may be lost, but Betty Goetz offered to retrieve old files.

   d. Recommends that the CARE Forum be updated and added to the new website.

   e. Recommends the CARE searchable publication database be discontinued and an updated version of the current endnote database be supported.

   f. Additional recommendations for the website to be completed prior to the 2019 TSC meeting are as follows:

      i. 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,”

      ii. Add table for agency contacts with e-mail address of agency leads and information on age readers and species; Add as google doc and have agencies update information by Friday April 12, 2019

iii. Update agency production numbers annually (finalize agency updates by April 19, 2019), and

3. Update Species Information page to include new codes;
4. Edits such as consistent capitalization on the Species Information page; find updated species list by Care 2021

iv. Agencies should work to provide links to structure inventories to be assessable on the new website before CARE 2021

g. Recommends that ongoing agency progress toward long term otolith storage issues be documented and distributed to the TSC before the 2020 meeting. Research from the IPHC, CDFO, and AFSC will be summarized and distributed.

h. Recommend posting list of maximum ages on CARE website and developing quality control processes for new 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).

i. Recommend evaluating and updating the current CARE Age Structure Exchange invoice to potentially exclude quality control statistics and include better notation before CARE 2021.

5. 2019 CARE to TSC

CARE currently has no recommendations for the TSC

8. TSC to CARE 2017/2018

2017

Recommends CARE to review yelloweye aging

2018

a. CARE did not directly respond to storage recommendations and CARE will carry this recommendation on this year and develop a working group to standardize otolith storage.

b. TSC Recommends carrying over yelloweye ageing review.

c. TSC encourages the use of otolith morphometrics to separate out cryptic species and suggests expanding the current working group to expand to other species.

d. TSC encourages CARE to evaluate the machine reading of otoliths as a valid method (near infrared), concern is that suitable criteria are met.

Table 1. Attendees of the CARE Conference, April 9-11, 2019, Seattle, Washington, U.S.A.

Last name	First name	Agency	Location	Country	Email
Hinds	Chris	ADF&G	Juneau	USA	chris.hinds@alaska.gov
McNeel	Kevin	ADF&G	Juneau	USA	kevin.mcneel@alaska.gov
Neil	Jodi	ADF&G	Juneau	USA	jodi.neil@alaska.gov
Anderl	Delsa	AFSC	Seattle	USA	delsa.anderl@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
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
Nadjkovic	Dustin	AFSC	Seattle	USA	dustin.nadjkovic@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
Stone	Kali	AFSC	Seattle	USA	kali.stone@noaa.gov
TenBrink	Todd	AFSC	Seattle	USA	todd.tenbrink@noaa.gov
Arrington	Morgan	AFSC/ UW	Seattle	USA	morgan.arrington@noaa.gov
Groot	Joanne	CDFO	Nanaimo	Canada	joanne.groot@dfo-mpo.gc.ca
Mitchell	Michele	CDFO	Nanaimo	Canada	michele.mitchell@ 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
Rudy	Dana	IPHC	Seattle	USA	dana@iphc.int
McBride	Richard	NEFSC	Woods Hole	USA	richard.mcbride@noaa.gov
Atkins	Nikki	NWFSC	Newport	USA	nikki.atkins@noaa.gov
Hale	Jamie	NWFSC	Newport	USA	james.hale@noaa.gov
Johnson	Tyler	NWFSC	Newport	USA	tyler.johnson@noaa.gov
McDonald	Patrick	NWFSC	Newport	USA	pmcdonald@psmfc.org
Kautzi	Lisa	ODFW	Newport	USA	lisa.a.kautzi@state.or.us
Rasmuson	Leif	ODFW	Newport	USA	leif.k.rasmuson@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

Table 2. 2019 CARE Hands-On Sessions – Species Aged, Participants, and Agency.

Species	Participants	Agency	Comments
Shortspine thornyhead	Jodi Neil	ADF&G-Juneau	Calibration
	Charles Hutchinson	AFSC	
	Todd TenBrink	AFSC	
Longnose skate	Morgan Arrington	AFSC, UW	Calibration
	Beth Matta	AFSC	
	Patrick McDonald	NWFSC-PSMFC	
	Tyler Johnson	NWFSC-PSMFC	

	Chris Gburski	AFSC	
Sablefish	Kevin McNeel	ADF&G	Calibration
	Jodi Neil	ADF&G	
	Chris Hinds	ADF&G	
	Delsa Anderl	AFSC	
	John Brogan	AFSC	
	Joanne Groot	CDFO	
	Michele Mitchell	CDFO	
	Patrick McDonald	NWFSC-PSMFC	
	Jamie Hale	NWFSC-PSMFC	
	Nikki Atkins	NWFSC-PSMFC	
	Dustin Nadjkovic	AFSC	
	Tyler Johnson	NWFSC-PSMFC	
	Kali Stone	AFSC	
Pacific cod	Kevin McNeel	ADF&G	Calibration
	Jodi Neil	ADF&G	
	Chris Hinds	ADF&G	
	Delsa Anderl	AFSC	
	John Brogan	AFSC	
	Dustin Nadjkovic	AFSC	
	Beth Matta	AFSC	
	Kali Stone	AFSC	
	Sandra Rosenfield	WDFW	
Cabezon	Lisa Kautzi	ODFW	Calibration
	Sandra Rosenfield	WDFW	

Table 3. CARE age structure exchanges initiated in 2018.

Exchange ID #	Species	Originating Agency	Coordinator	Participating Agency
18-010	Big skate	NWFSC-PSMFC	Tyler Johnson	AFSC
18-004	Canary rockfish	WDFW	Jennifer Topping	NWFSC
18-005	Canary rockfish	NWFSC	Patrick McDonald	WDFW
18-006	Longnose skate	AFSC	Beth Matta	NWFSC
18-002	Pacific cod	ADF&G-ADU	Jodi Neil	AFSC
18-001	Sablefish	NWFSC	Patrick McDonald	NWFSC, ADF&G-ADU, AFSC, CDFO
18-003	Sablefish	AFSC	John Brogan	NWFSC, ADF&G-ADU, AFSC, CDFO
18-007	Sablefish	ADF&G-ADU	Jodi Neil	NWFSC, ADF&G-ADU, AFSC, CDFO
18-008	Sablefish	CDFO	Barb Campbell	NWFSC, ADF&G-ADU, AFSC, CDFO
18-009	Yelloweye rockfish	ADF&G-Homer	Elisa Russ	ADF&G- ADU

APPENDIX-I

CARE 2019 Agenda
Twentieth 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

7600 Sand Point Way, NE, Seattle, WA, USA Bldg. #4, Jim Traynor Conference Room 2076 April 9 – 11, 2019

Tuesday, April 9, 2019

III. Call to Order [8:30 am] – CARE Chair (Kevin McNeel)

IV. Host Statement

1. Welcome statements & host info: safety/security orientation, refreshments, social. etc. (Tom Helser-Age & Growth Program Director)

III. Introductions

3. Round-table intro (name, agency, location)
4. Attendance-address, phone, email (written list distributed)

X. Approval of 2019 Agenda

XI. Working Group Reports [9:00 – 9:45] Activity since CARE 2015 (~ 5 min each)

1. TSC Meeting 2018 (Kevin McNeel)
2. Age Structure exchanges (Kevin McNeel)
3. Website (Jon Short)
4. CARE Forum (Nikki Atkins)
5. CARE Manual (TBD)
6. Charter Committee (TBD)

XII. CARE & TSC Recommendations [9:45 – 10:15]

9. CARE to CARE 2017 (see pages 23 & 24 in 2017 CARE Meeting Minutes)
10. CARE to TSC 2017 (see page 25 in 2017 CARE Meeting Minutes)
11. TSC to CARE 2017/2018 (see pages 533 and 23 in 2018 TSC Meeting Minutes)

Break 10:15 – 10:30

XIII. Agency Reports [10:30 – 12:00] Activity since CARE 2017 (~ 5 min each)

8. CDFO **–** (Steve Wischniowski)
9. IPHC **–** (Joan Forsberg)
10. AFSC **–** (Tom Helser)
11. ADF&G **–** (Kevin McNeel)
12. NWFSC **–** (Patrick McDonald)
13. WDFW – (Andrew Claiborne)
14. ODFW **–** (Lisa Kautzi)
15. Additional Attending Agencies

Lunch 12:00 – 1:15

XIV. Topics for Discussion/New Business [1:15 – 2:00]

3. Symposia/Conferences since CARE 2017 meeting & upcoming
4. Agency updates & verification of sp. info on CARE website
5. Non-agenda items

XV. Scientific PowerPoint Presentations [2:00 – 2:30]

1. Andrew Claiborne, *Results of the yelloweye rockfish exchanges: comparison of age determinations from Alaska, British Columbia, and the coasts of Washington and Oregon* (15 min)
2. Chris Hinds, *Importance of juvenile sablefish growth and methods of estimation* (15 min)

Break 2:30 – 2:45

X. Workshops, working groups, hands-on microscope work [2:45 – 5:30]

1. Yelloweye Working Group [2:45 – 5:30]
2. Working Groups (Traynor Room and Room 2079)
3. Hands-on microscope work and calibration (Traynor Room)

<u>Wednesday, April 10, 2019</u>

XI. Workshops, working groups, hands-on microscope work [8:30 – 12:00]

6. Sablefish Working Group [10:30 – 12:00]
2. Working Groups (Traynor Room and Room 2079 available all day)
3. Hands-on microscope work and calibration (Traynor Room)

--- Posters available for viewing during breaks from other tasks all day---

Lunch 12:00 – 1:15

XII. Recommendations [2:00 – 2:30]

6. 2019 CARE to CARE
7. 2019 CARE to TSC

CARE Administrative Business [2:30 –3:30]

1. Officer nominations
3. Schedule and location of 2019 meeting

Workshops, working groups, hands-on microscope work [3:30 – 5:30]

1. Working Groups (Traynor Room and Room 2079 available all day)

2. Hands-on microscope work and calibration (Traynor Room)
--- Posters available for viewing during breaks from other tasks all day---

CARE Business Meeting Adjourns [4:30]

<u>Thursday, April 11, 2019</u>

Working groups & Hands-on Workshop Continuation [8:30 – 12:00]

1. Workshop- Rapid Estimation of Fish Age Using Fourier Transform-near Infrared Spectroscopy (see attached schedule)
2. Working Groups – additional time available to meet and schedule tasks for 2019
3. Hands-on Workshop – dual microscopes available for calibration work until noon
4. Workshops – additional time if needed

CARE Social at the Elliot Bay Public House & Brewery -see sign-up sheet and directions (5:30-9:00)

APPENDIX-II

NOAA Fisheries, Alaska Fisheries Science Center, Western Regional Center, Building 4, Traynor Room 2076, 7600 Sand Point Way, NE, Seattle WA 981093, April 11th & 12th, 2019

<u>Thursday, April 11, 2019</u>

9:00 Welcome, introductions and workshop purpose (T. Helser – FT-NIR SIDT Chair)
9:30 *Introduction to NIR and FT-technology*. Jason Erickson, Applications Scientist, Bruker Optics.
10:00 *Data preprocessing for quantitative and qualitative models based on NIR spectroscopy*. Barry Wise, President, Eigenvector Research, Inc.
10:30 *Applications of near infrared spectroscopy to questions in animal physiology*. Carrie Vance, Professor, Mississippi State University.
11:00 coffee Break
11:20 *Near infrared reflectance spectroscopy detection of male northern dusky salamanders (Desmognathus fuscus) response to female pheromones*. Mariana Santos-Rivera, Mississippi State University.
11:40 *Predicting fish age at the speed of light*. Brett Wedding, Principle Scientist, Agri-Science Queensland Government, Australia.
12:00 Morning discussion and wrap up
12:30 Lunch and tour of the AFSC Spectroscopy Laboratory
14:00 *Age prediction of Gulf of Mexico red snapper using near infrared spectroscopy*. Beverly Barnett, Fishery Biologist, Southeast Fisheries Science Center, Panama City Laboratory.
14:20 *Using FT-NIR to predict daily ages in juvenile red snapper*. Michelle Passerotti, Ph.D. Candidate, University of South Carolina.
14:40 *Case study of FT-NIR spectroscopy for Bering Sea Pacific cod stocks*. Jordan Healy, M.S. Candidate, University of Washington.
15:00 *Application of near FT-NIR spectroscopy for Gulf of Alaska longnose skate vertebrae*. Morgan Arrington, M.S. Candidate, University of Washington.
15:20 *Anadromous chinook salmon otoliths ageing using near infrared spectroscopy*. Andrew Claiborne, Fishery Biologist, Washington Department of Fish and Game.
15:40 Coffee Break
16:00 *FT-NIR spectroscopy ageing of Bering Sea walleye pollock: Wavelengths to population parameters*. Irina Benson, Research Fishery Biologist, Alaska Fisheries Science Center, Age and Growth Laboratory.
16:20 Discussion and session wrap up.

Workshop Social: TBD

<u>Friday, April 12, 2019</u>

9:00 *Precision and accuracy metrics for ageing QA/QC: what is behind the numbers.* Richard McBride, Branch Chief, Population Biology, Northeast Fisheries Science Center, Woods Hole Laboratory.

9:30 *Ageing outputs in stock assessments in Queensland-focus on fisheries concerns moving the technology forward*. Julie Robins, Research Scientist, Department of Fisheries and Agriculture, Queensland, Australia.

10:00 *A new paradigm of FT-NIR age estimation and challenges in U.S. stock assessments.* TBD, Stock Assessment Scientist, Resource Ecology and Ecosystem Modeling, Alaska Fisheries Science Center.

10:30 *Operationalizing FT-NIR ageing enterprise in NOAA Fisheries: A conceptual pathway forward*. Thomas Helser, Supervisory Research Fishery Biologist, Alaska Fisheries Science Center, Age and Growth Laboratory.

11:00 *Report of the week's FT-NIRS multispecies analysis by the Strategic Initiative Development Team.* Discussion facilitated by T.E. Helser.

12:30 Lunch

14:00 Discussion of detailed strategic initiative work plan and report to NOAA Fisheries Science Board.

1) Group discussion – likelihood of success for implementing FT-NIRS ageing of fish from otoliths
2) Impediments to success - Prioritization and execution of central scientific questions to be answered
3) Unique requirements of NIR technology in fisheries science and its scalability
4) Implementation time lines for strategic initiative work plan

APPENDIX-III

CARE Meeting 2019

April 9-11, 2019

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 2019 CARE Meeting.

While no specific theme has been designated, topic sessions can focus on current research and the 2018 TSC recommendations: yelloweye rockfish, differentiating cryptic species, and evaluating machine reading of otoliths.

Please submit abstracts by Friday, March 8, 2019 to Kevin McNeel, CARE Chair:

kevin.mcneel@alaska.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 9-11, 2019. Presentation titles and abstracts will be published online in CARE the minutes.

- Oral presentations-Tuesday (afternoon), April 9th
- Poster presentation- will be displayed throughout the meeting

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: Results of the yelloweye rockfish exchanges: comparison of age determinations from Alaska, British Columbia, and the coasts of Washington and Oregon

Authors and affiliation:
Andrew Claiborne[1]
[1]Washington Department of Fish and Wildlife, 1111 Washington St SE Olympia WA, 98501

Abstract:
Yelloweye rockfish are an ecologically and commercially important species from Alaska to central California and one of the longer-living rockfish with a reported maximum age of 147. Several agencies and members of the Committee of Age Reading Experts (CARE) produce age estimates for yelloweye rockfish across their range, yet few CARE sample exchanges have occurred in the last two decades. Here we compare age estimates independently made between 5 laboratories with samples originating from Alaska to California. Overall, age estimates agreed between readers for yellow eye up to age-30. However, bias between labs was clear for ages ranging from 40 to 120. CARE exchange results are discussed in the context of the 2017 stock assessment of yellow eye in the federal and state waters of Washington, Oregon, and California, and recommendations to further validate ages of yelloweye rockfish.

Type of Presentation: Oral

Title: The importance of juvenile sablefish growth and methods of estimation

Authors and affiliation:
Wess Strasburger[1], Chris Hinds[2]
[1] Auke Bay Laboratories, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, United States Department of Commerce, 17109 Point Lena Loop Road, Juneau, AK 99801
[2]Alaska Department of Fish & Game, Division of Commercial Fisheries, Mark, Tag and Age Laboratory, Juneau, AK 99811

Abstract:

Gulf of Alaska sablefish biomass has declined since 1988 with only a few strong year classes supporting the fishery. Studies suggest that juvenile sablefish growth may be a better indicator of recruitment than spawning stock biomass, but that has not been studied in Alaska. To compare juvenile growth with recruitment and environmental factors, we developed three objectives: (1) compare daily increment counts between the

lapillus and sagitta otoliths to ensure that results using either otolith are comparable; (2) compare objective fish and otolith measurements to highlight growth differences across conditions; and (3) model growth rates across environmental and ecological conditions using daily increment widths and relate that to recruitment events. To compare lapillus and sagitta otoliths, samples from the 2014, 2016, 2017 National Marine Fisheries Surface Trawl were mounted to petrographic slides and polished using sand paper and lapping film to image daily growth bands. Using image analysis software, we found no difference between lapillus and sagitta daily growth counts (-0.75 + 7.2 SD differences between structures) and estimated an average hatch date of April 12th. Our preliminary analysis supports that there is no difference between daily counts for each structure and we will focus on the lapillus for the remainder of the study. To preliminarily compare objective otolith measurements, we took images of unpolished otoliths from the trawl samples and measured lapillus and sagitta otolith length and height using image analysis. We found a positive relationship between lapillus and sagitta otolith diameters and fish length and will further investigate this relationship across controlled environmental factors (temperature and food ration) to look for objective differences in otolith growth using fish that were reared at Auke Bay Laboratories. To model growth rates, juvenile sablefish otoliths from 1997-2018 Middleton Island rhinoceros auklet bill loads will be processed to estimate juvenile growth spanning over 20 years and juveniles reared at Auke Bay Laboratories in a controlled temperature and feeding study will be used to interpret and validate results. Given preliminary results from objectives 1 and 2, we will focus on processing lapillus from bill load samples and will continue to collect daily increment counts, otolith length and height measurements, and otolith increment widths to improve evaluation of objectives 2 and 3.

APPENDIX-V

Rougheye/Blackspotted/Shortraker Rockfish Working Group Report 2019

Notes from 2017 CARE meeting: Several agencies are dealing with this 'mixed bag' problem. Three in particular (AFSC, ADF&G and CDFO) are aware of the potential, and others (NWFSC, WDFW) may have the problem but are currently unaware of any specific problems with species identification in their collections as they are just starting to calibrate on this species group. We have some tools to develop (Kevin's R-based approach of otolith shape discrimination and Harris/Hutchinson rougheye-blackspotted shape morphometric project) that may help with this problem. It was suggested that a working group could potentially address this question from a more formal perspective and perhaps gain funding/prioritization via TSC. We need to prioritize collection and analysis of more vouchered shortraker via DNA analysis. RE/BS/SR RF Working Group = Charles Hutchinson (lead), Betty Goetz, Irina Benson, Tom Helser. Other agencies: Kevin McNeel, Elisa Russ, Joanne Groot, Stephen Wischniowski

AGENCY PROJECT STATUS REPORTS 2019

AFSC – Two projects are currently addressing this situation with Alaskan samples.
Problem Blackspotted/rougheye/shortraker mixed observer sample (Betty Goetz) - An observer collection of rougheye rockfish was submitted for ageing (B30713A) (n = 307) and initial testing suggested a potential problem with mixing. Some otoliths appear to have characteristics which suggested that they might be shortraker rockfish. We also knew that rougheye samples were typically mixes of blackspotted and rougheye rockfish. Although we already have a research plan to separate blackspotted rockfish from rougheye rockfish, this identification protocol requires ages and we do not yet have reliable ageing criteria for shortraker rockfish. The model developed would not assist in the separation of a third species. To address this problem, we have done the following:

(1) ImagePro morphometrics and otolith weights have been taken from all otoliths in the problem cruise.
(2) ImagePro morphometrics and otolith weights have been taken from DNA vouchered blackspotted and rougheye rockfish used in the Blackspotted/rougheye rockfish separation model.
(3) A selection of smaller shortraker rockfish collected from surveys (not observer samples) have been accessed and are ready for morphometric measurement/otolith weight.

Blackspotted/Rougheye Rockfish otolith separation model (Charles Hutchinson) -

ADF&G – The Alaska Department of Fish & Game has a consistent collection of shortraker and mixed rougheye and blackspotted otoliths from Prince William Sound, Alaska. Historically, the Alaska Department of Fish & Game Age Determination Unit (ADU) submitted species corrections to regional samplers based on otolith morphology and growth patterns. The ADU was seeking to automate this procedure and look for significance of species corrections using a small sample size of genetically verified species. The genetic results found a significant proportion of the rougheye rockfish were blackspotted rockfish and an automated shape analysis using R could significantly identify specimens within the genetic collection. However, use of the model for otoliths outside of the genetically verified specimens did not work, because of the small sample size. The ADU is seeking to continue this work and to verify results using results from the AFSC models and future work by CDFO to improve the current shape identification or species correction procedures done at the ADU.

CDFO – Looking at cost cutting measures to reduce DNA charges to groundfish for the identification of the Blackspotted/Rougheye Rockfish complex. 704 Blackspotted/Rougheye otoliths were collected from all groundfish surveys in 2018, all structures were genetically identified by the Molecular Genetics Lab at PBS. All structures were aged, imaged and weighed. A small subsample (~70) was tested during the 2019 CARE

workshop in Seattle, WA. Both techniques were employed, Kevin's R-based approach of otolith shape discrimination and Harris/Hutchinson rougheye-blackspotted shape morphometric project.
Unfortunately, time constraints worked against us and we were unable to determine the errors that were generated in the Harris/Hutchinson approach using ImagePro software. However, the R-based approach provided results that indicate that otolith shape is a viable means of determining species within this complex for fish caught of West Coast Vancouver Island.
The SCL is looking at the incorporation of both otolith weight and shape imagery during the age estimation process for all its species. This as a means increase the QA/QC before submitting age estimates to its clients.