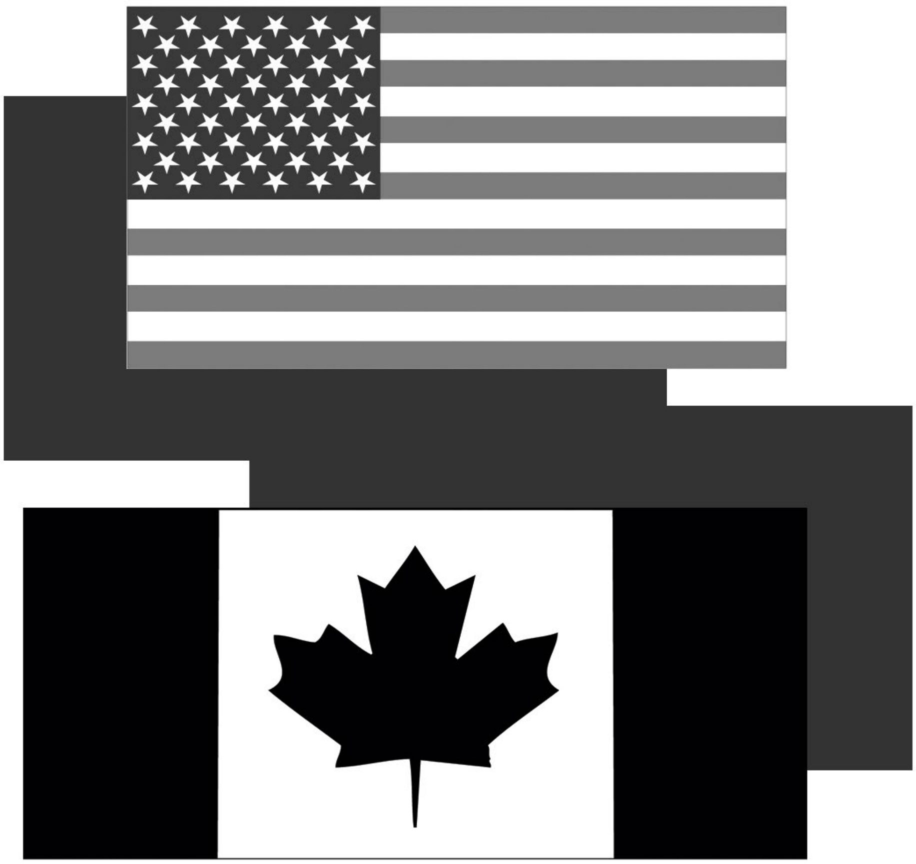
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

Annual Meeting of the TSC

April 20-21, 2021
Remote via Zoom



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
2020	No Meeting Held Due to Covid-19			
2021	April 20-21	Remote Meeting	via Zoom	Whitman

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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.

B. Executive Summary

The 2020 TSC meeting was cancelled due to the COVID pandemic. Rather than delay another year, the TSC met remotely on April 20 - 21, 2021. A list of attendees is included in the minutes. Alison Whitman, Oregon Department of Fish and Wildlife, chaired the meeting. As is done each year at the meeting, participants reviewed previous year (2020) research achievements and projected current year (2021) research for each agency. Each agency also submitted a written report summarizing groundfish accomplishments for the previous year. This year, the Chair also directed each agency to select three projects to highlight in more detail to the group. These highlighted projects generated considerable discussion among members and interest was expressed in continuing this practice in the future, and potentially, changing the agenda to reduce the focus on summarizing each agency's work and increase the opportunities for discussion and collaboration.

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 thanks Delsa Anderl (AFSC), the current CARE chair, for taking the time to attend the TSC meeting and present on CARE's progress over the past two years.

Alison Whitman, ODFW, will continue as Chair of the TSC for 2022. If an in-person meeting is possible next year, the next TSC meeting will be held in Victoria, British Columbia, on April 19 - 20th, 2022 and will be hosted by Fisheries and Oceans, Canada.

Meeting Notes
Sixty-First Annual Meeting of the Technical Subcommittee (TSC) of the Canada - U.S. Groundfish Committee
April 20-21, 2021
Remote (Zoom)
Chair: Alison Whitman (ODFW)

I. Call to order (8:30 am (PST) Tuesday April 20th)

II. Appointment of Rapporteurs

Olav Ormseth (AFSC), Dana Haggarty (DFO) and Traci Larinto (CDFW) volunteered to be rapporteurs. The Chair thanks these members for their assistance.

III. Housekeeping

The Chair noted that despite the virtual meeting setting, the typical morning and afternoon breaks would be observed, along with a one-hour break for lunch. The first day of the meeting would adjourn at roughly 4:30pm PST and the second day at roughly 1:00pm PST.

IV. Introductions/List of Attendees

Rhea Ehresmann, Sarah Webster (ADF&G)
Maria Cornthwaite, Dana Haggarty, Greg Workman (DFO)
Wayne Palsson, Olav Ormseth, Cara Rodgveller (AFSC)
Lara Erikson, Josep Planas (IPHC)
Alison Whitman (ODFW)
Melissa Monk, John Field (SWFSC)
Traci Larinto, John Budrick (CDFW)
Delsa Anderl (AFSC, representing CARE)
Stephen Phillips (PSMFC)

There were no representatives from WDFW, NWFSC, NPFMC or PFMC. Reports were submitted for WDFW, and for all other attendees' agencies. No reports were submitted by the NWFSC.

V. Approval of Agenda

The agenda was approved as submitted.

VI. Approval of 2020 Report

Final report was approved by all attendees and posted to the TSC website.

VII. Agency Overviews

Agency overviews were presented by each agency. Please see the individual agency reports for details.

VIII. Highlighted projects from each Agency

This year, the Chair asked each agency to present three projects of particular interest to the group that the agency wishes to highlight. Presentations were intended to be short with a single slide per project. Below is a summary of the information presented. Slides from each agency are available on the PSMFC website.

ADF&G presented their yelloweye and black rockfish coordinated assessments. Information is lacking and fishing is increasing. These efforts are a part of an ADF&G statewide rockfish initiative. ADF&G is also working on otolith and spine (fin-ray) ageing of lingcod. Their regions 1 and 2 are collaborating on this project. Both structures seem valid, but the amount of work for collection and analysis vary by structure and region. Delsa Anderl (CARE) mentioned the difficulty of reading spines and she intended to convene a mini-meeting of lingcod age readers from different agencies to talk about this. ADF&G also presented on their sample collections during COVID. There were challenges getting samples, but managed to collect ~15,000 samples (age/weight/length data and age structures for most species).

DFO presented on their Management Procedures framework to achieve stated fishing and conservation objectives even if explicit stock status cannot be reliably estimated (sort of an MSE approach). They also presented on efforts for passive acoustic monitoring of fishes during the “Anthropause” due to reduced vessel activity during COVID, reduced sound pressure levels of 86%. They’ve discovered rockfish and lingcod are “noisy”, and Pacific herring during spawning. DFO is adapting to COVID-19 in terms of fishery monitoring. At- sea observing was suspended in April, but used “emergency electronic monitoring measures”, including cameras electronic logs. No biological samples were collected and as of the TSC April 2021 meeting, observers are still not out there. There is dockside sampling for hake fishery only. Two groundfish surveys were conducted but only with contract personnel. Lara Erikson asked about challenges with returning to work and observer deployment, and if DFO had lost observers permanently, since they had no work for over a year. DFO confirmed this was occurring.

AFSC’s highlighted projects began with their Ecosystem and Socioeconomic profiles, which captures ecological and socioeconomic indicators related to specific fish stocks. They provided the example of sablefish. DFO noted that they use economic performance indicators and more discussions can take place when we reach sablefish in the agenda. In terms of the 2020 surveys, the bottom trawl surveys were canceled, the longline survey was conducted using contract personnel, and saildrones were used to get acoustic backscatter related to pollock in the EBS. The final highlighted project was a focus on sablefish, with huge year classes in recent years and the switch to whale-proof pots is complicating the assessment.

Desla Andrel presented on CARE's highlighted projects. For sablefish, ABL tagging has enabled getting otoliths from known-age fish. There was an exchange among ADFG, NWFSC, AFSC, DFO to compare ageing accuracy. Near-infrared spectroscopy is part of a 5-year project to determine if simple (and fast) scanning of otoliths provides reliable ages. So far, there are good results for pollock, cod, and East Coast red snapper. They are also working on scanning ovaries to get maturity state and whether it could be used for bioenergetics. Finally, CARE highlighted their efforts on otolith storage. Many agencies are moving towards dry storage to minimize degradation. Dry storage is usually in "tray biens". The company that makes them is going out of business but apparently, they have the molds and it might be possible to keep manufacturing them.

IPHC presented their fixed versus snap gear comparisons on the setline survey. The goal is to make the gear more comparable to commercial gear and broaden the number of vessels that can do the survey. They are also working on a reproductive assessment of female halibut to revise maturity ogives, which are outdated. Finally, there is an ongoing project on population genomics in halibut. They've completed full genome sequencing. The goal is to develop a genetic marker panel for population assignment. This is similar to work being done on Pacific cod.

ODFW presented on Oregon's Marine Reserves program's interactive data dashboard using Shiny app. This allows easy access to species-specific data from marine reserves. A project on yelloweye rockfish movement was presented as well. This project uses acoustic telemetry, which showed different behavior. Some fish didn't move but others left and came back. They are now using pop-up satellite tags to look at what happens to those "wanderers". Finally, ODFW has used an ROV for nearshore untrawlable habitat for ~20 years. The PFMC SSC did a review, which was generally positive but also identified some areas for improvement. ODFW is working on incorporating the data into federal stock assessment for the first time with quillback rockfish.

CDFW is working on estimating groundfish biomass using ROV data. ROV surveys were conducted inside and outside of MPAs and combined with habitat data in GAMs to generate density maps and abundance and biomass estimates. Also, CDFW has a focus on recreational groundfish sampling. There are opportunistic collections from fillet stations, which always include age structures, but sex and maturity information are only seldomly collected. Finally, CDFW detailed their groundfish sampling in 2020. There were large impacts to the California recreational fisheries survey. Sampling was shut down March-July, and sampling after July was modified. There were fishery openings varied throughout the state by county. Commercial sampling (done by PSMFC) was paused March-May.

IX. CARE Report

The CARE report was presented by Delsa Anderl (AFSC). The TSC thanks Dr. Anderl for her time and efforts on behalf of CARE and TSC. At ADF&G (ADU), Pacific cod, black and dark rockfish were the focus of aging efforts. There were limits to lab use due to COVID. Quality control, usually involving 2 age readers, was part of this effort. This has been difficult during COVID when people are working at home or different spots. The solution has been to share photos from a digital camera on the scopes. Some people feel that efficiency is better working at home.

At DFO, offices and labs were also shut down in March 2020. There were not enough laptops. Also, age readers reported that break and burn methodology was difficult at home due to alcohol flame. For these reasons, readers pushed to get back in the lab by July 2020 on a limited basis. There are lots of retirements coming up, so DFO is emphasizing training of new staff. They are ageing lots of rockfish and salmon. Due to COVID limitations, production of ages is down from previous years. DFO is implementing data collection on tablets rather than paper, which should improve efficiency. They are also looking at using otolith shape for species ID. They have noticed (AFSC sees this too) that otolith patterns in recent years are harder to discern. AFSC readers have noticed this as well, and questions if this is related to climate change. Similarly, changes in edge growth have been noted recently, which is an important diagnostic.

IPHC readers are still working at home. They are using some otoliths for genetic analyses.

WDFW readers are also working at home. They are using photos and exchanging physical otoliths among readers. Rockfish, lingcod, and sardines are the main species that they are working on.

AFSC staff have been on mandatory telework since March 2020. People have microscopes, saws, toaster ovens, and other equipment at home to create “home labs". Also, readers have used scope adapters with phones to take pictures. There is limited access to lab facilities. There were no surveys in 2020, so staff used the time to train readers in new species so that readers have a broader repertoire. The FTNIR project is a big focus, including using artificial intelligence to improve age prediction. Also staff are looking at whether FTNOR can discriminate among species.

ODFW has a single age reader. Rockfish are the focus of the majority of their time, but they are working on a project on age validation using oxygen isotopes.

NWFSC is also under mandatory telework. They are using scope adapters as well to share samples among readers.

For a long time, there were no California representatives on CARE, but now that has changed. SWFSC staff participated in a vermilion rockfish exchange with ODFW and NWFSC.

In general, CARE reported that there were lots of exchanges among agencies in the last year and age readers across the agencies were very resourceful to get work done in a challenging year.

Cara (AFSC) asked if images are being stored. Delsa (AFSC) noted that that is a good question and will try to get a coordinated answer. Delsa also wants to standardize photo taking among groups. Greg noted that the DFO database can store multiple images for each specimen. Delsa commended GO but noted that lots of labs are small and unfortunately, don't have that kind of tech support.

Alison (ODFW) noted that some labs were more successful than others at managing the COVID situation and asked if there were specific keys to their success. Delsa said that part of it is realizing how much can be done at home. She noted that ageing can be more efficient at home, unless your home situation (e.g. kids) is too distracting. Also, there can be safety issues with things like hoods and burners.

X. Surveys

ADF&G completed their longline surveys, and an ROV survey for yelloweye rockfish.

At DFO, COVID impacted surveys. Many surveys were missed, such as the collaboration on IPHC survey, and the hake survey). They did complete the West Coast Haida Gwaii (WCHG) Synoptic trawl and the Outside South Hard Bottom Longline (HBLL) survey. The sablefish survey was completed in collaboration with industry and observers, not DFO staff. Some survey trends are provided. WCHG POP is increasing, and Redstripe is bouncing around. SST is increasing. Lingcod is up in the Outside South HBLL. Yelloweye rockfish trends were not very informative – the HBLL trend is level, perhaps increasing in the south. Quillback rockfish is increasing in the Outside HBLL. Canary rockfish are increasing in HBLL. Dogfish declining in all outside surveys. Wayne (AFSC) noted that POP is also increasing in Alaska.

AFSC noted that they covered larger surveys in the highlighted projects earlier. 2020 was the 2nd year of synoptic beach seining collections in NE Alaska and S. Kodiak by fisheries behavior and ecology group. This survey targets juvenile fishes and was completed in both 2019 and 2020. There was a huge change in abundance for Pacific cod in 2020. Cara (AFSC) summarized the Auke Bay Lab surveys, including the sablefish longline survey. This survey is a long time series (a 44 year annual survey) at fixed stations covering 200 - 1000m. This survey encounters many species, and in 2020, the survey occurred without permanent staff due to COVID, but many projects were cut. Data are stored in the AKFIN database. Rhea (ADF&G) asked if there were any CPUE increases, as sablefish trend was increasing in the ADFG surveys. Cara planned to send the sablefish AFSC stock assessment to Rhea.

IPHC described their survey efforts. The FISS stations had a reduced design in 2020 (in the figure, the orange dots were the ones fished) on a 10 nautical mile grid. There were 898 stations. There was 100% coverage in 2C and 3A. Area 2B stations were not fished inside or WCVI. Trends by region were summarized. In Region 2 (BC to CA), halibut was in decline – an 8% decrease (over 2019). Area 3 (GOA) showed a slight increase (1%) and Area 4 (Bering Sea) showed a 2% increase, in particular, Area 4B (Western Aleutians) had an increase (2%). Overall, the coastwide estimate showed a 1% decrease. The WPUE data trends were similar, a 6% decrease (over 2019). There was a slight increase (7%) in Area 3, Area 4 had a 1% increase, Area 4B a 2% increase, and coastwide there was a 2% decrease. There appears to be more stock productivity from growth than recruitment.

At ODFW, fishery-dependent sampling continued in 2020. Their recreational boat survey monitors landings year-round at major and minor ports in summer but only major ports in the winter. Data are collected on catch and effort. Sampling in 2020 continued but without sampling for weights and lengths due to COVID safety protocols. The research program sampled some recreational catch. At-sea observers on charter vessels to observe discarded fish didn’t occur due to COVID in 2020 and this hasn’t resumed yet. All data goes into RecFIN. Commercial sampling was not very impacted. There was a decreased rate of sampling, due to avoiding fish plants with documented outbreaks. Commercial landings continue to be monitored at major ports.

CDFG summarized their ROV surveys and progress linking them to federal stock assessments as discussed this morning on highlight slides. CERF sampling for recreational catch into RecFIN. There was no biological data or species compositions for rockfish due to COVID sampling protocols. Survey for commercial catch was completed.

SWFSC was unable to report on their activities but they are summarized in their report.

XI. Reserves

ADFG, AFSC, IPHC and SWFSC had nothing to report.

DFO reported that the NSB MPA network was in consultation, and nothing firm was established yet. Planning is beginning for the Southern Shelf and Salish Sea. There were changes to RCAs and Sponge Reefs closures in Howe Sound to simplify conservation zones.

ODFW described their five state marine reserves, which include true marine reserves and some MPAs that allow some activities. Each of these reserves require a site-specific management plan that includes community outreach and research on impacts on recreational fishers. A study on coastal values and priorities was completed in 2020. Also, visitor surveys on Cape Perpetua reserve were completed. The Marine Reserves program is very active in infographics and has a great website. Their ecological research team is focused on building and maintaining relationships. Ecological monitoring continued in the intertidal and nearshore, but there was not much activity at sea due to COVID. These include oceanographic and intertidal monitoring.

CDFG continued with their MPA monitoring, at almost 10 years following implementation of the MPA network. This monitoring program prioritizes key metrics targeted with long-term monitoring and will be continuing through 2021. There is a 2022 comprehensive review where the MPA network performance will be analyzed. Baseline and long-term monitoring data will be used. A panel focused on MPA resilience to climate change was convened. This is a decadal-level evaluation working group and CDFG staff are working with monitoring partners on integration and synthesis for 2022. There is a nice website.

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

Only agencies with information in their report are summarized in this section. Please see each individual agency's report for more details.

A. Hagfish

CDFG made changes to traps to make regulations more enforceable. There has been some sampling. Some fishermen are landing hagfish cut instead of whole, and so CDFG is looking at conversion factors.

ODFW noted that their hagfish commercial fishery had a 99.2% attainment rate of the commercial quota in 2020.

ADFG reported that in SE Alaska, there is one active fisherman landing year-round. The fishery is open until achieving the quota (56mt), and recent limits have been increased.

B. Dogfish and other sharks

At ADFG, there are no research objectives related to dogfish or other sharks. In interviews of anglers, there were records of seven salmon sharks, one sleeper shark, and a number of dogfish, but most were not retained. On the commercial side, total harvest is minimal and ADFG does not have estimates for recreational shark harvest.

DFO last assessed dogfish in 2010. There is a project underway on possible displacement of dogfish by climate change. There is no active fishery for dogfish and <1% of the TAC is taken annually. There are no other commercial fisheries for sharks.

AFSC research on sharks includes studies by Cindy Tribuzio primarily. There was a paper on the genetics of Sleeper sharks vs. Greenland sharks (they are different species). Then a study on stock structure shows the two stocks intermixed in the North Pacific, perhaps due to homing for spawning or historic separation. There is a long-term aging project on spiny dogfish spines and another trying to age Sleeper sharks from eye lenses using C14, like was done for Greenland sharks. Two were aged to the 1950's but the largest shark wasn't that old, and so they likely have faster growth rate than Greenland sharks. A tagging project for spiny dogfish is ongoing, with 157 recovered pop-off tags and 8 tags were recovered. There appear to be two types of movements - one type hugs the nearshore while the other ventures further offshore. These data will be used for habitat mapping and essential fish habitat. They're also testing this on salmon sharks as well (which move a great deal).

On the stock assessment side, AFSC produces multiple shark assessments, also by Cindy Tribuzio. Spiny Dogfish biomass in 2019 in GOA was the lowest since 1990, and especially in the last four surveys, suggesting that recent conditions are not good. “Reliable biomass” is used to determine the annual allowable catch. In the Bering Sea, sleeper sharks are the predominant shark, and its trend is declining. Rhea (ADFG) asked about shark longline bycatch. Olav (AFSC) noted that survey data from IPHC FISS is increasingly used.

IPHC noted that they do some collections with NOAA fisheries. Olav (AFSC) noted that their data for other species is useful in stock assessment, mostly for sharks and skates.

C. Skates

ADFG noted their Eastern Prince William Sound population abundance index which comes from their state bottom trawl survey time-series. The 2020 survey was conducted in a different area. There was no assessment completed. There is very little effort in the commercial fishery and there is a 5% bycatch allowance. Only 11.5 mt were landed in 2020.

DFO noted that skates are commercially harvested but at low levels. 2015 was the last assessment for skates. Quota utilization is around 10%. There was no research completed on skates.

At AFSC, there wasn’t much research in 2020, though in last year’s report, there was some genetic work on skates. There are many species (13+) per area. Genetic work focused on stock structure in the Bering Sea. In stock assessment, skates are non-target species, but are lightly exploited with around 10% utilization of the annual quota. These species are primarily Bering, Aleutian, and Alaska skates but species composition changes with area. Biomass and fishery catch is primarily from the shelf in Alaska. There is an age-structured model used for Alaska skates. Other skates are declining some but close to the long-term mean. The trawl survey on Bering sea slope is likely to be cancelled for the near future, which will be a concern for many skate species, as well as some flatfish species like Greenland Turbot. Bering, Aleutian, GOA, and supplemental survey data are used in the assessment, and the IPHC FISS data are included with NMFS surveys to help monitor stock status.

D. Pacific Cod

ADFG’s commercial fisheries operated in SE Alaska and was sampled dockside in 2020. Datasets from this fishery include catch logbooks and fish tickets. The Prince William Sound bottom trawl survey index for Pacific cod was low, and there is no estimate for 2020 yet. There is some recreational catch. There is no state assessment. Some districts had open fisheries, but there was reduced effort and harvest. In the Bering Sea, there is a management plan in place for Pacific cod. This management plan was adopted for state waters, which allocates 35% of the Bering Sea ABC to state waters. There are new regulations in 2020, but management plans adopted in pot longline openings. Jig gear is also used. Trawl gear types were shut down. In the SE, the directed fishery opened on inside waters. There are catch data that are available in the report.

At DFO, data sources for Pacific cod include trawl and at-sea observers, but there was no commercial sampling in 2020. Pacific cod was last assessed in 2018. There are four stocks defined by management (SOG, WCVI, QCS-HS, and WCHG). There was no fishery and therefore, no assessment in SOG. In 2018, there was a drop in the survey index in WCVI, accompanied by three years of depressed commercial catch, and so there was concern that it would go below the LRP. The WCVI 2020 survey was postponed but is considered critical to evaluating stock status. The upcoming assessment will be completed with 2021 data when available. Catch has been reduced and there are winter spawning closures.

At AFSC, there is a great deal of research being conducted on Pacific cod. Pacific cod decreased in the Gulf of Alaska, as seen in the 2017 bottom trawl survey conducted after the warm water blob. Subsequent surveys saw a continued decline. The federal fishery closed and became a bycatch only fishery. In the Bering Sea, there was a bottom trawl survey in the Northern Bering Sea. There was a working group established. There are multiple projects described in the report. One project uses satellite pop-up tags to look at movement of Pacific cod. In 2010, cod distributions were centered on the outer coast and since then, in warmer years, their center of density moves north. There were abundance declines in the east and south, and a shift in the distribution to the north. At the Auke Bay lab (Cooper), a project is focused on the detection of juvenile cod in the Bering Sea in 2012, 2017, and 2019. When waters are warm, juvenile detections are seen more in the Bering Sea. Olav (AFSC) noted that there was major interest in changes in distribution, but there are harvest limitations due to limits of the spatial distribution of the ports in the Bering. For example, people are fishing out of Dutch Harbor, but it becomes difficult to catch the fish as they go farther north. With regard to genetic studies with the Northern Bering Sea, researchers don't believe it's a different or growing population in the north, but displacement. This hypothesis is supported by continuing genetic work. With regards to the question of whether movement is seasonal in the summer, and then returning to south in spawning season, there is evidence of age 0 and age 1 in the northern Bering Sea, indicating there may be some spawning in the north (unless larvae are advected northward, which is unlikely). Josep (IPHC) asked about shifting phenology of spawning. Wayne (AFSC) responded that they are conducting research on maturation schedules, but don't know this yet. Olav (AFSC) noted that Ben Laurel (AFSC) is modeling spawning habitat and related spawn timing. Cara (AFSC) noted that there is trouble identifying YOY fish, and so genetic identification is important, since there are saffron cod, Arctic cod, Pacific cod and walleye pollock that all look similar as YOY.

In terms of the assessment work at AFSC, staff noted that Grant Thompson (AFSC) is retiring soon. He's been the main assessment author in the EBS and AI (which used to be assessed together but is now two stocks). There are multiple gear-types used and they are complex assessments in the EBS. Ensemble modeling was used recently with various weighting schemes. However, the SSC went with a single model instead of an ensemble approach. Fishery-independent indices and catch are down due to the declining abundance. An Aleutian Islands assessment that includes only biomass and an estimate of natural mortality (Tier 5) is used, although an age-structured model is in development. In the Gulf of Alaska, there is an age-structured model. Steve Barbeaux

(AFSC) is developing a climate-linked model. The marine heat wave of 2014-2016 led to a massive increase in natural mortality and reduced numbers of fish. The 2019 assessment recommended no fishing in federal waters, but saw some slight improvement in terms of population dynamics. Associated with the Steller sea lion decline in Alaska, with any fish population considered a prey species for them, there's an additional level of precaution to keep them above 20% of unfished biomass, and this policy closed federal fishing in order to keep the stock above this threshold. However, there are some larger year classes that might be coming in.

In 2020, IPHC didn't collect lengths for Pacific cod on its FISS, due to the COVID reduced footprint of the survey and sampling, but they are working on an agreement to resume collections.

E. Walleye Pollock

At ADFG, there's limited activity for pollock. There are skipper interviews in the Prince William Sound bottom trawl fishery. The Tanner crab survey showed that pollock were below their long-term average in 2019. There were no management changes in 2020.

Sampling was reduced at DFO in 2020. There were no commercial samples. Pollock in BC was last assessed in 2017. There are two stocks in the assessment, one each in the north (WCHG-HS) and south (QCS-WCVI-some SOG).

At AFSC, there were multiple research projects that are detailed in the report. Cara (AFSC) noted that modeling by EMOP (?) showed a difference in temperature used to predict recruitment up to age 5 and 6 for pollock. With the warmer temperatures in 2019, there was a predicted impact on recruitment. Also, there was a report using copepod abundance to predict pollock recruitment. As an example, large copepods that are typically abundant were low in 2017, and so they predicted low recruitment of pollock. Wayne (AFSC) summarized projects in the GOA and Bering Sea. At the AFSC Newport lab, there are brood stocks of Pacific cod and pollock, and have facilities to manipulate CO_2 and other variables to evaluate the impacts of acidification on these species. Pollock seem to be heartier in high CO_2 levels than Pacific cod, but there is some inflation of swim bladders, which may increase mortality. In the Bering Sea and GOA, early life-stage surveys indicate a strong 2018 year-class. There was a small-mesh trawl survey of age 1 pollock but they disappeared from other surveys. There was also a prey availability and selection study. In the Bering Sea, there were differences in age 0 and depth distributions. There is additional work on management strategies for pollock as well.

In terms of AFSC assessment activity, staff noted that the EBS fishery is "gigantic". There is a cap on fish removals in the Bering Sea that is based on optimum yield in ecosystem models. Pollock catch could exceed this, so there is usually a reduced quota to allow for other fisheries to proceed. So, typically, the pollock harvest is below the annual ABC recommendation. Modeling approaches have been stable over time. There are some multi-species modeling efforts, but these aren't used for harvest recommendations and function as supplemental information. The Aleutian Islands stock is small. In the GOA, there are research efforts on spawning grounds and juvenile distribution. Primary data sources include the summer bottom trawl surveys. In the mid-

2010s, a large year class was moving though the population, and now the biomass is decreasing as there are no new large recruitment events. There were some improvements seen in the acoustic and bottom trawl surveys and are now more in agreement. There is a risk table in every assessment that includes ecosystem status and specific facets of model issues, such as retrospective patterns, that might indicate a problem with the stock. The NPFMC SSC has the ability to reduce the ABC depending on the information presented in the risk table. This table is intended to communicate items of concern and to increase transparency. A spatiotemporal model (VAST) of the surveys is being used, as opposed to design-based estimates.

F. Pacific Whiting (Hake)

Pacific whiting landings in Alaska are limited and monitored in an “other bycatch” aggregate category at ADFG.

In BC, there is commercial harvest and DFO actively manages two stocks: offshore and South of Georgia. Last year was a “research year”, so there was not a survey. They used sail drones to conduct target strength studies. There was the annual Canada-US assessment in February. The TAC was set, but there was no agreement by joint-management, so each country was left to set their own TAC. The Canada total is around 575 tonnes, which is less than the ABC in the assessment. The current trend is a decline following the large year class in 2010. There was a successful fishery in Canada that attained 80% of the TAC, but reports indicate that fishing was spotty.

At ODFW, staff noted that they defer to federal management for hake but actively participate in policy determination. In April 2020, management implemented a rule to allow at-sea processing of Pacific whiting. This was an attempt to mitigate the risk of COVID. This resulted in processing on catcher vessels and increasing mother ship operations.

G. Grenadiers

In Alaska (ADFG), management requires a permit for grenadiers. There is no directed fishery but aggregate for bycatch monitoring.

At DFO, staff noted that there is no directed fishery and no research on grenadiers. There is incidental catch with sablefish and some of the deep rockfishes. There were no landings in 2020.

AFSC conducts a grenadier assessment, which is considered an ecosystem component in the North Pacific and not an actively managed species. Grenadiers are caught in great numbers in sablefish and deep longline surveys and are mostly giant grenadiers. Grenadiers can be aged and have some maturity data available. There is no official assessment but the last unofficial assessment was completed in 2020, which found the catch to be below allowable ABC.

CDFG noted that Pacific grenadiers are in the groundfish FMP managed by the PFMC, but they are not often encountered.

H. Rockfish – nearshore, shelf, and slope

There were multiple rockfish research projects at ADFG in 2020. Southeast Region samplers collect biological samples from the directed fishery as well as bycatch in other fisheries, including Pacific Halibut. Central Region samplers collect data from the directed fisheries as well as a bottom trawl survey for Tanner crab. The population abundance index for rougheye rockfish, as sampled in the Prince William Sound bottom trawl survey, was estimated to be its lowest in 2019 since the survey began in 1991. Westward Region port sampling focused on black and dark rockfish. The hydroacoustic surveys of black and dark rockfish continued in 2020 and are used to generate biomass estimates. Sport Fish Research collects catch and harvest data for rockfish relevant to the recreational fisheries. In the Southcentral Region, there was a study in Prince William Sound on the ability of six species to descend without help. The Age Determination Unit is also reconstructing reproductive histories of Yelloweye Rockfish using opercular hormone profiles.

In terms of assessment at ADFG, the Southeast Region conducts assessments for the DSR complex using an ROV survey, which estimates Yelloweye rockfish densities, that are expanded to the DSR assemblages using proportion of DSR species in the commercial catch. There is no stock assessment for DSR for inside waters due to a lack of surveys since 2002. The Westward Region conducts assessment surveys using hydroacoustic were used to assess black and dark rockfish.

The Southeast Region DSR was closed in 2020, including commercial and personal use. The Central Region had no management changes. The West Kodiak black rockfish GHL was met in four of five areas. Sportfish Management is split between pelagic and non-pelagic rockfishes. Beginning in 2020, sport fishing in deep water requires a release mechanism onboard with release at 100 ft or depth of capture. Also there is SRI, which is an interdivisional project to develop harvest strategies for black and Yelloweye rockfish. As noted earlier, the Southeast Region DSR fishery was closed in 2020. Bycatch of DSR species totaled 98 mt outside, and 19.6 mt in internal waters. There is minimal effort in the directed black rockfish fishery. In the Central Region, total rockfish harvest was 17.9 mt in 2020, mostly from the jig fisheries, whereas in Prince William Sound rockfish are taken as bycatch mostly in longline fisheries. In terms of sport harvest, descending devices are required statewide, but ADFG is not sure how it’s enforced. Theoretically, any boarding will result in checking for it. Regulations state that fishers have to keep the first Yelloweye rockfish and then descend the rest.

DFO reported on multiple research projects. One project uses passive acoustic monitoring (SPEERA) using paired visual (divers and drop cameras) and audio surveys (soundtraps) with species of interest including Pacific herring, and copper, yelloweye and quillback rockfishes. Results have shown that rockfish are pretty vocal. They have developed automatic fish detectors so that they don’t have to listen to the entire recording. The reduction in noise levels due to COVID was quite high and allowed them to look at possible impacts of noise on fish acoustic behavior. The Rockfish Conservation Area (RCA) monitoring and compliance project is looking to monitor and improve compliance with rockfish conservation areas and marine protected areas. Angler’s Atlas has upgraded their app, My Catch, to include the location of all RCAs and will provide a warning if the user strays into a RCA. The app does not require cell service to work, and allows the user to upload information about their use of a descending device. Work is beginning to assess the recreational compliance in RCAs. Barotrauma experiments have continued looking at the impact of barotrauma and descenders on rockfish mortality and abundance estimates. A graduate student is currently studying the survival of rockfish when a descending device was used by having a camera follow the fish to depth and record the release of rockfish. However, between bad weather and COVID, not a lot of tagging was done in 2020 (n=42 fish), but they hope to start up again in 2021. The plan is to add camera arrays near release locations to see what they do after release. Finally, DFO is looking at detectability and comparability of ROV to the longline survey. They have a new vessel to do ROV surveys, but the vessel needs upgrades. The plan is to compare CPUE from longline survey to ROV survey.

On the DFO assessment side, there is a quillback rockfish assessment coming up in 2021. The last assessment was in 2010 and showed both inside and outside were in the cautious zones, but with high uncertainty. These results point to the need to use Management Procedure Framework. Workshops were held with the public to determine the objectives, which were worthwhile. DFO put yelloweye rockfish through the Management Procedure Framework to evaluate the objective of the rebuilding plan. A reanalysis of Inside Yelloweye Rockfish last year resulted in upgrading from special concern to threatened. It was shown that there was a greater than 75% decline over the time period. A recovery potential analysis is planned to help the government to decide what to do. They didn't have the data to say if anything is different between inside and outside. DFO is hoping to be able to use ROV surveys to provide this information for quillback. However, ROV projects are sporadic and require a long term monitoring program. Longliners have always been excluded from the RCAs. For offshore rockfish, DFO works with an industry-sponsored scientist for assessments, including rougheye and blackspot rockfish in 2020 and Bocaccio, Canary, and Yellowmouth Rockfishes in 2021. The 2019 Bocaccio assessment showed a big increase in biomass, but since the fish have not recruited into the fishery yet, it is still in critical zone. They hope to reassess some with new data. Rougheye and Blackspotted Rockfish are assessed as a complex. Commercial samples are collected as a complex while the research survey identifies them to species, but rely on genetics to confirm ID. It appears there are two populations-north and south, with the north primarily being Blackspot Rockfish and the south, Rougheye Rockfish. The Heceta Strait area has mixing and was excluded for assessment. The north was found to be in the healthy zone, while the south slightly less positive, 75% in the healthy zone. Ongoing work is being done at age labs looking at otolith morphology. Other species have not been assessed in some time. Yellowmouth Rockfish was last assessed in 2011 and listed as threatened, with a revised assessment coming in 2021. Finally, DFO has mapped the genome of copper and quillback, and results will soon be published. This was part of Canada's 150th anniversary, with 150 species to be mapped.

At AFSC, research is ongoing to update age at maturity for blackspotted, rougheye, and shortraker rockfish. Due to evidence of skipped spawning, additional data are needed to determine if the skip spawning rates vary with time. Some research revealed that Rougheye/Blackspotted in the Bering Sea can show almost complete reproductive failure in a given year. Rougheye Rockfish show a 13-36% failure rate with smaller failure rates for other species. There's also ongoing research evaluating shortspine thornyhead stock structure using genetics, which may affect management areas. Research is going on in trawlable habitats.

There is a lot of research and stock assessments conducted by the Auke Bay Lab. In Pacific Ocean Perch, assessments show a population increase from 1990 to 2020 in the Aleutian Islands, with the biomass now leveling out. There was no biennial bottom trawl survey last year, and so even one missed survey becomes a three or four year gap. In the Gulf of Alaska, Pacific Ocean Perch is fished mostly with other rockfish in the eastern Gulf of Alaska, but in the western Gulf of Alaska, trawling is prohibited. Pacific Ocean Perch are a Tier 3 species for assessment, since there are ages available and the stock is more data rich. POP are not subject to overfishing currently. The Dusky Rockfish assessment in the Gulf of Alaska was conducted in 2020 and included new catch data and trawl survey data from 2019. This assessment uses a spatial model, which many assessments are moving towards. Dusky Rockfish is not subject to overfishing. Northern Rockfish in the Bering Sea and Aleutian Islands is part of a biennial assessment cycle, and should have been done last year but AFSC was going through a prioritization process. There is not a great deal of biomass, but it is stable and exploitation is minimal. Northern Rockfish in the Gulf of Alaska uses a VAST model to estimate survey biomass. It's considered a tier 3, data rich species. There are separate allocations within the Western and Central Gulf of Alaska, but in the Eastern Gulf of Alaska, northern rockfish is managed within the Other Rockfish group.

The Shortraker Rockfish in the Bering Sea from the lack of survey. It's considered a tier 5 stock, and the survey's biomass estimate is multiplied by natural mortality to get an OFL. Harvest specifications for Shortraker Rockfish are unchanged because the survey wasn't completed. For shortraker in the Gulf of Alaska, the trawl survey biomass estimates from last year will be rolled over. This is also a Tier 5 stock with no ages or maturity, so the assessment is based on biomass. Staff have tried to age Shortraker Rockfish but have been unsuccessful. The Other Rockfish complex assessment in the Bering Sea and Aleutian Islands is now conducted by Auke Bay Lab. Other Rockfish are generally tier 5, with Dusky Rockfish the main species in the complex. A random effects model, which the NPFMC SSC approved, is used for all tier 5 species. For Other rockfish in the Gulf of Alaska, there are 27 species, with 17 species present across all regions. No stock assessments were conducted in 2020, but there will be one this coming year. Some of the stocks are assessed as tier 4, 5 or 6, depending on the amount of data.

Rougheye and Blackspotted Rockfish in the Bering Sea and Aleutian Islands are modeled as a complex because there aren't enough data on species to separate them. The spatial distribution in the Aleutian Islands is different from the eastern Bering Sea. They are looking at utilizing small TACs in different areas in an attempt to reduce fishing mortality. The species are not targeted but bycatch limits can exceed the TACs easily due to small spatially explicit limits. Biomass is down somewhat due to loss of older fish in the survey. For rougheye and blackspotted rockfish in the Gulf of Alaska, both species are modeled as a complex as well, although there are documented differences in their life histories, maturity and growth. This complex is a Tier 3 stock because there are ages available and might be able to speciate based on otolith shape. A random effects model is used but incorporates the trawl survey and another survey with two different gear types.

For the IPHC, there are some rockfish coastwide catch rates from the FISS available on web, and they still have standing MOU with WDFW rockfish stations for the next five years so they will continue to collect rockfish for them.

At ODFW, there is ongoing research on deacon rockfish, including an age, growth and maturity study in relation to depth with both nearshore and offshore study areas. There are significant differences in age and growth between nearshore and offshore sites with larger fish at the offshore sites. However, there were not enough samples for a maturity study. This information was plugged into the latest stock assessment working with the primary assessment author Aaron Burger (NWFSC), and the difference in growth rates does change projection but still within the levels of uncertainty estimated by the original assessment. Also, there is a deacon rockfish tagging study. Fish were tagged with an acoustic tag on a nearshore reef. This study found about half of the fish exhibited high site fidelity with a small home range, while some left the array and may have gone to another reef. Fish who stayed had a high level of daytime activity. Additionally, there was a hypoxic event during the study and the fishes exhibited reduced activity levels and started moving greater distances. A paired drop camera hydroacoustic survey for midwater rockfish is going to start in the fall of 2021. Yelloweye Rockfish inter-reef movement study using popup tags was already mentioned in the highlighted projects for ODFW at the beginning of the meeting. Finally, telemetry data for five rockfish species to try to understand the habitat utilized by the species and how far off the bottom during the day will feed into hydroacoustic survey. There are differences among rockfishes in terms of viability for the survey. For example, Black/Deacon Rockfish are a good candidate for survey, but Copper Rockfish aren’t as good as they are closely associated with the bottom. Yelloweye Rockfish are a little more difficult as well, because they have variable behavior.

In terms of assessments, ODFW participates on STATs for several rockfish assessments for 2021, including copper, quillback and vermilion rockfishes.

In terms of management, ODFW manages a nearshore live gear fixed gear fishery. Attainment was down last year due to market disruptions. On the federal side, offshore commercial limited-entry fixed gear and open access trip limits have been increasing dramatically as species recover. For the recreational fishery, black rockfish is the dominant species, but the harvest limit is decreasing as the assessment ages. There should be a new assessment for black rockfish in 2023. In spite of COVID shutting everything down, recreational fishing effort was high for the year - it was the third highest on record. Outreach continues with the No Floaters campaign to release rockfish at depth. Starting in 2017 descending devices have been required on CPFVs. ODFW has been able to give away descending devices for free with the help of some small grants.

At the SWFSC, they're completing an assessment for Vermilion/Sunset Rockfish Assessment in California waters. They are an important part of catches in California but have yet to be successfully assessed. There are lots of age and survey data. There is a relative abundance index from the hook-and-line survey, but they aren't a good species to develop an index from the West Coast bottom trawl survey. They are still trying to understand differences in age and growth between two species. There are multiple rockfish projects. One is using autodiametric imaging to estimate fecundity using a software program to look at the diameter of eggs and then estimate the number of eggs. This was done for Yellowtail, Chilipepper and Rosy Rockfishes. This should allow them to increase fecundity work as the autodiametric method is about 5 times faster than the gravimetric method. Finally, there was a small boat juvenile rockfish survey completed last year. The NOAA ship was cancelled due to COVID. There were only 15 stations rather than 60 on average over time series. The vessel crew collected fish and brought them back to shore for NMFS to process in the office. There were lots of adult anchovies and pyrosomes and few young-of-the-year rockfish. YOY rockfish had the second lowest abundance on record. This juvenile rockfish survey is combined with NWFSC's pelagic juvenile survey to look at coastwide abundance to inform stock assessments. Pelagic YOY rockfish are most abundant in central and southern California, mostly Shortbelly Rockfish. There are differences in species composition between Cape Mendocino and Point Conception.

CDFG conducted some groundfish research including collecting fish from the commercial fishery to increase the biological data collected as well as from the party boat fleet. They also provide support for Council processes.

I. Thornyheads

ADFG noted that there was no research or assessment conducted on thornyheads in 2020, and there is no directed fishery for thornyheads, although they can be taken as bycatch in other fisheries.

DFO stated that there is no commercial sampling for thornyheads, along with reduced research sampling in 2020. Longspine Thornyheads were designated special concern in 2007 and are currently being reassessed. Shortspine Thornyheads were assessed in 2015.

AFSC has had a large tagging program since 1992 during the federal longline survey. There have been low returns of thornyheads (1.6%). AFSC has also looked at capture effects on thornyheads that were brought back to the lab and held in natural conditions. Changes to reflexes were observed and could result in increased predation. For the thornyhead assessment, shortspine and longspine are assessed as a complex, though it is mostly shortspine. The longline survey and trawl survey data are used to estimate biomass. GOA thornyheads are not subject to overfishing, according to the most recent assessment.

J. Sablefish

At ADFG, sablefish annual mark-recapture study using longline pots continued with almost 8,000 sablefish tagged to date. Sablefish are captured in the tanner crab bottom trawl survey in Prince William Sound, and are mostly age one-four fish. The CPUE index for sablefish has declined but has been increasing in the last two surveys. Biological data was collected from the sportfish fishery in the Central and Southeast Regions. They have been investigating daily growth in sablefish for age=0 otoliths by looking at relationships between various otolith parameters. They found a close correlation between otolith size and fish size.

A new statistical catch-at-age (SCAA) model was used in the Northern Southeast Inside (NESI), with the longline survey contributing CPUE and biological data, along with fishery CPUE and biological data. The SCAA model resulted in 580.8 mt ABC for the NESI, but due to management rules, which allow for a maximum of 15% increase, a 551.9 mt ABC was set. In the Southern Southeast Inside (SSEI), the assessment uses information from the longline survey to provide biological information as well as relative abundance trends. Because there is substantial movement in and out of the SSEI, the sablefish population is managed based on relative abundance trends in the longline survey and biological data. In the SSEI, the sablefish ABC was reduced 3% in 2019, noting they are seeing fewer older fish.

On the management side, ADFG manages five different sablefish fisheries. Fisheries in the Southeast Region attained almost the entire quota.

DFO uses a Management Strategy Evaluation for sablefish. In addition to the annual Sablefish survey, they have been participating in an informal collaboration with NOAA and ADFG to develop a range-wide spatial model of abundance across the eastern North Pacific. The last assessment was in 2019, the stock status has gone through the MSE process, and shows that the sablefish stock is going from cautious to healthy. The 2015 year class was eight times the historic average, but that is highly uncertain, and unless there is another good year class, the allowed catch will be ramping down again. Simulation evaluation of models showed that the largest risk is tuning the maximum harvest rate to the large numbers of juvenile sablefish, if they fail to recruit to the fishery. DFO staff also detailed some personnel changes. Brenda Connors has moved to salmon, Kendra back from salmon to groundfish. Ralph retired and now works for industry.

At AFSC, the Auke Bay Lab has had a tagging program since late 1970s, with about 2,000 sablefish tags deployed during the longline survey. Some fish were tagged with archival tags as well. In 2020, there were about 400 sablefish tag returns, with the longest time at liberty of 40 years. They also tag other species, but not as many. There is an ongoing juvenile sablefish tagging study – the majority of samples are one-year olds (based on length), which may indicate a large 2019 year class. ADF&G did the tagging and AFSC thanks ADF&G for their effort. There is also a sablefish post release study. AFSC doesn't have data on discard mortality rates for fish brought up and later returned to the ocean. Fish in this study were kept in the lab after being out of the water for three, six and 11 minutes. While fish had no internal injuries, some had reflex issues even a week later. This impairment could be critical for whale depredation (sperm whales) in the Gulf of Alaska if their reflexes are subpar. AFSC also has a sablefish starvation study, where juvenile sablefish were reared in the lab and taking them to the point of starvation to look at starvation resiliency. Also, a southeast coastal monitoring survey collected oceanographic data and juvenile pink salmon survival based on adult returns. They found a strong correlation between Chlorophyll *a* values collected during the survey and age 2 sablefish. This correlation confirmed that 2000, 2014 and 2016 were huge year classes. It's possible this information will be used in future stock assessments.

The stock assessment for sablefish included updated and projected whale depredation effects. The 2020 Gulf of Alaska trawl survey was not conducted. An estimate of the take by killer and sperm whales is deducted from ABC. There were huge year-classes in 2014, 2016 and likely 2017. Trawl biomass for shelf has quadrupled since 2014. The fishery CPUE index was at its lowest point in 2018, but increased 20% in 2019. Maximum ABC in the model was really high and the assessment authors recommended a lower ABC of 57% because the future depends on large fish and these haven't contributed substantially to the biomass yet. There is uncertainty in the projected increase in biomass, given that the population still lacks older fish; however, recent marine heat waves were a positive sign for recruitment.

The AFSC has a series of coastwide research efforts, in collaboration among AFSC, NWFSC, ADF&G and DFO has been underway since 2017. AFSC has a postdoc from Canada and a PhD student working on movement and growth of sablefish to look at potential bias and risk as doing local assessment rather than coastwide. There is an upcoming workshop to get stakeholder feedback on this, with the goal to make folks feel more included.

On the management side, currently, there is a 100% retention requirement for the directed IFQ fishery. Industry wants to discard small fish, "careful release" is Council term. There is concern from enforcement if there is no size limit, however scientists are concerned about not knowing discard mortality without size limit for stock assessment. This will come up again at the June NPFMC meeting.

IPHC provides sablefish catch rates during their set line survey, and the logbook program is a joint program with logbook collection, verification and analysis. It's interesting to note regarding the high number of small sablefish that the Pacific halibut size limit is not conservation based, but a marketing tool. The IPHC is looking at changing the size limit, as reducing it might have economic advantage. Having funding issues due to reduced catches. There is limited cost recovery work done in Alaska.

ODFW participates in the federal PFMC process, but the fishery is not managed by the state. ODFW staff are involved in gear switching issues (the IFQ fishery is looking to use non-trawl gear to harvest sablefish). There is a periodic review of the IFQ permit stacking program. An MSE introductory workshop scheduled for next week that ODFW staff are planning on participating in.

The SWFSC noted that the sablefish stock assessment is planned for review in June 2021. The NWFSC is the lead. This will be an update of the 2019 assessment and may show how strong the 2016 year-class was.

Like ODFW, CDFW provides support to the PFMC process, but there is no state managed fishery.

K. Lingcod

At ADFG, the southeast dockside commercial sampling included 1,051 Lingcod for biological data. In the central region skipper interviews and port sampling were conducted in 2020. In the southeast region, recreational catch, harvest and biological data for lingcod were collected. There was no lingcod assessment in the southeast region. There was no ROV survey in the central region. Management of the directed commercial fisheries in the southeast region are managed by season, GHRs, and gear restrictions. In the Sportfish southeast region, there is a regional lingcod management plan. In the southeast region, there is a dinglebar fishery which landed 137 mt in 2020, while there was 39 mt landed as bycatch in the Pacific Halibut and other groundfish fisheries, and 9 mt as bycatch in salmon fisheries.

DFO has many research projects for rockfish that are also for lingcod. The acoustic survey (discussed previously) shows lingcod are very “chatty” fish, and chased away other fish. The trawl survey was skipped last year, so there was little data collection for lingcod, making this year a priority for hard bottom areas. The Outside longline survey was conducted last year and collected data and fin rays. Stock assessment is coming up in 2023. ADFG wanted to wait for assessment until biological data was available. There was a science advisory request on the traditional use of lingcod eggs by First Nation people that DFO needs to review, but they need to have an egg to whole fish ratio for accounting purposes. These people use rakes at low tide to get lingcod, but they need to eat the eggs just post-spawn; otherwise, they are quite chewy.

At ODFW, recreational lingcod fin rays were mounted in house using alternate technique that doesn’t require use of a fume hood. They used crystal bond, which is non-toxic, rather than Cytoseal which requires a fume hood. They also used clear nail polish after the crystal bond. Mark Terwilliger is their new age reader and completed the research. ODFW sent the commercial fin rays to WDFW to age. ODFW staff are on the STAT for lingcod assessment, primarily helping with northern assessment. ODFW collects fishery-dependent data that contributes to assessment. On the management side, the open access fleet is active in Oregon. In 2020 trip limits for both open access and limited entry; however, landings in 2020 were down by 25%, due to COVID. Lingcod are a popular target in the recreational bottom fishery, and have a daily bag limit and size limit.

At the SWFSC, the southern stock assessment for lingcod is underway and Melissa Monk (SWFSC) is on the STAT. John Field (SWFSC) will be chairing the review panel in the summer.

CDFW had lingcod fin rays to contribute to the assessment, but due to COVID, they were not able to be aged in time.

L. Atka Mackerel

AFSC staff are still finishing up a paper from 10 year study. There was a 2019 assessment for the Bering Sea and Aleutian Islands that was unchanged since last year. In the Gulf of Alaska, there are limited data.

M. Flatfish

At ADFG, there is not much going on for flatfish. There is only one permit in Cook Inlet for pot gear.

At DFO, there were no recent flatfish assessments, but there are plans for an updated petrale sole in 2021, followed by dover sole in 2022, and English sole and southern rock sole in 2022/23. On the management side, arrowtooth flounder has a directed fishery with four or five vessels specializing in heavy pressure on spawning population, which resulted in a precipitous decline in indices of abundance. As a result, there is a moratorium on targeting arrowtooth flounder, pending the fall 2021 stock assessment using SS3. The last arrowtooth flounder stock assessment said it was impossible to overharvest, but it’s occurring. Vessels are targeting fresh flatfish, including dover sole. Landings are nominal from all but arrowtooth flounder.

AFSC has a series of research projects for flatfish. There is a study on yellowfin sole and rock sole in the eastern Bering Sea looking at diet and growth based on prey availability, and also the temperature effect in warmer years. The yellowfin sole tends to move north, and the rock sole expands into that area. Another study looking at the latitudinal variation of juvenile flatfish in the Bering Sea. Rearing northern rock sole at different temperatures looking at growth rates, warmer water yields faster growth.

On the stock assessment side, yellowfin sole is the largest flatfish fishery in the world. The survey catchability is linked to bottom temperature. The 2020 yellowfin sole assessment estimated biomass 17% higher than the 2018 stock assessment. Greenland turbot biomass was the same, but the spawning biomass was lower, so the ABC was reduced. The eastern Bering Sea survey was discontinued, which hurt the assessment. The arrowtooth flounder in the Bering Sea-Aleutian Islands biomass estimate was 27% above average. The catch continues to be set well below ABC. Harvest species increased 8%. Arrowtooth flounder in the Gulf of Alaska had a partial assessment, with updated harvest numbers. The ABCs and OFL were little changed. Kamchatka flounder, much less biomass than arrowtooth flounder. The two were separated in 2011 because a directed fishery developed for Kamchatka flounder. Northern Rock Sole in the Bering Sea-Aleutian Islands stock assessment female biomass dropped 25%, but is lightly exploited. Flathead sole in the Bering Sea-Aleutian Islands had a small change in the assessment with slightly lower harvest. Alaska Plaice in the Bering Sea-Aleutian Islands had a slight change. For the Other flatfish complex, including starry flounder, rex sole and others, the biomass increased slightly from last assessment. These shallow flatfish are tier 5 species. It was an off year for the assessment of deepwater flatfish in the Gulf of Alaska.

At the SWFSC, the Dover sole assessment is happening this year and led by NWFSC.

N. Pacific Halibut & IPHC activities

The ADFG has a big sport fishery and is able to collect data.

The AFSC noted that the NPFMC has had difficulty in linking Pacific halibut as bycatch in other fisheries.

The IPHC presented their report. On the research side, migration and distribution larval and early juvenile dispersal has been a focus. The degree of inter-basin (Bering Sea vs. Gulf of Alaska) larval connectivity is influenced by spawning location. They estimated the percentage of larval Pacific Halibut that were spawned in the Gulf of Alaska and ended up in the Bering Sea. Pacific Halibut spawned in the Bering Sea stay in the Bering Sea, yet some larvae from the Gulf of Alaska do travel to the Bering Sea, with the percentage of larvae moving to the Bering Sea decreasing the farther away from the island passes that they are spawned. Region 2, closest to Unimak Pass, had over 50% of larvae transported to the Bering Sea. Region 3, just east of Kodiak Island, has about 20% of larvae transported to the Bering Sea. This feeds into genomic studies. Juvenile (ages 2-6) Pacific halibut settling in the eastern Bering Sea (Bristol Bay) tend to migrate towards Unimak Pass by age four and then go through Unimak Pass back into the Gulf of Alaska by age 6. Reproduction studies continue with the collection of maturity data. There are growth studies focusing on the effects of temperature on physiological markers for growth. Population density, dominance and capture stress study by subjecting juvenile Pacific Halibut to higher temperatures that increase growth, then colder temperatures decrease growth. From this, they were able to identify potential growth markers—23 genes are associated with decreased growth, while 10 genes are associated with increase in growth. IPHC continues to evaluate DMRs and survival assessment in both longline caught and the guided recreational fishery. This is a new project where the IPHC is looking at hook sizes and handling practices using dockside surveys. They are conducting field experiments to investigate the relationship between gear types and capture conditions and size composition of captured fish. If the body and tail are supported, the Pacific Halibut has the best chance of survival. They are developing injury profiles and physiological stress levels to develop assessment of mortality of discarded fish based on accelerometer (80) tags (auto detach, pop-up don't need fish) and wire tags (480) for fish caught during an upcoming 2021 study. There are multiple ongoing data collections. IPHC has staffed NOAA bottom trawl surveys in the Bering Sea and Gulf of Alaska collecting data on Pacific Halibut. In 2021, they didn't participate in the Gulf of Alaska survey. There is also a comprehensive logbook data collection program and biological collection program for the commercial fishery.

On the assessment side, the total mortality was down to 35.5 Mlbs from 40 Mlbs—84% retained, rest bycatch. The female spawning biomass was estimated at 192Mlbs, which corresponds to 41% change of being below $SB_{30\%}$. Stock is not considered overfished, although at fishing intensity 43% might result in further declines in biomass in the near future. The stock distribution has been decreasing in Region 3, and increasing in Regions 2 and 4.

The IPHC's annual meeting in January 2021 was virtual due to COVID, with the IPHC's website containing information about the annual meeting. For the 2022 meeting, there could be discussion of a year-round fishery, but before that, the IPHC needs to talk to stakeholders and contracting parties about the implications of a year-round fishery. Some are wanting a year-round fishery and that could work in British Columbia, but sablefish in British Columbia is from February to February. In Alaska, it could be a challenge to get it in place for the start of the season. This would include pot gear, as long as it's allowed by the other agencies.

In Oregon, the Pacific Halibut recreational fishery is popular. ODFW sets up a series of long weekends that allow all depth fishing. Attainment down due to COVID. Anglers reported a lot of small fish in 2020.

CDFW continues to collect data from the recreational and commercial fisheries for the IPHC.

O. Other groundfish species

At ODFW, they are encouraging fishermen to catch more of the other groundfish. Cabezon is getting close to the state harvest guideline, with the recreational side having only a two-month season. ODFW noted that ageing is a "one-man shop" focused on copper and black rockfish. ODFW also provided vermilion rockfish age validation studies on black rockfish.

XIII. Ecosystem Studies

AFSC is working with Russian scientists to use their survey data to look at the relative distribution of Pollock, Alaska Plaice and Pacific Cod. Brought a scientist over and shared data. The AFSC and Russian surveys have different sampling protocols. Based on 2017 surveys conducted by both countries, only 33% of the Pollock, 37% of the Pacific Cod, and 26% of Alaska Plaice population is in the eastern Bering Sea, down from 2010 (58%, 71% and 30%, respectively). This also showed that all three species are moving north to varying degrees. NMFS would like to use this as a model for looking at other transboundary stocks.

There is an upcoming ICES workshop on unavoidable survey effort reduction, basically how to cope with funding or vessel issues. This is an issue that all agencies face, usually with little time to plan or look at how the options affect information loss. Bycatch reduction of salmon in the Bering Sea midwater trawl fishery looking at industry and looking into excluder devices. A couple of trips using the excluder device were conducted in 2020 with cameras in the net, including artificial lights near the excluder. They are assessing salmon behavior, possibly looking at salmon vision vs. the color of the gear. This is needed to quantify pollock loss. There is a need for better bathymetry for surveys in the western Gulf of Alaska. This is in response to a paper showing that shallow areas are artifacts of bad bathymetry. There is a paper looking at geologic history of Shelikof Strait and how glaciers made basins. This information is redefining all passes in the Aleutian Islands and is helpful for modeling oceanography between Bering Sea and Gulf of Alaska, and will be contributing to Arctic bathymetry.

AFSC will be updating essential fish habitat descriptions, with a focus on how fisheries are impacting EFH. They used GAM modeling to look at spatial distribution to look at EFH. Essential fish habitat has to be reviewed every 5 years. Additionally, electronic data collections of survey data have improved efficiency. There is a systematics program with Jay Orr (AFSC, retired last year) focused on getting out a lot of papers on systematics. There is a great deal of research in trawlable habitat to develop catchability and to determine how to assess trawlable habitat. There was a stereo camera survey to see if the commercial fishery can help with independent index of abundance for rockfish using industry nets.

Every year, AFSC produces an ecosystem status report that includes food habits. There is also an annual economics and social science report.

IPHC has their setline survey collecting oceanographic data, reviewing and finalizing the data about to add to data on our website. They are now requiring vessels to provide bathymetric data.

ODFW is using video landers to look at species composition and number of fish. ODFW staff also assisted on the untrawlable habitat survey with NWFSC and SWFSC. Some of the video review took place last year.

CDFW provided their report. The Pacific States Marine Fisheries Commission, which conducts the groundfish commercial sampling program in California, is moving into the final testing of a speech recognition program for dockside sampling that was developed by SWFSC staff. This will replace paper data sheets, streamlining data collection. Drs. Milton Love (UC-Santa Barbara), and Julianne Passarelli (Cabrillo Marine Aquarium) led the massive effort to update California's fish ID guide by Miller and Lea, first published in 1972. The new edition, published in 2020, is called Miller and Lea's Guide to the

Coastal Marine Fishes of California and describes 753 species found off California's coast and is published by the University of California.

At the SWFSC, the EXPRESS campaign targets deepwater areas of the West coast states with the goal of collecting spatially explicit habitat information. During a survey in the Channel Islands National Marine Sanctuary while collecting deep sea coral sponge, they found some petrale sole spawning habitat.

XIV. Progress on Previous Year's Recommendations

A. From TSC to CARE

- **Consider aging lingcod otoliths using NI-spectrometry to eliminate the need to collect fin rays.** The TSC recognizes that Delsa (AFSC, current CARE Chair) is planning on convening a meeting to discuss lingcod ageing. Dana (DFO) suggested having a biologist there might be helpful. While multiple agencies are aging lingcod, not all agers are talking to each other. Delsa has also an initial meeting planned to see what agers are doing. Rhea (ADFG) would like to participate as well.
- **Create a video library of aging methods as a learning tool.** AFSC is starting this, and Delsa will present this to CARE.

B. From TSC to Itself

- **Recommends all members pursue travel funds to attend annual TSC meeting**. There was considerable discussion about maintaining a virtual option for future meetings. Members recognized the need to balance in person vs. virtual to save money for member agencies. If a virtual option is available, there was concern that some agencies would be more likely to say that staff cannot attend in person.
- **Engage with Western Groundfish Conference** organizing committee to identify a TSC-sponsored session topic for the 2022 meeting in Alaska. One suggestion was to present on how agencies dealt with sampling and other work accomplished during the COVID pandemic.
- **Development of additional guidance on agency reports**. There is a need for a greater level of specificity on the length of agency reports and how to highlight the reports and projects (or not) at the meeting. Members liked the option to highlight specific projects in the meeting. Members also agreed that, where appropriate, providing hyperlinks and a clickable table of contents was helpful in agency reports.
    - Rhea (ADFG) thought it would be helpful to have more guidance on the content of the report and what it should entail. Each region provides their updates, some provide updated harvest some don't, so some additional consistency is required.

    - Wayne (AFSC) suggested a need for a terms of reference document. This could also be handed out to scientists that TSC members are querying agency colleagues for abstracts for agency reports. This could also include summary slides. For some agencies, there are significant contributions throughout the calendar year. Wayne (AFSC) also suggested that minimizing the use of clickable links might be less work long-term, as they will eventually need to be updated. Wayne suggested there was a need to focus on surveys and research and recognized that additional guidance is still needed. Wayne has a document from the 2015 TSC meeting that may be similar to a TOR. This could be merged with the current outline provided as a part of the meeting agenda.
    - Traci (CDFG) will send notes on the Chair's duties. The accomplishments section mentions a TOR document, but it is high level and somewhat dated.
- **Draft letters** of recognition for former retirees (Lynne Yamanaka, Jon Heifetz and Tom Wilderbuer). The last chair was not able to complete this. The current TSC chair will do this.
    - Wayne (AFSC) announced that he would be retiring at the end of the year. Congratulations Wayne!
- **Review TSC** minutes within two months. The chair will continue with this practice as closely as possible.
    - Minutes within two weeks on Google Docs
    - Agency reports finalized by the end of June
    - Are there additional regional/management entities that would benefit from seeing the TSC annual Report?
    - Needs to go into terms of reference. Seems to work, the delay in minutes due to field season. Add local staff to take notes, prepare minutes--add to terms of reference.
- **Urging member** agencies to make contacts with other countries. Members suggested that this recommendation could be rolled over. PISCES is an international organization, which could be used to make contact. Some DFO members are involved in PISCES, and the DFO TSC members volunteered to ask those folks. North Pacific Research Board also has links to other countries.

C. From TSC to Parent Committee

- **Request the Parent Committee to advocate** for maintaining and increasing survey effort by member agencies.
- **Request to the Parent Committee to reach** out to member agencies to clarify the management disadvantages of not allowing for ecological monitoring in closed areas.

XV. Current Year Recommendations

A. From TSC to CARE

1. Consider ageing lingcod otoliths using NI-spectronomy to eliminate the need to collect fin rays (rollover)
2. Create a record of aging methods as a learning tool (rollover)
3. Thank CARE for looking into the glycerin/thymol solution and switching to dry storage for otoliths (new)

B. From TSC to Itself (Responsible parties)

1. The TSC would like to emphasize the value of in-person meetings to connect and discuss research opportunities (Chair, Lara) (rollover)
2. The TSC recommends sponsoring a WGC session topic on COVID impacts, including comparison and discussion of potential long-term impacts (Chair) (rollover)
3. Develop additional guidance for agency reports, including developing draft TORs and report timing. Add NPRB and PISCES to the distribution list. Add guidance for the Chair. (Chair, Stephen, Wayne). (rollover)
4. Draft letters of recognition to recent retirees (Lynne Yamanaka, Jon Heifetz and Tom Wilderbuer) (Chair) (rollover)
5. Review TSC minutes and finalize Agency reports within two months, including having the minutes in Google docs for review within two weeks and agency reports final by the end of June (Chair) (rollover)
6. Recommend a TSC subcommittee be created to identify data sharing mechanisms across agencies and countries. Add a section to report on data sources (any open-source and other datasets). Explore international fishery data sharing efforts, such as OBIS.org or OpenCanada (which DFO is already utilizing). Consider creating a list of how each agency is sharing data in the next annual TSC report (Chair) (new).

C. From TSC to Parent Committee

1. Recommend that the Parent Committee advocate for maintaining and increasing survey effort by member agencies (rollover)
2. Recommend that the Parent Committee reach out to member agencies to clarify the management disadvantage of not allowing for ecological monitoring in closed areas (rollover)
3. Recommend that the Parent Committee send a letter to member agencies commending them for staff efforts during COVID year (new)
4. Recommend to the Parent Committee to advocate for an investigation into calibrating the different gear used by agencies on their surveys with the goal of being able to use multi-agency surveys when looking at coastwide populations. We all use different gear (nets) within

agencies and between agencies try to calibrate these different nets to look at things coastwide. (new)

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

Given that Wayne Palsson (AFSC) updated this document in 2019, this agenda item was deferred to the 2022 meeting if needed.

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

The 2022 TSC meeting would take place on April 19 – 20th, 2022. Members expressed interest in an in-person meeting in Victoria, B.C. (as planned for 2020) if possible. This will be re-evaluated in six months. Alison Whitman agreed to continue as Chair for 2022.

XVIII. Adjourned at 2:10 PM (PST) Wednesday April 21st

XIX. Parent Committee Minutes

Minutes of the 61st Annual Meeting of the
Canada-U.S. Groundfish Committee
(a.k.a. "Parent Committee")

[Note: The Parent Committee did not meet in 2020]

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 1:30 pm PDT, April 21, 2021.

B. The Agenda

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

C. The 2019 Parent Committee Meeting Minutes

The 2019 Parent Committee meeting minutes were adopted as presented

D. Progress on 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.

   The Parent Committee continues to actively request participation from all relevant agencies

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 with member agencies to make clear the management disadvantages of this policy

decision, which compromises the ability to evaluate efficacy of the closed areas.

No Action taken because of Covid-19 closures.

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.

Letters have been drafted and are awaiting signature

E. 2021 Parent Committee Recommendations

- The Parent Committee concurs with the TSC on the importance of maintaining and increasing survey effort by member agencies.
- The Parent Committee concurs with the TSC on the importance of reaching out to member agencies to clarify the management disadvantages of not allowing for ecological monitoring in closed areas.

XX. Other Business

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

2. The Parent Committee thanks Olav Ormseth (AFSC), Dana Haggarty (DFO) and Traci Larinto (CDFW) for acting as rapporteurs for the TSC meeting and expresses its deep appreciation to Alison Whitman for chairing the 2021 meeting.

XXI. Selection of the next Chair, Schedule and Location of the 2022 Meeting

The 2022 TSC meeting would take place April 19 – 20th, 2022. Members expressed interest in an in-person meeting in Victoria, B.C. (as planned for 2020), if possible. This will be re-evaluated in six months. Alison Whitman agreed to continue as Chair for 2022.

XXII. The Parent Committee meeting was adjourned at 3:00 pm, Wednesday, April 21, 2021.

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

AGENCY REPORTS

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

Alaska Fisheries Science Center of the National Marine Fisheries Service

2020 Agency Report to the Technical Subcommittee of the
Canada-US Groundfish Committee

April 2021

Compiled by: Wayne Palsson, Cara Rodgveller, and Olav Ormseth

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2020

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 2020 our activities were guided by our Strategic Science Plan (www.afsc.noaa.gov/GeneralInfo/FY17StrategicSciencePlan.pdf) with annual priorities specified in the FY19 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. 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.

. GAP also carried out the biennial Gulf of Alaska Bottom Trawl Survey.

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 composed 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 science 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 2019, RACE Groundfish Assessment Program (GAP) and Shellfish Assessment Program (SAP) scientists conducted a bottom trawl survey of Alaskan groundfish and invertebrate resources over the eastern and northern Bering Sea shelf
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 western and central Gulf of Alaska (summer).   A collaborative cruise to test the efficacy of a new type of trawl excluder 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 Gulf of Alaska 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, Arrowtooth Flounder, and Northern & Southern Rock Sole. Summer surveys concentrate on the age-0 and age-1 juvenile stages of the winter/spring spawners as well as summer spawners (e.g. forage fishes including Capelin, Eulachon, and Pacific Herring). This survey also estimates whether or not age-0 fish have sufficient energy reserves to survive their first winter.

Research on environmental effects on groundfish and crab species such as the impacts of ocean acidification on early life history growth and survival continue at our Newport, Oregon and Kodiak facilities. Similarly, the Newport 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 2019 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. During the 2019 summer survey we observed one of the smallest cold pool extents in the history of our time series. 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 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 hosted an ICES workshop on the impacts of unavoidable survey effort reduction (ICES WKUSER) in the winter 2019/2020. Work on the topic began in late 2018 and substantial progress was made before the 2020 meeting. A workshop report will soon be available on the ICES web page (https://www.ices.dk/community/groups/Pages/WKUSER.aspx). 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.

The Fisheries Behavioral Ecology Program (FBE) conducts laboratory experimental studies and field studies on the ecology, energetics, behavior, habitat associations, and climate responses of the early life stages of groundfish and crab species including walleye pollock, Pacific cod, Arctic cod, sablefish, northern rock sole, yellowfin sole, Tanner crab, and snow crab. Laboratory studies are performed at NOAA's Newport Research Station in Newport, OR. Areas of investigation include the effects of temperature, elevated CO_2, and oil exposure on the survival and growth performance of eggs, larvae and juveniles. In addition to targeted field studies on habitat associations, FBE performs an annual beach seine and camera survey of age-0 and age-1 Pacific cod in the central Gulf of Alaska.

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. <u>REFM DIVISION</u>

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 Researc**h (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 Assessmen**t (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) publishes groundfish stock assessments for rockfish in the Gulf of Alaska, and sharks, sablefish, and grenadiers for all of Alaska. They also conduct management strategy evaluations (MSEs). MESA also conducts biological research, such as movement, growth, stock structure, ageing, and maturity. Presently, the program is staffed by 11 full time scientists and 1 term employee. ABL's Ecosystem Monitoring and Assessment Program (EMA) capture groundfish in their surveys in the Bering Sea and the Arctic Ocean and conduct research on impacts of the environment on groundfish. The Recruitment Energetics and Coastal Assessment Program (RECA) studies the energetics and diet of juvenile groundfish and the Genetics Program conducts research on cod, pollock, sablefish, shark, and forage fish stock structure and distribution.

Projects at ABL included: 1) ageing and movement studies of sharks, 2) predicting pollock recruitment from a temperature change index, 3) researching copepods as an indicator of walleye pollock recruitment, 3) utilizing biophysical indices as an indicator of sablefish abundance, 4) whole genome sequencing of multiple groundfish, 4) population structure and distribution of pollock and cod species, 5) tagging juvenile sablefish nearby Sitka, AK, 6) the continuation of the long-term groundfish tagging program, 7) the continuation of a sablefish coast-wide assessment and research group (CA, OR, WA, BC, AK), 8) conducting the AFSC's annual longline survey throughout Alaska, and 9) evaluating the effects of capture and time out of water on sablefish and shortspine thornyhead health.

In 2020 ABL prepared 12 stock assessment and fishery evaluation reports for Alaska groundfish: Alaska sablefish, Gulf of Alaska (GOA) Pacific ocean perch, GOA northern rockfish, GOA dusky rockfish, GOA rougheye/blackspotted rockfish, GOA shortraker rockfish, GOA and Bering Sea/Aleutian Islands "Other Rockfish", GOA thornyheads, and GOA and Bering Sea/Aleutian Islands sharks, and Alaska grenadiers.

For more information on overall programs of the Auke Bay Laboratories, contact the ABL Laboratory Director Dana Hanselman at (907) 789-6626, Dana.Hanselman@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 please contact Jennifer Ferdinand, (206) 526-4194.

E. HEPR

The Habitat and Ecological Processes Research Program focuses on integrated studies that combine scientific capabilities and create comprehensive research on habitat and ecological processes. The HEPR Program focuses on four main research areas.

Loss of Sea Ice

Climate change is causing loss of sea ice in the Bering, Chukchi and Beaufort Seas. Addressing ecosystem-related shifts is critical for fisheries management, because nationally important Bering Sea commercial fisheries are located primarily within the southeastern Bering Sea, and for successful co-management of marine mammals, which at least thirty Alaska Native communities depend on.

Essential Fish Habitat

Alaska has more than 50 percent of the U.S. coastline and leads the Nation in fish habitat area and value of fish harvested, yet large gaps exist in our knowledge of Essential Fish Habitat (EFH) in Alaska.

Habitat Research in Alaska

Major research needs are

1. to identify habitats that contribute most to the survival, growth, and productivity of managed fish and shellfish species; and
2. to determine how to best manage and protect these habitats from human disturbance and environmental change.

Essential Fish Habitat Research Plan in Alaska

Project selection for EFH research is based on research priorities from the EFH Research Implementation Plan for Alaska. Around $300,000 is spent on about six EFH research projects each year. Project results are described in annual reports and the peer-reviewed literature. Study results contribute to existing Essential Fish Habitat data sets.

For more information, contact Dr. James Thorson (james.thorson@noaa.gov).

II. Surveys

2020 Eastern Bering Sea Continental Shelf and Northern Bering Sea Bottom Trawl Surveys –

RACE GAP

AFSC's Resource Assessment and Conservation Engineering (RACE) Division canceled the 2020 Eastern Bering Sea Continental Shelf and Northern Bering Sea Bottom Trawl Surveys due to the uncertainties and risks from conducting the survey during the novel COVID-19 pandemic.

2020 Aleutian Islands Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources-RACE GAP

AFSC's Resource Assessment and Conservation Engineering (RACE) Division canceled the 2020 Aleutian Islands Bottom Trawl Surveys due to the uncertainties and risks from conducting the survey during the novel COVID-19 pandemic.

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

Scientists from the Alaska Fisheries Science Center conducted 2 acoustic-trawl surveys in the Gulf of Alaska during late winter and early spring 2020 to estimate the distribution and abundance of walleye pollock (Gadus chalcogrammus) at several of their main spawning grounds. These pre-spawning pollock surveys covered the Shumagin Islands (202001; Feb. 11-18) and Shelikof Strait (202003; March 2-16) areas. Historical surveys also frequently included Sanak Trough, Morzhovoi Bay, and Pavlof Bay since 2002 as part of the Shumagins survey, and the continental shelf break near Chirikof Island, and Marmot Bay as part of the Shelikof Survey. None of these ancillary areas were surveyed in 2020 due to 1) time constraints in February because vessel departure from winter repairs was delayed and 2) a necessity of ending the March survey early due to increased concerns about the growing global COVID-19 pandemic.

The surveys were conducted with the NOAA ship Oscar Dyson, a 64-m stern trawler equipped for fisheries and oceanographic research. Midwater and near-bottom acoustic backscatter at 38 kHz was sampled to estimate the abundance of walleye pollock using an LFS1421 trawl and an Aleutian Wing 30/26 Trawl (AWT). This is the first winter survey where the LFS1421 replaced the AWT as the primary sampling trawl. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques.

In the Shumagin Islands acoustic backscatter was measured along 882.8 km (476.7 nmi) of transects spaced an average of 4.3 km (2.3 nmi) apart with spacing varying from 1 to 5 nmi in the survey area. Pollock and eulachon were the most abundant species by weight in the 5 LFS1421 hauls, contributing 94.5% and 3.1% of the catch by weight. Pollock and eulachon were also the most abundant species by numbers with 62% and 25.6%, respectively. Pollock were observed throughout the surveyed area and were most abundant to the northwest and southwest of Korovin Island. Adult pollock were detected in both of these regions, but not in the Shumagin Trough. Juveniles (< 30 cm FL) were concentrated in the areas directly north and south of Korovin Island and were rare elsewhere in the survey area. Adult pollock were detected at 100 m depth, 50 m from the seafloor, and juvenile pollock were similarly distributed but slightly higher in the water column. Pollock with lengths 10-15 cm FL, age-1 pollock, accounted for 48.3% of the numbers and 3.2% of the biomass of all pollock observed in the Shumagin Islands. Pollock 16-29 cm FL, indicative of age-2s, accounted for 14.9% by numbers and 11.5% by biomass. Pollock ≥ 30 cm FL accounted for 36.8% and 85.2% of the numbers and biomass, respectively. Both male and female pollock observed in the Shumagin Islands were predominately in the pre-spawning maturity stage. The maturity composition of males > 40 cm FL (n = 40) was 0% immature, 1% developing, 52% pre-spawning, 42% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 30) was 0% immature, 35% developing, 49% pre-spawning, 0% spawning, and 11% spent. The abundance estimate of 28.8 million pollock weighing 4,798t (relative estimation error of 12.2%) was 27.6% of that observed in 2019 (17,390 t) and 7 % of the historic mean of 68,375 t . Survey biomass estimates in 2017, 2018, and 2019 are the smallest since the mid-1980s, and the 2020 biomass estimate continues this downward trend.

In the Shelikof Strait, acoustic backscatter was measured along 1425 km (769.5 nmi) of transects spaced mainly 13.9 km (7.5 nmi) apart with spacing varying from 6.1 to 15 nmi in the survey area. Due to the emergence of the global COVID-19 pandemic, management determined that the survey should be completed as quickly as possible, so once backscatter amounts decreased near the Semidi Islands (where backscatter amounts have historically decreased) transect spacing was doubled to 27.8 km (15 nmi) for the final two transects. Pollock and eulachon were the most abundant species by weight in the 23 LFS1421 hauls, contributing 91.5% and 7.8% of the catch by weight respectively. Eulachon and pollock were the most abundant species by numbers with 46.2% and 38% of total catch numbers, respectively. Adult pollock were detected throughout the Strait, with most distributed along the west side from Cape Nukshak to Cape Kekurnoi and in the center of the sea valley south of Cape Kekurnoi, as is typical for most previous Shelikof surveys. Most pollock were detected between depths of 200-250 m with juveniles (< 30 cm FL) also found in a layer at 50-100 m depth. Pollock 10-16 cm FL, indicative of age-1 pollock, accounted for 1.7 % of the numbers and ≤ 0.1% of the biomass of all pollock observed in Shelikof Strait. Pollock 17-29 cm FL, indicative of age-2s, accounted for 30.5% by numbers and 8% by biomass of all pollock. Pollock ≥ 30 cm FL accounted for 67.8% and 92% of the numbers and biomass, respectively. The maturity composition in the Shelikof Strait of males > 40 cm FL (n = 312) was 0% immature, 0% developing, 3% pre-spawning, 85% spawning, and 5% spent. The maturity composition of females > 40 cm FL (n = 258) was 6% immature, 0% developing, 88% pre-spawning, 1% spawning, and 5% spent. The abundance estimate of 978 million pollock weighing 456,713 t (relative estimation error 4.9%) was 35.7% of that observed in 2019 (1,281,083 t) and 63.18% the historic mean of 722,885 t.

Winter acoustic-trawl surveys of pre-spawning walleye pollock near Bogoslof Island - MACE

An acoustic-trawl survey of walleye pollock (Gadus chalcogrammus) in the southeastern Aleutian Basin near Bogoslof Island was conducted 19-23 February, 2020 aboard the NOAA Ship Oscar Dyson. The survey covered 1,449 nmi2 of the Central Bering Sea Convention Specific Area.

Acoustic backscatter was measured at 38 kHz along 26 north-south parallel transects, which were spaced 3-nmi or 6-nmi. The wider 6-nmi spacing was strategic to conserve transecting time in areas where low pollock density was observed in 2016 and 2018, when 3-nmi transect spacing was used throughout the survey. The survey was divided into two regions, Umnak (transects 1-10), and Samalga (transects 11-26). Survey operations were conducted 24 hours/day, from east to west.

Midwater acoustic backscatter was sampled using midwater trawl hauls to identify the species composition and to provide biological samples. The LFS1421 trawl (LFS) was the primary sampling tool for analysis, while the Aleutian Wing 30/26 trawl (AWT) provided additional samples. Pollock dominated the trawl catches in both midwater nets by weight and number, representing 99.2% of the total catch by weight for the 6 AWT hauls, and 96.8% of the total catch by weight for the 8 LFS hauls. Lanternfishes were the second most numerous group captured in the AWT hauls (8.8%), whereas shrimp species were the second most numerous group captured in the LFS hauls (14.9%). Pollock lengths ranged from 27 to 69 cm fork length (FL), with a primary mode at 52 cm, and a secondary mode at 38 cm FL.

Pollock specimens were visually examined for maturity stages. The maturity compositions here are for female pollock that were at least 40 cm in length. For the Umnak region (n = 195), the maturity composition was 3% immature, 31% developing, 50% pre-spawning, 10% spawning, and 6% were in the spent stages. For the Samalga region (n = 169), 0% immature, 1% developing, 98% pre-spawning, and 1% were in the spent stage. The average gonado-somatic-index for pre-spawning mature (i.e., FL≥ 40 cm) female pollock in the Umnak region was 0.15, and in the Samalga region it was 0.17.

Pollock biomass was distributed on all transects with 12% of the biomass distributed in the Umnak region, and 88% of the biomass distributed in the Samalga region. The densest concentration was located on transect 22, within the Samalga region, which represented 44% of the estimated pollock biomass. This layer extended horizontally for about 7.5 nmi with a vertical extent from 260 m down to 600 m below the surface.

The pollock abundance estimate in 2020 was 350 million fish weighing 345 thousand metric tons for the entire surveyed area. The overall size-composition for the pollock was unimodal at 50 cm FL, with an average length at 51.6 cm. The estimates represent an decrease of 64% in abundance and 48% in biomass from the 2018 survey estimates of 964 million fish weighing 663 thousand metric tons. Based on the 1D geostatistical analysis, the relative estimation error for the biomass estimate was 15.8%.

The estimated age-composition for pollock ranged from 2 to 14 years of age. Sixty percent of the estimated biomass were 10-11-year old fish (2010-2009 year classes), and another 15% were 9-year-old fish (2011 year class).

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

The COVID-19 pandemic resulted in the cancellation of many fisheries surveys worldwide in 2020. This posed a challenge for fisheries management, which relies on timely and consistent abundance estimates of fish stocks to characterize the state of marine ecosystems to support management decisions (ICES, 2020). This was the case for walleye pollock (Gadus chalcogrammus) in the eastern Bering Sea (EBS), which support the largest fishery in the United States with recent landings of ~1.3 million tons and a value of ~1.4 billion dollars (Ianelli et al., 2020). The research vessel (RV) based surveys of this stock were delayed and subsequently cancelled due to the risk to survey crews and the remote communities where crew exchanges and resupply activities occur. In response, we applied recent advancements in uncrewed surface vehicles (USVs) instrumented with calibrated echosounders (De Robertis et al., 2019) to conduct a USV-based acoustic survey. The goal was to mitigate the loss of information from pollock midwater abundance surveys used to support management of this important fishery.

The 2020 AT survey of pollock in the EBS was cancelled due to safety concerns associated with the COVID-19 pandemic. Instead, three chartered Saildrone USVs were deployed from Alameda, CA, to the Bering Sea to estimate pollock abundance and distribution. The transects covered the same area as previous AT surveys, but were spaced farther apart. The USVs followed a curtailed survey plan designed in case an abbreviated RV-based survey had been possible. The survey consisted of 14 transects spaced 74 km apart with a total length of 4727 km (Fig. 1). This represents half the sampling density of previous RV-based surveys (transects 37 km apart). The USVs measured 38 kHz pollock backscatter, but population biomass (kg) is used in the stock assessment model. Thus, the USV backscatter measurements were converted to biomass units based on an empirical relationship between pollock backscatter and biomass observed in previous surveys. The additional uncertainty introduced by the increased transect spacing and the backscatter-to-biomass conversion was investigated via simple simulations.

Total pollock backscatter in the survey area was 4.32x107 m2, 45.0 % higher than in the last survey in 2018. The spatial distribution of pollock backscatter was consistent with recent surveys, with pollock most abundant in the north-west portion of the survey area. The biomass estimate for 2020 was 3.6 x109 kg of pollock, which represents an increase of 45.0.% relative to the estimate of 2.5x109 kg in the last survey in 2018 (Fig. 2). Adding the USV data to the assessment model provided assurance that the stock status was stable and suggested a slight increasing trend compared to the previous survey and other model scenarios (Ianelli et al., 2020). The USV data were broadly consistent with other data components fit within the assessment model. Furthermore, the pollock spatial pattern depicted by the USV data in 2020 was consistent with the patterns observed in the fishery. The model scenario incorporating the USV data was selected by the North Pacific Management Council as the basis for management advice. Although the EBS pollock USV survey could not produce information on species, size, and age compositions typically collected from research vessels, it allowed the AT survey time series to be extended in a situation when crewed ship-based surveys were not possible.

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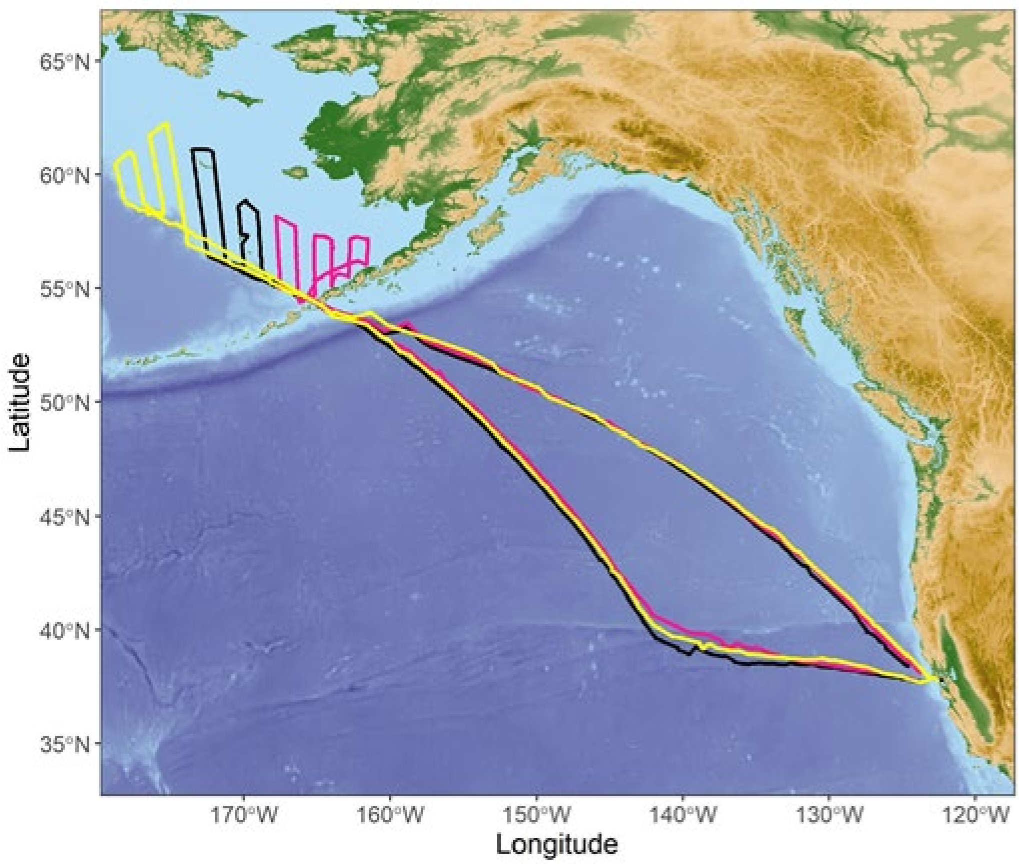

Fig. 1. Path taken by saildrones as they sailed from California across the North Pacific to the survey area in the Bering Sea and returned. Each USV track is depicted in a different color

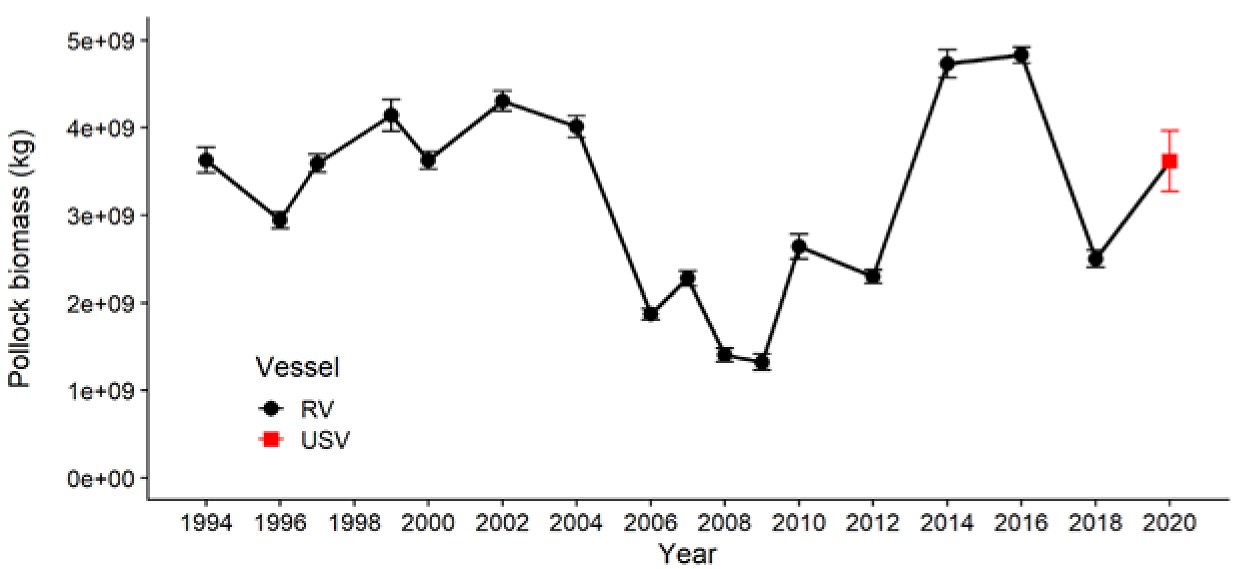

Fig. 2. Time series of EBS pollock acoustic-trawl abundance estimates with error bars showing ± 1 standard deviation of the estimate based on geostatistical 1-D estimates. The 2020 estimate (red

square) was conducted with USVs at half the transect spacing of previous surveys. The 2020 uncertainty estimate accounts for the increased uncertainty introduced by the backscatter to biomass conversion.

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

Due to the COVID-19 pandemic, the annual bottom trawl survey of the eastern Bering Sea shelf was cancelled, thus these acoustic data of opportunity were not collected.

Nearshore age-0 seine survey - RACE FBEP and Alaska Coastal Observations and Research (ACOR)

An extensive nearshore survey was conducted between 2 July and 8 August, 2020. Beach seines were the primary sampling method. A total of 75 beach seine sets were made in 14 different bays on Kodiak Island, the Alaska Peninsula, and the Shumagin Islands (Fig. 1). For each set, habitat information, temperature, and salinity were recorded. In addition, a CTD cast was made in each study bay to record temperature and salinity profiles.

The primary target for the seine survey is age-0 Pacific cod, as this age class is most abundant in shallow coastal nursery areas where environmental conditions (e.g., temperature and food availability) are optimal. As a result, age-0, and to some degree age-1, GOA Pacific cod are present in very shallow (0-4 m) nearshore habitats at densities several orders of magnitude higher than found in offshore habitats (Abookire et al. 2007, Laurel et al. 2007, 2009). These nursery habitats are accessible by inexpensive beach seine sampling gear, and beach seine and inexpensive camera gear are currently the only effective means for studying age-0 and age-1 gadids in the Gulf of Alaska. AFSC biologists have conducted post-settlement beach seine surveys for Pacific cod at two Kodiak Island bays during July and August since 2006, and have expanded the survey across 14 more bays along Kodiak and the Alaska Peninsula (Fig. 1). This time series is the only long-term directed program for studying juvenile Pacific cod in the Central and Western GOA and invaluable data on juvenile growth and condition across warm and cold environmental stanzas. The time series demonstrates strong links between age-0 and age-1 abundances in consecutive years, indicating that it may provide an early indication of the strength of recruitment to the adult population, and recently, these data are included in the stock assessment process for GOA Pacific cod. In addition, the survey also catches high abundance of age-0 walleye pollock and pink salmon that may also be useful to management.

In 2020, a total of 27,992 individuals of 47 fish species were captured in beach seines. Pacific cod and walleye pollock were the most common species. All Pacific cod and pollock captured were young of the year. The abundance of the age-0 2020 cohort was nearly 2 orders of magnitude higher than average CPUE observed in the heatwave years of 2019 and 2014-16. Detailed demographic information was collected on 2,219 Pacific cod (length, weight, condition) and ~1,400 of these fish were retained for a variety of laboratory studies, including analysis of body condition, diets, lipid profiles, otolith microchemistry, and otolith reading to infer hatch phenology and daily growth increments. An additional 642 fin clips were retained for genetic studies.

Sampling at 10 m was also conducted using baited cameras. The camera survey is designed to sample age-1 Pacific cod that are typically beyond the maximum depth range of the beach seine, but too shallow to be available to trawl gear. A total of 40 camera sets were conducted in 12 bays in

2020.

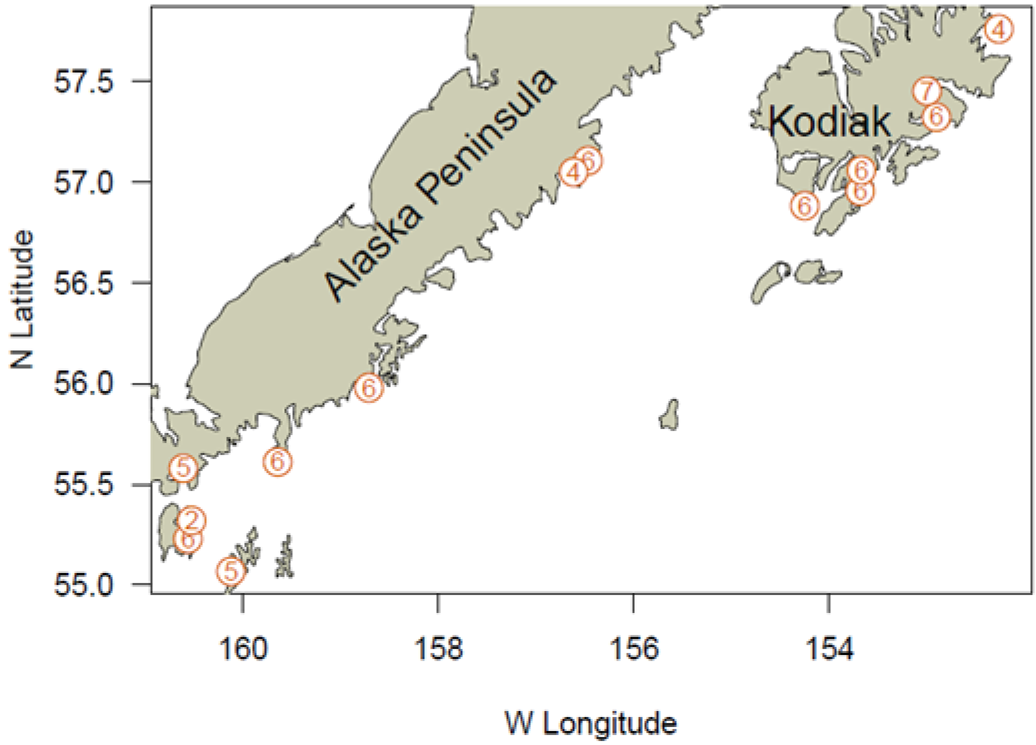

Figure 1: Beach seine sampling locations. Numbers inside circles indicate the total number of seine sets in each bay. A total of 27,992 individuals of 47 species of fish were captured, with age-0 Pacific cod and walleye pollock ranking most common. An additional 40 baited camera sets were also conducted across bays.

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Rapid Larval Assessment in the Bering Sea - RACE RPP (EcoFOCI)

An onboard Rapid Larval Assessment (RLA) was planned on the EcoFOCI spring larval survey from May 14 to May 29, 2020 in the Bering Sea. The RLA is designed to provide early abundance and geographic distribution data for larvae of commercially important fish species, prior to in-depth laboratory assessments. While onboard rough counts of Walleye Pollock have been routinely conducted on EcoFOCI surveys, the protocol was expanded in 2018 to include Pacific Cod, Southern Rock Sole, Northern Rock Sole, and rockfishes. Due to COVID 19, the survey was cancelled and no RLA was taken.

Longline Survey – ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2020. 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 samples gullies not previously sampled during the cooperative longline survey. In 2020, the 43rd annual longline survey sampled the upper continental slope of the Gulf of Alaska and the eastern Aleutian Islands. One hundred and fifty-two longline hauls (sets) were completed during June 3 – August 29 by the chartered fishing vessel *Alaskan Leader*. Total groundline set each day was 18 km (9.7 nmi) and contained 180 skates with 8,100 hooks.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), shortspine thornyhead (*Sebastolobus alascanus*), Pacific cod (*Gadus macrocephalus*), Pacific halibut (*Hippoglossus stenolepis*), and rougheye/blackspotted rockfish (*Sebastes aleutianus/S. melanostictus*). A total of 154,839 sablefish, with an estimated total round weight of 342,601 kg (755,306 lb), were caught during the survey. This represents increases of 30,415 fish and 94,251 kg (207,788 lb) of sablefish over the 2019 survey catch. Sablefish (1,230), shortspine thornyhead (103), and Greenland turbot (*Reinhardtius hippoglossoides*, 1) were tagged with external Floy tags and released during the survey. Length-weight data and otoliths were collected from 2,751 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at seven stations in the eastern Aleutian Islands, five stations in the western Gulf of Alaska and one station in the central Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 14 stations in 2020. Sperm whales were observed depredating on the gear at one station in the western Gulf of Alaska, three stations in the central Gulf of Alaska, four stations in the West Yakutat region, and six stations in the East Yakutat/Southeast region.

In 2020, AFSC permanent staff did not go to sea on the longline survey due to travel restrictions imposed during the COVID-19 global pandemic. In order to keep the survey in operation, a highly experienced contractor served in the role of Chief Scientist for the duration of the survey. With reduced scientific staff onboard, special projects were curtailed but did include the collection of stereo imagery of the hauling station for validating electronic monitoring and a collection of stylasterid corals for an analyses of skeletal and reproductive tissues.

Longline survey catch and effort data summaries are available through the Alaska Fisheries Science Center's website: https://apps-afsc.fisheries.noaa.gov/maps/longline/Map.php. Full access to the longline survey database is available through the Alaska Fisheries Information Network (AKFIN). Catch per unit effort (CPUE) information and relative population numbers (RPN) by depth strata and management regions are available for all species caught in the survey.

For more information, contact Pat Malecha (pat.malecha@noaa.gov). For data access, contact Cara Rodgveller (cara.rodgveller@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.

During 2020 the FMA Division was faced with enormous challenges in facilitating observer training and deployment. Data from observers is essential for managing federal fisheries and choosing to not deploy them was simply not an option. Training and equipping observers from the Seattle campus was challenging because the campus was closed to all but essential staff, and multiple layers of precaution were necessary due to the pandemic. Deployment of observers was difficult due to limits on travel, quarantine requirements, and the risk of infection. In addition, the challenges varied considerably during the year as the assessment of the pandemic, the state and national standards for preventing infection, and the fishing industry's implementation of those standards changed. For further information regarding FMA activities please access the AFSC website or contact Jennifer Ferdinand at Jennifer.Ferdinand@noaa.gov.

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 AFSC and other institutions. Assessments are conducted annually for major commercial groundfish stocks, with biennial or quadrennial 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 accessed on the AFSC website (https://www.fisheries.noaa.gov/alaska/ population-assessments/north-pacific-groundfish-stock-assessments-and-fishery-evaluation).

A. <u>Hagfish</u>

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

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 ~400 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, as well as Antarctic sleeper shark from the Southern Ocean. 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 Antarctic samples have not been run yet. 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. All samples have been consolidated and are being prepared for next generation genome sequencing.

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Ageing of Pacific Sleeper Sharks – ABL

A pilot study is underway by staff at ABL, REFM, the Lawrence Livermore National Laboratory and the American River College 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. For the pilot study, eyes from six animals were removed whole and stored frozen until lab processing. One lens from each shark was excised and lens layers were removed and cleaned by sonication and dried. For larger sharks, both the lens core (earliest deposited material) and outer layer (most recently deposited material) were saved for analysis. Dry samples were sent to an accelerator mass spectrometry (AMS) facility for carbon isotope analyses (^{14}C, ^{13}C), measurement error, and conventional radiocarbon age, when applicable (pre-bomb (<1950); Gagnon et al. 2000) — it was expected that all outer layer samples would be modern and that some cores could have pre-bomb or early bomb ^{14}C rise levels based on rough estimates of age.

Preliminary results demonstrate that ^{14}C is measurable in the eye lens cores and outer layers, and two of the PSS had values that could be correlated with the ^{14}C rise period (late 1950s to mid-1960s; Figure). Specifically, results from the largest shark sampled (310 cm TL) indicate the age was not older than 50 years. This observation is in contrast to the Nielsen et al. (2016) study, which estimated an age of 105 years for a Greenland shark of the same length. Further, our results suggest that the growth rate of PSS could be twice as high as that of the Greenland shark (Figure, inset). For the pilot study, we assumed that the regional bomb ^{14}C reference curve was from two long-lived teleost fishes from the GOA and that exposure and uptake of ^{14}C by PSS was similar. In 2020, we submitted a proposal to further fund this study and address the concerns and assumptions highlighted by the pilot study work.

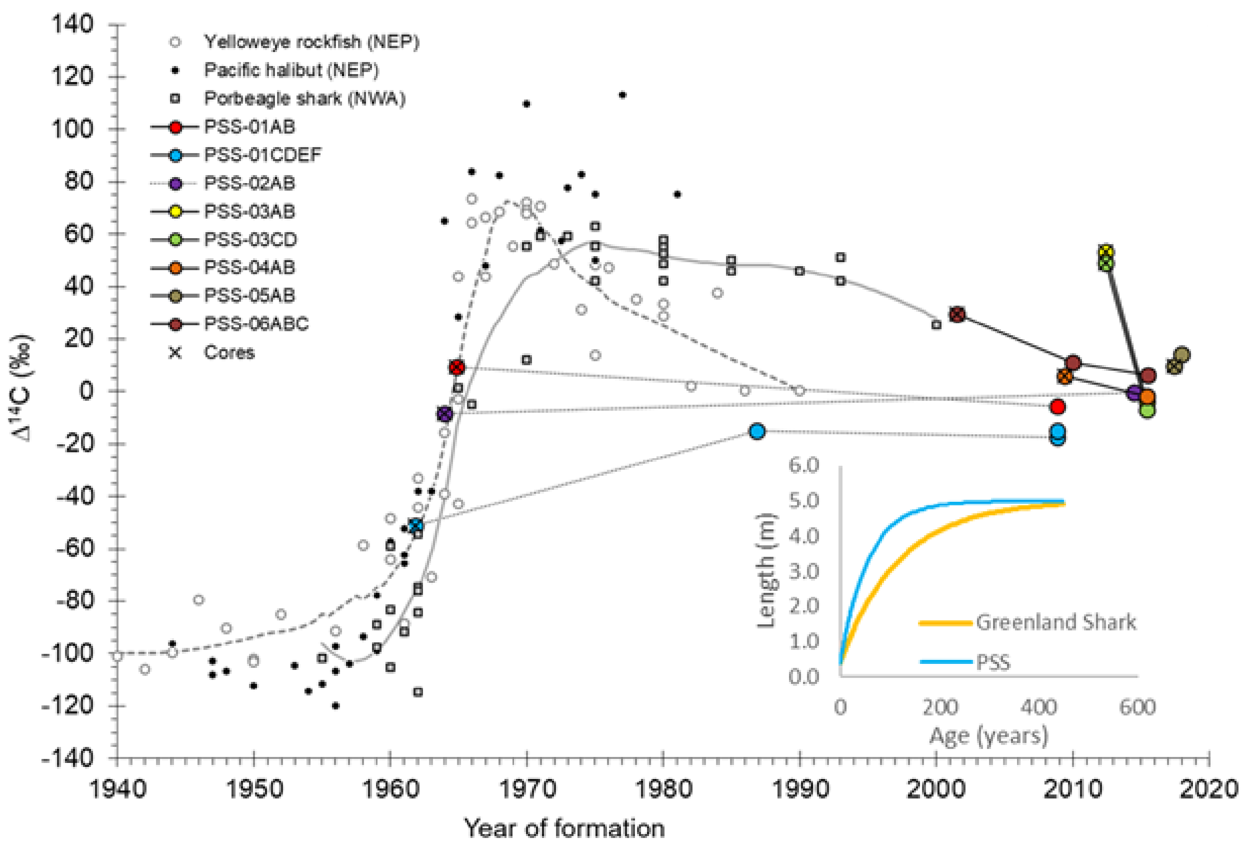

Figure. Pacific sleeper shark (PSS) eye lens 14C values from the pilot study plotted as estimated year of formation relative to regional 14C references. Data from six sharks (PSS-01 to PSS-06, Table 1) are shown as a series of samples from the core to the outer eye lens. Both eye lenses were sampled in two sharks (PSS-01 and PSS-03). Core ("birth year") layers are indicated with an X over the colored specimen symbol. Published bomb 14C chronologies were used as temporal references from the northeastern Pacific Ocean (yelloweye rockfish (Kerr et al. 2004) and Pacific halibut (Piner and Wischniowski 2004). A shark chronology from the northwestern Atlantic Ocean is shown for comparison (porbeagle shark; Campana et al. 2002). (inset) Von Bertalanffy growth curves based on pilot study results. The PSS growth curve is adjusted from the Greenland shark curve to intersect the data for the largest fish in our pilot study, resulting in the blue curve. These results suggest that the PSS growth coefficient (k) is roughly two times greater than that of the

Greenland shark.

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Shark tagging – 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, along with Julie Nielsen (Kingfisher Marine Research) have developed a Hidden Markov Movement (HMM) model based on these tag data which incorporates environmental variables (e.g. temperature/depth profiles and sea-surface temperature). The HMM model provides 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. A manuscript detailing the model development is in review. Further manuscripts are in preparation.

Staff at ABL, UAF, the Alaska Sea Life Center, Kingfisher Marine Research, and Wildlife Technology Frontiers have begun a collaborative tagging project on Pacific sleeper shark. This NPRB funded project will apply modern modelling techniques to historical PSAT data, as well as deploy and analyze data from recent and future tags.

Staff at ABL are collaborating with ADF&G, UAF, and Kingfisher Marine Research to deploy tags on salmon shark in the GOA. To date, two male salmon shark have been tagged in the Northern Bering Sea, each with both a SPOT (i.e., GPS) and PSAT tag. The SPOT tags provide multiple years of position data when the shark is at the surface, while the PSAT provides detailed temperature and depth movement. The two data sets will be combined to validate the HMM model. This study is unique in that nearly all previous tagging on the species was on females captured in Prince William Sound. Early results suggest seasonal migration to/from the Northern Bering Sea, but not necessarily the same movement pattern between years. A manuscript is in review detailing first year movement for each of the two sharks (Figure). Further tags are planned for 2021 and onwards as tags and opportunities are available.

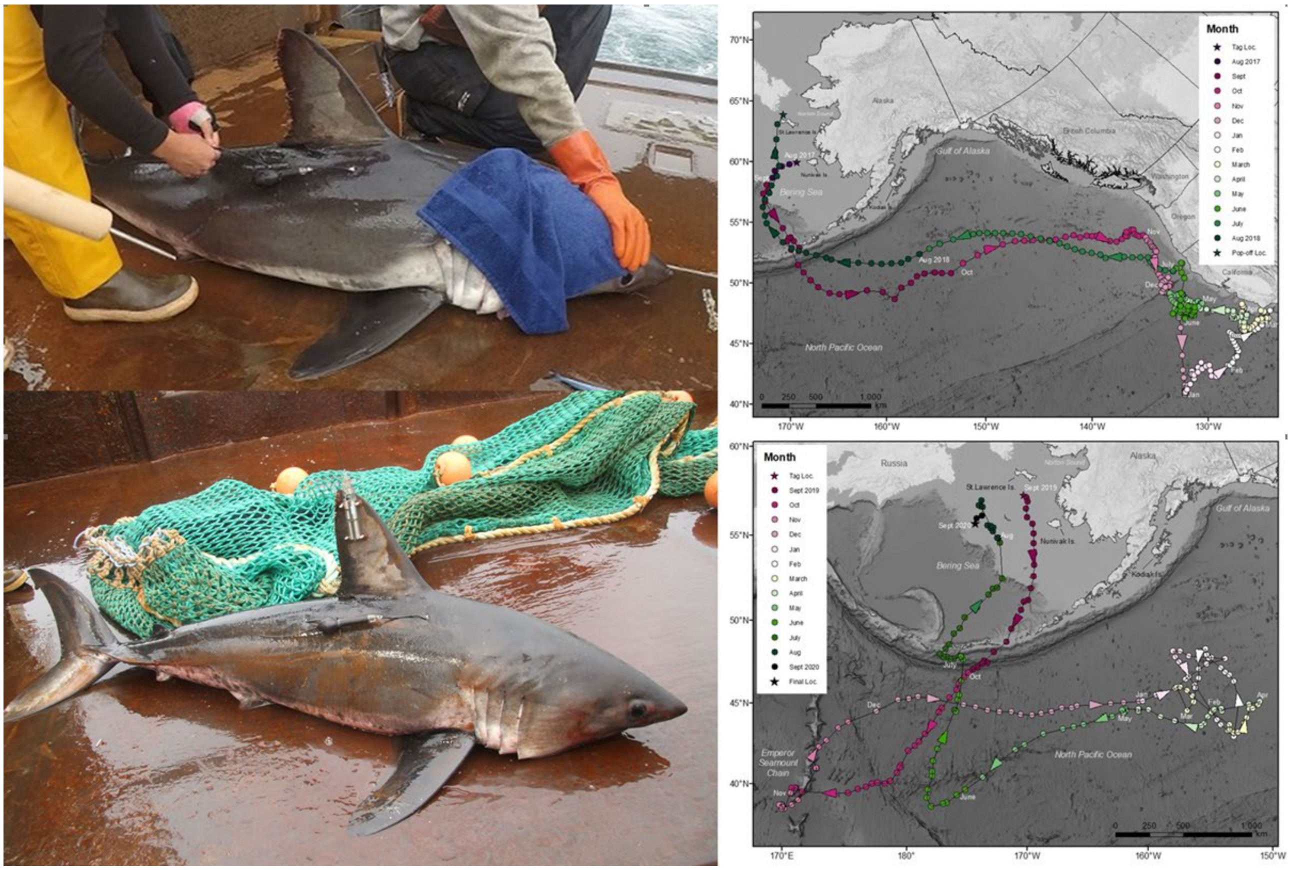

Figure. (Left) Shark A (top) being tagged with a PSAT using two tethers on August 27, 2017. The harness of the second tether attachment is being looped around the body of the tag. Shark B (bottom) with a SPOT-257 tag affixed to the dorsal fin and a PSAT attached with two tethers in the musculature beneath the dorsal fin. Data from Shark B's PSAT are not reported here. (Right) Monthly HMM-derived locations from August 27, 2017 – August 28, 2018 for Shark A (top) and best daily locations transmitted by a SPOT tag carried by Shark B (bottom) from September 7, 2019 through September 6, 2020. Arrows depict swim direction.

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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 2020 assessments, catch estimates from 2003-2020 were updated from the NMFS Alaska Regional Office's Catch Accounting System. In the GOA, total shark catch in 2020 was 1,625 t, which was down from the 2019 catch of 1,997 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), 194 t in 2019 and 306 t in 2020, 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 GOA trawl survey was in 2019, with the next planned for 2021. The trawl survey biomass estimates are used for ABC and OFL calculations for spiny dogfish and are not used for other shark species. The 2019 survey biomass estimate for spiny dogfish (22,014 t, CV = 15%) was the lowest biomass since the 1990 survey and substantially lower than the last four surveys (2017 biomass was 59,979, CV = 19%). 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. Spiny dogfish are Tier 5, where the random effects biomass estimates are adjusted by a catchability parameter and multiplied by $F_{OFL} = F_{max}$ from a demographic analysis to estimate the OFL. 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 = 3,775 t and OFL = 5,006 t for 2021 and 2022.

The shark stock complex in the BSAI are all considered Tier 6 because the survey biomass estimates are highly uncertain and not informative. 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 2021 and 2022 were ABC = 517 t and OFL = 689 t. In the BSAI, estimates of total shark catch from the Catch Accounting System from 2020 were 180 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 (92 t and 106 t salmon shark in 2019 and 2020, respectively and 53 t and 68 t of Pacific sleeper sharks).

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C. <u>Skates</u>

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.

The skate complex in the BAI is assessed biennially, with full assessments in even years and partial updates in odd years.For the skate complex as a whole, the ABC for 2020 is 41,543 t and the OFL for 2020 is 49,792 t.

Gulf of Alaska (REFM)
There are currently no target fisheries for skates in the Gulf of Alaska (GOA), and directed fishing for skates is prohibited. Incidental catches in other fisheries are sufficiently high that skates are considered to be "in the fishery" and harvest specifications are required. The GOA skate complex is managed as three units. Big skate (*Beringraja binoculata*) and longnose skate (*Raja rhina*) have separate harvest specifications, with Gulf-wide overfishing levels (OFLs) and Acceptable Biological Catches (ABCs) specified for each GOA regulatory area (western [WGOA], central [CGOA], and eastern [EGOA]). All remaining skate species are managed as an "other skates" group, with Gulf-wide harvest specifications. All GOA skates are managed under Tier 5, where OFL and ABC are based on survey biomass estimates and natural mortality rate. Effective January 27, 2016 the Alaska Regional Office indefinitely reduced the maximum retainable amount for all skates in the GOA from 20% to 5%.

Following are the main developments in the 2019 skate assessment:

1) Big skate biomass increased relative to 2017 (2019 survey estimate of 43,482 t versus 33,610 in 2017). This resulted in a slight increase in the random-effects model biomass estimate and corresponding increase in the overall recommended harvest. Because the distribution of big skate biomass among areas shifted in 2019, the ABC in the CGOA actually declined and the increased ABC occurred in the WGOA and EGOA.
2) The longnose skate biomass decreased in 2019 (survey biomass estimates of 32,279 t in 2019 versus 49,501 t in 2017). The area ABCs fell in the CGOA and EGOA while increasing slightly in the WGOA.
3) The biomass of other skates continues to decline from a peak in 2013. This resulted in reduced OFL and ABC.
4) The increased biomass of big skates on the eastern Bering Sea shelf observed beginning in 2013 continues. There is strong evidence to suggest that these skates originated in the GOA and that there is exchange between the areas. This movement is likely influencing GOA biomass estimates.

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D. Pacific Cod

1. Research

Multiple AFSC research activities regarding Pacific cod- REFM, RACE, ABL
There have been dramatic developments regarding the Pacific cod populations in Alaskan waters over the last few years. In the BSAI region, there is strong evidence that cod moved north in the

Bering Sea when temperatures were warm and ice cover was reduced. In the GOA region, the mid-decade marine heat wave appears to have negatively impacted the cod stock with lingering aftereffects. For these reasons and others, Pacific cod have become a major research focus for the AFSC.

The AFSC allocates personnel and funding according to diverse activity plans. Beginning in 2018 and continuing into 2021, the AFSC initiated a cross-divisional activity plan specific to Pacific cod. This activity plan is directly responsive to AFSC's core research portfolio as well as national initiatives including the Next Generation Stock Assessment Improvement Plan, NMFS Climate Science Strategy and the EBFM roadmap.

Cod appear unique in their strong spatial structuring, migration patterns, and sensitivity to temperature. The projects outlined here are designed to test and implement the performance of an ecosystem-based fisheries management approach for Pacific cod in the eastern Bering Sea (EBS), Aleutian Islands (AI), and GOA and to examine key mechanisms governing the past, current, and future role of climate variability and change on the distribution and abundance of Pacific cod stocks. Tagging work conducted in 2019 has confirmed the utility of satellite tagging, and a small number of cod tagged in the northern Bering Sea appeared to move southward later in the year. More work is needed to understand spawning and migration patterns and responses to climate change that can be integrated into model projections. Research will be conducted in 2021 to resolve important management issues, including: (1) migration patterns of cod found in the western GOA, EBS shelf, northern Bering Sea and Chukchi Sea; (2) whether EBS stocks will establish new spawning grounds in the north or change spawn timing; (3) gear selectivity parameters for assessment; and (4) how juvenile ecology in the western GOA relates to stock recovery under continuing climate anomalies.

The research activities listed below are designed to provide resolution to pressing issues related to Pacific cod:

1. Bioinformatics support to prepare GTseq panel for rapid identification of spawning population of origin of Pacific cod: Ongoing work since 2017 (funded by a Saltonstall-Kennedy grant and AFSC) has successfully sequenced the whole genome of 384 cod throughout their range in Alaska and development of a genotyping-by-sequencing panel (GTseq) is underway. The GTseq panel will incorporate several hundred SNPs that identify Pacific cod to their spawning population of origin.

2. Maturation studies: This project was initiated in 2019, and in 2021 will prioritize sampling and processing efforts towards developing region-specific maturity curves to be used in stock assessments.

3. Incorporating Pacific cod novel spatial dynamics in the stock assessment model: During recent years Pacific cod movement patterns have changed in the EBS, increasing the displacement northwards into the NBS. These patterns are expected to persist in future due to global warming, and will cause changes in several aspects of the cod population dynamics such as spawning and recruitment areas and natural mortality rates, aspects that need to be considered in the assessment. The Pacific cod stock assessment is implemented in Stock Synthesis (SS), a flexible modeling platform that allows for a wide range of data types, including movement patterns. Using SS and information from previous and ongoing studies, we evaluate the effects of observed spatial patterns on stock assessment outputs by simulating: i) spatial changes in spawning grounds and recruitment

areas, and ii) variations in survival and growth of new recruits. Also, we will evaluate effective ways to incorporate this complex spatial dynamic into the stock assessment model. The results of this effort will provide an important improvement to the current assessment and plan for future consequences to the productivity of the stock.

4. Understanding Pacific cod availability to survey vs. fishery: This work will analyze existing fishery and survey catch data from EBS and Aleutian Islands including spatial and temporal comparison of catch rates and length distribution and existing tag data (conventional, PSAT, and archival) to better understand cod availability to the survey vs. fishery. Project will incorporate existing selectivity ratio estimation methodology developed by Kotwicki and will result in a peer-reviewed publication and priors for stock assessment. Further, this study will incorporate food habits data to identify occurrences of midwater species prey.

5. Assessment of age-0 juvenile cod in the Western GOA: This is the 3rd year of annual sampling using a beach seine in 0-3 m water along 13 different bays from the east side of Kodiak Island, the Alaska Peninsula, and into the Shumagin Islands. Sampling covers 72 fixed-site locations and 36 non-fixed sets of video surveys (baited cameras, 5 - 20 m). The project provides CPUE data for age-0 Pacific cod and other key species. Age-0 Pacific cod length, weight, condition, diet, and tissue samples (for lipids and genetics) are also obtained from each of the 13 bays. This survey, along with a smaller-scale Kodiak survey, provides direct observations on the lingering effects of marine heatwaves on Pacific cod populations in the GOA at a spatial scale that overlaps with the presumed main spawning area of the region. This work is also a sampling platform for a funded genetics project to identify the natal spawning area of sampled juveniles.

6. Can cod spawn North? Pacific Cod larval and juvenile dispersal from the NBS: Using retrospective analyses on Pacific cod larval and juvenile distribution in the Bering Sea, we will: 1) statistically determine phenology and habitat features that correlate with Pacific cod larvae and juveniles, and 2) simulate larval dispersal trajectories, foraging, and growth, from newly putative spawning areas, using IBM and hindcast/forecast of existing ocean circulation models. Simulations will include scenarios to address potential adaptive strategies, such as change in phenology and pelagic larval duration (PLD). These simulations will reveal whether new spawning activity northward of current spawning grounds is likely to be successful, given the foraging and nursery requirements of larval and juvenile cod, and whether there is adaptive potential (phenology, PLD) for establishing new spawning areas. Specifically, this project will fund a post-doc for 1 year.

7. PSAT #2 - Gulf of Alaska (Winter 2021); EBS and Chukchi, Summer 2021: Continuation of project to examine annual variation of migratory movement patterns including tagging in the Western Gulf of Alaska, over the EBS shelf, NBS, and southern Chukchi using pop-up satellite archival tags.

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Pacific cod juveniles in the Chukchi Sea-RPP

Dan Cooper, Kris Cieciel, Louise Copeman, Libby Logerwell, Pavel Emelin, Robert Levine, Robert Lauth, Lyle Britt, Rebecca Woodgate, Jesse Lamb, Ben Laurel, Nissa Ferm, Johanna Vollenweider, and Alexei Orlov.

Past data have shown that the spatial distribution of Pacific cod shifted northward in the Bering Sea between 2010 and 2017, during the recent warm period (Stevenson and Lauth, 2019). In the Chukchi Sea, however, although Pacific cod juveniles have historically been present in some years, there are no known (to us) records of adults. From 2010 to 2019, we surveyed the eastern and western Chukchi Sea using a variety of trawl gears. We use length modes of juvenile Pacific cod to assign fish to age-0 and age-1 age classes. Age-0 Pacific cod were present in the eastern Chukchi Sea in 2017 and 2019, but were absent in 2012. Our data show that age-0 fish in the eastern Chukchi Sea use both pelagic and benthic habitat to feed on different prey resources, however fatty acid analysis indicates that the fish may move between pelagic and benthic habitat, and poor lipid accumulation by juvenile fish may lead to high mortality. Age-1 fish were present in the eastern Chukchi Sea in 2012, and in the western Chukchi Sea in 2018 and 2019, suggesting that the 2011, 2017, and 2018 year classes either successfully recruited to the Chukchi Sea and overwintered, or moved into the Chukchi Sea from the northern Bering Sea. We suggest that age-0 recruitment to the eastern or western Chukchi Sea is associated with warm temperatures and increased northward transport through the Bering Strait in the spring, when Pacific cod larvae are present in the northern Bering Sea. We found no evidence that Pacific cod juveniles in the Chukchi Sea survive past age-1. The first known (to us) adult Pacific cod were present in the western Chukchi Sea in 2018 and 2019, although estimated densities were very low. One adult Pacific cod was caught in the eastern Chukchi Sea in 2019, however estimated densities in the eastern Chukchi Sea are unknown due to lack of monitoring with a benthic trawl capable of catching adult fish. It is unknown whether the Pacific cod observed in the Chukchi Sea will perish, migrate somewhere else, or survive in the Chukchi Sea as part of a further northward range expansion.

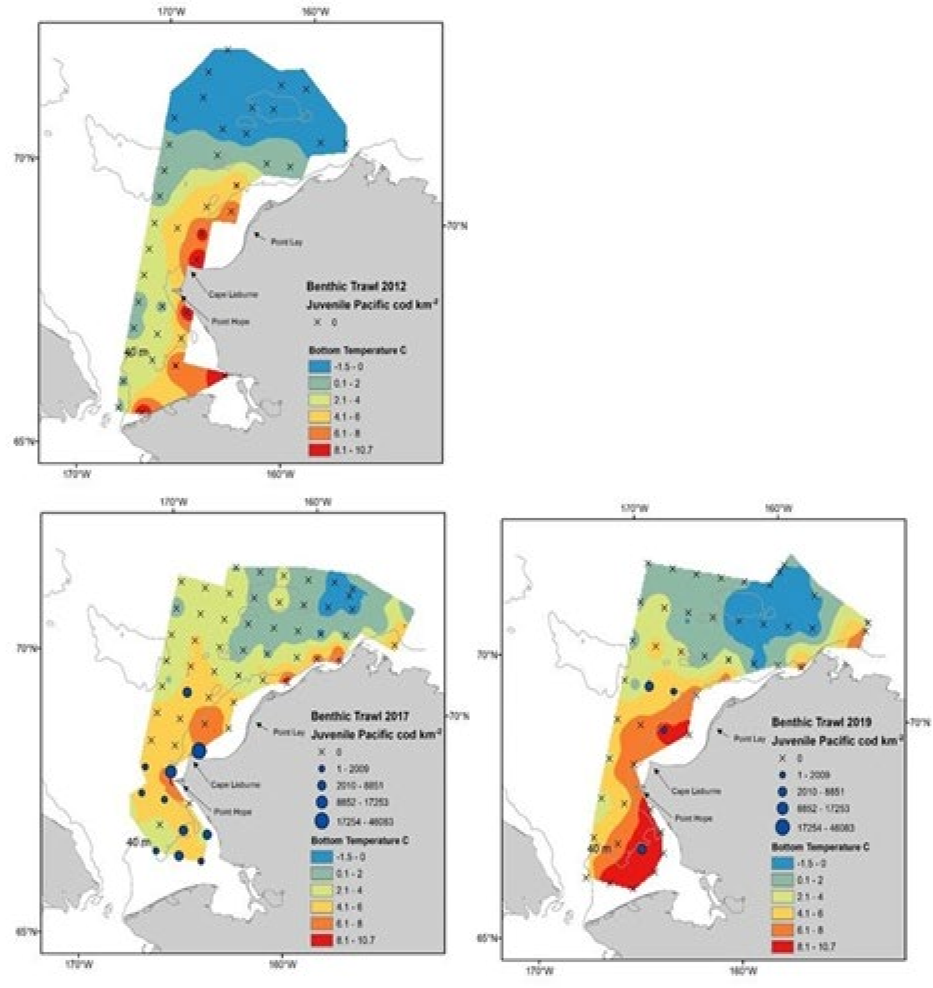

Figure 1. Age-0 Pacific cod catch per unit effort and bottom temperature interpolations from 2012, 2017, and 2019.

Cod species and population structure in the Arctic - ABL

Adult gadids were collected in 2012-2013 by the Bering Arctic Subarctic Integrated Survey (BASIS) and age-0 gadids in 2017 and 2019 by the Arctic Integrated Ecosystem Research Program (Arctic IERP). Surveys of the Chukchi Sea during the colder years of 2012 and 2013 detected few age-0 walleye pollock amidst a many arctic cod. During the 2017 and 2019 surveys, approximately half of the age-0 gadids were initially misidentified morphologically at sea. Survey results, and thus information for downstream analyses, were corrected for species identification by genetically analyzing over 6000 age-0 gadids from the 2017 and 2019 collections. This genetic identification data revealed a dramatic shift north of walleye pollock (*Gadus chalcogrammus*) and arctic cod (*Boreogadus saida*), as well as Pacific cod (*Gadus macrocephalus*) and saffron cod (*Eleginus gracilis*). A small number of *Arctogadus glacialis* (n=12) were identified in the northernmost areas of the survey (latitude 73N). Throughout the warmer years of 2017 and 2019, walleye pollock became the dominant cod species in the Chukchi Sea.

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2. Stock Assessment

Eastern Bering Sea (REFM)
Pacific cod (*Gadus macrocephalus*) is a transoceanic species, ranging from Santa Monica Bay, California, northward along the North American coast; across the Gulf of Alaska and Bering Sea north to Norton Sound; and southward along the Asian coast from the Gulf of Anadyr to the northern Yellow Sea; and occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34 N latitude, with a northern limit of about 65 N latitude. Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area. Tagging studies have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA). However, recent research indicates the existence of discrete stocks in the EBS and AI. Research conducted in 2018 indicates that the genetic samples from the NBS survey in 2017 are very similar to those from the EBS survey area, and quite distinct from samples collected in the Aleutian Islands and the Gulf of Alaska. Although the resource in the combined EBS and AI (BSAI) region had been managed as a single unit from 1977 through 2013, separate harvest specifications have been set for the two areas since the 2014 season.

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 and during 2017-2019, 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 have been made or considered in the stock assessment model since the 2018 assessment. Seven models (including the current base model) were presented in this year's preliminary assessment. After reviewing the preliminary assessment, the SSC and Team requested that all of the models from the preliminary assessment be presented in the final assessment. In addition, the SSC requested three more new models. Following further explorations by the senior author and consultation with the SSC co-chairs and the Team and SSC rapporteurs assigned to this assessment, a compromise set of ten models (including the current base model) are included here. The nine new models are treated both individually and as an ensemble, with results for the latter presented as both weighted and unweighted averages.

Female spawning biomass for 2020 and 2021 is estimated by ensemble weighted average to be 259,509 t and 211,410 t, respectively, both of which are below the B40% value of 266,602 t. Given this, the ensemble weighted average estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2020 and 2021 as follows: in 2020 OFL is 185,650 t and maxABC is155,873 t ; in 2021 OFL is 123,331 t and maxABC is 102,975 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. For 2020 and 2021, the recommended ABC is 20,600 t, and OFL is 27,400 t.

Gulf of Alaska (REFM)
The 2019 assessment indicates that the stock has been lower in abundance than previously thought. It shows that the stock was likely below B20% since 2018 and will remain below until 2021. Although the AFSC bottom trawl survey index value did increase, the increase was not as high as last year's model had predicted. To accommodate these new data the model estimated the spawning biomass to have been lower than what was estimated last year relative to the unfished biomass. This not only drove 2018-2019 to be below B20%, but also, despite an increasing trend, predicted that the stock would remain below B20% in 2020. For 2020 the stock is estimated to be at B17.6%, above but very near the overfished determination level. The beginning of the year 2020 spawning biomass level is projected to be the lowest of the time series and with the 2017 and 2018 year classes should see an increase above B20% at the start of 2021.

Spawning biomass for 2020 is estimated by this year's model to be 32,958 t at spawning. This is below the B40% value of 75,112 t, thereby placing Pacific cod in sub-tier "b" of Tier 3. Given this, the model estimates the 2020 OFL at 17,794 t and the maxABC at 14,621.

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

F. <u>Walleye Pollock</u>

1. Research

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

Description of indicators: The temperature change (TC) index is a composite index for the preand post-winter thermal conditions experienced by walleye pollock (*Gadus chalcogrammus*) from age-0 to age-1 in the eastern Bering Sea (Martinson et al., 2012). The TC index (year t) is calculated as the difference in the average monthly sea surface temperature in June (t+1) and August (t) (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 (193.1, 198.8 longitude). Time series of average monthly sea surface temperatures were obtained from the NOAA Earth System Research Laboratory Physical Sciences Division website. Sea surface temperatures were based on NCEP/NCAR gridded reanalysis data (Kalnay et al., 1996, data obtained from http://www.esrl.noaa.gov/psd/cgi-bin/data/timeseries/timeseries1.pl). Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock.

Status and trends: The 2020 TC index value is -6.30, lower than the 2019 TC index value of -1.96, indicating below average conditions for pollock survival from age-0 and age-1 from 2019 to 2020. The decrease in expected survival is due to the larger difference in sea temperature from late summer (warm) to the following spring (warm). The late summer sea surface temperature (August 13.3 °C) in 2019 was 3.5 °C higher the longer term average (9.8 °C) and spring sea temperature (June 7.0 °C) in 2020 was warmer than the long-term average of 5.2 °C in spring since 1949. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-6 for the longer and shorter periods, significantly correlated for ages 5 and 6 for 1996-2014, -2013 year classes, but not significantly correlated for the shorter period for age-1 (including the 1996-2018 year classes) through age-4 pollock (including the 1996-2015 year classes) (Table 1).

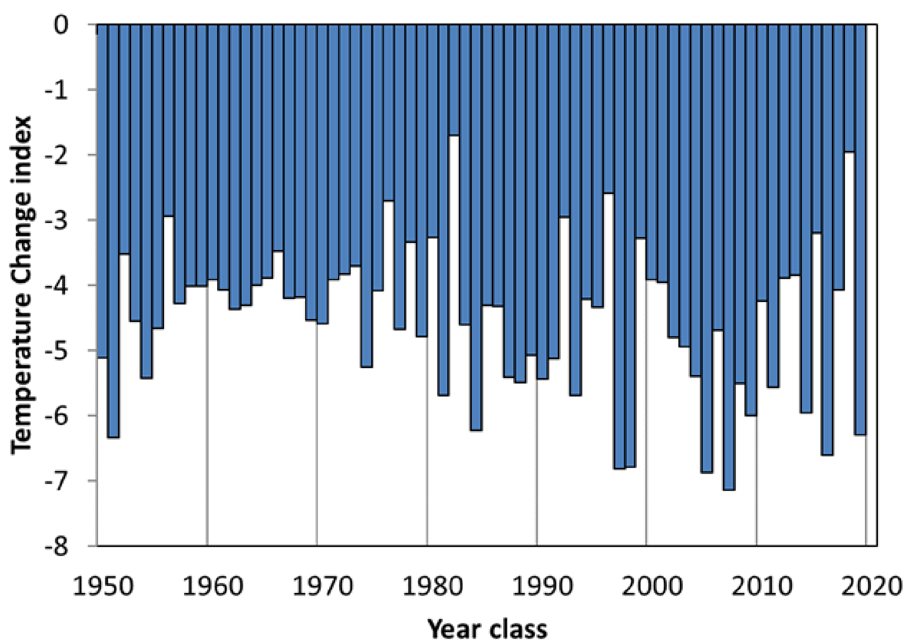

Figure 1: The Temperature Change index values for the 1950 to 2019 year classes of pollock. Values represent the differences in sea temperatures on the south eastern Bering Sea shelf experienced by the 1950-2019 year classes of pollock. Less favorable conditions (more negative values) represent a warm 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.

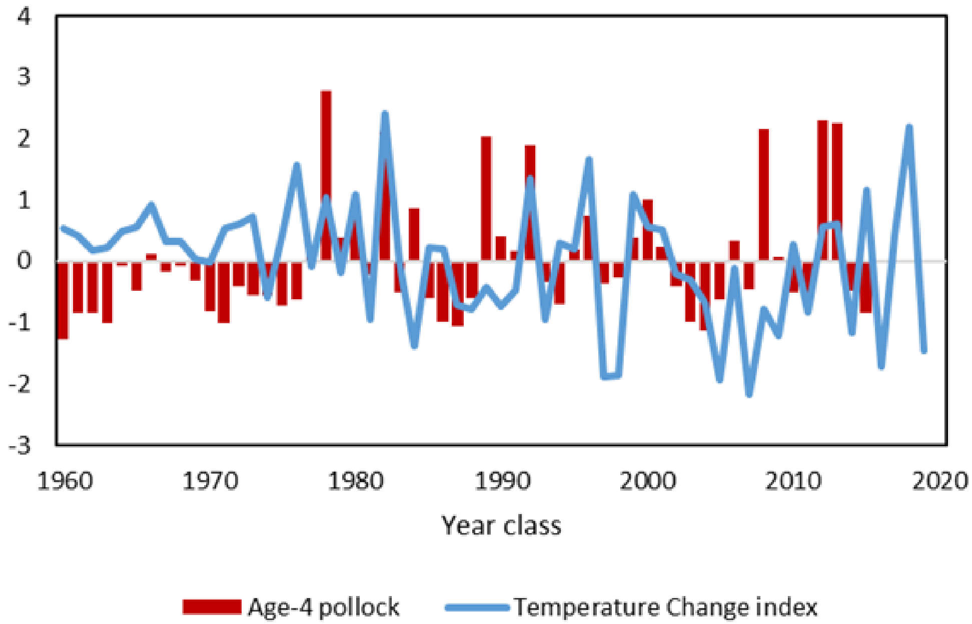

Figure 2: Normalized time series values of the temperature change index indicating conditions experienced by the 1960-2019 year classes of pollock during the summer age-0 and spring age-1 life stages. Normalized values of the estimated abundance of age-4 walleye pollock in the eastern Bering Sea from 1964-2019 for the 1960-2015 year classes. Age-4 walleye pollock estimates are from Table 30 in Ianelli et al. 2019. The TC index indicate below average conditions for the 2019 year classes of pollock.

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

	Correlations					
	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
1964-2018	**0.34**	**0.37**	**0.36**	**0.31**	**0.31**	**0.30**
1977-2018	**0.41**	**0.45**	**0.46**	**0.45**	**0.52**	**0.52**
1996-2018	0.32	0.38	0.40	0.38	**0.48**	**0.44**

Factors causing observed trends: According to the original Oscillating Control Hypothesis (OCH), warmer spring temperatures and earlier ice retreat led to a later oceanic and pelagic phytoplankton bloom and more food in the pelagic waters at an optimal time for use by pelagic species (Hunt et al., 2002). The revised OCH indicated that age-0 pollock were more energy-rich and have higher over wintering survival to age-1 in a year with a cooler late summer (Coyle et al., 2011; Heintz et al., 2013). Therefore, the warmer later summers during the age-0 phase followed by warmer spring temperatures during the age-1 phase are assumed unfavorable for the survival of pollock from age-0 to age-1. The 2019 year class of pollock experienced above average summer temperatures during the age-0 stage and a warm spring in 2019 during the age-1 stage indicating below average conditions for over wintering survival from age-0 to age-1.

Implications: The 2020 TC index value of -6.3 was below the long-term average of -4.58, therefore we expect below average recruitment of pollock to age-4 in 2023 from the 2019 year class (Figure 2).

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

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

Contributions from: Ellen Yasumiishi, Lisa Eisner, and David Kimmel

Description of indicator: Interannual variations in large copepod abundance during the age-0 life stage were compared to age-3 walleye pollock (*Gadus chalcogrammus*) abundance (billions of fish) for the 2002-2018 year classes on the southeastern Bering Sea shelf, south of 60°N, < 200 m bathymetry (Eisner et al. 2020). 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 (Coyle et al. 2011). 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 or 60 cm, 505 µm nets, depending on taxa and stage for 2012-2018. Data were collected on the Bering Arctic Subarctic Integrated Survey (BASIS) fishery oceanography surveys and along the 70 misobath during mid-August to late September, for four warm years (2002-2005) followed by one average (2006), six cold (2007-2012), four warm (2014-2016, 2018) and an average year (2017, 70 m isobath only) using methods in Eisner et al. (2014). Zooplankton data were not available for 2013. Age-3 pollock abundance was obtained from the stock assessment report for the 2002-2016 year classes (Ianelli et al., 2019). Two estimates of large copepod abundances were calculated, the first using means among stations (sample-based), and the second using the means estimated from the geostatistical model, Vector Autoregressive Spatial Temporal (VAST) package version 9.4.0 (Thorson et al., 2016a, b; Thorson and Barnett, 2017). We specified 30 knots, a log normal distribution, and the delta link function between probability or encounter and positive catch rate in VAST.

Status and trends: Positive significant linear relationships were found between BASIS sample-based mean abundances, BASIS VAST-modeled mean abundances, and sample-based mean abundances from the 70 m isobath surveys of large copepods collected during the age-0 stage of pollock and stock assessment estimates of age-3 pollock for the 2002-20155 year classes (Figure 1). For the BASIS survey stations, the stronger relationship of age-3 pollock with the large copepod index using the VAST model compared to observed means among stations (R^2 = 0.720 vs R^2= 0.43) appeared to be partially due to the VAST model filling in data for survey area missed in some years (e.g., 2008).

Fitted means and standard errors of the age 3 pollock abundances were estimated from the linear regression model using large copepod estimates from the BASIS VAST model and compared to the pollock stock assessment estimates from Ianelli et al. (2019) (Figure 2). Using the linear regression model relating copepods to age-3 pollock for the 2002-2016 year classes, the VAST copepod estimates in 2018 (5321 #/m^2) predicts below average abundance of age-3 pollock in 2021 (3959 million, SE=642 million) for the 2018 year class. For data collected from the 70m isobath, the large copepod index from 2017 predicts relatively higher recruitment of Pollock to age-3 in 2020 than from the 2018 year class that will recruit to age-3 in 2021. However, the low values of the copepod indices predict relatively low recruitment to age-3 for the 2017 and 2018 year classes of pollock.

Implications: Our results suggest low availability of large copepod prey for age-0 pollock during the first year of life in 2017 and 2018. These conditions may not be favorable for age-0 pollock overwinter survival and recruitment to age 3. Information from the 70 m isobaths survey may be useful in years of no BASIS survey in the southeast Bering Sea. 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, from zooplankton data collected three years prior. This relationship also provides further support for the revised oscillating control hypothesis that suggests as the climate warms, reductions in the extent and duration of sea ice could be detrimental large crustacean zooplankton and subsequently to the pollock fishery in the southeastern Bering Sea (Hunt et al., 2011).

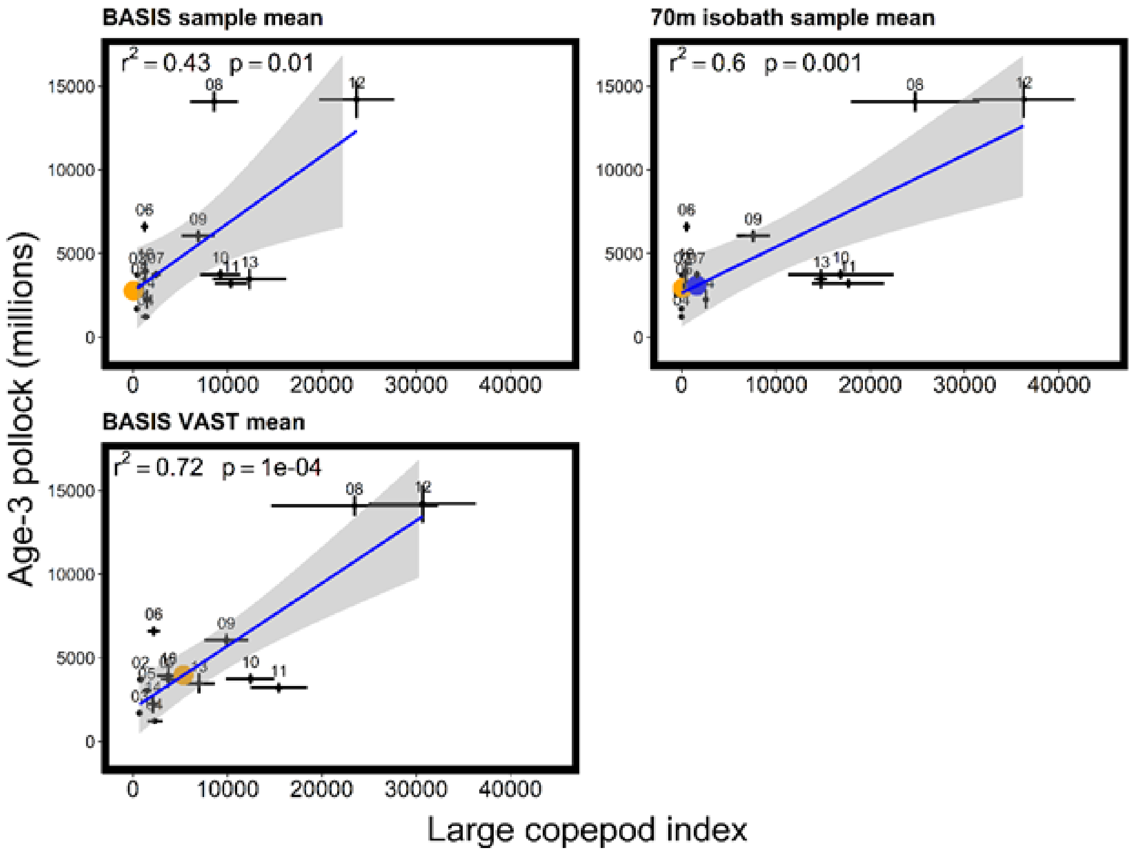

Figure 1. Linear relationships between sample-based (top) from the BASIS and 70 m isobaths surveys and BASIS VAST-model (bottom) estimated mean abundance of large copepods (C+MN, sum of *Calanus marshallae/glacialis, Metridia pacifica* and *Neocalanus* spp.) during the age-0 life stage of pollock, and the estimated abundance (millions) of age-3 pollock from Ianelli et al. (2019) for 2002-2016 year classes. No zooplankton data were available for 2013. The orange dots represents the values for the large copepod index in 2018 and the blue dot for the 2017 year class.

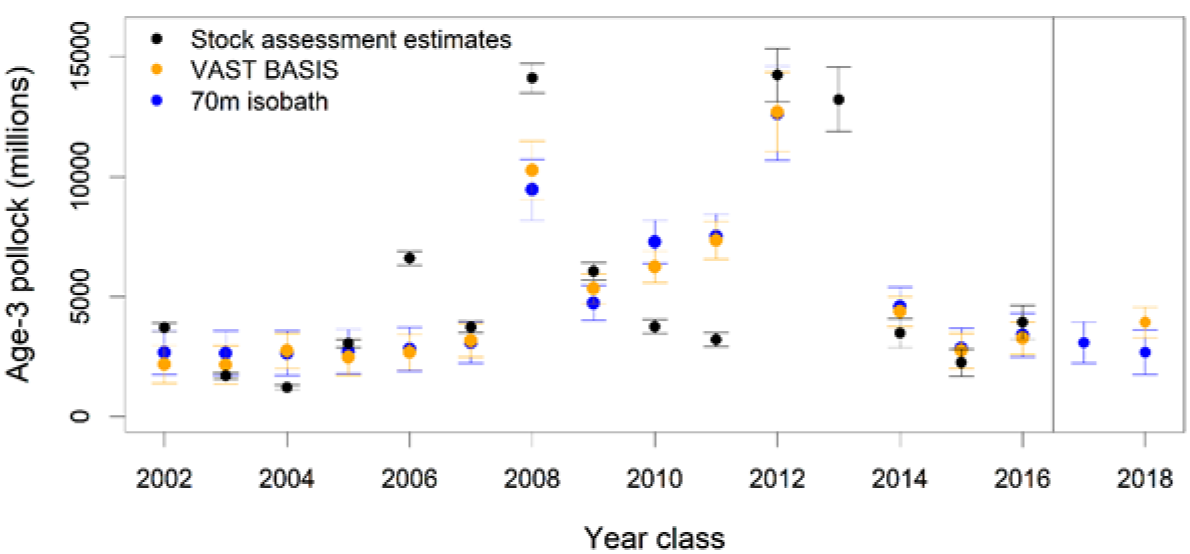

Figure 2. Fitted means and standard errors of the age-3 pollock abundance estimated from the linear regression models using VAST estimates of large copepods (orange), sample mean abundance of large copepods at the 70m isobaths stations (blue), and means from the pollock stock assessment estimates (black) from Ianelli et al. (2019). Predicted estimates of age-3 pollock (recruited into fishery as age 3's in 2021) are shown for the 2017 and 2018 year classes.

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Ocean acidification effects in larval walleye pollock-FBE RACE

Laboratory analyses were conducted to broaden understanding of the effects of increasing oceanic CO_2 levels (ocean acidification) on walleye pollock. This work builds upon an initial work which indicated general resiliency of walleye pollock to high CO_2 levels and the observation of sub-lethal effects of CO_2 on Pacific cod and other gadids. This work examined the effect of CO_2 on aspects of larval development, growth, survival, swimming patterns, and energy storage. Observations on growth rates were consistent with previous work showing little effect on growth rate or condition factor. There was a notable effect of high CO_2 resulting in a reduced rate of swim bladder inflation in larval pollock. Inflation of the swim bladder is an important milestone in the development of the fish and includes both physiological and behavioral components. While these finding generally support the notion that walleye pollock are less sensitive to elevated CO_2 levels than other marine gadids, it is possible that the reduced rate of swimbladder inflation could carry over with negative impacts on growth or survival in later larval stages.

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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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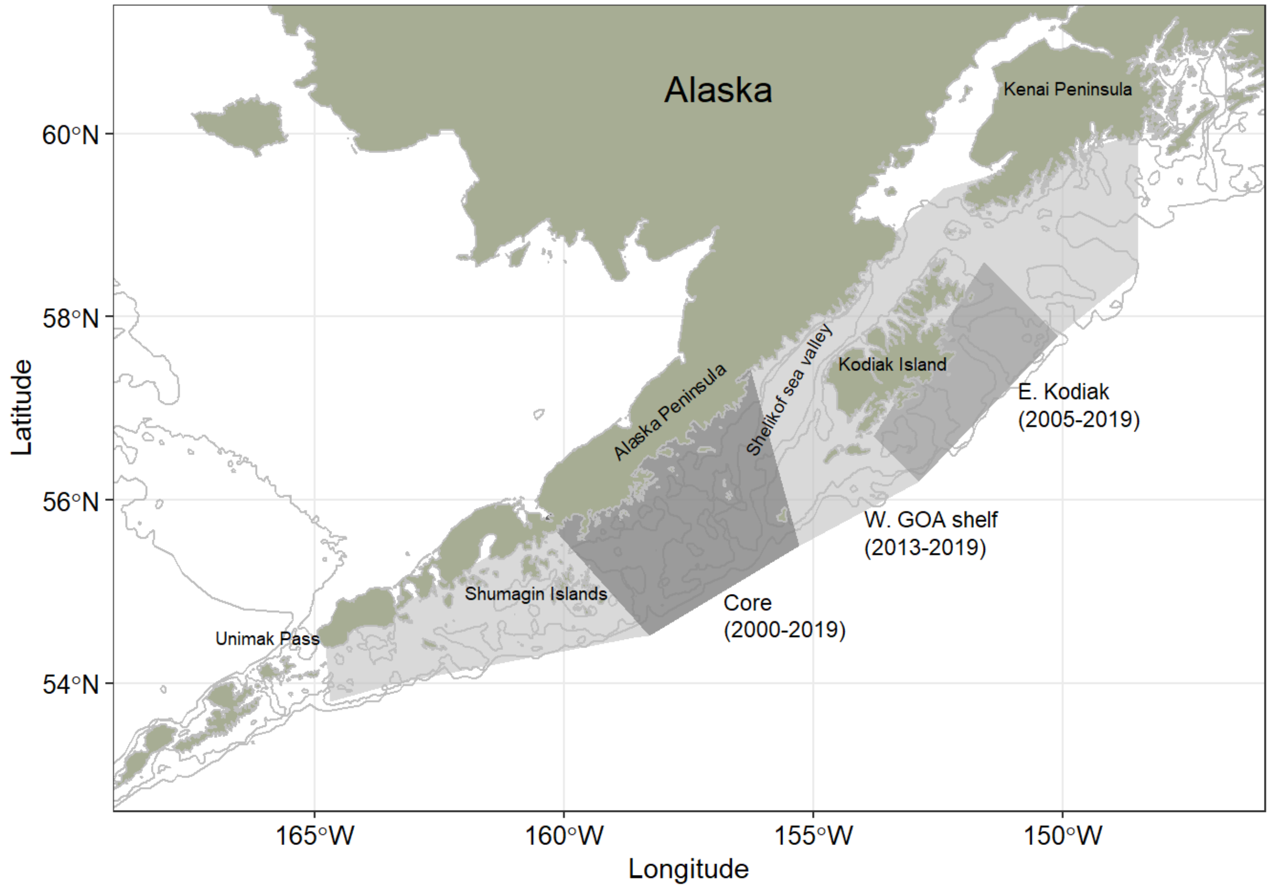
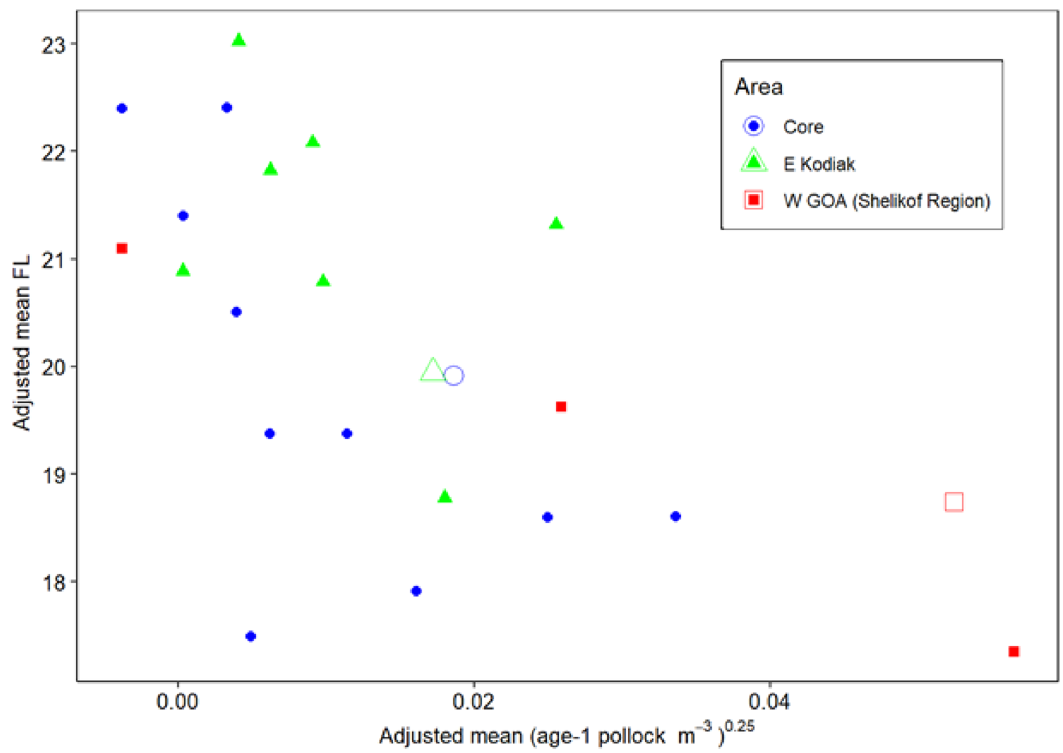
Gulf of Alaska

On the apparent sudden curtailment of the 2018 year-class of walleye pollock in the Gulf of Alaska: Late-summer age-1 abundance and body length

Matthew T. Wilson

Large decreases typically occur early in the life of a year class due to normally high mortality when individuals are larvae; however, high survival of larvae does not always result in a strong year class due to subsequent curtailment of abundance. In this study, estimates of abundance and body length of age-1 walleye pollock from late-summer, small-mesh trawl surveys are being examined to better understand the apparent sudden curtailment of the 2018 year-class of walleye pollock in the Gulf of Alaska. The surveys target small neritic fishes and have been conducted by NOAA's Ecosystems & Fisheries-Oceanography Coordinated Investigations (EcoFOCI) Program during 2000 and 2001-2019 odd years only (Fig. 1). Estimates of age-1 population density and fork length (cm) are based on mixture models applied to annual size compositions (fish m^{-3} cm^{-1}). The first objective is to determine whether age-1 abundance and body length was unusual during the 2019 late-summer survey (2018 year class) within the survey time series (2000, 2001-2019 odd years only). Preliminarily, population density (fish m^{-3}) of the 2018 year class was concentrated in the Shelikof Region, similar to the 2012 year class (2013 survey year). There is some indication that, outside of the Shelikof Region, the 2018 year class was more southwesterly distributed than was the 2012 year class. Interestingly, as population density increased among years body length decreased (Fig. 2). The second objective is to determine whether the 2018 year class was curtailed before or after late-summer 2019 by comparing late-summer age-1 abundance indicators to age-1 abundance from the assessment model (Dorn et al. 2019); this comparison is also useful for evaluating the utility of the late-summer age-1 abundance index for predicting year-class strength. Preliminarily, population density of the 2018 year class was in line with other year classes given assessment-model estimates of abundance (Fig. 3). Thus, the apparent curtailment of the 2018 year class must have occurred sometime between late-summer 2019 and the early-spring 2020 spawner survey.





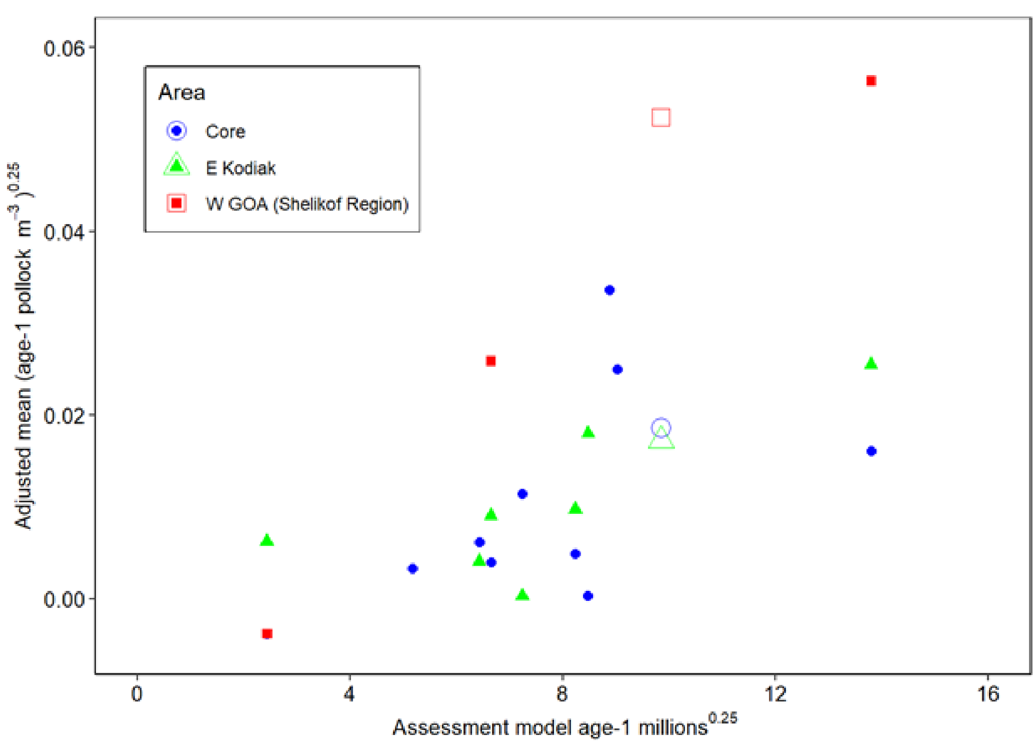


Figure 3. Age-1 pollock abundance indicators during late summer in relation to Gulf-wide

abundance estimates based on data collected prior to late summer. Abundance indicators are the adjusted population density means (fish $m^{-3})^{0.25}$ for three survey areas: Core, E Kodiak, W GOA (Shelikof Region). Abundance estimates ($millions^{0.25}$) are from the assessment model (Dorn et al. 2019). Large, unfilled symbols distinguish the 2019 survey year (2018 year class).

Reference

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Prey availability and prey selection resulted in regional differences in size and abundance in the 2013 year class of Gulf of Alaska walleye pollock- EcoFOCI

A survey-based time series (2001-2019) of abundance showed that age-0 walleye pollock (*Gadus chalcogrammus*) occurred in very high abundances in 2013 compared to other years, however recruitment of the 2013 year-class to age-1 was lower than average. To assess the potential for resource competition, diets of age-0 fish were examined from the 2013 year class. High abundances of smaller age-0 fish were found at stations southwest of the Shumagin Islands (domain A) compared to low abundances of larger fish found near and around Kodiak Island (domain C). Fish in the Shumagin Islands region showed a higher intake of low-quality food items such as pteropods and larvaceans compared to fish from the Kodiak Island region that had consumed mostly higher quality prey such as large copepods and euphausiids (Fig 1). No significant differences were found in fish condition throughout the study region. However, Prey-specific Index of Relative Importance analysis showed Shumagin region fish selected from a larger suite of prey items, where fish from the rest of the study area primarily selected large copepods and euphausiids as preferred prey (Fig 2). These results suggest that very high abundances of smaller pollock found near the Shumagin Islands experienced resource limitation inhibiting overwinter survival, had potentially increased mortality through competition, and potential cannibalism from the strong prior year class.

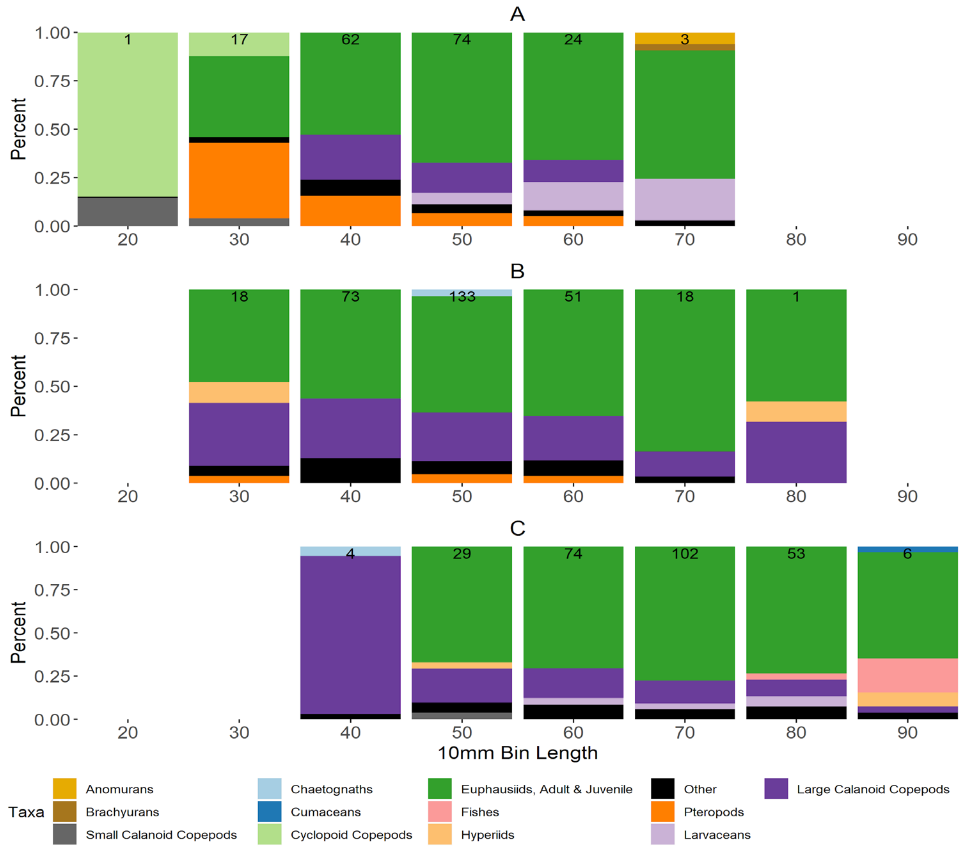

Figure 1. Age-0 pollock diet composition (percent weight) by 10mm length bins. The "Other" prey category was the sum total of prey categories that comprised less than 3% of the total prey weight in both regions.

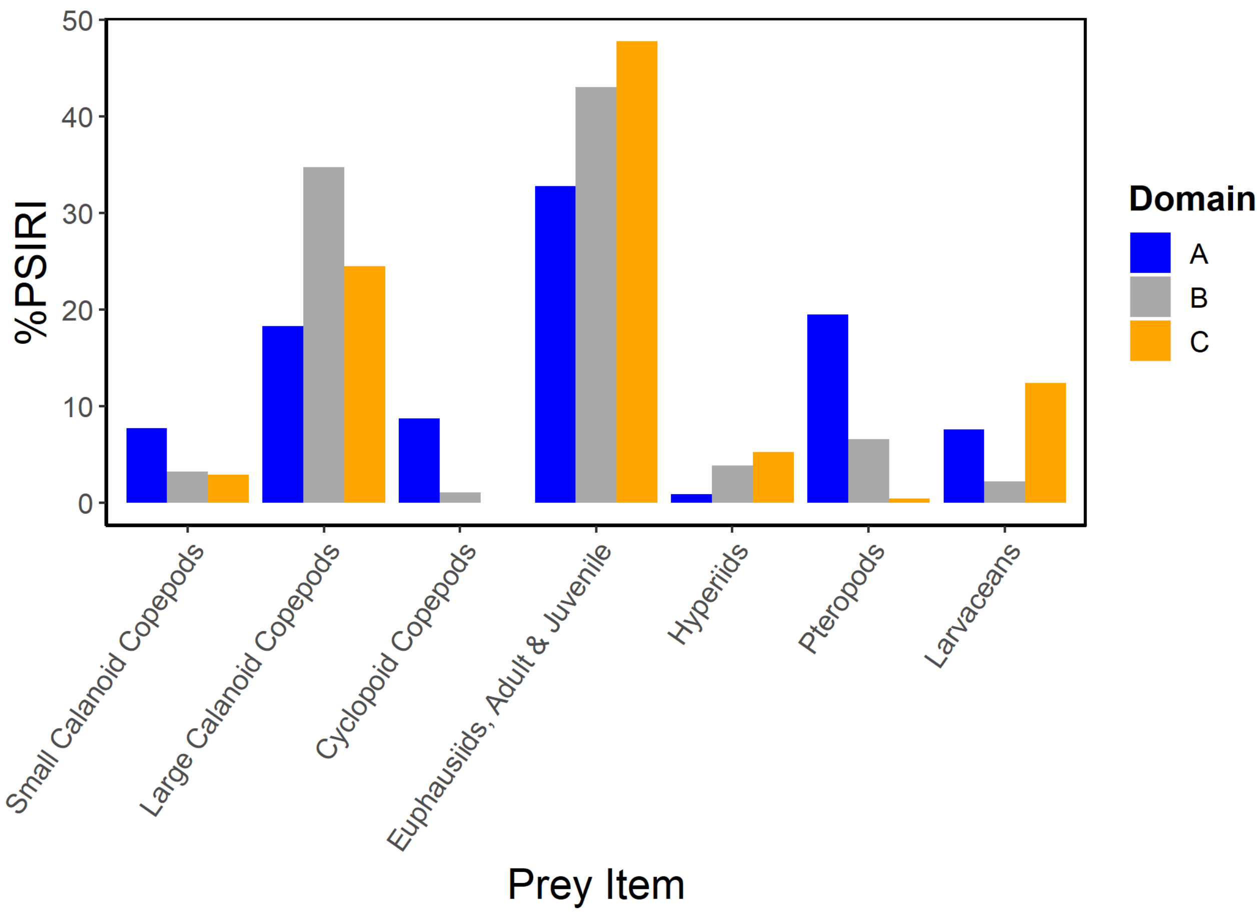

Figure 2. The top five selected prey taxa as determined by the PSIRI for stations southwest of Shumagin Is. (Domain A), between the Shumagin Is. and Kodiak Is. (Domain B) and stations surrounding and to the northeast of Kodiak Isl. (Domain C).

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Bering Sea

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

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 (Figure 1). Juvenile pollock that were caught in deeper depths were more energy dense, than fish caught in the surface, in both warm and cold years (Figure 2). 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.

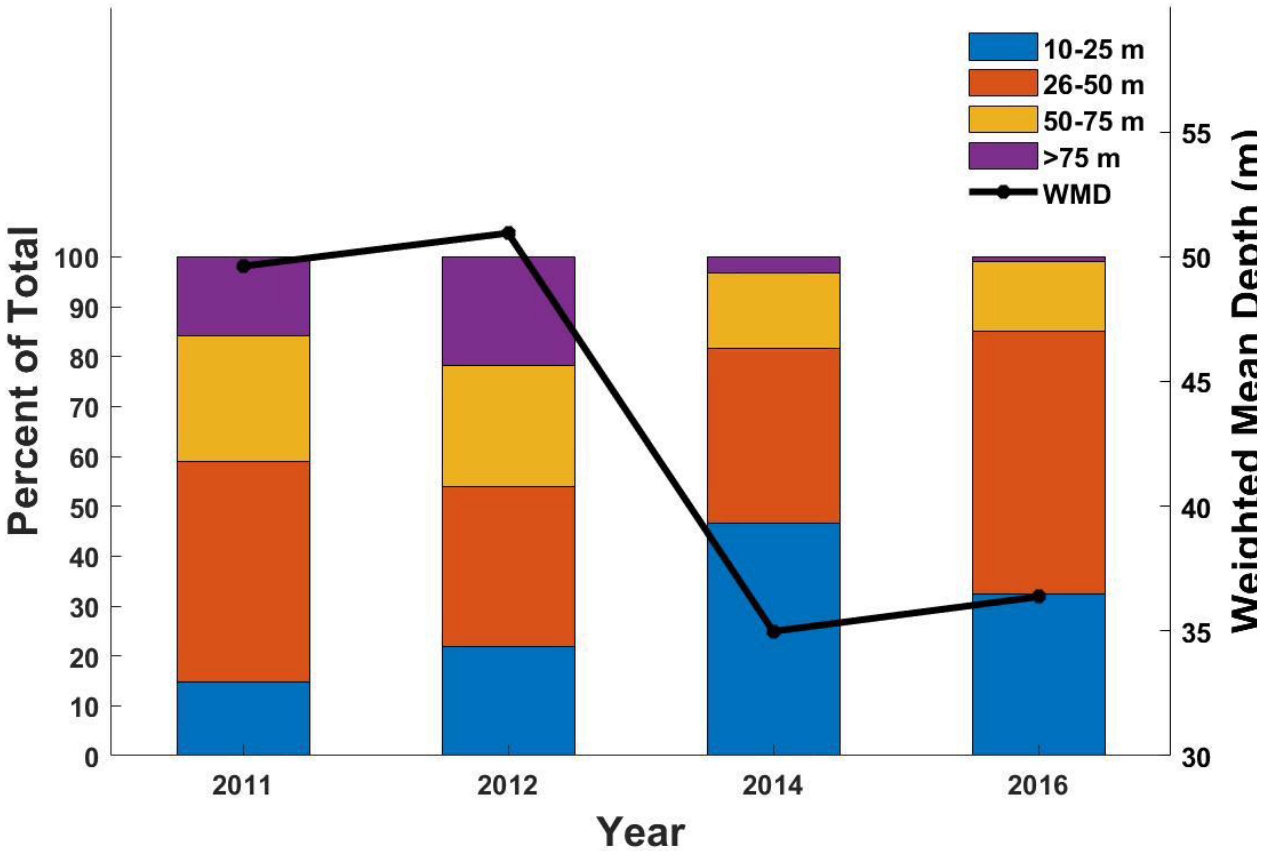

Figure 1. Depth distribution as percent of total abundance (fish nmi^{-2}) and weighted mean depth of age-0 pollock estimated by acoustic-trawl methods in 2011,2012, 2014,2016.

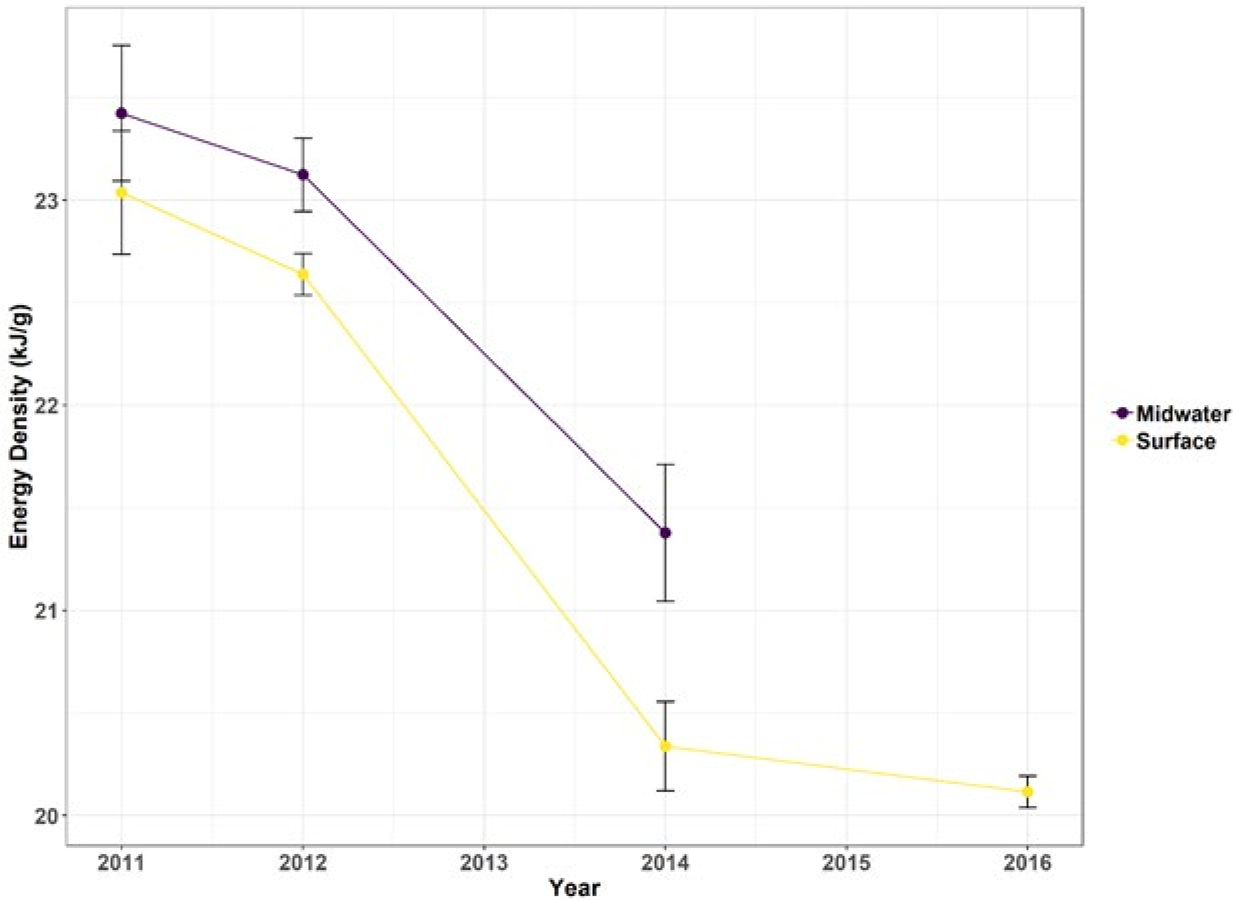

Figure 2. Energy density (± S.E.) for age-0 pollock caught in surface and midwater trawls.

Duffy-Anderson, J.T, Stabeno, P.J., Siddon, E.C., Andrews, A., Cooper, D., Eisner, L., Farley, E., Harpold, C., Heintz, R., Kimmel, D., Sewall, F., Spear, A., and Yasumishii, E. 2017. Return of warm conditions in the southeastern Bering Sea: phytoplankton- fish. *PLOS ONE*. https://doi.org/10.1371/journal.pone.0178955

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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)
Walleye pollock (Gadus chalcogrammus; hereafter referred to as pollock) are broadly distributed throughout the North Pacific with the largest concentrations found in the Eastern Bering Sea. Also known as Alaska pollock, this species continues to play important roles ecologically and economically. This is a mature assessment done annually with new catch, survey, and composition information.For the 2019 assessment this included data from the 2019 NMFS bottom-trawl (BTS) and acoustic-trawl (ATS) surveys as well as total catch through 2019. In addition, opportunistic acoustic data from vessels (AVO) conducting the 2019 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 2018 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 along with spawning exploitation rates below 20% since 2008. Spawning biomass is projected to be well above BMSY in 2020. The 2020 OFL is 4,273,000 t and the maximum ABC is 3,578,000 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.

Aleutian Islands (REFM)
The Aleutian Islands (AI) pollock stock assessment has changed to a biennial cycle with full assessments in even years timed with the Aleutian Islands bottom trawl survey, and partial assessments in odd years. Partial assessments include updated harvest recommendations; the 2020

OFL is 66,973 t and 2020 maximum ABC is 55,120 t.

Bogoslof Island (REFM)
Assessments for Bogoslof-area pollock are performed in even years and the harvest recommendations are not revised in off years. 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 2020 is 183,080 t and the maximum permissible ABC for 2020 is 137,310 t.

Gulf of Alaska (REFM)

The base model projection of female spawning biomass in 2020 is 206,664 t, which is 42.6% of unfished spawning biomass (based on average post-1977 recruitment) and above B40% (194,000 t), thereby placing GOA pollock in sub-tier “a” of Tier 3. New survey data in 2019 continue to show strong contrast, with the 2019 Shelikof Strait acoustic survey indicating high biomass, and the 2019 NMFS bottom trawl survey indicating relatively low biomass (the second lowest in the time series). The 2019 ADF&G bottom trawl is also low, while the 2019 summer acoustic survey is intermediate.

The authors’ 2020 ABC recommendation for pollock in the Gulf of Alaska west of 140° W longitude (the main portion of the GOA pollock stock) 108,494 t, which is a decrease of 20% from the 2019 ABC, but very close to the projected 2020 ABC in last year’s assessment. The author’s recommended ABC was obtained by applying a 10% buffer to the maximum permissible ABC, based on the concerns about the stock assessment detailed above. A buffer of 10% to address substantially increased concerns is slightly lower than the buffer that was applied last year (14%) to address slightly more elevated concerns, and seemed an appropriate starting point for Plan Team and SSC deliberations. The author’s recommended ABC for 2021 is 111,888 t, using the same 10% buffer to the maximum permissible ABC in 2021. The OFL in 2020 is 140,674 t, and the OFL in 2021 if the ABC is taken in 2020 is 149,988 t. It should be noted that the ABC is projected to stabilize over the next few years, due recruitment of the strong 2018 year class into the fishery.

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).

G. Pacific Whiting (hake)

There are no hake fisheries in Alaska waters.

H. Rockfish

1. Research

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. Another goal of this project is to examine the variability of rockfish reproductive parameters over varying temporal and spatial scales. The analysis of maturity for three deep water rockfish species, blackspotted rockfish, *Sebastes melanostictus,* rougheye rockfish, *S. aleutianus,* and shortraker rockfish, *S. borealis,* has been complicated by the presence of a significant number of mature females that skip spawning. Additional data are needed to determine if skip spawning rates and other maturity parameters vary with time. Recent studies suggest variation in size and age at maturity may occur for the three most commercially important rockfish species, Pacific ocean perch, *S. alutus,* northern rockfish, *S. polyspinis,* and dusky rockfish *S. variabilis.* Researchers at the AFSC Kodiak Laboratory will be examining annual and spatial 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 2021 reproductive season.

Northern and Dusky Rockfishes - RACE
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. In the upcoming year historic samples of northern rockfish will be examined to see if there have been temporal changes in maturity, fecundity, and reproductive failure. Spatial differences in the reproductive potential of northern rockfish will also be examined as well as the relationship between reproductive potential and fish condition.

Conrath, C. 2019. Reproductive Potential of Dusky and Northern Rockfish within the Gulf of Alaska. Fishery Bulletin 117: 140-150.

Rougheye and blackspotted rockfish - RACE
The recent discovery that rougheye rockfish are two species, now distinguished as 'true' rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further highlights 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. This study re-examined 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 skipped spawners. 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 rockfish were collected from the 2016 reproductive season and were analyzed to compare temporal differences in reproductive parameters and rates of spawning omission. Rougheye rockfish had a smaller length and age at maturity during 2015 (447 mm, 17.7 years) compared to the earlier sampling period (450 mm, 19.6 years), but neither the interaction of length and time period ($P = 0.507$) nor the interaction of age and time period ($P = 0.270$) was significant. Relative fecundity for rougheye rockfish was not significantly different between the two time periods ($P = 0.444$). Skipped spawning rates were significantly lower in 2015 for rougheye rockfish (2010 = 37.4 %, 2016 = 21.8 %, $P < 0.001$). This study was a first step in examining how reproductive parameters for these species may change over time. A comprehensive approach to examining temporal trends in reproductive parameters will aid in the understanding of how changing environmental conditions are affecting the productivity of commercially important species.

Conrath, C.L. and P-J. F. Hulson. 2021. Temporal variability in the reproductive parameters of deep water rockfishes in the Gulf of Alaska. Fisheries Research 237: 1-9.

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

Shortraker rockfish - RACE

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 were analyzed to compare temporal differences in reproductive parameters and rates of spawning omission. Shortraker rockfish also had a smaller length at maturity during 2015 (467 mm) compared to the earlier period of time (499 mm) and the interaction of length and time period was not significant ($P = 0.830$). Relative fecundity for shortraker rockfish was not significantly different between the two time periods. Skipped spawning rates were significantly lower in 2015 for shortraker rockfish (2010 = 60.0 %, 2016 = 47.0 %, $P < 0.001$). This study was a first step in examining how reproductive parameters for these species may change over time. A comprehensive approach to examining temporal trends in reproductive parameters will aid in the understanding of how changing environmental conditions are affecting the productivity of commercially important species.

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

Conrath, C.L. and P-J. F. Hulson. 2021. Temporal variability in the reproductive parameters of deep water rockfishes in the Gulf of Alaska. Fisheries Research 237: 1-9.

Whole genome resequencing of rockfish, sablefish, and Pacific cod - ABL

The genetics group at AFSC is using whole genome resequencing to understand population structure in a number of groundfish species including rockfish, sablefish, and Pacific cod. The focus of this work will be understanding the population structure of these species in Alaskan waters. The initial rockfish species that will be analyzed include blackspotted (*Sebastes melanostictus*), shortspine thornyhead (*Sebastalobus alascanus*), and Pacific ocean perch (*Sebastes alutus*).

For more information, contact Wes.Larson@noaa.gov.

2. Assessment

Pacific Ocean Perch (POP) – Bering Sea and Aleutian Islands - REFM
In 2005, BSAI rockfish were moved to a biennial assessment schedule with full assessments in even years to coincide with the occurrence of trawl surveys in the Aleutian Islands (AI) and the eastern Bering Sea (EBS) slope. In odd years, partial assessments include revised harvest recommendations. The 2020 OFL is and the 2020 maximum ABC is 58,956 t and the 2020 OFL is 48,846 t.

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

Pacific Ocean Perch - Gulf of Alaska - ABL

In 2020, an assessment was conducted for Gulf of Alaska Pacific ocean perch. New data in the 2020 assessment included updated 2019 catch and estimated 2020 catch, and survey age compositions for 2019. Changes to the model included updating the prior for the bottom trawl survey catchability parameter and natural mortality parameter.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 207,096 t in 2021 and to decrease to 198,179 t in 2022. 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 126,814 t, 0.10, and 0.12, respectively. Spawning biomass for 2021 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier "a" of Tier 3. The 2021 and 2022 catches associated with the $F_{40\%}$ level of 0.10 are 36,177 t and 34,602 t, respectively, and were the authors' and Plan Team's recommended ABCs. The 2021 and 2022 OFLs are 42,977 t and 41,110 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2021: Western GOA = 1,643 t, Central GOA = 27,429 t, and Eastern GOA = 7,105 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 2021 is 1,705 t and for E. Yakutat/Southeast the ABC in 2021 is 5,400 t. The recommended OFL for 2021 is apportioned between the Western/Central/W. Yakutat area (45,003 t) and the E. Yakutat/Southeast area (6,414 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

A Center for Independent Expert review is scheduled to take place from March 30 – April 1, 2021.

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

Dusky Rockfish-- Gulf of Alaska - ABL

In 2020 a full assessment for GOA dusky rockfish was conducted with new catch data and using survey data through 2019 (the last complete survey). This assessment uses a geospatial model (VAST) for survey abundance estimates, and the VAST model parameterization 'best practices' had changed since the last full assessment was done. The GOA dusky rockfish stock is a Tier 3a species. The estimate of female spawning biomass for 2021 and 2022 were 38,362 and 37,530 t, respectively. The female spawning biomass in both projected years is above the B40% reference point of 24,342 t. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching an overfished condition.

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

Northern Rockfish – Bering Sea and Aleutian Islands - REFM

A full assessment for BSAI northern rockfish was performed in 2019. The stock is not overfished or approaching an overfished condition. The recommended 2020 ABC and OFL are 16,243 t and 19,751 t, which are 30% and 31% increases from the values specified last year for 2020 of 12,396 t and 15,180 t. The reason for the increase in the harvest level is updated data showing larger weight at age for the fishery than was used in previous assessments, and a change in the estimated survey selectivity curve that scaled the population higher than previous assessments.

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

Northern Rockfish - Gulf of Alaska - ABL

In 2020 a full assessment was conducted for Gulf of Alaska northern rockfish. The input data were updated to include survey biomass estimates for 2019, survey age compositions for 2019, final catch for 2018 and 2019, preliminary catch for 2020, fishery age compositions for 2018, and fishery size compositions for 2019. The survey biomass estimate was estimated using a Vector Autoregressive Spatio-temporal (VAST) model for the GOA. The aging error matrix was updated with data through 2017, the previous matrix had data through 2008. No changes were made to the assessment model.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 102,715 t in 2021 decreasing to 99,597 t in 2022. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and

$F_{35\%}$ exist for this stock, thereby qualifying northern rockfish for management under Tier 3. With $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ estimated at 33, 933 t, 0.073, and 0.061, respectively. Spawning biomass in 2021 is projected to exceed $B_{40\%}$, thereby placing northern rockfish in Tier 3a. The 2021 and 2022 catches associated with an $F_{40\%}$ are 5,358 t and 5,100 t, respectively. These catches were put forward as the authors' and Plan Team's recommended ABCs. The 2021 and 2022 OFLs are 3,396 t and 6,088 t.

A random effects model was used to establish regional ABCs based on the proportions of model-based estimates for 2021 with 2,023 t allocated to the Western GOA, 3,334 t to the Central GOA, and 1 t to the Eastern GOA. The Eastern GOA allocation is managed within the "Other Rockfish" complex. The recommended OFLs for 2021 and 2022 are not regionally apportioned. Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For more information contact Ben Williams, ABL, ben.william@noaa.gov.

Shortraker Rockfish - - Bering Sea and Aleutian Islands - REFM

The Bering Sea and Aleutian Islands (BSAI) shortraker rockfish stock is classified as a Tier 5 stock for setting the acceptable biological catch (ABC) and overfishing level (OFL). In accordance with the new assessment schedule frequency, we conducted a full assessment for shortraker rockfish in 2020; however, since there were no new surveys for this assessment the ABC and OFL were rolled over from the previous assessment. The recommended 2021 ABC and OFL for BSAI shortraker rockfish are 541 t and 722 t, respectively. The stock is not being subject to overfishing. Please refer to this year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Shotwell et al., 2020, available online at https://www.fisheries.noaa.gov/resource/data/2020-assessment-shortraker-rockfish-stock-bering-sea-and-aleutian-islands).

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

Shortraker Rockfish – Gulf of Alaska – ABL

Gulf of Alaska (GOA) shortraker rockfish are assessed on a biennial stock assessment schedule with a full stock assessment produced in odd years and no stock assessment or document produced in even years. Because this is an "off year," the 2020 values are rolled over for the 2021 fishery.

Estimated shortraker rockfish biomass is 31,465 t. The NPFMC's Tier 5 ABC definitions state that FABC ≤0.75M, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 708 t for the 2021 fishery. Gulfwide catch of shortraker rockfish was 496 t in 2020. This is down from 701 t in 2019.

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

Other Rockfish – BSAI – ABL

The BSAI Other Rockfish complex is currently managed under Tier 5 harvest control rules, which define FOFL and FABC as M and 0.75M, where M is the natural mortality rate. This complex is assessed fully in even years to coincide with the AI groundfish trawl survey. The Other Rockfish complex includes all species of Sebastes and Sebastolobus, except Pacific ocean perch, northern rockfish, rougheye rockfish, and shortraker rockfish. Because of differences in the assumed M among species, the Other Rockfish complex is assessed in two parts: (1) shortspine thornyhead (SST; M=0.03), which comprise approximately 95% of the estimated total Other Rockfish exploitable biomass; and (2) the remaining "non-SST" species, which are dominated by dusky rockfish (M=0.09) but include at least eleven other rockfish species. New data for the stock assessment included 2020 catch and fishery lengths and a zero biomass observation for the non-SST component of the stock in the 2019 EBS shelf trawl survey. The 2020 AI and EBS shelf surveys were canceled due to Covid-19, and there has been no EBS slope survey since 2016. No changes to assessment methodology were made in 2020.

The recommended Tier 5 random effects model was used to estimate exploitable biomass from time series of EBS shelf, EBS slope, and AI trawl survey data. Combined Other Rockfish biomass in 2021/2022 is estimated to be 53,248 t. The recommended BSAI ABC and OFL for 2021/2022 are 1,313 t and 1,751 t, respectively. The area-apportioned ABCs in the AI and EBS for 2021 are 394 t and 919 t, respectively.

The 2020 stock assessment is available online at: https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/BSAIorock.pdf

For more information contact Jane Sullivan, ABL, at 907 789-6000 or jane.sullivan@noaa.gov

Other Rockfish – Gulf of Alaska – ABL

The Other Rockfish complex in the Gulf of Alaska (GOA) is composed of 27 species, but the composition of the complex varies by region. The species that are included across the entire GOA are the 17 rockfish species that were previously in the "Other Slope Rockfish" category together with yellowtail and widow rockfish, formerly of the "Pelagic Slope Rockfish" category. Northern rockfish are included in the Other Rockfish complex in the eastern GOA and the Demersal Shelf rockfish species are included west of the 140 line (i.e. all of the GOA except for NMFS area 650). The primary species of "Other Rockfish" in the GOA are sharpchin, harlequin, silvergray, redstripe and yelloweye rockfish; most of the others are at the northern end of their ranges in Alaska and have a relatively low abundance here. Rockfish in the GOA have been moved to a biennial stock assessment and the "Other Rockfish" stock complex is assessed in odds years as per prioritization. The last full assessment was in the fall of 2019 and the next full assessment will be completed in the fall of 2021.

This complex consists of species assessed as Tier 4, Tier 5 or Tier 6, based on data availability. The complex is managed as a whole and the acceptable biological catch (ABC) and overfishing level (OFL) for each species are summed to create the ABC/OFL for the complex. The Tier 4/5 species ABC/OFLs are based on a random effects model applied to the biennial GOA trawl survey data. This results in a current exploitable biomass of 96,107 t for "Other Rockfish". Applying either an $F_{ABC} \leq F_{40\%}$ rate for sharpchin rockfish or an $F_{ABC} \leq 0.75M$ (*M* is the natural mortality rate) for the tier 5 species to the exploitable biomass for Other Rockfish results in a recommended ABC in the GOA of 3,847 t, which was combined with the tier 6 ABC of 193 t for a total complex ABC of 4,040 t for 2019 and 2020.

Gulfwide catch of Other Rockfish was 1,205 t and 957 t in 2018 and 2019, respectively. Other rockfish is not considered overfished in the Gulf of Alaska, nor is it approaching overfishing status. However, the apportioned ABC for the Western GOA has often been exceeded. Beginning in 2014, the Western and Central GOA apportioned ABCs were combined. This was not deemed a conservation concern because the combined catch of the Western and Central GOA does not always exceed the combined ABC of the two areas, nor is the catch of Other Rockfish approaching the complex ABC.

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

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 separate assessments, so they are combined as a complex in one assessment.In 2005, BSAI rockfish were moved to a biennial assessment schedule with full assessments in even years to coincide with the occurrence of trawl surveys in the Aleutian Islands (AI) and the eastern Bering Sea (EBS) slope. In odd years, partial assessments include revised harvest recommendations. The 2020 maximum ABC is 817 t and the 2020 OFL is 675 t.

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. The GOA rougheye and blackspotted rockfish (RE/BS) complex is fully assessed as a Tier 3 stock in odd years to correspond with the GOA trawl survey. As an off-cycle assessment in 2020, only the projection model was run and no changes were made to the assessment model. New data in the 2020 assessment included updated 2019 catch and estimated 2020 and 2021 catches.

The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. Female spawning biomass is estimated to be increasing and is projected to be 12,540 t in 2021 and 12,563 in 2022. These estimates are well above the $B_{40\%}$

reference point of 8,263 t, thereby placing RE/BS in sub-tier "a" of Tier 3. The 2021 and 2022 ABCs associated with the target $F_{40\%}$ of 0.040 are 1,212 t and 1,221 t, respectively. The recommended 2021 and 2022 OFLs are 1,456 t and 1,467 t.

The apportionment methods were changed in 2019 and now use a version of the random effects model incorporating both the longline and GOA trawl survey relative abundance indices with equal weighting. During off-cycle assessments, apportionment percentages are carried over from the last full assessment (2019). Area apportionments based on the two survey random effects method are as follows for 2021: Western GOA = 168 t, Central GOA = 456 t, and Eastern GOA = 588 t.

The 2020 stock assessment is available online at: https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/GOArougheye.pdf

For more information contact Jane Sullivan, ABL, at 907 789-6000 or jane.sullivan@noaa.gov.

I. Thornyheads

1. Research

Effects of capture on acute and long-term reflex impairment, survival, and health of shortspine thornyhead - ABL

Shortspine thornyhead (*Sebastolobus alaskanus*) are a deep-water fish that have been tagged annually since 1992 in Alaska. They have a low tag return rate of 1.6%, which may be at least partially attributed to mortality related to capture. In this study, 21 shortspine thornyhead were caught on bottom longline gear, as they would be on tagging surveys, given reflex tests, held in the lab for 10 – 42 days, given reflex tests again, and then histopathology was performed on tissues. After histological review there were no findings that resulted from capture and holding; however, there were occurrences of protozoa, myxozoans, or nematode parasites that were sometimes related to minor inflammation in multiple organs. The absence of prominent inflammatory lesions associated with the organisms is consistent with adaptation or co-evolution of a host and parasite. The sound response reflex was only found in 24% of fish on-deck and 56% of fish after holding in the lab. The vestibular-ocular response was positive in 47% of fish on-deck and 89% of fish in the lab. The ability to right itself (flip over) was successful at-sea in 62% of fish (43% responded quickly) and 100% in the lab. Some reflex impairments may be permanent or may take more than days or weeks to improve. Other reflexes were 95-100% successful. Impaired reflexes increase the risk of whale predation by whales after release and may affect other behaviors that relate to survival and productivity.

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 the 2019 and 2020 Relative Population Weights (RPWs) from the AFSC longline survey, the 2019 trawl survey biomass estimate, and updated catch. 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 the AFSC longline survey RPW index (1992 – 2020) and the AFSC bottom trawl survey biomass index (1984 – 2019), to estimate the exploitable biomass that is used to calculate the recommended ABC and OFL values for the 2021 fishery. Estimated thornyhead biomass is 86,802 t, which is a decrease of 3% from the 2018 estimate. The NPFMC's Tier 5 ABC definitions state that FABC ≤0.75M, where M is the natural mortality rate. Using an M of 0.03 the recommended ABC is 1,953 t for the 2021 fishery. Gulfwide catch of thornyhead rockfish was 777 t in 2019 and 462 t in 2020. Thornyhead rockfish in the GOA are not being subjected to overfishing. It is not possible to determine whether this complex is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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

J. <u>Sablefish</u>

1. Research

Groundfish Tag Program - ABL

The ABL MESA Tag Program continued the processing of groundfish tag recoveries and administration of the tag reward program and Groundfish Tag Database during 2020. While sablefish is the primary species tagged, tags from shortspine thornyhead, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, Pacific cod, Pacific ocean perch, and rougheye rockfish are also maintained in the database. Total tag recoveries for the year were ~400 sablefish, 5 thornyhead, 3 Greenland turbot, and 1 Pacific ocean perch. Twenty four percent of the recovered sablefish tags in 2020 were at liberty for over 10 years. About 39 percent of the total 2020 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 37 percent within 100 – 500 nm, 16 percent within 500 – 1,000 nm, and 8 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 40 years (14,739 days), and the greatest distance traveled of a 2020 recovered sablefish tag was 1,504 nautical miles from a fish tagged in the southeast Aleutian Islands on 6/8/2012 and recovered off Baranof Island in Southeast Alaska on 5/13/2020. One juvenile sablefish and one shortspine thornyhead tagged with archival tags were recovered in 2020. Releases in 2020 on the AFSC groundfish longline survey totaled 1,230 adult sablefish, 103 shortspine thornyhead, and 1 Greenland turbot. An additional 437 juvenile (age-1) sablefish were tagged during one juvenile sablefish tagging cruise in 2020.

The AFSC groundfish tag data can now be viewed online through a series of summary tables and interactive maps, at this location: https://www.fisheries.noaa.gov/resource/map/alaska-groundfish-tagging-map.

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

Juvenile Sablefish Studies – ABL

Juvenile (age-1) sablefish tagging studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2020 thanks to the efforts of the Alaska Department of Fish and Game-Sitka and the crew of the *R/V* Kittiwake. When MESA staff were unable to perform this fieldwork due to COVID restrictions, ADFG graciously volunteered their time and service to ensure this historical time series was not interrupted. The ADFG sampled St. John Baptist Bay near Sitka, AK for two days (Sept. 1-2), tagging 437 juvenile sablefish. This ties 2016 for highest CPUE (9.9 fish per rod hour). The average length of fish was 315 mm, which indicates that much of the catch was 1-year-olds. This is the second lowest average length in the 36 year time series. The lowest was in 2016.

Thank you to the Alaska Department of Fish and Game - Sitka: Rhea Ehresmann, Jess Coltharp, Anthony Walloch, Mariah Leeseberg, Mathew Pallister, Jake Wieliczkiewicz, and Eric Fotter.

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

Sablefish reflex impairments, health, and mortality after capture and time out of water - ABL

It is unknown if capture coupled with time on-deck, in the air, affect sablefish (*Anoplopoma fimbria*) health, reflexes, and acute or delayed mortality. In this study, 35 sablefish were caught using hook-and-line gear fished and given 6 reflex tests after capture. Thirty-two were subsequently transported to the lab, held for 45-52 days, and then experimentally held out of the water for either 0, 3, 6, or 11 minutes; 3 were sacrificed at-sea. After 7-10 days of holding in the lab, to monitor for mortalities, reflexes were tested for the second time and necropsies and histopathology were performed. There were no histological findings that resulted from capture and experiments and no mortalities; however, there were parasites and minor inflammation. All occurrences were not a result of capture or experiments. Some reflexes were absent after capture (77% could right themselves, 69% responded to a tail grab, and 57% responded to sound.) The only test where the reflex did not improve to 100% in the lab was the sound response. It was highest for control fish (63%) and there were no positive sound responses for fish held out of water for 11 minutes. The absence of reflexes may result in predation by whales after release and issues with feeding or communication in the short and long-term.

For more information contact cara.rodgveller@noaa.gov.

Sablefish Point of No Return - RPP

The Gulf of Alaska Integrated Ecosystem Research Project (GOA IERP, 2011-2013) examined the distributional patterns of Sablefish throughout the Gulf of Alaska at different life stages through studies examining larval drift and connectivity, but the project did not resolve variables that mitigate feeding and growth. The GOA IERP results underscored the need to characterize the impact of environmental factors on Sablefish vital rates that likely influences recruitment forecasts. Our NPRB funded study will build from GOA IERP work to:

(1) determine how many days individuals can survive without prey (starvation resiliency) in first feeding larval Sablefish

(2) assess how starvation resiliency is influenced by temperature, and

(3) adapt rearing protocols for the Newport rearing facility.

In FY21, we conducted rearing experiments in Seattle to determine the time to starvation in first feeding Sablefish at 6°C, an average late May sea surface temperature in the western Gulf of Alaska in non-marine heatwave conditions. Unfortunately, rearing was unsuccessful due to high egg and early larval mortality so experiments could not be completed as planned. Pilot rearing is also being conducted in Newport, Oregon to adopt Sablefish rearing protocols to the FBE rearing facility. Egg mortality was high but each tank did produce surviving larvae, suggesting that the rearing protocols were successfully adopted to this facility, although the aim will be to reduce mortality next year.

For more information, contact Ali Deary at (518) 366-6703 or alison.deary@noaa.gov.

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

Description of indicator: Biophysical indices from surveys in 2018 and 2019 and salmon returns in 2020 were explored in predicting the recruitment of sablefish to age-2 in 2020 and 2021, for the 2018 and 2019 year classes (Hanselmann 2019, Yasumiishi et al. 2015a, 2015b). Biophysical indices were collected during the southeast coastal monitoring (SECM) survey. The SECM survey has an annual survey of oceanography and fish in inside and outside waters of northern southeast Alaska since 1997 (Orsi et al. 2012). Oceanographic sampling included, but was not limited to, sea temperature and chlorophyll *a*. An index for pink salmon survival was based on adult returns of pink salmon to southeast Alaska (Piston and Heinl, 2014). These oceanographic metrics may index sablefish recruitment, because sablefish use these waters as rearing habitat early in life (late age-0 to age-2). Chlorophyll a is an indicator for primary production, or phytoplankton, prey from small copeods that are fed on by euphausiids that are consumed by age-0 sablefish.

Status and trends: We modeled age-2 sablefish recruitment estimates from 2001 to 2019 (1999-2017 year classes) as a function of sea temperatures during 1999-2017, chlorophyll a during 1999-2017, and adult pink salmon returns in 2000-2018. A regression model indicated a significant positive coefficient for the predictor variable chlorophyll a, but not significant for sea temperature and pink salmon returns ($R^2 = 0.78$, Adjusted, $R^2 = 0.77$, F-statistic: 59.8 on 1 and 17 DF, p-value: 0.0000006). Trends in the scaled chlorophyll a indicate high values in 2000, 2014, and 2016 that relate to strong year classes of sablefish (Figure 1). Based on the recent low values of chlorophyll *a* in 2018 and 2019, 1.70 and 1.49 respectively, we predict below average abundance of age-2 sablefish for the 2018 and 2019 year classes (Figure 2).

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

Implications: Expect weak 2018 and 2019 year classes of sablefish.

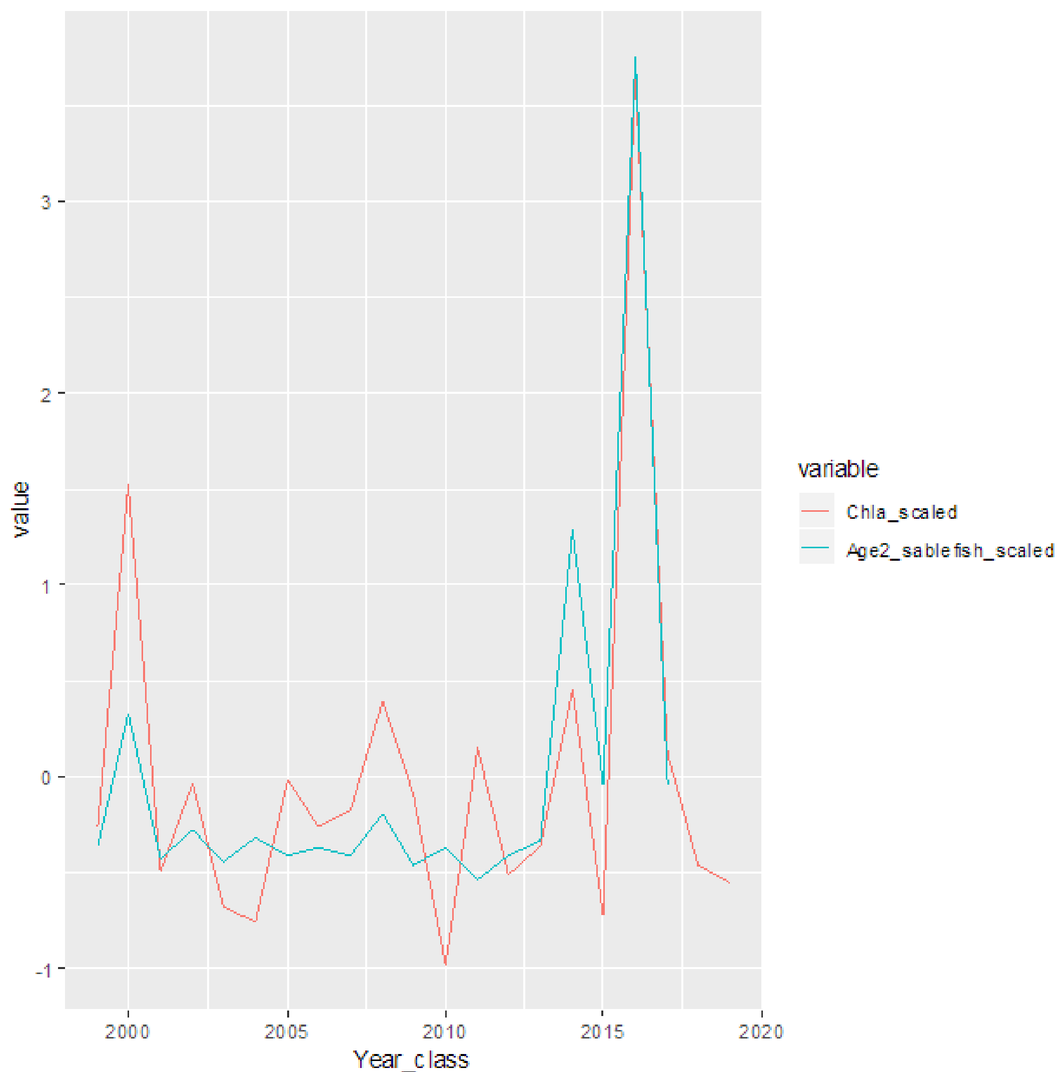

Figure 1. Scaled time series of age-2 sablefish lagged to year class 1999 to 2017 (Age2_sablefish_scaled) and scaled data for chlorophyll a sampled in Icy Straits during the Southeast Coastal Monitoring survey from 1999-2019 (Chla_scaled) during the age-0 life stage of sablefish.

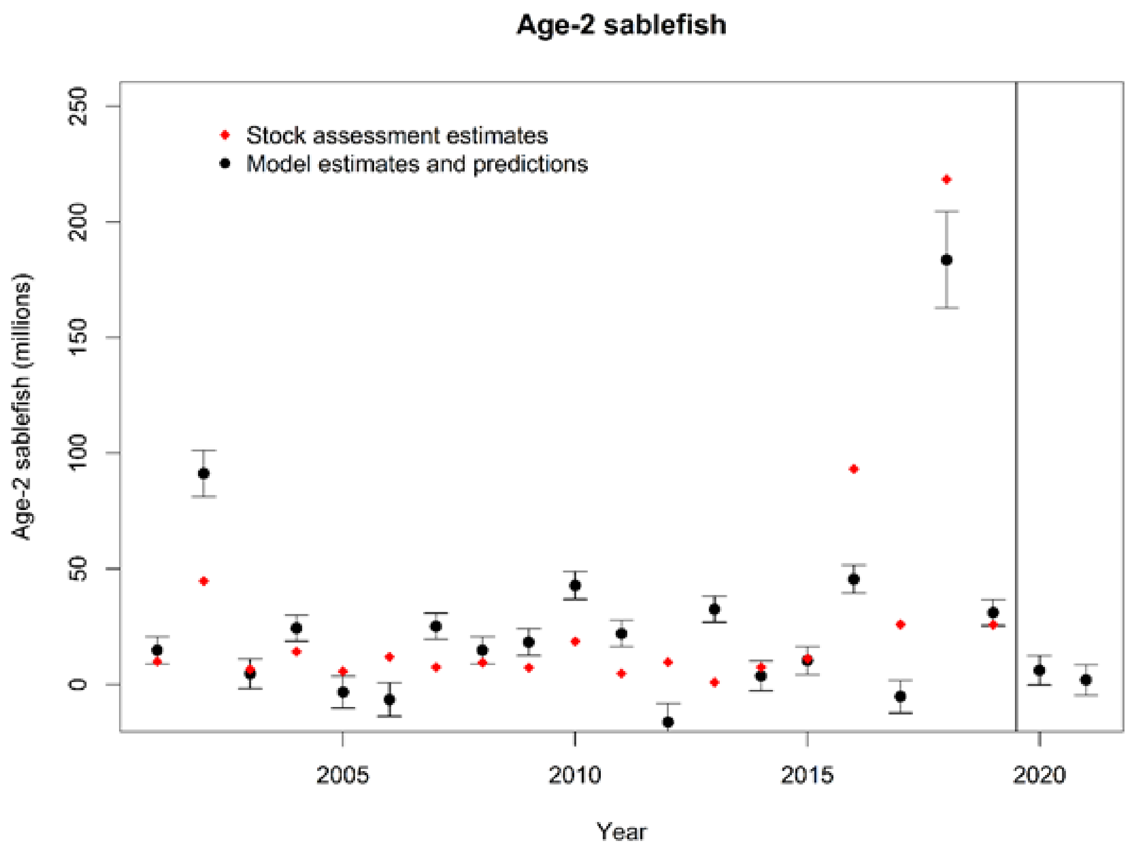

Figure 2. Stock assessment estatimes (2001-2019), model estimates (2001-2019), and the 2020 and 2021 predictions for age-2 Alaska sablefish. Stock assessment estimates of age-2 sablefish were modeled as a function of late August chlorophyll *a* levels in the waters of Icy Strait in northern southeast Alaska during the age-0 stage (*t*-2). This predictor is an indicators for the conditions experiences by age-0 sablefish, conditions include. Stock assessment estimates of age-2 sablefish abundances are from Hanselman (personal communications)

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2. Stock Assessment

Sablefish in the Bering Sea, Aleutian Islands, and Gulf of Alaska - ABL

New data included in the assessment model were relative abundance and length data from the 2020 longline survey, relative abundance and length data from the fixed gear fishery for 2019, length data from the trawl fisheries for 2019, age data from the longline survey and fixed gear fishery for 2019, updated catch for 2019, and projected 2020 - 2022 catches. Estimates of killer and sperm whale depredation in the fishery were updated and projected for 2020 - 2022. In 2020, there was not a NMFS Gulf of Alaska trawl survey.

The longline survey abundance index (relative population numbers, RPNs) increased 32% from 2019 to 2020 following a 47% increase from 2018 to 2019. Similarly, the trawl survey biomass was at a time series low in 2013, but has more than tripled since that time. The fishery catch-rate (CPUE) index was at the time series low in 2018, but increased 20% in 2019 (the 2020 data are not available yet). The age and length composition data continue to indicate strong year classes in 2014, 2016, and a potentially strong, albeit highly uncertain, 2017 year class.

Based on the strength of these recent year classes, biomass estimates have nearly quadrupled to 687,000 t in 2020 since a time series low in 2015. Given that most of these recent year classes are still primarily immature fish, spawning biomass has not rebounded as rapidly as total biomass. Yet, from the time series low in 2018, SSB has increased by 44% to 94,000 t in 2020. The updated point estimate of $B_{40\%}$, is 126,389 t, while projected female spawning biomass (combined areas) for 2021 is 134,401 t (i.e., 6% higher than $B_{40\%}$, or equivalent to $B_{42\%}$). The maximum permissible 2021 ABC (combined areas) based on the NPFMC harvest control rule is 52,427 t. Instead of maximum permissible ABC, the authors recommended that the 2021 ABC be held at the 2020 specified ABC of 22,551 t, which translated to a 57% reduction from maximum ABC. The recommended ABC represented a 3,250 t (17%) increase from the author recommended 2020 ABC in 2019, and an 88% increase in the ABC since 2016 when the lowest ABC on record (11,795 t) was enacted. The author recommended ABCs for 2021 and 2022 are lower than maximum permissible ABC for several important reasons, which are summarized below.

Mainly, the sablefish projections are likely to be overly optimistic for two reasons: reliance on uncertain estimates of large recent year classes and their survival, as well as, increasingly large and consistent retrospective patterns that indicate an uncertain assessment model. The 2014 and 2016 year classes are projected to comprise approximately 27% and 22% of the 2021 spawning biomass, respectively. Conversely, the remnants of the two previously strong year classes in 2000 and 2008 continue to be removed from the population and represent only 4% and 5.5% of the projected 2021 spawning biomass, respectively. Thus, projections of future SSB increases rely heavily on fish from recent strong recruitment events surviving to maturity along with future data and assessments verifying year class strength. Perhaps more importantly, uncertainty in the estimates of recent year class strength has resulted in a consistent positive retrospective bias in assessment model outputs of SSB and recruitment. Therefore, model outputs from the 2020 stock assessment for sablefish are likely overly optimistic and models in future years may indicate that both recruitment and SSB were overestimated.

While there are clearly positive signs of strong incoming recruitment, concerns exists regarding the lack of older fish contributing to spawning biomass, the uncertainty surrounding the estimates of the strength of the 2014, 2016, and 2017 year classes, and ambiguity related to how existing environmental conditions may affect the success of these year classes in the future. Recent environmental conditions, including multiple marine heat waves, appear favorable to recruitment success for sablefish. However, it is unclear whether this is a permanent productivity regime shift or a transient phase. These cohorts are also beginning to recruit to the various gear types as young, small fish with associated increases in removals, especially as bycatch in the BS trawl fisheries. Increased mortality on young fish may reduce the number of fish from these year classes that survive and mature, whereas active avoidance of lower value small fish by the directed fisheries could lead to further removals of larger, mature fish and put additional strain on the severely truncated age structure and SSB. When projections were performed assuming that the 2016 and 2017 year classes were fixed at average levels, the resulting ABC decreased dramatically to 22,000 t. Thus, the uncertainty in recent recruitment has important implications for the determination of future catch limits.

The following bullets summarize additional concerns that led to suggesting a lower than maximum ABC:

- The estimate of the 2014 year class strength declined 68% from the 2017 to 2020 assessment models, while the 2016 year class was downgraded by 25% from the 2019 assessment; declines of this magnitude illustrate the uncertainty in these early recruitment estimates.
- 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.
- Evenness in the age composition has dramatically declined, which means future recruitment and fishing success will be highly dependent on only a few cohorts of fish.
- Age-4 body condition of the 2014 year class was below average and lower than for previous large year classes in the early 2000s; poor condition could lead to reduced survival and delayed maturity.
- Fits to abundance and biomass indices are poor for recent years, particularly fishery CPUE and the GOA trawl survey, due to the model overstating population growth compared to what is indicated in the observed indices.

- Another marine heat wave formed in 2018, which may have been beneficial for sablefish juveniles in the 2014 – 2017 year classes, but it is unknown how it will affect movement, survival, growth, and maturity of late-stage juveniles and recently matured adult fish.
- Small sablefish are being caught incidentally at unusually high levels, which is shifting fishing mortality spatially and demographically; further analysis is required to fully understand the effects or whether this might reduce future contributions of the recent, large year classes to SSB.

Recommending an ABC lower than the maximum should result in more of the 2014, 2016, and 2017 year classes entering into the spawning biomass and becoming more valuable to the fishery. This precautionary ABC recommendation buffers for uncertainty until there are more observations of these potentially large year classes.

For more information contact Dan Goethel (daniel.goethel@noaa.gov)

Coastwide research discussions for sablefish – ABL

A research collaboration between the Alaska Fisheries Science Center, the Northwest Fisheries Science Center, Alaska Department of Fish and Game, and the Department of Fisheries and Oceans Canada has been underway since 2017. A movement model using data from all regions is near completion. A management strategy evaluation aimed at providing the best science available and informing us of the potential bias or risks to our regional assessment approach is in progress. A workshop to solicit stakeholder feedback is planned for late April 2020.

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

IFQ Sablefish Release Allowance - NPFMC Initial Review - ABL

Under current regulations, releases of any sablefish by the sablefish IFQ fishery is prohibited so long as there is remaining IFQ for persons onboard the fishing vessel. Unusually large year classes of sablefish in 2014 and 2016 have led to increased fishery catches of small sablefish with much lower economic value than more desirable market categories. The Council initiated action to consider allowing sablefish to be released by the IFQ fishery, prior to filling their quota, in December 2019. Two alternatives for analysis were developed by the Council – Alternative 1 (no action) and Alternative 2 (allow voluntary careful release of sablefish in the IFQ fishery).

The Council conducted an initial review of the sablefish release allowance during its February 2021 meeting. While the intent of this action was to allow fishermen to release small sablefish, the elements/options did not include a size limit for sablefish or a mechanism for release mortalities to be deducted from IFQ accounts in-season. Few direct studies were available to narrow the range of potential sablefish discard mortality rates (DMRs) and any study specific to sablefish in Alaska would take years to provide useful results. Finally, the analysis highlighted substantial concerns related to fishery monitoring, catch accounting, and increased uncertainty in the sablefish stock assessment and estimation of biological reference points.

At the February 2021 meeting, the Council suspended further action on this issue and requested that the IFQ Committee provide recommendations on the action's relative priority. The IFQ Committee's recommendations on relative priority will be provided as part of its report at the April 2021 Council meeting. The Council could either resume action on this issue or extend the timeline for action conditional on the fulfillment of other actions, or indefinitely.

The Council motion, analysis, and associated meeting materials are available under "C3" of the 2021 February Council meeting eAgenda: https://meetings.npfmc.org/Meeting/Details/1844

Provided by Jane Sullivan; for more information contact James Armstrong, NPFMC, james.armstrong@noaa.gov

K. 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.

L. Atka Mackerel

1. Research

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 2019 included catch through 2019 (2019 projected) and 2018 fishery age compositions.

In the 2019 assessment, the addition of the 2018 fishery age composition information impacted the estimated magnitude of the 2011 year class which decreased 2%, relative to last year's assessment, and the magnitude of the 2012 and 2013 year classes which increased 10 and 12% respectively, relative to last year assessment. The 2011 and 2013 year classes are about 10% below average, and the 2012 year class is estimated to be 28% above average. Estimated values of B100%, B40% , B35% are 3% higher relative to last year's assessment. Projected 2020 female spawning biomass (109,900 t) is 3% higher relative to last year's estimate of 2019 female spawning biomass, and 7% higher relative to last year's projection for 2020.

Projected 2020 female spawning biomass is below B40% (116,600 t) at B38%, thereby placing BSAI Atka mackerel in Tier 3b. The current estimate of F40% adj= 0.41 is 7% lower relative to last year's estimate of F40% adj due to changes in the fishery selectivity used for projections. The projected 2020 yield at maxFABC = F40% adj = 0.41 is 70,100 t, which is 2% higher relative to last year's estimate for 2019. The projected 2020 overfishing level at F35% adj = 0.48 is 81,200 t, which is 2.5% higher than last year's estimate for 2019.

Gulf of Alaska (REFM)
In the GOA, Atka mackerel are assessed on a biennial basis to coincide with the GOA bottom trawl

survey that takes place in odd years. No assessment was conducted in 2020. Harvest recommendations are based on historical catches during a set time period and do not change with each new assessment. Since 1996, the maximum permissible ABC has been 4,700 t and the OFL has been 6,200 t.

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

M. <u>Flatfish</u>

1. Research

Yellowfin sole and northern rock sole habitat - GAP

The first data on the growth and condition of juvenile yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS) in natural field settings across the Bering Sea shelf were analyzed. In this study, the Bering Sea was divided into three latitudinal subareas to assess the implications of a northward habitat shift or expansion on juvenile flatfish production potential. The growth, diet, and condition of juveniles were compared among subareas from 2016 to 2018. Temperatures in 2016 and 2018 were anomalously warm, but 2017 temperatures were close to the 2010-2018 average. Juveniles of both species grew faster in the southern subarea, but the results of this study suggests that growth and condition of juvenile flatfish may not continue to increase if current high temperatures persist in their habitat. There was no evidence of food limitation across the Bering Sea. The morphometric-based condition of juvenile YFS was higher in the northern subarea. Since NRS were not abundant in the northern subarea, we were unable to compare their condition between the northern and southerly subareas. Warmer bottom temperatures in juvenile habitats may lead to faster growth and higher biomass production in both species up to the point of their upper thermal physiological tolerance for growth and energy storage, which may be lower for YFS than for NRS. More data are necessary to test these initial hypotheses.

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

Cynthia Yeung, Louise A. Copeman, Mary E. Matta, Mei-Sun Yang. Latitudinal variation in the growth and condition of juvenile flatfishes in the Bering Sea. Estuarine and Coastal Shelf Science (In review).

Northern rock sole and yellowfin sole growth potential-FBE RACE

Laboratory experiments were conducted to compare the age-dependence and temperature-dependence of age-0 and age-1 flatfishes in the shallow-water complex. Fish for the lab experiments were collected from nursery grounds in the Gulf of Alaska and Bering Sea in 2018 and 2019 with the experimental series completed in 2020. In both species, fish were reared for 6-8 weeks at temperatures of 2, 5, 9, 13, and 16°C. Fish were fed *ad libitum* daily and were measured at bi-weekly intervals for determination of maximum growth potential. Both age classes of yellowfin sole and age-1 northern rock sole exhibited maximum growth potential at 13°C. In contrast, growth rates of age-0 northern rock sole were slightly higher at 16°C than 13°C suggesting higher tolerance of warner temperatures in demersal juveniles of this species. These thermal sensitivities may play a role in habitat suitability for these species as climate conditions change in the Gulf of Alaska and Bering Sea. Samples from these experiments are being examined for lipid composition to determine whether temperature effects on energy storage mirror the patterns observed in growth or if there is a tradeoff between growth and storage in these species.

For further information, contact Tom Hurst, 541-867-0222, thomas.hurst@noaa.gov

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. In 2019 a new model was introduced based on the 2018 model that retains female natural mortality fixed at 0.12 while allowing the model to estimate male natural mortality.

An unexpected 32% decrease in the NMFS eastern Bering Sea survey biomass was observed in 2018. In 2019 the survey biomass was 6% higher than in 2018 at 2,006,510 t. Spawning biomass estimated by Model 18.2 remained high at 1.94 * BMSY. Therefore, Yellowfin Sole continues to qualify for management under Tier 1a. Similar to recent years, the 1978-2013 age-1 recruitments and the corresponding spawning biomass estimates were used to fit the stock recruitment curve and determine the Tier 1 harvest recommendations.

This assessment updates last year's assessment with results and management quantities that are higher than the 2018 assessment. This is due to a higher 2019 survey biomass point estimate, 6% higher than the 1 2018 estimate. Secondarily, the model estimated male natural mortality slightly higher than female natural mortality, 0.135, which increased biomass estimates.

Catch as of October 28, 2019 was 109,620 t. Over the past 5 years (2014 - 2018), 92.4% of the catch has taken place by this date. Therefore, the full year's estimate of catch in 2019 was 118,642 t. Future catch for the next 10 years, 2020 - 2029 was estimated as the mean of the past 10 years catch, 137,230 t.

Yellowfin Sole continue to be above BMSY and the annual harvest remains below the ABC level. The projected estimate of total biomass for 2020 was higher by 17% from the 2018 assessment of 2,331,500 t, to 2,726,370 t. The model projection of spawning biomass for 2020, assuming catch for 2019 as described above, was 1,051,050 t, 132% of the projected 2020 spawning biomass from the 2018 assessment of 796,600 t. The 2020 and 2021 ABCs using FABC from this assessment model were higher than the 2018 ABC of 249,100 t; 296,060 t and 296,793 t. The 2020 and 2021 OFLs estimated in this assessment were 321,794 t and 322,591 t.

Greenland turbot - Bering Sea and Aleutian Islands - REFM

The BSAI Greenland turbot assessment is conducted in even years, with a partial update in odd years that includes revised harvest recommendations. For 2020, the OFL is 11,319 t and the maximum ABC is 9,625 t.

For further information contact Meaghan Bryan (206) 526-4694

Arrowtooth flounder - Bering Sea and Aleutian Islands - REFM
The Bering Sea and Aleutian Islands (BSAI) arrowtooth flounder stock is classified as a Tier 3 stock for setting the acceptable biological catch (ABC) and overfishing level (OFL). In accordance with the new assessment schedule frequency, we conducted a full assessment for arrowtooth flounder in 2020. We use a statistical age-structured model as the primary assessment tool for arrowtooth flounder. New data for this year included estimates of catch through October 25, 2020, updated and new fishery size compositions, new biomass, age and size data for the eastern Bering Sea shelf bottom trawl survey, and new age data from the Aleutian Islands bottom trawl survey. Additionally, early survey data from 1982-1991 were removed from the eastern Bering Sea trawl survey index as this data occurred when there was low confidence in the identification of arrowtooth flounder.

There were no changes in the assessment methodology as we continue to use the 2018 assessment model (18.9). The 2019 eastern Bering Sea trawl survey estimate increased 13% from the 2018 estimate and is now 27% above average. No 2020 surveys were conducted in the eastern Bering Sea and the Aleutian Islands this year due to Covid-19. Catch for arrowtooth flounder is generally low and has been between 10-18% of the ABC since 2011 when speciation began in the catch accounting system for this stock. Current catch as of October 25, 2020 is at 13.8% of ABC. The total allowable catches (TACs) for arrowtooth flounder are generally set well below ABC and have been between 11- 27% since 2011. The 2020 ratio of TAC to ABC was 14%. For the 2021 fishery, we recommend the maximum allowable ABC of 77,349 t from the 2018 accepted model (Model 18.9). This is an 8% increase from last year's ABC of 71,618 t. The projected female spawning biomass for 2021 is 497,556 t and the projected age 1+ total biomass for 2021 is 923,646 t. Female spawning biomass is well above B40%, and projected to be stable. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. Please refer to this year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Shotwell et al., 2020, available online at https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/BSAIatf.pdf).

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

Arrowtooth flounder - Gulf of Alaska - REFM
The Gulf of Alaska (GOA) arrowtooth flounder stock is classified as a Tier 3 stock for setting the acceptable biological catch (ABC) and overfishing level (OFL). In accordance with the new assessment schedule frequency, we conducted a partial assessment for arrowtooth flounder in 2020. We use a statistical age-structured model as the primary assessment tool for arrowtooth flounder. For this off-cycle (even) year, we present a partial assessment consisting 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 2019 catch estimate and new catch estimates for 2020-2022. In on-cycle (odd) years, we will present a full stock assessment

document with updated assessment and projection model results to recommend harvest levels for the next two years. Please refer to last year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Spies et al., 2019, available online at (https://appsafsc.fisheries.noaa.gov/refm/docs/2019/GOAatf.pdf).

Based on the projection model results, recommended ABCs for 2021 and 2022 are 126,970 t and 123,445 t, respectively, and the OFLs are 151,723 t and 147,515 t. The new ABC and OFL recommendations for 2021 are similar to the 2020 ABCs and OFL developed using the 2017 full assessment model. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished.

Please refer to this year's full stock assessment and fishery evaluation (SAFE) report for further information regarding the stock assessment (Shotwell et al., 2020, available online at https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/GOAatf.pdf). For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

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. The BSAI Kamchatka flounder assessment is conducted in even years, with a partial update in odd years that includes revised harvest recommendations. For 2020, the OFL is 11,495 t and the maximum ABC is 9,708 t.

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 assessment was performed in 2019, s 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
The BSAI flathead sole assessment is conducted in even years, with a partial update in odd years that includes revised harvest recommendations. For 2020, the OFL is 82,810 t and the maximum ABC is 68,134 t.

Flathead sole - Gulf of Alaska - REFM
This assessment is conducted using Stock Synthesis on a four-year schedule. 2019 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 38,196 t from

the updated projection. The FOFL is set at F35% (0.36) which corresponds to an OFL of 46,572 t.

For further information contact Carey McGilliard (206) 526-4696

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. The 2019 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 recommended ABC for 2020 is 31,600 t based on an F40% = 0.125 harvest level, a 9% decrease from 2018. The 2020 overfishing level of 37,600 t is based on a F35% (0.15) harvest level.

Rex sole - Gulf of Alaska - REFM
This stock is on a four-year assessment cycle and a full assessment is due in 2021. In 2019 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 14,878 t and an OFL of 18,127 t.

For further information contact Carey McGilliard (206) 526-4696

"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 2020. Harvest recommendations are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL) and are not revised during off years. 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 2020 OFL and ABC are 21,824 t and 16,368 t respectively.

For further information contact Meaghan Bryan (206) 526-4694

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. A full assessment was conducted in 2017 and will be repeated in 2021. For 2019 a partial assessment was done, and the projection model for northern and southern rock sole was re-run to generate new harvest recommendations. The resultant 2020 OFL and ABC are 68,010 t and 55,463 t respectively. Area ABCs are apportioned based on random-effects model estimates of survey biomass.

For further information contact Carey McGilliard (206) 526-4696

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 2019 a full 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 2020 OFL is 7,163 and 2020 ABC is 6,030 t, substantially lower than the previous full assessment.

N. Pacific halibut

1. Research

Abundance-based management of halibut bycatch in Alaska's federal fisheries
The NPFMC has been actively working for several years to improve management of halibut bycatch. Following is the purpose and need statement for the Council's current actions:

Halibut is an important resource in the Bering Sea and Aleutian Islands (BSAI), supporting commercial halibut fisheries, recreational fisheries, subsistence fisheries, and groundfish fisheries. The International Pacific Halibut Commission (IPHC) is responsible for assessing the Pacific halibut stock and establishing total annual catch limits for directed fisheries and the North Pacific Fishery Management Council (Council) is responsible for managing prohibited species catch (PSC) in U.S. commercial groundfish fisheries managed by the Council. The Amendment 80 sector is accountable for the majority of the annual halibut PSC mortality in the BSAI groundfish fisheries.

While the Amendment 80 fleet has reduced halibut mortality in recent years, continued decline in the halibut stock requires consideration of additional measures for management of halibut PSC in the Amendment 80 fisheries. When BSAI halibut abundance declines, PSC in Amendment 80 fisheries can become a larger proportion of total halibut removals in the BSAI, particularly in Area 4CDE, and can reduce the proportion of halibut available for harvest in directed halibut fisheries. The Council intends to establish an abundance-based halibut PSC management program in the BSAI for the Amendment 80 sector that meets the requirements of the Magnuson-Stevens Act, particularly to minimize halibut PSC to the extent practicable under National Standard 9 and to achieve optimum yield in the BSAI groundfish fisheries on a continuing basis under National Standard 1. The Council is considering a program that links the Amendment 80 sector PSC limit to halibut abundance and provides incentives for the fleet to minimize halibut mortality at all times. This action could also promote conservation of the halibut stock and may provide additional opportunities for the directed halibut fishery.

For more information please consult the NPFMC website (https://www.npfmc.org/); you may also contact Jim Ianelli at jim.ianelli@noaa.gov or Carey McGilliard at carey.mcgilliard@noaa.gov.

O. 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 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 FMPs as "Ecosystem Components". These are stocks for which there are not active conservation concerns, but which 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). Sculpins are also included in the FMP as Ecosystem Components but receive no reports.

Estimating spatiotemporal availability of transboundary fishes to fishery-independent surveys - RACE GAP, HEPR, REFM

In the paper 'Estimating spatiotemporal availability of transboundary fishes to fishery-independent surveys', we combined United States and Russian data from the northern, eastern, and western Bering Sea to understand the proportion of fish biomass within the extent of the eastern survey ("availability"). Surveys are within close proximity to each other, but with different sampling protocols (hence catch a different proportion of local densities, termed "sampling efficiency ratio"). We use Alaska pollock (Gadus chalcogrammus), Pacific cod (Gadus macrocephalus), and Alaska plaice (Pleuronectes quadrituberculatus) as case studies to calculate survey efficiency ratios and two area-swept estimators, termed local and conventional, to summarize groundfish biomass over various spatial scales across the Bering Sea. We estimated variation in spatial availability of transboundary stocks to the eastern Bering Sea (EBS) survey. In 2017, the most recent available year of survey coverage that included all three Bering Sea regions, estimated availability in the EBS of pollock biomass was ~33%, cod biomass was ~27%, and plaice biomass was ~26%, down from ~58%, ~71%, and ~30% respectively in 2010. This is the first study to provide an empirical way to combine Russian and US data in the Bering Sea to assess changes in the availability of groundfish biomass, which in turn will alter the interpretations and values of population indices used in regional management. We recommend leveraging this approach using existing global fishery-independent data sets that span different spatiotemporal footprints to monitor transboundary stocks, and as a template to initiate international cooperation on the assessment of spatial availability of stocks common to multiple countries.

For further information, contact Cecilia O'Leary (cecilia.oleary@noaa.gov).

Understanding transboundary stocks availability by combining multiple fisheries-independent surveys and oceanographic conditions in spatiotemporal models. RACE GAP, HEPR, REFM

In this study, we illustrate the necessity for novel partnerships in the North Pacific when responding to climate-driven distribution shifts. We specifically develop the first-ever biomass estimate for groundfishes across the North Pacific, combining scientific fishery-independent bottom trawl data from the United States and Russia. We use three groundfish species across the Bering Sea as case studies, estimating biomass across the Bering Sea in a spatio-temporal model using the Vector Autoregressive Spatio-Temporal (VAST) model. We estimated a fishing-power correction as a catchability ratio to calibrate the disparate data sets and also estimated the impact of an annual oceanographic index, the cold pool extent index (CPI), as a covariate to explain variation in groundfish spatiotemporal density. We found that for major groundfish species included in this analysis, 'hot spots' or areas of high density span across the international border, particularly in warmer years when the cold pool extent is lower than the long-term average. We also found that groundfish densities increase throughout the entire Bering Sea region relative to historical densities, and all three groundfish species are shifting northward to varying degrees. The proportion of groundfish biomass found in the eastern and western sides of the Bering Sea is highly variable, but the majority of biomass was consistently found in the eastern Bering Sea until the final few years in this study. We conclude that International partnerships are key to tracking fish across international boundaries as they shift beyond historical survey areas. Research effort should be directed towards international collaborations to combine and calibrate past data, and to coordinate efforts in future data collection in order to fully understand biomass changes and manage shifting distribution of fish species as ocean conditions change.

For further information, contact Cecilia O'Leary (cecilia.oleary@noaa.gov).

Workshop on Unavoidable Survey Effort Reduction (WKUSER) – GAP and others
The International Council for the Exploration of the Sea Working Group on Improving Use of Survey Data for Assessment and Advice (WGISDAA) invited survey and stock assessment scientists to investigate challenges and responses to unavoidable reductions of survey effort scheduled for early January 2020. Most survey programs are at one time or another asked to make substantial short-term changes to survey operations due to budget reductions, weather, and vessel breakdowns and unavailability. These short-term effort reductions typically compromise the long-term objectives of survey series in terms of accuracy, precision, and consistency of population estimation. Usually these reductions leave little time for planning and quantitative evaluation, so there is a real need to develop methods that provide a better understanding of the risks of different implementation options. Participants at this workshop will examine methods that can minimize the amount of information loss and seek appropriate methods for the survey design and objectives. These tools aim to assist survey scientists to make better decisions when unexpected events force changes, to facilitate better contingency planning, and to convey the likely consequences to assessment scientists and policy makers.

Participants were encouraged to contribute to the following topics:

- The current processes dealing with unavoidable reductions in survey effort and examining the existing coping strategies (e.g. spatial coverage, survey frequency, or sampling density) and their qualitative consequences.
- Develop key quality metrics that can be used to describe "total survey uncertainty" for common survey designs and indices of abundance.
- Define "changes to survey designs" that require inter-survey calibration and what changes can be resolved by a model-based approach to index generation.
- Develop methods that can provide quantitative decision-making tools describing impacts on the quality of survey deliverables and advisory products.

GAP and other AFSC scientists have been preparing several analyses for oral presentations on the following topics:

Stan Kotwicki Challenges and priorities for WKUSER and beyond.

Michael Martin	An overview of NOAA Fisheries Surveys.
Anne Hollowed	SSC perspective on trade-offs among trawl survey schemes in federal waters off Alaska under varying funding scenarios.
Ned Laman	Effects of sampling density changes on biomass estimates from stratified random bottom trawl surveys in the Gulf of Alaska.
Jim Thorson	Measuring the impact of increased ageing effort: theory and case-study demonstration.
Stan Kotwicki	The effect of variable sampling efficiency on the reliability of observation error as a measure of uncertainty in abundance indices from scientific surveys.
Elaina Jorgensen	Systematic reduction in survey effort and the effect on variance of fish abundance.
Peter Munro	Comparing three estimators of change in trawl survey mean catch per unit effort (CPUE) the Mean Squared Error (MSE) of the estimate under different simulated scenarios.
Paul Spencer	Variance propagation from fishery-independent surveys to the stock assessment outputs.
Paul Von Szalay	A Comparison of Bottom Trawl Sampling Strategies in the Gulf of Alaska: Design vs. Model-Based Approaches.
Kresimir Williams	Cameras vs Catch: potential effects of implementing open codend tows for acoustic midwater fish surveys.
Jason Conner	Impact of reducing sample density on the accuracy and precision of design-based estimators of an abundance index for a bottom trawl survey in the eastern Bering Sea.
Meaghan Bryan	The Impact of survey frequency and intensity on detecting environmental anomalies and shifts in abundance.
Lauren Rogers	Evaluation of a survey with an adaptive sampling domain to capture climate-driven shifts in larval fish distributions.
Jon Richar	Considering changes in sampling density and survey frequency, and their effects on eastern Bering Sea crab population time series.
Cynthia Yeung	Survey Effort Reduction Impacts on the Assessment of the Thermal State of the Bering Sea Ecosystem.

For further information visit the ICES website at
https://www.ices.dk/community/groups/Pages/WKUSER.aspx

Or contact Stan Kotwicki (stan.kotwicki@noaa.gov) or Wayne Palsson (wayne.palsson@noaa.gov).

CONSERVATION ENGINEERING (CE)

The Conservation Engineering (CE) group of the NMFS Alaska Fisheries Science Center (AFSC) (Dr. Noëlle 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 2020, CE research focused on evaluating a bycatch reduction device (BRD) designed to reduce Pacific salmon bycatch (primarily chum, Oncorhynchus keta, and Chinook, O. tshawytscha) in the eastern Bering Sea walleye pollock (“pollock”, Gadus chalcogrammus) pelagic trawl fishery.

Pacific salmon (Oncorhynchus spp.) bycatch is a significant driver in the management of pollock trawl fisheries in the North Pacific. In 2019, in collaboration with science and industry partners, CE developed and field tested a novel salmon 'excluder' (a BRD that provides an open area for salmon to escape between the net and codend; Breddermann et al., 2019; Yochum et al., 2021). In 2020, CE aimed to conduct further testing of that excluder to deepen our collective mechanistic understanding of what influences excluder efficacy and to improve the excluder design. In addition, in 2020 CE began developing methods for quantifying target catch loss (i.e., pollock) when using an excluder.

In light of the limitations to conduct field work due to Covid-19, the scope of the 2020 research plan was reduced and data collection was done through a modified approach. CE worked with the fishing company contracted to conduct the field testing, the NOAA observer program, and the observer company to have the on-board observer install the research equipment (cameras, sensors, etc.) into the net (as per the study design) during commercial fishing operations. To accomplish this, CE conducted thorough training with the observer before he boarded the vessel, had discussions with the captain, and produced a detailed manual and datasheets. In addition, locations for installation of the equipment were marked on the trawl in advance. The observer then worked with the fishing crew to attach the equipment and collect the data.

In August 2020, during two commercial fishing trips, the trawl was fished with the CE developed excluder and data were gathered as described above to inform salmon escapement and behaviour, and the loss of pollock. CE is currently conducting analysis on these data. The results will be included with those from a 2021 charter, where more data will be gathered to address questions about drivers of salmon excluder efficacy. This includes: (i) evaluating the potential to increase escapement rates using artificial lights near the escapement area of the excluder; (ii) assessing salmon behavior, and evaluating changes relative to tow period, water flow, tow speed, and ambient light; and (iii) further developing methods to quantify pollock loss.

References:

Yochum, N., Stone, M., Breddermann, K., Berejikian, B.A., Gauvin, J.R., and Irvine, D.J. 2021. Evaluating the role of bycatch reduction device design and fish behavior on Pacific salmon (Oncorhynchus spp.) escapement rates from a pelagic trawl. Fisheries Research. April 2021.

Breddermann, K., M. Stone, and N. Yochum. 2019. Flow analysis of a funnel-style salmon excluder. In Contributions on the theory of fishing gear and related marine systems. Proceedings of the 14th International Workshop on Methods for the Development and Evaluation of Maritime Technologies (DEMaT), 5-7 November, 2019. Izmir, Turkey, pp. 29- 42. Ed. by M. Paschen and A. Tokaç.

For more information, contact MACE Program Manager, Sandra Parker-Stetter, sandy.parker-stetter@noaa.gov.

Bathymetry and Geomorphology of Shelikof Strait and the Western Gulf of Alaska - RACE GAP

Comment on "Global Choke Points May Link Sea Level and Human Settlement at the Last Glacial Maximum" by Jerome E. Dobson, Giorgio Spada & Gaia Galassi - RACE GAP

Dobson et al. (2020) described the “Bering Transitory Archipelago” as a second route (after Beringia) for human migration from Asia to North America. These “islands” along the Eastern Bering Sea Slope, interpreted from a GIA model (Glacial Isostatic Adjustment) of satellite-derived bathymetry (ETOPO1; Amante and Eakins, 2009), are errors in a global map of the oceans. Therefore, without such features, the likelihood of a Bering Transitory Archipelago is low.

Global seafloor maps of predicted bathymetry, based on correlation between satellite-determined gravity anomalies and underlying bathymetry, have been published by Smith and Sandwell (1997 and others). Successful prediction requires well-calibrated depth measurements to estimate bathymetry in poorly charted ocean waters. These predicted bathymetric data have been used for bathymetric compilations, such as GEBCO’s map (Weatherall et al. 2015) but lack sufficient calibration in some areas.

We are familiar with the Eastern Bering Sea Slope and errors in compilations of modeled and observed bathymetry in this area, because we recently published a map of this region using only direct depth observations (see Figure 9: Zimmermann and Prescott, 2018), totaling 18 million soundings from 200 individual sources. When comparing our map to previously published maps that cover this region (Amante and Eakins, 2009; Weatherall et al., 2015), we found numerous large errors of hundreds of meters that were both positive (shallow) and negative (deep) in a zone extending northwest from the Bering Sea’s Pribilof Islands. Errors from Weatherall et al. 2015 and ETOPO1 are described and discussed in Zimmermann and Prescott (2018). These large, local aberrations are the consequence of interpolation errors (e.g. Smith and Wessel, 1990) in a global seafloor map (an extraordinary feat) in regions of limited underlying ship measurements and as such, these local aberrations must be taken with a grain of salt. The topic of inadequate and erroneous global seafloor maps is important for a variety of reasons (e.g. navigation, resource utilization, oceanography, and anthropology, etc.). The need for accurate maps is currently being addressed by the Nippon Foundation-GEBCO’s Seabed 2030 Project (https://

seabed2030.gebco.net/).

For further information, contact Mark.Zimmermann@noaa.gov

Zimmermann, M., Prescott, M.M. 2020. Comment on “Global Choke Points May Link Sea Level and Human Settlement at the Last Glacial Maximum” by Jerome E. Dobson, Giorgio Spada & Gaia Galassi, 2020, Geographical Review, 110:4, 621-622, DOI: 10.1080/00167428.2020.1802966

Contributions to The International Bathymetric Chart of the Arctic Ocean Version 4.0- RACE GAP

Bathymetry (seafloor depth), is a critical parameter providing the geospatial context for a multitude of marine scientific studies. Since 1997, the International Bathymetric Chart of the Arctic Ocean (IBCAO) has been the authoritative source of bathymetry for the Arctic Ocean. IBCAO has merged its efforts with the Nippon Foundation-GEBCO-Seabed 2030 Project, with the goal of mapping all of the oceans by 2030. Here we present the latest version (IBCAO Ver. 4.0), with more than twice the resolution (200 × 200 m versus 500 × 500 m) and with individual depth soundings constraining three times more area of the Arctic Ocean (∼19.8% versus 6.7%), than the previous IBCAO Ver. 3.0 released in 2012. Modern multibeam bathymetry comprises ∼14.3% in Ver. 4.0 compared to ∼5.4% in Ver. 3.0. Thus, the new IBCAO Ver. 4.0 has substantially more seafloor morphological information that offers new insights into a range of submarine features and processes; for example, the improved portrayal of Greenland fjords better serves predictive modelling of the fate of the Greenland Ice Sheet.

Jakobsson, M., Mayer, L.A., Bringensparr, C. [and many others, including Zimmermann, M.]. 2020. The International Bathymetric Chart of the Arctic Ocean Version 4.0. Nature Sci Data 7, 176. https://doi.org/10.1038/s41597-020-0520-9.

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Research on surveying untrawlable habitats-RACE MACE & GAP

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

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

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

- Acoustic-optics studies
- Experiments with stationary triggered cameras
- Mapping and habitat classification efforts
- Remotely operated vehicle surveys
- Studies of fish response to camera equipment and movement

- A study of fish visual spectrum sensitivity
- Research into computer automated image analyses

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

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Developing Model-based Estimates for Bottom Trawl Survey Time Series—GAP

Some stock assessment authors are exploring models that utilize model based bottom trawl survey biomass estimates. Members of the RACE GAP program are preparing to produce these estimates for stock assessment authors. Efforts in 2019 including developing standardized survey indices using the VAST model applied to selected species in the Eastern Bering Sea Shelf and the Gulf of Alaska and conducing preliminary runs and consultations with stock assessment authors from REFM and ABL. Analyses focusing on model parameters such as the number of knots, which base model to use, and which species to select were conducted in 2019. The aim is now to provide useful model-based results that can be compared to design-based estimates for the 2020 assessment cycle for key species in each survey area.

Contact Stan Kotwicki (stan.kotwicki@noaa.gov) or Jason Conner (Jason.conner@noaa.gov)

Trade-offs in covariate selection for species distribution models: a methodological comparison – GAP

Authors: Brodie, S.J., Thorson, J.T., Carroll, G., Hazen, E.L., Bograd, S., Haltuch, M.A., Holsman, K.K., Kotwicki, S., Samhouri, J.F., Willis-Norton, E. and Selden, R.L..

Species distribution models (SDMs) are a common approach to describing species' space-use and spatially-explicit abundance. With a myriad of model types, methods and parameterization options available, it is challenging to make informed decisions about how to build robust SDMs appropriate for a given purpose. One key component of SDM development is the appropriate parameterization of covariates, such as the inclusion of covariates that reflect underlying processes (e.g. abiotic and biotic covariates) and covariates that act as proxies for unobserved processes (e.g. space and time covariates). It is unclear how different SDMs apportion variance among a suite of covariates, and how parameterization decisions influence model accuracy and performance. To examine trade-offs in covariation parameterization in SDMs, we explore the attribution of spatiotemporal and environmental variation across a suite of SDMs. We first used simulated species distributions with known environmental preferences to compare three types of SDM: a machine learning model (boosted regression tree), a semi-parametric model (generalized additive model) and a spatiotemporal mixed-effects model (vector autoregressive spatiotemporal model, VAST). We then applied the same comparative framework to a case study with three fish species (arrowtooth flounder, pacific cod and walleye pollock) in the eastern Bering Sea, USA. Model type and covariate parameterization both had significant effects on model accuracy and performance. We found that including either spatiotemporal or environmental covariates typically reproduced patterns of species distribution and abundance across the three models tested, but model accuracy and performance was maximized when including both spatiotemporal and environmental covariates in the same model framework. Our results reveal trade-offs in the current generation of SDM tools between accurately estimating species abundance, accurately estimating spatial patterns, and accurately quantifying underlying species–environment relationships. These comparisons between model types and parameterization options can help SDM users better understand sources of model bias and estimate error.

Spatio-temporal analyses of marine predator diets from data-rich and data-limited systems - GAP

Authors: Grüss, A., Thorson, J.T., Carroll, G., Ng, E.L., Holsman, K.K., Aydin, K., Kotwicki, S., Morzaria-Luna, H.N., Ainsworth, C.H. and Thompson, K.A

Accounting for variation in prey mortality and predator metabolic potential arising from spatial variation in consumption is an important task in ecology and resource management. However, there is no statistical method for processing stomach content data that accounts for fine-scale spatio-temporal structure while expanding individual stomach samples to population-level estimates of predation. Therefore, we developed an approach that fits a spatio-temporal model to both prey-biomass-per-predator-biomass data (i.e. the ratio of prey biomass in stomachs to predator weight) and predator biomass survey data, to predict "predator-expanded-stomach-contents" (PESCs). PESC estimates can be used to visualize either the annual landscape of PESCs (spatio-temporal variation), or can be aggregated across space to calculate annual variation in diet proportions (variation among prey items and among years). We demonstrated our approach in two contrasting scenarios: a data-rich situation involving eastern Bering Sea (EBS) large-size walleye pollock (Gadus chalcogrammus, Gadidae) for 1992–2015; and a data-limited situation involving West Florida Shelf red grouper (Epinephelus morio, Epinephelidae) for 2011–2015. Large walleye pollock PESC was predicted to be higher in very warm years on the Middle Shelf of the EBS, where food is abundant. Red grouper PESC was variable in north-western Florida waters, presumably due to spatio-temporal variation in harmful algal bloom severity. Our approach can be employed to parameterize or validate diverse ecosystem models, and can serve to address many fundamental ecological questions, such as providing an improved understanding of how climate-driven changes in spatial overlap between predator and prey distributions might influence predation pressure.

Brodie, S.J., Thorson, J.T., Carroll, G., Hazen, E.L., Bograd, S., Haltuch, M.A., Holsman, K.K., Kotwicki, S., Samhouri, J.F., Willis-Norton, E. and Selden, R.L., 2020. Trade-offs in covariate selection for species distribution models: a methodological comparison. Ecography, 43(1), pp.11-24.

Grüss, A., Thorson, J.T., Carroll, G., Ng, E.L., Holsman, K.K., Aydin, K., Kotwicki, S., Morzaria-Luna, H.N., Ainsworth, C.H. and Thompson, K.A., Spatio-temporal analyses of marine predator diets from data-rich and data-limited systems. Fish and Fisheries.

Advancing Essential Fish Habitat (EFH) Species Distribution Modeling (SDM) Descriptions and Methods for North Pacific Fishery Management Plan (FMP) Species --GAP, AKRO

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.

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)

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 of survey vessels. 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 App" is now used on all groundfish surveys. A specimen collection app was deployed in 2017 and is now used on all survey vessels in 2019. A new "At Sea" editing application will be tested at sea in 2021.

Future plans include establishing two-way communication between the tablets and a wheelhouse database computer, so all collected biological data can be fully integrated real-time into a centralized database. This effort aims to allow us to collect more, and more accurate, biological data, in a more efficient way.

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

Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2020. Duane Stevenson recently published a study of the population structure and demographic history of the pelagic smooth lumpsucker (Okazaki, Stevenson, and others, 2020), and has a taxonomic revision of the agonid genus *Pallasina* in press (Stevenson, Orr, and Kai). Jay Orr, along with Stevenson and others, published descriptions of two new species of snailfishes of the genus *Careproctus* (Orr, 2020; Orr et al., 2020), and has another paper describing three more new species in press. He continues to collaborate with Jenny Gardner and Luke Tornabene of the University of Washington on the description of two additional species of *Careproctus*. Orr also contributed to the description of a new species of the snailfish genus *Elassodiscus* (Kai et al., 2020) from the western North Pacific and Bering Sea. Orr and Sharon 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 also been made in examining morphological variation related to recently revealed genetic heterogeneity in rockfishes (*Sebastes crameri*; Orr, with NWFSC) and flatfishes (*Hippoglossoides*; Orr, Stevenson, Spies, Paquin, Raring, and Kai).

GAP systematists are also working with AFSC geneticists on several genetic studies. An examination of population-level genetic diversity, using NextGen sequencing techniques, in the Alaska Skate, *Bathyraja parmifera*, especially as related to its nursery areas, is underway (Spies, Orr, Stevenson, and Hoff). Orr and Stevenson, with Ingrid 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 collaborated with Spies and other AFSC and UW authors on a genetic analysis of northward range expansion in Pacific cod (Spies et al., 2020), and will be collaborating with Spies on a total genomic analysis of walleye pollock (along with post-doc Ellie Bors). Orr is collaborating with R. Wilborn, Spies, Chris Rooper (DFO), and P. Goddard on a report of genetically identified rockfish larvae associated with coral. Molecular and morphological studies on *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies) are also continuing.

In addition to systematic publications and projects, GAP systematists have been involved in works on the zoogeography and skeletal anatomy of North Pacific fishes. Orr has completed a chapter in a book on the biology of freshwater flatfishes, as well as a contribution to the upcoming second edition of Miller and Lea's Guide to the Coastal Marine Fishes of California. Stevenson recently published a range extension for a rare species of manefish into the central North Pacific (Frable and Stevenson, 2020), and has contributed to IUCN Red List assessments of 22 species of marine flatfishes in the North Pacific. Orr recently concluded an investigation of the influences of habitat on the skeletal structure of snailfishes (Gerringer et al., in press), and Stevenson is continuing a collaboration with UW graduate student Kayla Hall on the early development of skate embryos.

2020 Publications:

Frable, B. W., and D. E. Stevenson. 2020. First record of *Platyberyx rhyton* (Teleostei: Perciformes: Caristiidae) outside of Japanese waters and description of juvenile morphology. Species Diversity 25:377–380.

Gerringer, M. E., A. Dias, A. von Hagel, J. W. Orr, A. P. Summers, and S. Farina. In press. Habitat influences skeletal morphology and density in the snailfishes (Family Liparidae). Frontiers in Zoology, 64 ms pp.

Kai Y., K. Matsuzaki, J. W. Orr, T. Mori, and M. Kamiunten. 2020. A new species of *Elassodiscus* (Cottoidei: Liparidae) from the North Pacific with an emended diagnosis of the genus. *Ichthyological Research*, published first online, https://doi.org/10.1007/s10228-020-00764-4.

Okazaki, T., D. E. Stevenson, Y. Kai, Y. Ueda, T. Hamatsu, and Y. Yamashita. 2020.

Genetic population structure and demographic history of a pelagic lumpsucker, *Aptocyclus ventricosus*. Environmental Biology of Fishes 103:283–-289.

Orr, J. W. 2020. Snailfishes, pp. 211–218. In: M. S. Love and J. K. Passarelli (eds.). *Miller and Lea's Guide to the Coastal Marine Fishes of California, 2nd Ed*. Davis: University of California Agriculture and Natural Resources Publication 3556 and Cabrillo Marine Aquarium, San Pedro, CA.

Orr, J. W. 2020. A new snailfish of the genus *Careproctus* (Teleostei: Cottiformes: Liparidae) from the Beaufort Sea. *Copeia* 108(4):815–819.

Orr, J. W. In press. Three new small snailfishes of the genus *Careproctus* (Teleostei: Cottiformes: Liparidae) from the Aleutian Islands, Alaska. *Copeia*, 32 ms pp.

Orr, J. W., D. Pitruk, R. Manning, D. E. Stevenson, J. R. Gardner, and I. Spies. 2020. A new species of snailfish (Cottiformes: Liparidae) closely related to *Careproctus melanurus* of the eastern North Pacific. *Copeia* 108(4):711–726.

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V. Ecosystem Studies

Ecosystem and Socioeconomic Profiles (ESP) – REFM
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 socioeconomic 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 termed the Ecosystem and Socioeconomic Profile or ESP that facilitates the integration of ecosystem and socioeconomic factors within the stock assessment process and acts as a proving ground for use in management advice (Shotwell et al., 2020). The ESPs are a commitment to a process that allows for creating a proactive strategy in response to change. Here we are building on the rich history of identifying ecosystem pressures on stocks in the Alaska region and designing a research template that tests these linkages for providing advice. 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.

There are four steps to the ESP process. In the first step, we start with a focused effort to review information from national initiatives on prioritization, vulnerability, and classification and combine that with regional priorities to develop a list of priority stocks for producing ESPs. Once an ESP has been prioritized for a stock, we then move to grading a standard set of descriptive stock metrics and then evaluate ecosystem and socioeconomic processes driving stock dynamics to develop a mechanistic understanding of the drivers for the stock. This leads to defining a suite of indicators to monitor and analyzing trends of these indicators using tests appropriate to the data availability for the stock. The process is completed with a standardized reporting template that is concise and conveys the status of the leading indicators to fisheries managers within the stock assessment cycle (Shotwell et al., In Review).

Three annual workshops planned to fine-tune the ESP framework to the needs of the AFSC have recently been completed. The first data workshop summarized the available data for use in an ESP from a large variety of programs both within and external to the AFSC. This workshop was conducted in May 2019 and results were presented at the Preview of Ecosystem and Economic Considerations (PEEC) meeting in June 2019 and at the Joint Crab and Groundfish September Plan Team 2019. The second model workshop was conducted in March 2020 through two small in-person host sites and large remote participation due to current events regarding COVID-19. The workshop presentations reviewed current progress on the ESPs as well as modeling applications to create value-added metrics or indicators for the ESPs and models to evaluate indicators for use in the ESPs and the operational stock assessments. A one-day follow-up discussion session was conducted in September 2020 to provide a short review of the presentations and engage in-group discussions that were truncated due to the largely remote participation of the workshop.

The third ESP advice workshop was conducted entirely remotely in March 2021 due to the persistence of COVID-19; however, attendance was higher than the previous two workshops. Progress on new ESPs and ESP teams were reviewed as well as presentations on data accessibility and reproducibility and a series of program updates that reviewed avenues for interfacing with the ESPs. Two evaluation gates have now been established for including indicators within an ESP (gate 1) and within a stock assessment model (gate 2). A series of presentations reviewed the types of indicators currently in ESPs and forecasting with climate enhanced single and multispecies models. Two discussion sessions included creating guideline criteria for entering the two ESP gates. The final workshop day included presentations on how the ESPs are currently used for management advice and a discussion session on interfacing more with stakeholders and the public. A one-day ESP session is now scheduled to coincide with the PEEC workshop to review new and upcoming ESPs and have discussions on further developing the ESP process both regionally and nationally.

A methods manuscript detailing the four-step ESP framework, along with technical memorandums of the workshops are planned for 2021. Additional web applications and data repository are also in development to provide access to the data and model output for use in the ESPs. These products will improve communication of the ESP framework and allow timely and consistent access to regional or stock-specific ecosystem and socioeconomic indicators for use in the ESPs. Altogether, the workshops and reports 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. We plan to expand the ESPs to other regions to form a more coordinated national effort of integrating ecosystem information within our next generation stock assessments.

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

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Gulf of Alaska Climate Integrated Modeling Project - REFM and other divisions
The Gulf of Alaska ecosystem supports valuable and diverse marine fisheries and most of the human population of Alaska resides in the Gulf of Alaska region. Large changes in climate are expected in the Gulf of Alaska in the coming decades. Scientists are using an integrated modeling approach to identify factors affecting present and future ecosystem-level productivity and to assess the economic and social impacts on Gulf of Alaska fishing and subsistence communities of Climate Change. This is an interdisciplinary collaboration and a complement to a successful project developed for the eastern Bering Sea.

This multidisciplinary modeling effort applies a regional lens to global climate models. Scientists are combining regional socio-economic, oceanographic data and biological models including single-species, multispecies and ecosystem models to develop a regional multi-model (an ensemble model) to provide quantitative advice to support resource management given climate variability and long-term change. One important management application of this research is to evaluate the Optimum Yield (OY) range (160,000–800,000 t) in the Groundfish Fishery Management Plan for the Gulf of Alaska in a changing climate.

Scientists will begin to address the critical need to anticipate those changes and evaluate their impact on the ecosystem and its inhabitants. By providing near-term and long-term projections, scientists hope to help resource managers and local communities anticipate and better plan for environmental and ecological changes due to Climate Change in the Gulf of Alaska. This effort represents a substantial step towards meeting the objectives of Gulf of Alaska Climate Science Regional Action Plan and the NOAA Fisheries Climate Science Strategy. This project will examine how individuals, families, and communities adapt to climate variability and associated changes in fisheries and marine ecosystems. We will also identify the factors underlying adaptation choices, and tradeoffs associated with those adaptations.

Project activities

- Develop and apply the Atlantis model as an element of a multi-model ensemble to evaluate fisheries management strategies in a changing climate.
- Combine oceanographic modeling driven by climate projections of earth system models (ESM) with biological models including single species, multi-species, and ecosystem models. This includes the Atlantis end-to-end ecosystem model, food web models for the Gulf of Alaska (Ecopath and Ecosim) and a Gulf of Alaska multi-species (CEATTLE).
- Explore recent climate change impacts on the Gulf of Alaska social-ecological system (e.g., use the 2013-2016 marine heat wave, PDO variation, and climate projections as natural experiments to explore ecosystem-level and species-specific responses to physical forcing).
- Apply the coupled climate-biological-social multi-model ensemble to explore the implications of long-term changes in physical forcing on various management questions (e.g., current OY range in the Gulf of Alaska; implementation of catch share programs, etc.), taking into account model uncertainty.
- Evaluate performance of management strategies under climate change (e.g., estimate system-level OY for Gulf of Alaska using the multi-model ensemble)
- Evaluate and predict the impacts of major environmental anomalies to an endangered population of Steller sea lions using the 2013-2016 marine heatwave as a natural experiment.
- Model fleet dynamics and fishery landings responses to ecosystem and management change

Greater detail can be found at https://www.fisheries.noaa.gov/alaska/socioeconomics/gulf-alaska-climate-integrated-modeling-socioeconomics-climate-communities. Also , for more information please contact Martin Dorn at Martin.Dorn@noaa.gov.

Resource Ecology and Ecosystem Modeling Program (REEM)

Multispecies, foodweb, and ecosystem modeling and research are ongoing. A detailed program overview is at: https://www.fisheries.noaa.gov/resource/data/alaska-marine-ecosystem-status-reports-interactive-overview.

Ecosystem Status Report 2020: 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: https://www.fisheries.noaa.gov/alaska/population-assessments/2020-north-pacific-groundfish-stock-assessments#ecosystem-status-reports.

Groundfish Stomach Sample Collection and Analysis - REFM
The REEM Program continues regular collection of food habits information on key fish predators in

Alaska's marine environment. Much of this information comes from samples collected during standard assessment surveys, most of which were canceled in 2020 due to the pandemic. As a result, no stomach samples were collected by REEM in 2020.

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 SAFE document (https://www.fisheries.noaa.gov/alaska/population-assessments/2020-north-pacific-groundfish-stock-assessments), 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. Because of the lag in data availability and ensuing analysis, the 2020 Economic SAFE largely focuses on the results of the fisheries in 2019. The economic SAFE is summarized briefly below; the full document is available at: https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/econGroundfishSafe.pdf.

Alaska's federal groundfish fisheries target six major species/complexes: Alaska pollock, Pacific cod, sablefish, Atka mackerel, the flatfish complex, and the rockfish complex, plus Pacific halibut (which is not an FMP groundfish). The fisheries for these species/complexes are distributed across two regions: the Bering Sea & Aleutian Islands (BSAI) and the Gulf of Alaska (GOA). Each region can be broadly divided into two sectors: catcher vessels which deliver their harvest to shoreside processors, and the at-sea processing sector, whose processed product sells directly to the first-wholesale market. Catcher vessels account for a higher proportion of the ex-vessel value of groundfish landings than total catch because a higher share of their revenues come from high-priced species such as sablefish. The ex-vessel value of the at-sea sector is imputed from observed first-wholesale value to exclude the value added by at-sea processing.

The commercial FMP groundfish fisheries off Alaska had a total catch of 2.2 million metric tons (mt) in 2019 (including catch in federal and state waters), a decrease of 1.8% from 2018. Groundfish accounted for 83% of Alaska's 2019 total catch. Total catches of Alaska's FMP groundfish fisheries increased in 2019 for sablefish, and the flatfish and rockfish species complexes, and decreased for pollock, Pacific cod, and Atka mackerel.

The aggregate ex-vessel value of the FMP groundfish fisheries off Alaska was $981 million, which was 50% of the ex-vessel value of all commercial fisheries off Alaska in 2019. After adjustment for inflation, the real ex-vessel value of FMP groundfish decreased $30 million in 2019 was also due to an aggregate real ex-vessel price decrease of 1.7% to $0.21 per pound. Nominal pollock ex-vessel prices increased 7% to $0.16 per pound in the BSAI, and 12% to $0.14 per pound in the GOA. Pacific cod nominal ex-vessel prices increased 5% to $0.42 per pound in the BSAI, and 8% to $0.49 per pound in the GOA. Among the other species that are the focus of the shoreside ex-vessel fisheries: The GOA flatfish ex-vessel price fell 22%, GOA rockfish prices were unchanged, GOA Pacific cod prices rose 8%, BSAI Pacific cod prices rose 5%, and GOA sablefish prices fell 27% (in nominal terms). For Alaska FMP groundfish in aggregate, the change in catch was larger than the change in price (Tables 5.6 and 5.10). For other fisheries in Alaska, halibut, salmon, herring, and shellfish ex-vessel revenues increased (Table 4).

The gross value of the 2019 groundfish catch after primary processing (first-wholesale) was $2.5 billion, a decrease of 3% in real terms from 2018. This change was the combined effect of a 2% decrease in the real aggregate 2019 first-wholesale price to $1.2 per pound while aggregate production volumes decreased 0.6% to 931.3 to thousand mt. In the BSAI, aggregate first-wholesale value was stable and value was increasing for pollock and most flatfish except for yellowfin and rock sole. Value was decreasing for Pacific cod, Pacific ocean perch, and sablefish. In the GOA aggregate first-wholesale value decreased (16%) with decreases in value for pollock, pacific ocean perch, and sablefish while arrowtooth and Pacific cod value increased.

The first-wholesale value of Alaska's FMP groundfish fisheries accounted for 53% of Alaska's total first-wholesale value from commercial fisheries. First-wholesale value of Alaska's fisheries products other than FMP groundfish fisheries totaled $2.18 billion, most of which ($1.7 billion) came from Pacific salmon. Pacific salmon value increased 9.3%, in part, because of the typical cycle in salmon returns and production, though year-over-year prices were down. Pacific halibut fisheries, which are concentrated in the Gulf of Alaska, saw an increase of 2.9% in value to $109 million in 2019.

The groundfish fisheries off Alaska are an important segment of the U.S. fishing industry. In 2018, it accounted for 50% of the weight of total U.S. domestic landings and 18% of the ex-vessel value of total U.S. domestic landings (Fisheries of the United States, 2018). Alaska fisheries as a whole (including salmon, halibut, herring, and shellfish) accounted for 57% of the weight of total U.S. domestic landings and 35% of the ex-vessel value of total U.S. domestic landings.

NOAA Fisheries collects only limited data on employment in the fisheries off Alaska. The most direct measure available is the number of 'crew weeks' on at-sea processing vessels and catcher vessels of FMP groundfish. These data indicate that in 2019 crew weeks for both sectors totaled 150,169 with the majority of them (122,248) occurring in the BSAI groundfish fishery. In the BSAI, the months with the highest employment correspond with peak of the pollock seasons in February-March and July-September. In the Gulf of Alaska, crew weeks peak February-May with the catcher vessel hook and line fisheries targeting sablefish and Pacific cod. Relative to 2018, annual crew weeks in Alaska decreased in 2019 by 1.2%.

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

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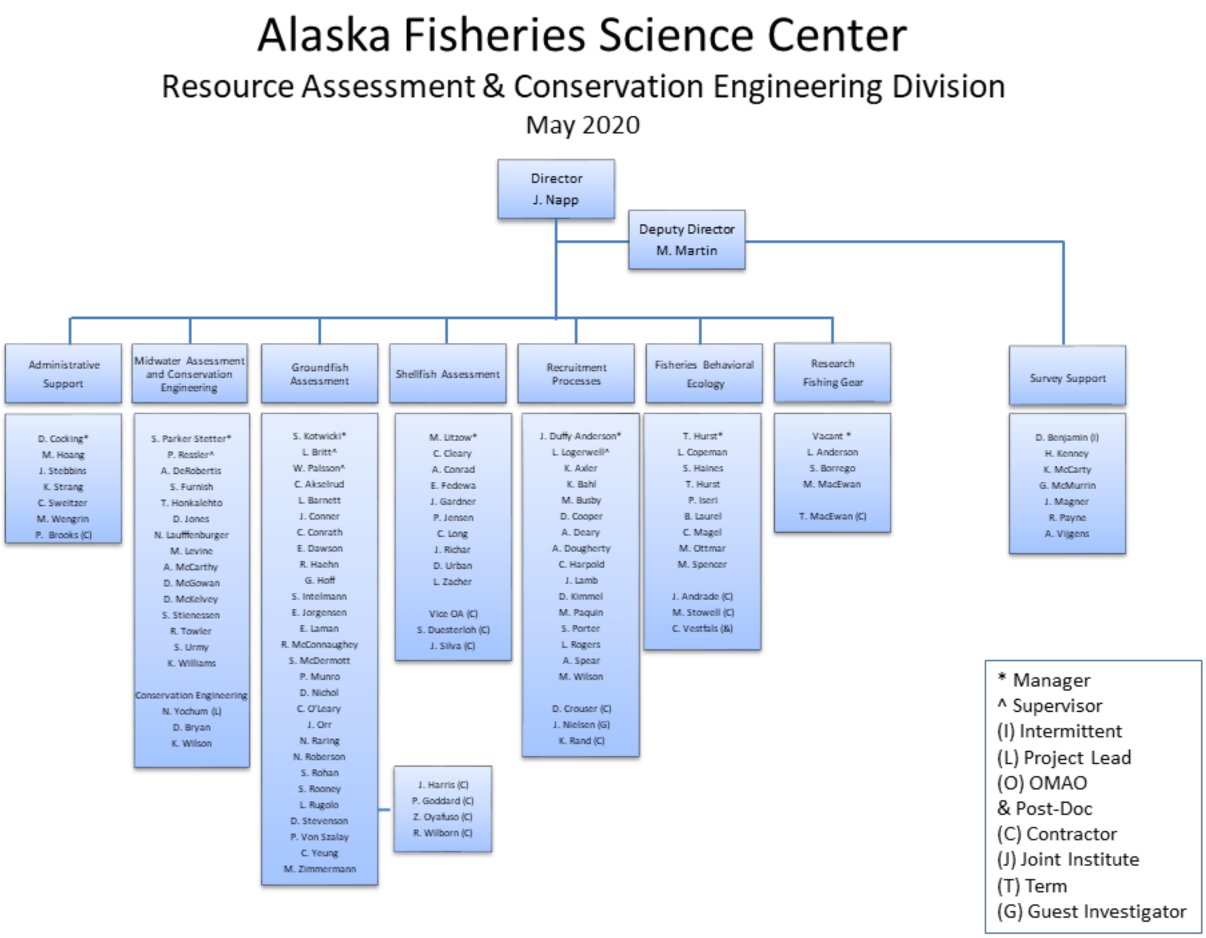
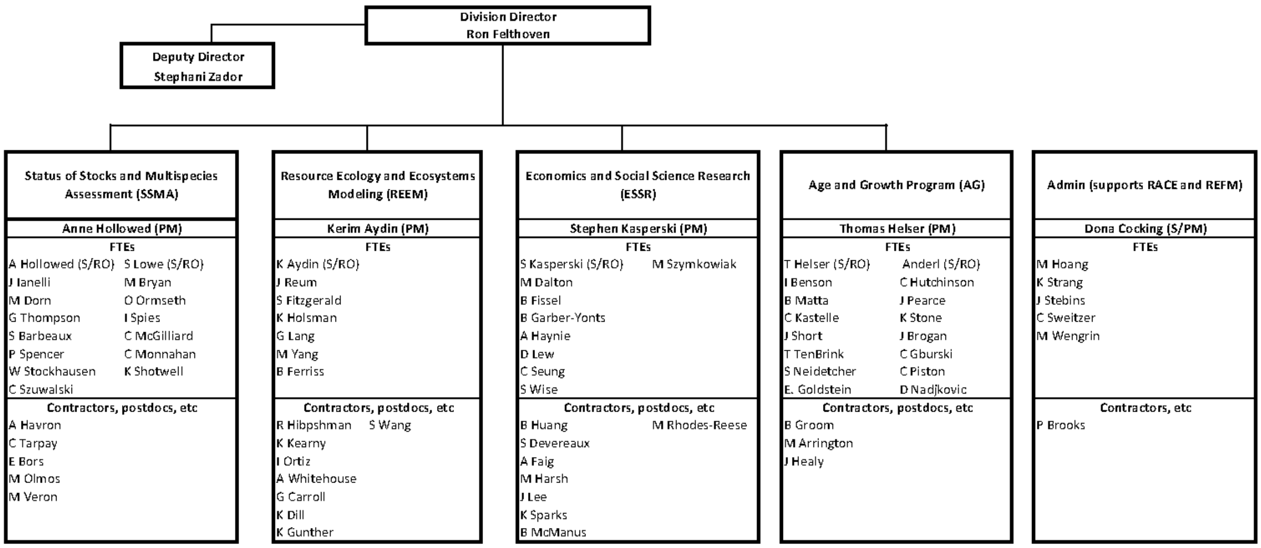
APPENDIX I. RACE ORGANIZATION CHART

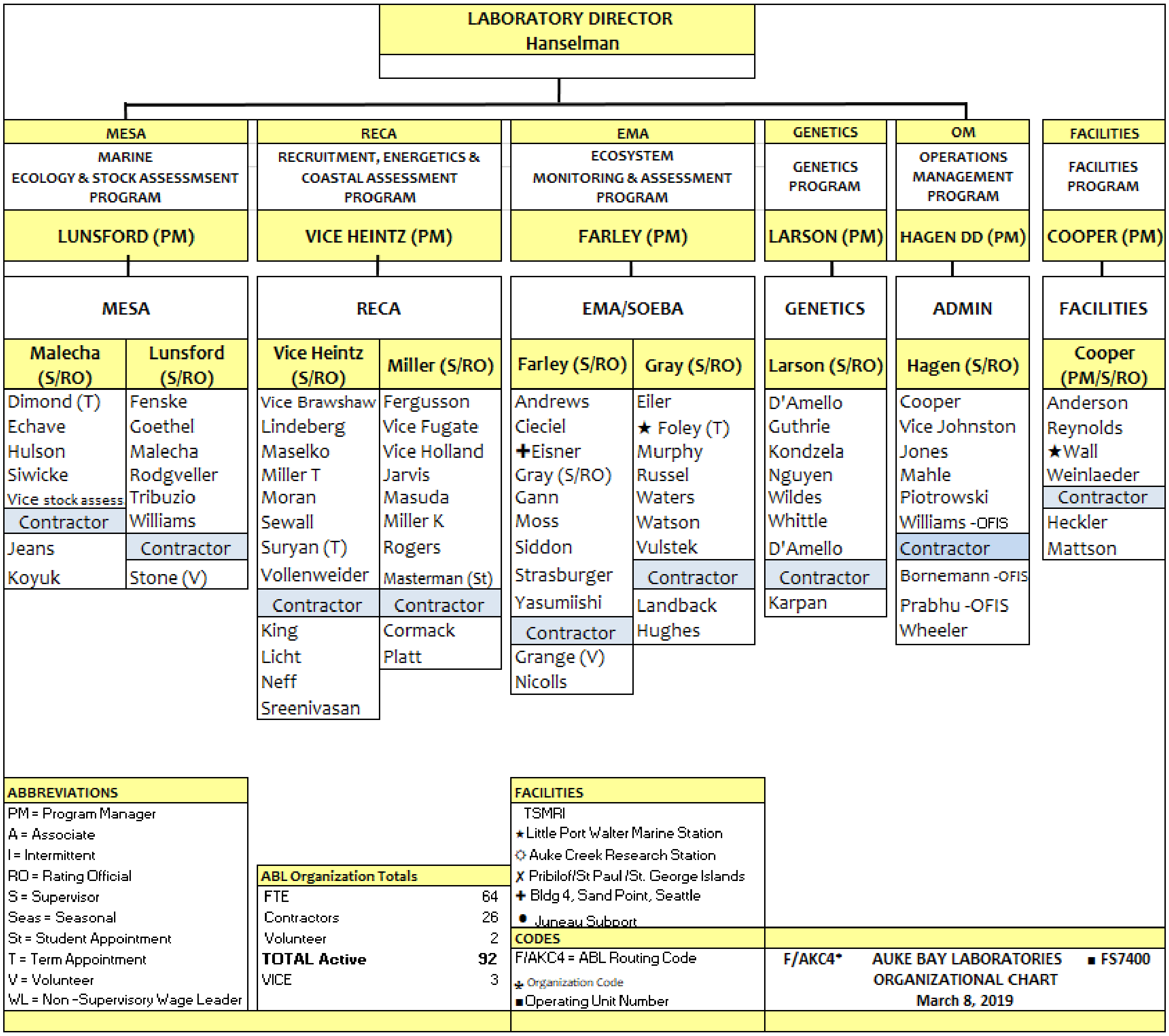


APPENDIX II. REFM ORGANIZATION CHART

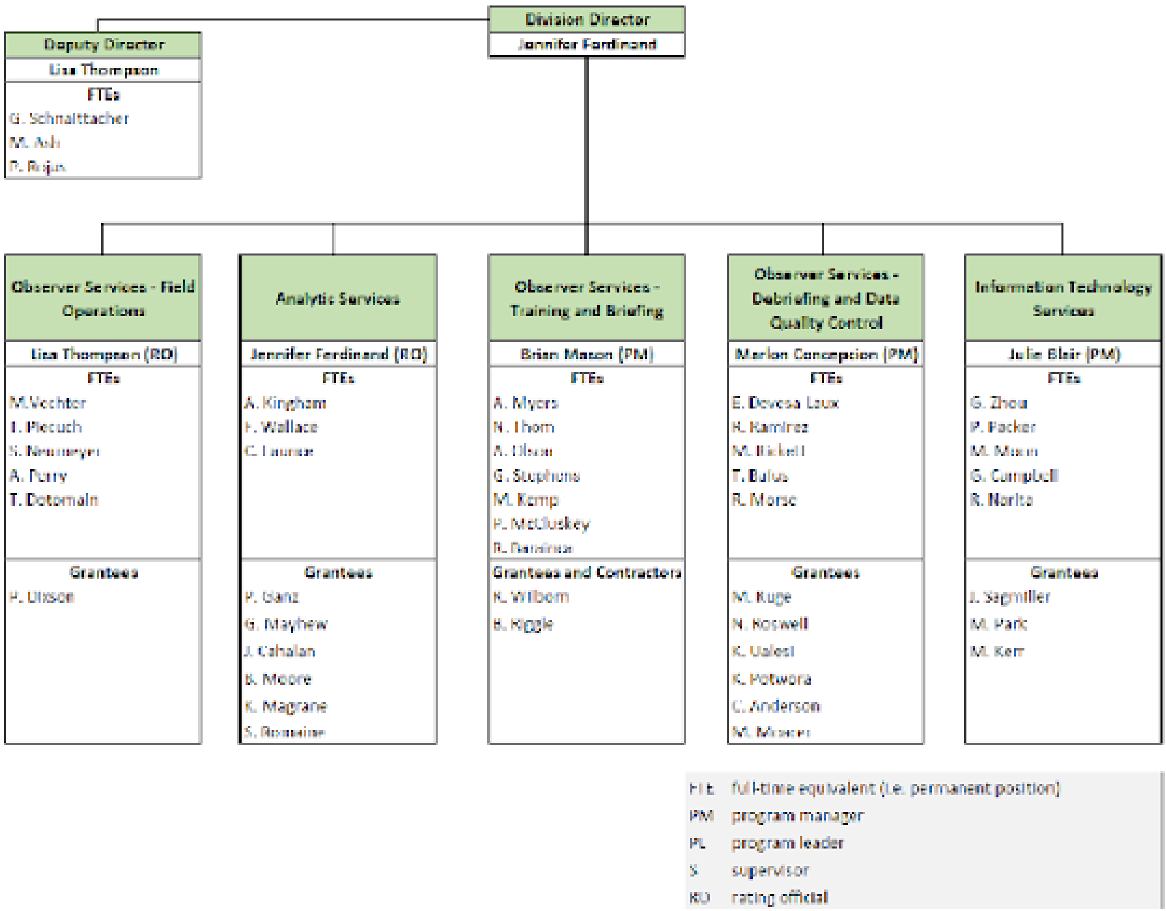


FTE	full-time equivalent (i.e. permanent position)
PM	program manager
PL	program leader
S	supervisor
RO	rating official
vice	vacant position

APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART



APPENDIX IV – FMA ORGANIZATIONAL CHART



CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2020

April 2021

Prepared for the
Technical Sub-Committee of the Canada-United States Groundfish Committee

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I. Agency Overview

Fisheries and Oceans Canada (DFO) has its regional headquarters office (RHQ) for the Pacific Region (British Columbia and Yukon) in Vancouver, British Columbia, with area offices and science facilities at various locations throughout the Region. Groundfish fishery management is conducted by the Groundfish Management Unit within the Fisheries Management Branch at RHQ, while Groundfish stock assessment and research is conducted by Science Branch at the Pacific Biological Station (PBS) in Nanaimo, and at the Institute of Ocean Sciences (IOS) in Sidney. Within Science Branch, a variety of programs are responsible for delivering groundfish stock assessments and research and for providing science advice to fishery managers, species at risk coordinators, marine spatial planners, etc. Directors, division managers, and section heads are as follows:

<u>Fisheries and Oceans Canada Minister: The Honourable Bernadette Jordan</u>

<u>Regional Headquarters Office (RHQ)</u>

Regional Director General: Rebecca Reid

<u>Fisheries and Aquaculture Management Branch</u>

Regional Director of Fisheries Management:	Andrew Thomson
Regional Director of Resource Management:	Neil Davis
Regional Manager of Groundfish:	Adam Keizer

<u>Science Branch</u>

Regional Director of Science:	Carmel Lowe
Strategic Science Initiatives Division (SSID):	Brenda McCorquodale
• Centre for Science Advice – Pacific:	Al Magnan
• Strategic Partnerships and Programs:	March Klaver
Stock Assessment and Research Division (StAR):	John Holmes
• Groundfish Section:	Greg Workman
• Quantitative Assessment Methods Section:	Chris Rooper
• Fisheries and Assessment Data Section:	Shelee Hamilton
• Marine Invertebrates Section:	Ken Fong
• Salmon Assessment:	Antonio Velez-Espino
• Salmon Coordinator:	Diana Dobson
Aquatic Diagnostics, Genomics & Technology Division (ADGT):	Lesley MacDougall
• Applied Technology:	Henrik Kreiberg
• Genetics:	John Candy
• Aquatic Animal Health:	Mark Higgins
Ocean Science Division (OSD):	Kim Houston
• Ecology and Biogeochemistry:	Andrew Ross
• Modelling & Prediction:	Jon Chamberlain

- State of the Ocean: Charles Hannah

Ecosystem Science Division (ESD): Eddy Kennedy
- Marine Spatial Ecology & Analysis: Miriam O
- Aquatic Ecosystem & Marine Mammals: Sean MacConnachie
- Freshwater Ecosystems: Jeffery Lemieux
- Nearshore Ecosystems: Cher LaCoste
- Regional Ecosystem Effects on Fish & Fisheries: Kim Hyatt

Canadian Hydrographic Service (CHS): Mark LeBlanc

Groundfish research and stock assessment work is conducted amongst the Groundfish, Fisheries and Assessment Data, and Quantitative Methods Sections within StAR. Groundfish specimen ageing and genetics are conducted in the Applied Technologies and Genetics Sections in ADGT. Acoustic fisheries research and surveys are led by the Ecology and Biogeochemistry Section in OSD. Ecosystem studies, marine protected areas research and planning, and habitat research is undertaken in collaboration with staff in the Ecosystems Science Division (ESD).

Fishery Managers and other clients receive science advice from StAR through the Canadian Centre for Scientific Advice Pacific (CSAP) review committee. Groundfish subject matter experts meet periodically throughout the year to provide scientific peer review of stock assessment working papers and develop scientific advice; every peer review process involves both internal (DFO) and external reviewers. 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 frequency of review meetings and production of stock assessment advice for fisheries managers varies depending on departmental, branch and regional priorities.

The Canadian Coast Guard operates DFO research vessels. These research vessels include the J.P. Tully, Vector, Neocaligus, and the Sir John Franklin. The Sir John Franklin, replacement for the W.E Ricker, was deployed for its inaugural field season in 2020. However, due to the COVID-19 pandemic, crew training and vessel familiarization in relation to fishing activities was curtailed and there were a limited number of surveys deployed on the vessel (and no groundfish surveys). Training and familiarization activities are expected to continue in 2021, followed by a full suite of surveys.

Groundfish commercial fisheries continued to operate in 2020; however, on April 2, 2020 the Minister of Fisheries and Oceans Canada suspended the use of at-sea observers due to the COVID-19 pandemic. On April 14, 2020, "Emergency Electronic Monitoring (EM)" measures were introduced for groundfish trawl trips which would normally have been subject to monitoring by the at-sea observer program.

The Groundfish 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. The 2020 Groundfish Integrated Fisheries Management Plan v.1.3 (IFMP) is available from the Federal Science Library: https://waves-vagues.dfo-mpo.gc.ca/Library/40935218.pdf.

Allocations of fish for financing scientific and management activities are identified in the Groundfish IFMP. Collaborative Agreements were developed for 2020-21 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 2021-22.

II. Surveys

A. 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 was successfully 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 approximately 29 thousand trips and approximately 11.7 million individual fish specimens. In 2020, data entry activities concentrated on input of current-year groundfish research cruises and biological data from at-sea and dockside observers, fish ages, as well as some non-groundfish survey data from other DFO surveys.

B. 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 (EM) including video. 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.

Changes to commercial fishery monitoring and sampling programs due to COVID-19

Prior to the COVID-19 pandemic, all vessels fishing under an Option A trawl license (groundfish trawl trips outside the Strait of Georgia, excluding the hake fishery) were required to be accompanied by an at-sea observer. On April 2, 2020, the Minister of Fisheries and Oceans Canada issued a Fisheries Management Order (FMO 2020-01) under section 9.1 of the Fisheries Act "*to lift the existing at-sea observer requirements imposed under existing licences to fish, which create a human health risk for at-sea observers and fishers and constitute a public human health risk*." On April 14, 2021, an Emergency Electronic Monitoring (EM) Program was initiated, requiring vessels fishing with an Option A trawl license to be outfitted with an approved EM system in place of an at-sea observer. Effective October 29, 2020, the emergency EM measures were expanded to require a specific version of the EM system as well as the installation and use of video-monitored fixed measuring grids for releasing fish. Alternatively, vessels were once again permitted to carry an at-sea observer (subject to availability and applicable COVID-19 guidelines); however, all vessels opted to continue with the EM measures.

The absence of at-sea observers from all commercial trips after April 2, 2020 means that no at-sea biological samples were collected after that date. Dockside samples continued to be collected

C. Research Surveys

The Fisheries and Oceans, Canada (DFO) Groundfish section of the Stock Assessment and Research Division conducts a suite of fishing 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. The randomized surveys include the Multispecies Synoptic Bottom Trawl, Hard Bottom Longline Hook, and Sablefish Longline Trap surveys (Figure 1).

Data from the synoptic bottom trawl surveys and hard bottom longline hook surveys are published annually to the Government of Canada Open Government Portal and to OBIS:

- Open Government Portal
  - Synoptic Bottom Trawl Surveys
  - Hard Bottom Longline Surveys
- OBIS
  - Queen Charlotte Sound Bottom Synoptic Trawl Survey
  - West Coast Vancouver Island Synoptic Trawl Survey
  - Hecate Strait Synoptic Trawl Survey
  - West Coast Haida Gwaii Synoptic Trawl Survey
  - Strait of Georgia Synoptic Trawl Survey
  - Inside North Hard Bottom Longline Survey
  - Inside South Hard Bottom Longline Survey
  - Outside North Hard Bottom Longline Survey
  - Outside South Hard Bottom Longline Survey

All the surveys follow similar 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 randomized surveys, a fixed-station longline hook survey targeting North Pacific Spiny Dogfish in the Strait of Georgia is completed every three years. The Groundfish section also routinely participates in the Canadian portion of the Joint Canada US Hake Acoustic Survey, collects groundfish information from a DFO Small-Mesh Bottom Trawl Survey, and funds an additional technician during the International Pacific Halibut Commission (IPHC) Setline Survey (Figure 2).

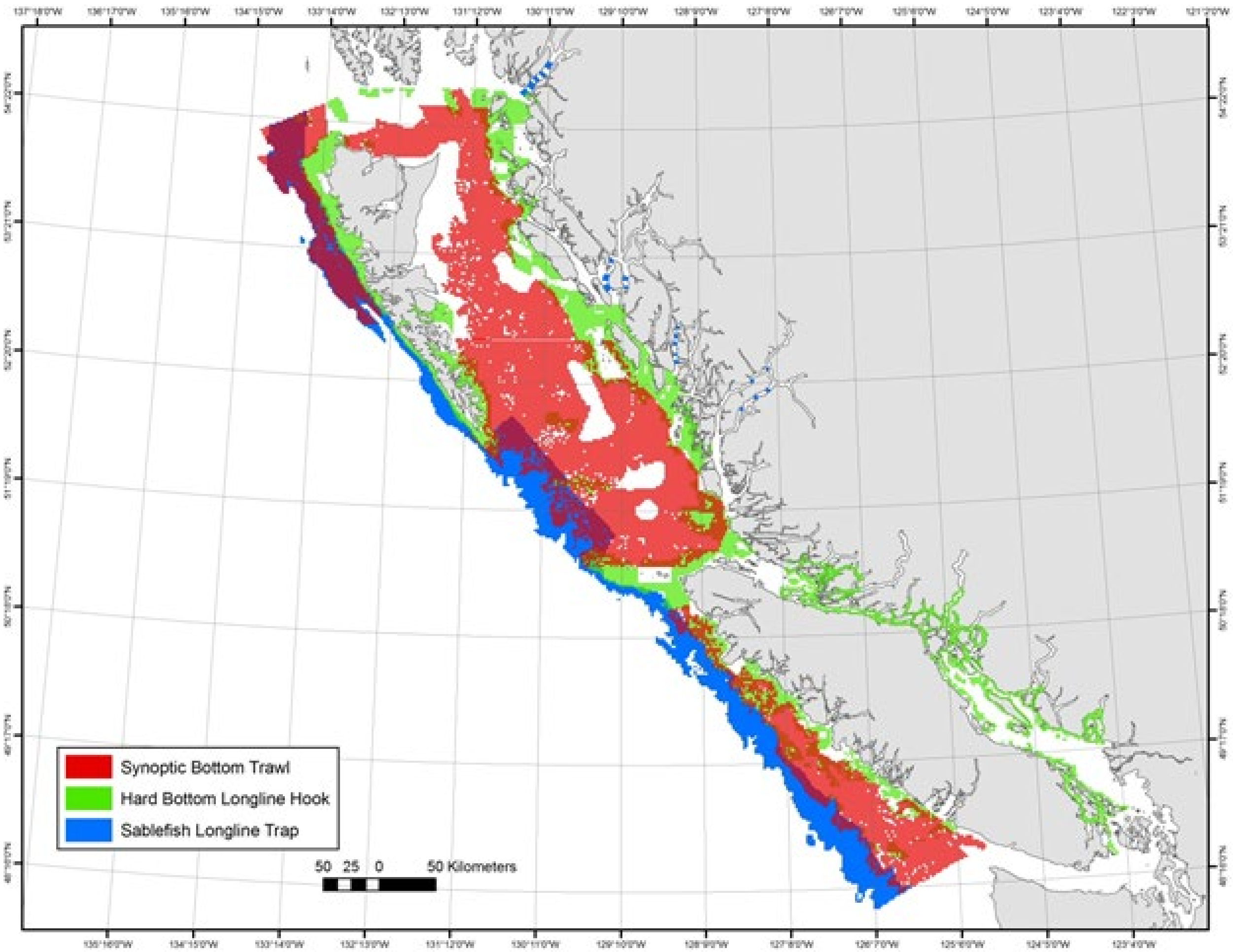

Figure 1. Random depth-stratified survey coverage.

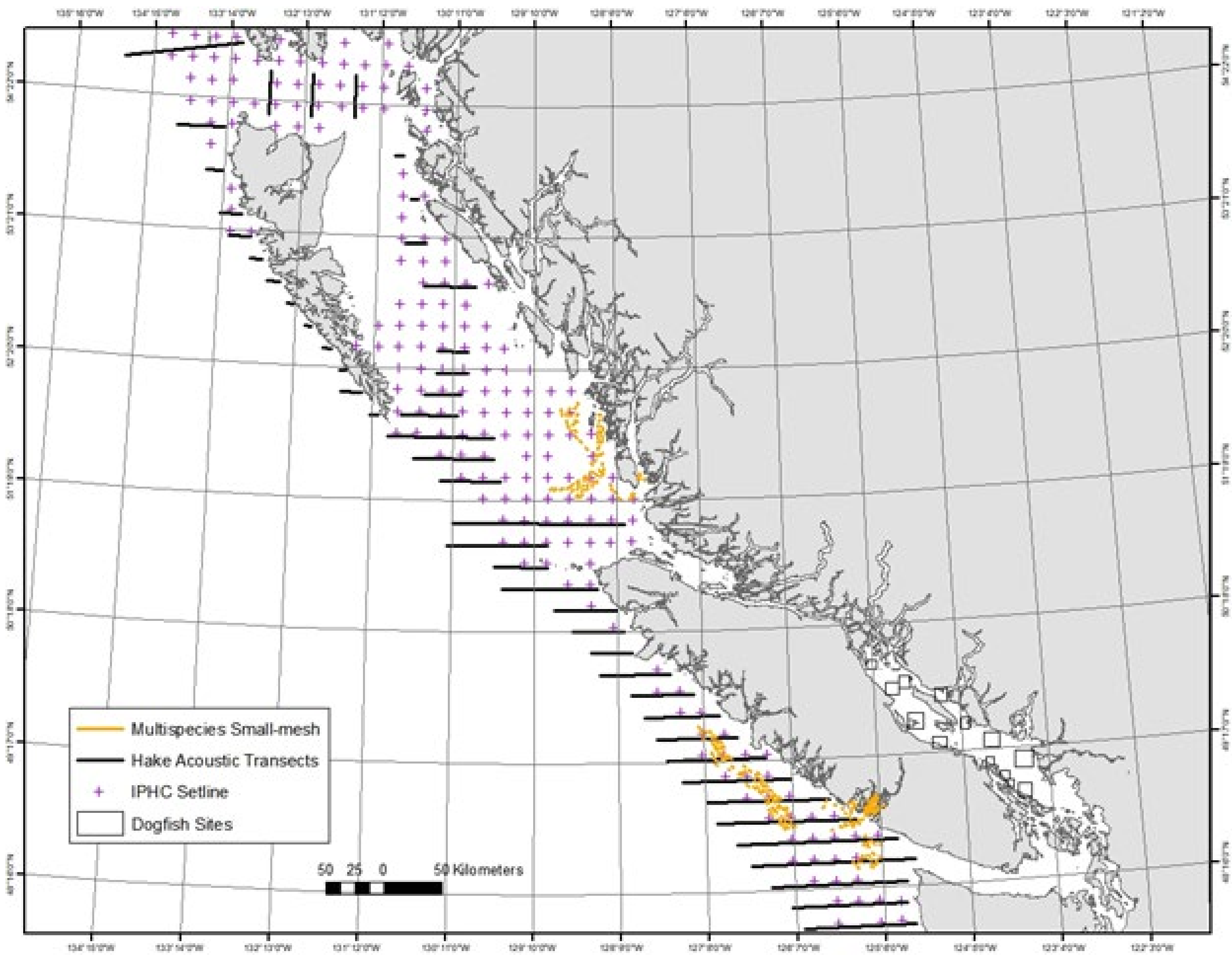

Figure 2. Non-random depth-stratified surveys that form part of the Groundfish surveys program including the Multispecies Small-mesh Bottom Trawl Survey, the Pacific Hake Acoustic Survey, the International Pacific Halibut Commission (IPHC) Setline Survey and the Strait of Georgia Dogfish Longline Hook Survey.

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 (Figure 3). 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.

These surveys are conducted under a collaborative agreement with the Canadian Groundfish Research and Conservation Society (CGRCS) and, in typical years, one survey occurs on a Canadian Coast Guard Vessel with DFO staff, and one survey occurs on a chartered commercial fishing vessel with a mix of DFO staff and contracted technicians. In aggregate, the surveys provide coast-wide coverage of most of the trawlable habitat between 50 and 500 meters depth.

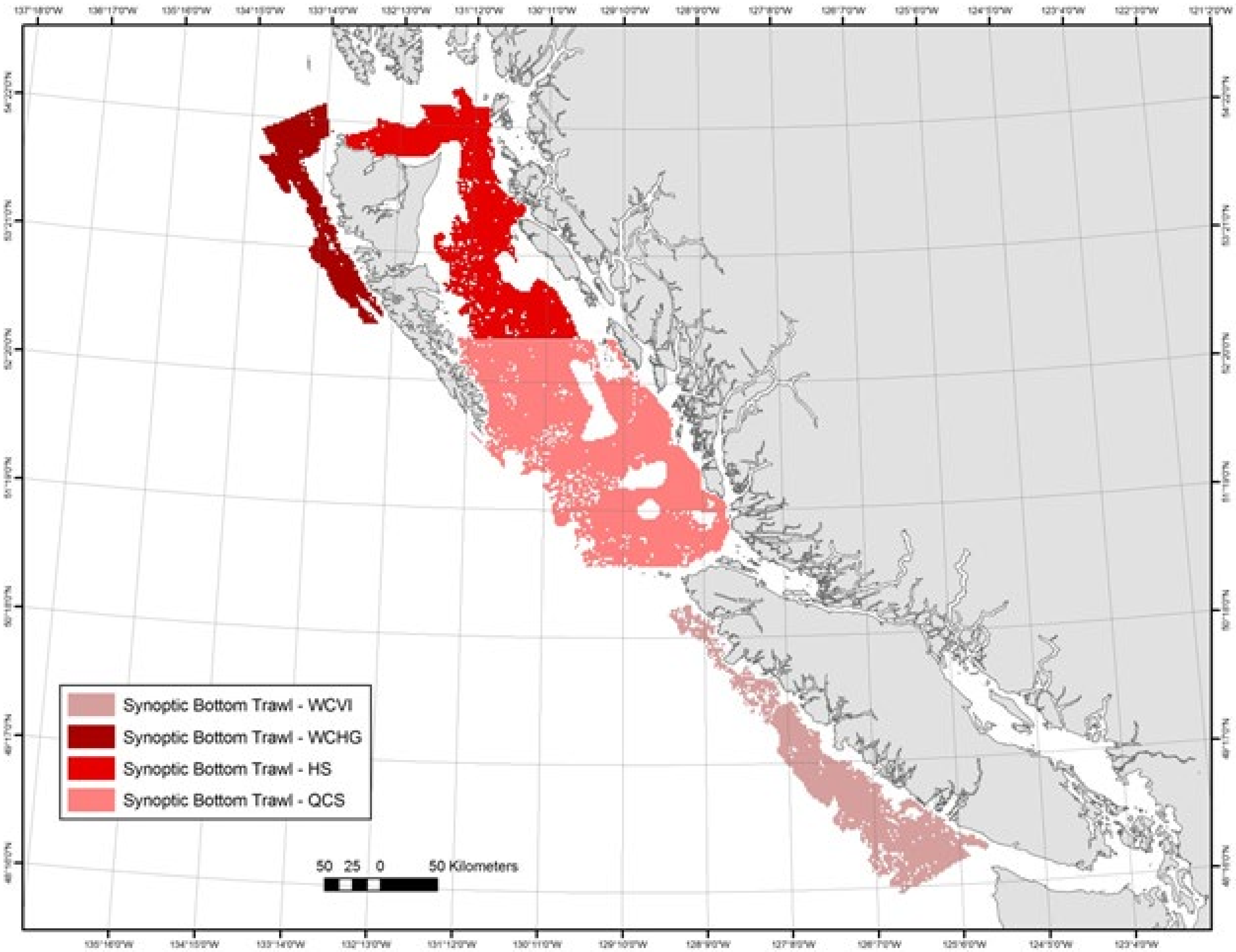

Figure 3. Multispecies Synoptic Bottom Trawl Survey coverage.

The WCHG survey was the only synoptic bottom trawl survey completed in 2020. The WCVI survey was scheduled for mid-May to mid-June in 2020, but was postponed to 2021 due to the COVID-19 pandemic. The WCHG survey was completed by contracted technicians on the F/V Nordic Pearl from late August to late September 2020. Ninety-six successful tows were completed (Figure 4). The dominant species in the catch were Pacific Ocean Perch (*Sebastes alutus*), Silvergray Rockfish (*Sebastes brevispinis*), the Rougheye/ Blackspotted Rockfish complex (*Sebastes aleutianus/melanostictus*), and Yellowmouth Rockfish (*Sebastes reedi*).

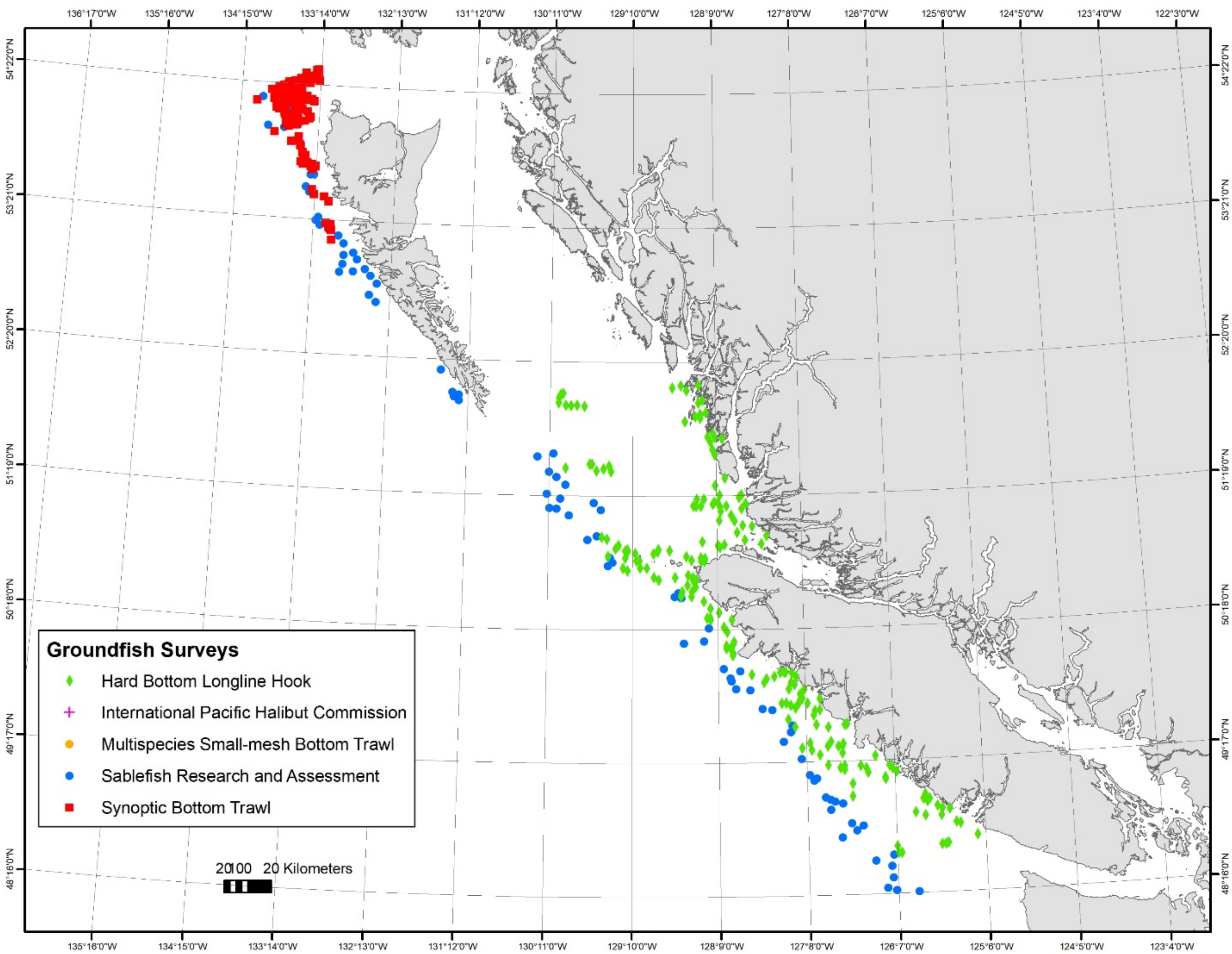

Figure 4. Fishing locations of the 2020 Groundfish surveys.

The **Hard Bottom Longline Hook (HBLL) Surveys** are typically 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 surveys annually alternate between the regions such that the whole coast is surveyed over a two-year period. The outside surveys are conducted under a collaborative agreement with the Pacific Halibut Management Association (PHMA) and occur on chartered commercial vessels and are conducted by contracted technicians, while the inside surveys are conducted by DFO and occur on a Canadian Coast Guard vessel. In aggregate, the HBLL surveys provide coast-wide coverage of most of the untrawlable habitat between 20 and 220 meters depth.

In 2020 the southern region of the outside area was surveyed. The survey in the inside area was scheduled for the southern region but was postponed to 2021 due to the COVID-19 pandemic (Figure 4). The outside HBLL survey was conducted on the chartered commercial longline vessels Banker II, and Borealis 1 during August and September. A total of 196 sets were completed. The dominant species in the catch were Yelloweye Rockfish (*Sebastes ruberrimus*), Pacific Halibut (*Hippoglossus stenolepis*), Sablefish (*Anoplopoma fimbria*), and Quillback Rockfish (*Sebastes maliger*).

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 a collaborative agreement with the Canadian Sablefish Association and occurs on a chartered commercial vessel, and is typically conducted by a mix of DFO staff and contracted technicians. This survey covers the depth range of 150 m to 1250 m for the entire outer BC coast as well as a number of central coast inlets.

In 2020, the survey was conducted on the F/V Pacific Viking from early October to late November by contracted technicians. A total of 89 sets were completed in the offshore areas while the inlet portion of the survey was canceled due to the COVID-19 pandemic (Figure 4). The most abundant fish species encountered were Sablefish (*Anoplopoma fimbria*), Pacific Halibut (*Hippoglossus stenolepis*), Lingcod (*Ophiodon elongatus*), North Pacific Spiny Dogfish (*Squalus suckleyi*), and Yelloweye Rockfish (*Sebastes ruberrimus*).

The **Small-mesh Bottom Trawl Survey** is an annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island that was initiated in 1973, and occurs on a Canadian Coast Guard Vessel with DFO staff. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Groundfish staff provide assistance in catch sorting and species identification and also collect biological samples from selected fish species. The 2020 survey was canceled due to the COVID-19 pandemic.

Details of each survey are included in Appendix I.

III. Reserves

Canada has surpassed its marine conservation target commitment of protecting 10 percent of coastal and marine areas through effectively managed networks of protected areas and other effective area-based conservation measures by 2020, a commitment made under the United Nations Convention on Biological Diversity (UN CBD) Aichi Target 11. Approximately 14% of Canada's EEZ are now protected. Marine Conservation initiatives in British Columbia are illustrated in Figure 5.

In the Pacific Region, an initiative is underway to develop a network of Marine Protected Areas (MPAs) in BC's Northern Shelf Bioregion (NSB). A draft MPA network scenario was released for comment by stakeholders on the advisory committee on February 28, 2019, and consultation on this plan is ongoing. In 2020, the partners continued to work through outstanding questions including scope and level of detail for the action plan, approach to phased implementation, and principles that will guide future governance and implementation. The Marine Protected Area Technical Team (MPATT) will consider all spatial advice received and work towards a revised network scenario and a socio-economic analysis will be completed on a revised scenario. A revised draft scenario will be shared with stakeholders, local governments and the public for review and comment in 2021.

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 the NSB MPA network, as will the Gwaii Haanas National Marine Conservation Area Reserve (NMCAR) and Haida Heritage Site. The Scott Islands marine National Wildlife Area (NWA), an area that conserves a vital marine area for millions of seabirds on the Pacific coast, will also be part of the NSB MPA. Fishing activity is currently not prohibited in the NWA.

Parks Canada and the Archipelago Management Board have introduced new zoning to the NMCAR 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 came into effect on May 1, 2019. The two Rockfish Conservation Areas that were formerly within the NMCAR boundaries have been rescinded and replaced with the new zoning. Parks Canada is also still working to establish an NMCAR in the Salish Sea.

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 5). 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 vent ecosystem.

The SGaan Kinghlass-Bowie Seamount 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 (https://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. 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).

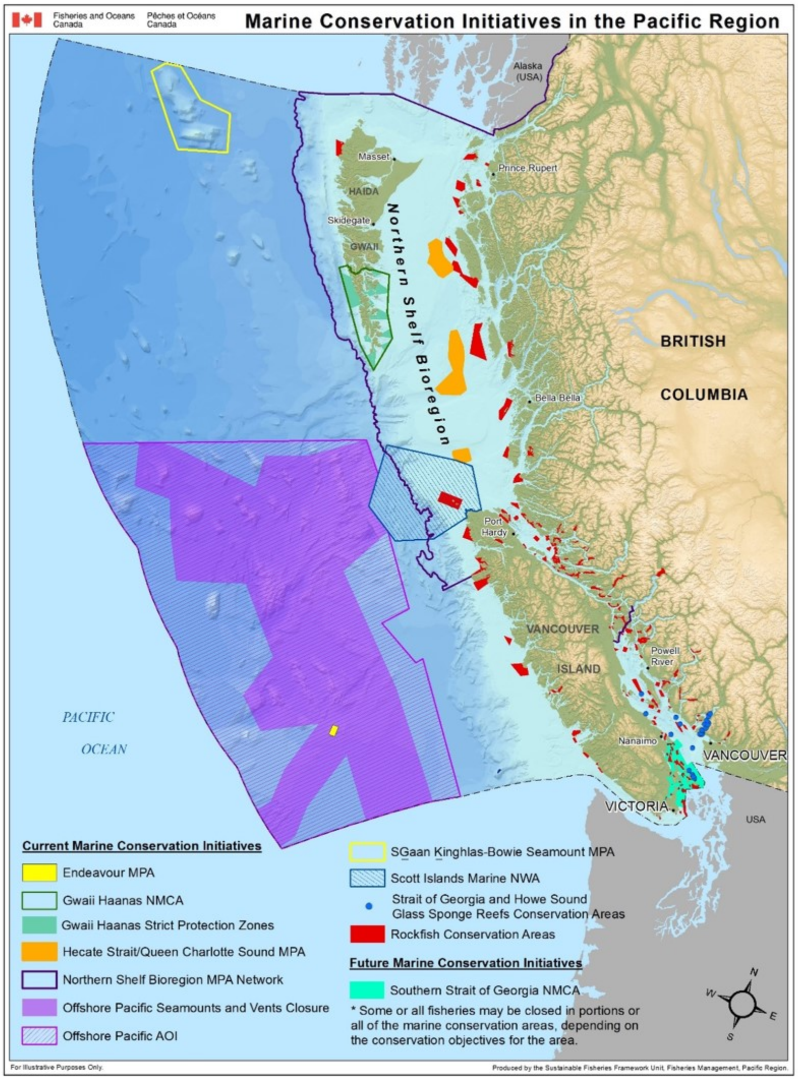

Figure 5. Marine Conservation Initiatives in the Pacific Region (Map by F. Yu).

IV. Review of Agency Groundfish Research, Assessment and Management

A. Hagfish

1. Research

No new research in 2020.

2. Assessment

Nothing to report.

3. Management

There is currently no fishery for Hagfish in BC, although there continues to be interest in redeveloping the fishery. One proponent has submitted a proposal that has been reviewed by DFO, but no decision has been made.

B. Dogfish and other sharks

1. Research

i) North Pacific Spiny Dogfish

Data collection continued in 2020 through the annual groundfish multispecies trawl and longline surveys and commercial catch monitoring. North Pacific Spiny Dogfish are routinely sampled in surveys and by observers, however in 2020 due the suspension of the At Sea Observer Program and reduced survey sampling by contracted survey technician no biological samples were collected.

ii) Other Shark Species

Other species of shark are sampled opportunistically during annual groundfish multispecies trawl and longline surveys and at-sea observer sampling of the trawl fishery. In 2020 however sampling was severely curtailed with only five Blue sharks sampled. Anecdotal information on encounters with other shark species is also collected through the Shark Sightings Network (https://www.dfo-mpo.gc.ca/species-especes/sharks/info/sightings-eng.html).

2. Assessment

i) North Pacific Spiny Dogfish

North Pacific Spiny Dogfish were last assessed in 2010. No new assessment is currently scheduled.

In 2011, the Committee on the Status of Wildlife in Canada (COSEWC) assessed the conservation status of North Pacific Spiny Dogfish as Special Concern, citing low fecundity, long generation time (51 years), uncertainty regarding trends in abundance of mature individuals, reduction in size composition, and demonstrated vulnerability to overfishing as the causes for concern. Nevertheless, COSEWIC acknowledged that the population remains relatively abundant, and overfishing is currently unlikely.

COSEWC status reports are available at https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports.html.

ii) Other Shark Species

As no directed commercial fisheries for sharks other than North Pacific Spiny Dogfish exist in British Columbia, there have been no requests for any stock assessments.

The Committee on the Status of Wildlife in Canada (COSEWC) has assessed the conservation status of a number of British Columbia shark species, and three species are listed under the Canadian Species at Risk Act (SARA):

- Basking Shark: Designated Endangered in 2007. Status re-examined and confirmed in 2018. Listed under SARA.
- Bluntnose Sixgill Shark: Designated Special Concern in 2007. Currently being re-examined. Listed under SARA.
- Tope Shark: Designated Special Concern in 2007. Currently being re-examined. Listed under SARA.

Blue Shark (North Pacific population) was examined by COSEWIC in 2016 and designated Not at Risk. White Shark and Brown Cat Shark were considered in 2006 and 2007 and placed in the Data Deficient category.

COSEWC status reports are available at https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports.html.

3. Management

i) North Pacific Spiny Dogfish

North Pacific Spiny Dogfish are managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP), and are permitted to be retained in the recreational fishery. There is currently no targeted fishing for Dogfish as markets have essentially collapsed, with the directed dogfish fleet harvesting 0% of its TAC in 2020 and the trawl fleet intercepting only 6,9 % 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. The hook and line fleet in aggregate has taken about 1.0% of their dogfish quota. Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

ii) Other Shark Species

Currently, there is no directed commercial fishery for other shark in Canadian Pacific waters; only Salmon Shark are permitted to be retained in the recreational fishery. Species at Risk Act prohibitions only apply to species listed as extirpated, endangered or threatened; thus, they do not apply to species of special concern. Nevertheless, commercial fisheries are no longer permitted to retain Species at Risk Act listed shark species − all bycatch for these species is to be released at sea with the least possible harm. Catch limits for the recreational fishery have been reduced to “no fishing” for all species listed under the Species at Risk Act, and “zero retention” (catch and release) for all other shark species except Salmon Shark. Codes of conduct have been developed for encounters with Basking Sharks (https://www.dfo-mpo.gc.ca/species-especes/publications/sharks/coc/coc-basking/index-eng.html) and other sharks (https://www.dfo-mpo.gc.ca/species-especes/publications/sharks/coc/coc-sharks/index-eng.html).

C. Skates

1. Research

Data collection continued in 2020 through trawl and longline surveys and commercial fishery monitoring. Most individual skates encountered on groundfish research surveys are sampled (length, weight if feasible, sex) and released alive if possible, however none were sampled in 2020 due to a reduced sampling protocol implemented for contracted survey technicians. Species sampled in the commercial fishery by EM derived visual estimates of length and weight in 2020 were Longnose Skate (n=43), Sandpaper Skate (n=18) and Roughtail Skate (n=7).

2. Assessment

Big Skates and Longnose Skate were assessed in 2013 (King et al 2015). No new assessment is currently planned. No other skate species in British Columbia are assessed.

Based on tagging results and fishery spatial patterns, Big Skate and Longnose Skate were assessed based on four Skate Management Areas: 3CD (Groundfish Major Areas 3C, 3D, and Minor Areas 19 and 20 of 4B); 5AB (Major Areas 5A, 5B, and Minor Area 12 of 4B); 5CDE (Major Areas 5C, 5D, and 5E); and 4B (Minor Areas 13-18, 28, and 29 of Major Area 4B).

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.

Big and Longnose skates are IVQ (individual vessel quota) species managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

Literature Cited:

King, J.R., Surry, A.M., Garcia, S., and Starr, P.J. 2015. Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*) stock assessments for British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/070. ix + 329 p. https://waves-vagues.dfo-mpo.gc.ca/Library/362171.pdf

D. Pacific Cod

1. Research

Data collection continued in 2020 through trawl and longline surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling.

2. Assessment

The last full assessments of Pacific Cod stocks were done in 2018, using the same delay-difference model that was used in 2013. The Research Document (Res Doc 2020/70) is available at https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2020/2020_070-eng.html . The Science Advisory Report (SAR 2019/008) is available at http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2019/2019_008-eng.html.

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; however, for the 2018 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 as there is no directed commercial fishery there.

Both 3CD and 5ABCD stock assessments were updated in 2020 and published as a Science Response (https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2021/2021_002-eng.html) following an approximate 75% drop in the synoptic survey index in 2018 in 3CD, accompanied by three years of commercial catches well below average. There is a 2-10% probability that the 3CD stock will fall into the Critical Zone in 2022 under a range of 2021 catch levels. There is a < 0.01% probability that the 5ABCD stock will fall into the Critical Zone in 2022. Given the large decrease in the 2018 3CD survey index and the lack of a survey in 2020 due to COVID-19, a 2021 survey observation is critical. An update to the 3CD stock assessment is scheduled to occur once the 2021 survey data are available.

3. Management

Pacific Cod is an IVQ (individual vessel quota) species, managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2019 Groundfish surveys, research catches are allocated before defining the TAC. Following the 2020 assessment update, the commercial TAC in Area 3CD was reduced to 300 metric tonnes. See Appendix 2 for details. In addition, winter spawning closures are in effect in both Areas 3CD and 3CD.

E. Walleye Pollock

1. Research

Data collection continued in 2020 through trawl and longline surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling after March, 2020.

2. Assessment

Walleye Pollock was assessed in 2017 but the research document is still awaiting translation before appearing on the CSAS website. The Science Advisory Report (SAR 2018/020) is available at http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2018/2018_020-eng.html.

Walleye Pollock was assessed as two stocks based on differences in observed mean weights between northern British Columbia (~1kg/fish) and southern British Columbia (~0.5 kg/fish). The BC North stock encompasses Major areas 5C, 5D, and 5E, while the BC South stock encompasses Major Areas 3C, 3D, 5A, 5B, plus minor areas 12 & 20 in 4B. The Strait of Georgia (i.e. “Gulf” - Major Area 4B not including minor areas 12 & 20) was not assessed. The assessment speculated that the northern stock might be the southern tip of a larger SE Alaskan stock.

3. Management

Walleye Pollock is an IVQ (individual vessel quota) species, managed as part of the integrated mixed species multi-gear groundfish fishery under the Integrated Fisheries Management Plan (IFMP). Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

F. Pacific Whiting (Hake)

1. Research

There are two commercially harvested and managed stocks of Pacific hake. The offshore stock is the principal 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 large 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-numbered years, to continue the biennial time series.

With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling at sea after March 2020; however, dockside sampling continued for the duration of the year.

2. Assessment

As in previous years, and as required by the Agreement Between the Government of Canada and the Government of the United States of America on Pacific hake/Whiting (the Pacific Whiting treaty), the 2021 harvest advice was prepared jointly by Canadian and U.S. scientists working together, collectively called the Joint Technical Committee (JTC) as stated in the treaty. The assessment model used was Stock Synthesis 3 (SS3). The 2021 model had almost the same model structure used in 2020, with updates to catch and age compositions. Standard sensitivities requested by the Scientific Review Group showed little difference when compared with the base model. The largest cohort caught in the fishery was age-6's, followed by age 4's. The three cohorts currently sustaining the fishery were born in 2010, 2014, and 2016. There has not been an assessment of Pacific hake in the Strait of Georgia.

3. Management

The coastwide TAC for 2020 was not agreed upon by the Joint Management Committee, which means that the TAC for 2020 was set by each country individually without further mediation. Canada set their TAC to 104,480 t which is 26.12% of 400,000 t. The U.S. set their TAC to 424,810 t which is 73.88% of 575,000 t. In the usual case where the two countries agree on a coastwide TAC, Canada is allocated 26.12% and the US is allocated 73.88% of the total as agreed upon in the hake treaty. In this case, each country decided a coastwide TAC for themselves and then applied their proportion of the TAC to that. Canadian commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

G. Grenadiers

1. Research

There is no directed work conducted on Grenadiers. Opportunistic sampling occurs on groundfish trawl surveys, but no Grenadiers were encountered in 2020.

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 incidentally in the deep-water rockfish (Rougheye/Shortraker/Thornyhead) and Dover Sole fisheries and in the Sablefish trap fishery. 100% of the catch is discarded.

H. Rockfish

1. Research

Biological samples are collected on an ongoing basis from annual trawl, longline, and trap surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling after March 2020.

i) Inshore Rockfish

Dr. 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) to develop the novel method of passive acoustic monitoring (PAM) for fishes. Species of interest for this project include Pacific Herring and three rockfish species: Copper, Yelloweye, and Quillback Rockfishes. Most of the field work has now been done using paired visual (diver and drop camera) and audio surveys (soundtraps). 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. Although Dr. Archer has left DFO, she remains involved in the project and Dr. Philina English has been hired as a term research scientist to lead the project.

We have now developed and tested an automatic fish detector for the acoustic data to facilitate data processing and are currently fine-tuning this detector with additional data. We were also able to deploy acoustic recorders at our sites near Nanaimo during the spring and summer 2020 COVID lockdown. After accounting for differences in the wind speeds in April of 2020, lockdown-related reductions in ferry traffic, seaplane activity, and recreational boating activity near Nanaimo (Snake Island) combined to reduce the sound pressure levels by 86% when compared with same time period in 2019. We are now using this dataset and this natural experiment to further our exploration of impacts of noise on fish acoustic behaviour. Also in spring of 2020, we were able to record instances of herring spawning and are in the process of describing the acoustic signature of herring spawn.

Dr. Haggarty is also collaborating with colleagues at UVic and Ballstate University as well as industry (Angler's Atlas) to improve and monitor compliance in Rockfish Conservation Areas (RCAs) and Marine Protected Areas (MPAs). Angler's Atlas has already upgraded their smart phone App, MyCatch, to include the location of all RCAs and to provide users with warnings when they are in an RCA. The app works by employing the cell phone's internal GPS and with downloaded maps, so users do not need to be on cell networks for it to function. There is also a function to collect data on the use of descending devices for rockfishes and an outreach program associated with this. This project was funded by the BC Salmon Restoration and

Innovation Fund (BCSRIF) until the end of 2022-23. We think that the up-take of the MyCatch app by anglers was affected by the COVID19 pandemic; however, we are hoping to increase awareness about the app in 2021. A graduate student, Taylor Saucier, has started at Ball State University with collaborator Dr. Paul Venturelli under this project and is continuing work that Dana and collaborators have done to assess recreational compliance in RCAs.

Dana is also working with a graduate student at the University of Victoria, Hailey Davies, with collaborator Dr. Francis Juanes. Hailey is studying survival of rockfish following the use of a descending device by using a tag-recapture experiment as well as the use of camera systems to record the release. We completed an initial field season in October-November 2020 and are planning additional field work in the summer of 2021.

ii) Offshore Rockfish

The Offshore Rockfish program in 2020 continued with one DFO person working in collaboration with an industry-sponsored scientist. All efforts were devoted to stock assessment. To facilitate stock assessment, the Offshore Rockfish program maintains a suite of PBS R software packages (https://github.com/pbs-software). The Groundfish Surveys program coordinates all sample collections (otoliths, genetic tissues, morphology measurements, etc.) and the Sclerochronology Lab researches ageing protocols and methods.

2. Assessment

i) Inshore Rockfish

British Columbia (BC) “Inside” stocks are generally those occurring in Area 4B (Queen Charlotte Strait, Strait of Georgia, and Strait of Juan de Fuca), while “Outside” stocks occur outside Area 4B (West Coast Vancouver Island, West Coast Haida Gwaii, Queen Charlotte Sound, Hecate Strait, Dixon Entrance).

Outside Yelloweye Rockfish

The Outside population of Yelloweye Rockfish was designated as Threatened in December of 2020 by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC). DFO is now responsible for completing a Recovery Potential Analysis which will probably be completed in 2021, drawing from the results presented in the 2019 rebuilding plan analysis (Cox et al 2020).

Cox, S.P., Doherty, B., Benson, A.J., Johnson, S.D., and Haggarty, D. 2020. Evaluation of potential rebuilding strategies for Outside Yelloweye Rockfish in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/041.

Inside Yelloweye Rockfish

The inside stock of Yelloweye Rockfish is a data-limited stock, occurring in Groundfish Management Area 4B (Queen Charlotte Strait, Strait of Georgia, and Strait of Juan de Fuca) in British Columbia (BC). The stock was assessed as being below the limit reference point (LRP) in 2010, which resulted in a published rebuilding plan. We applied the newly developed Management Procedure (MP) framework for groundfish species (DFO 2021) to evaluate the principal objective of the rebuilding plan which is to rebuild the stock above the LRP over 1.5 generations with at least 95% [19 times out of 20] probability of success. We also evaluated performance of MPs with respect to two additional conservation metrics, four average-catch objectives, and one catch-variability objective. To account for uncertainty in underlying population dynamics and data sources, we developed six alternative OM scenarios, which differed with respect to specific model and data assumptions. These OM scenarios were divided into a “reference set” (four OMs) and a “robustness set” (two OMs). We conditioned all OMs on observed catch data, indices of abundance, and available age composition data. We used closed-loop simulation to evaluate the performance of the MPs and screened out MPs that did not meet a basic set of criteria, resulting in five remaining candidate MPs: annual constant-catch MPs of 10 tonnes or 15 tonnes, and three MPs that adjust the TAC based on the relative slope of the inside hard-bottom longline (HBLL) survey index of abundance. All five final MPs met the principle objective with greater than 0.98 probability (49 times out of 50), across all four OM reference set scenarios. This was largely because none of the reference set OMs estimated the stock to be below the LRP in 2020. Within the two OM robustness set scenarios, the scenario that simulated higher variability in the future HBLL survey performed similarly to the reference set scenarios. However, under the scenario that assumed a lower rate of natural mortality for the stock (“Low M”), all MPs had lower probabilities of meeting the principle objective, with the lowest probability achieved by the current MP (constant catch of 15 t). Because all the MPs met the principle objective under the reference set scenarios, there were no strong trade-offs between conservation and catch objectives. Of the two OM robustness set scenarios, trade-offs were most apparent under the Low M scenario, where the probability of meeting the principle objective decreased as the probability of achieving an average short-term catch of 10 t increased. We discuss major uncertainties, including uncertainty in natural mortality, selectivity, and historical catches, noting that we attempted to account for these uncertainties by evaluating performance of MPs across multiple OMs. We highlighted issues regarding estimates of current stock status for Inside Yelloweye Rockfish, and the role of reference points in the MP Framework. Performance of MPs with respect to meeting two alternative assessment criteria for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are also evaluated.

The Inside population of Yelloweye Rockfish was designated as Threatened in December of 2020 by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC). DFO is now responsible for completing a Recovery Potential Analysis which will probably be completed in 2021, drawing from the results presented in the 2020 rebuilding plan analysis (Haggarty et al 2021).

DFO (Fisheries and Oceans Canada). 2020. Evaluation of management procedures for the inside population of Yelloweye Rockfish rebuilding plan in British Columbia. Canadian Science Advisory Secretariat Science Advisory Report 2020/nnn. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2020/2020_056-eng.html.

Haggarty, D.R., Huynh, Q.C., Forrest, R.E., Anderson, S.C., Bresch, M.J., Keppel, E.A. in press. Evaluation of potential rebuilding strategies for Inside Yelloweye Rockfish (Sebastes ruberrimus) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/nnn. vi + 142 p.

DFO (Fisheries and Oceans Canada). 2021. A management procedure framework for groundfish in British Columbia. Canadian Science Advisory Secretariat Science Advisory Report 2021/002. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2021/2021_002-eng.html

Quillback Rockfish

The Inside and Outside management units of Quillback Rockfish were last assessed in 2010 after the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) designated them as threatened in November 2009. A Bayesian state space surplus production model was used in the stock assessment for the two management units. The model required fishery catch reconstructions to provide catch series from 1918 to 2010, as well as, abundance trends for the two management units. Reference Case model runs provided median biomass estimates for 2011 of 6,480 tonnes (CV 1.21) for the outside management unit and 2,668 tonnes (CV 0.60) for the inside management unit. B2010/Bmsy for the outside and inside is 0.736 (95%CI is 0.266 to 1.814) and 0.493 (95% CI is 0.252 to 0.945), respectively. The probability that the biomass of the outside Quillback Rockfish is above 0.4 Bmsy is 81.2 % and above 0.8 Bmsy is 45.6%. The probability that the biomass of the inside Quillback Rockfish is above 0.4 Bmsy is 70.2% and above 0.8 Bmsy is 11.5%. Stocks in both management areas appear to be within the cautious zone.

Quillback is due to be reassessed in 2021 in advance of a COSEWIC reassessment. In preparation to do so, we have begun analyzing data for the inside and outside stocks and have developed initial operating models for the inside stock. We have also held a series of workshops to discuss the decision context and to develop objectives to be used for the Quillback Rockfish stocks in a MP framework analysis. We have applied for funding to continue this work which is being led by Dana Haggarty and done by consultant Quang Huynh at Blue Matter Science. We expect to complete work on the inside stock before the end of 2021-22 and to in 2022-23 for the outside stock. Completion of work on the outside stock is delayed due to the COVID19-related shut-down and subsequent reduced capacity of the PBS Sclerochronology lab which will delay completion of the outside Quillback age request.

Yamanaka, K.L., McAllister, M.K., Etienne, M.-P., and Flemming, R. 2011a. Stock assessment and recovery potential assessment for Quillback Rockfish (*Sebastes maliger*) on the Pacific coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/135: vii + 151 p.

Other Inshore Rockfish Species (Copper, China, Tiger, Brown, Black, Deacon Rockfishes).

Inshore Rockfishes were assessed as a group in 2001, but none of these other inshore species have been assessed individually by DFO.

ii) Offshore Rockfish

Bocaccio

Bocaccio (BOR) were designated as 'Endangered' by COSEWIC in 2013. However, a strong cohort was born in 2016, and subsequently starting appearing in increasing numbers in survey catches and commercial fisheries coastwide. A coastwide assessment in 2019 using a composite base case suggested that the BOR spawning population was in the Critical Zone (with a probability >0.99), as did the three component runs. This was in spite of the stock being moderately productive and exploitation rates being uniformly low. For instance, the median exploitation by the trawl fishery, which accounted for 95% of the catch, in the final year was estimated to be 0.025 (0.012, 0.044)[1] even at the very low biomass levels. A strong cohort, estimated at 44 times the long term average recruitment (range: 30-58), was born in 2016 and was projected to bring this stock out of the Critical Zone by the beginning of 2023 and would have a better than 50% probability of being in the Healthy Zone in that same year. A model update in 2021 using new survey and commercial CPUE indices will re-assess the magnitude of the large recruitment event.

The Research Document (RD) for the 2019 assessment is not available at present as it needs to be translated into French; however, the Science Advisory Report (Science Advisory Report 2020/025) is publicly available on the CSAS website.

Pacific Ocean Perch

The most recent stock assessment (2017) is publicly available on the CSAS website (Research Document 2018/031).

Redstripe Rockfish

The most recent stock assessment (2017) is still awaiting translation; however, a summary report is available (Science Advisory Report 2018/049).

Rougheye/Blackspotted Rockfish

The Rougheye/Blackspotted (REBS) complex, called Rougheye Rockfish Type II and Type I, respectively, by COSEWIC was designated as ‘Special Concern’ in 2007. In 2020, a stock assessment was conducted on two stocks of the REBS complex (SAR 2020/047), based loosely on the spatial distribution of genetically confirmed specimens from surveys: a northern stock in 5DE called ‘REBS north’ and southern stock in 3CD5AB called ‘REBS south’. The REBS stocks were assessed using a two-fishery, annual two-sex catch-at-age model, implemented in a Bayesian framework to quantify uncertainty of estimated quantities. For each stock, a composite base case that combined nine models for REBS north and six for REBS south, using three fixed values for natural mortality (*M*), to incorporate the uncertainty in this parameter, and three values of catch per unit effort (CPUE) process error, were used to evaluate stock status.

For REBS north, the median female spawning biomass at the beginning of 2021 (B_{2021}) was estimated to be 0.595 (0.405, 0.840) of unfished female spawning biomass (B_0). Also, B_{2021} was estimated to be 2.21 (1.50, 3.15) times the equilibrium spawning biomass at maximum sustainable yield, B_{MSY}. There was an estimated probability of 1 that $B_{2021} > 0.4B_{MSY}$ and a probability of 1 that $B_{2021} > 0.8B_{MSY}$ (i.e., of being in the Healthy zone, Figure 6). The probability that the exploitation rate in 2020 was below that associated with MSY was 1 for both groundfish trawl and commercial non-trawl (Other) fisheries.

For REBS south, the median female spawning biomass at the beginning of 2021 (B_{2021}) was estimated to be 0.286 (0.155, 0.680) of unfished female spawning biomass (B_0). Also, B_{2021} was estimated to be 1.07 (0.582, 2.61) times the equilibrium spawning biomass at maximum sustainable yield, B_{MSY}. There was an estimated probability of >0.99 that $B_{2021} > 0.4B_{MSY}$ and a probability of 0.74 that $B_{2021} > 0.8B_{MSY}$ (i.e., of being in the Healthy zone, Figure 7). The

[1]denoting median and 0.05 and 0.95 quantiles of the Bayesian posterior distribution

probability that the exploitation rate in 2020 was below that associated with MSY was 0.42 for the groundfish trawl fishery and 0.64 for the combined commercial non-trawl (Other) fisheries.

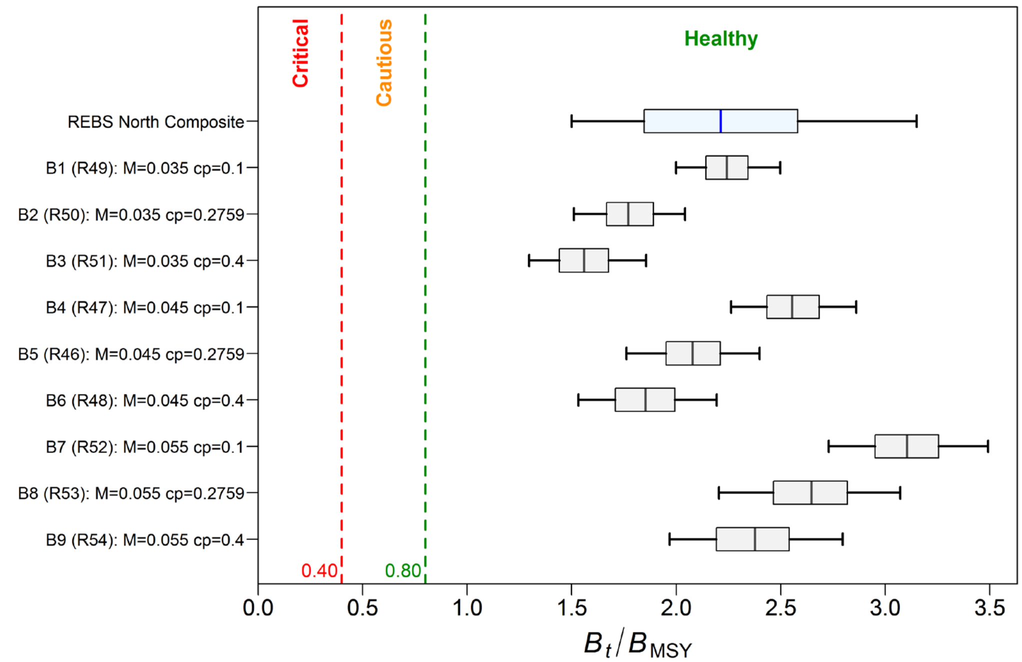

Figure 6. Status of the REBS north 5DE stock relative to the DFO Precautionary Approach (PA) provisional reference points of 0.4B_{MSY} and 0.8B_{MSY} for the t=2021 composite base cases and the component base runs that are pooled to form the composite base cases. Boxplots show the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles from the MCMC posterior.

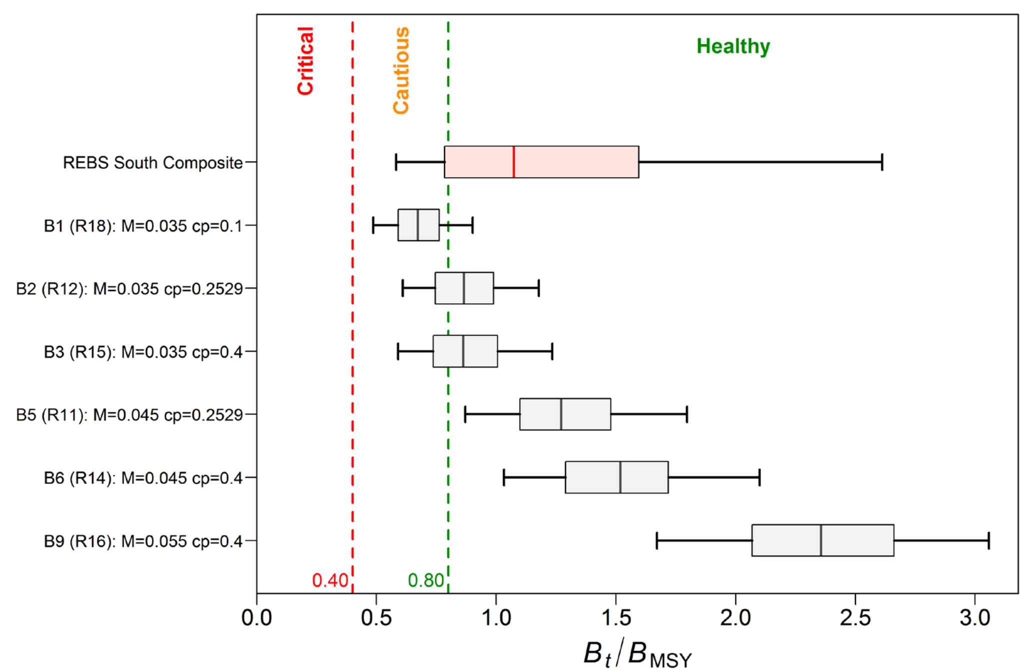

Figure 7. Status of the REBS south 3CD5AB stock relative to the DFO Precautionary Approach (PA)

provisional reference points of 0.4B_{MSY} and 0.8B_{MSY} for the t=2021 composite base cases and the component base runs that are pooled to form the composite base cases. Boxplots show the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles from the MCMC posterior.

Widow Rockfish

Widow Rockfish (WWR) along the BC coast was assessed in 2019. The research document is in translation; however, a summary report is available (Science Advisory Report 2019/044).

The composite base case for WWR suggested that low exploitation in the early years, including that by foreign fleets, coupled with several strong recruitment events (in 1961 and 1990) have sustained the population to the present. Exploitation rates were high during a period of heavy fishing by the domestic fleet extending from the mid-1980s to the mid-1990s, causing the stock size to diminish. Exploitation rates dropped with the implementation of 100% observer coverage in 1996 and the introduction of catch limits coupled with IVQs in 1997.

The spawning biomass (mature females only) at the beginning of 2019 was estimated to be 0.37 (0.26, 0.54) of unfished biomass. This biomass was estimated to be 1.51 (0.92, 2.61) of the spawning biomass at maximum sustainable yield, B_{MSY}.

Yellowtail Rockfish

Yellowtail Rockfish was last assessed in 2014. The Science Advisory Report (SAR 2015/010) is available on the CSAS website.

Canary Rockfish

In 2007, Canary Rockfish along the Pacific coast of Canada was designated as ‘Threatened’ by COSEWIC, with commercial fishing identified as the primary threat. The Canary Rockfish stock assessment was last updated in 2009 (Science Response 2009/019). In 2017, DFO prepared a summary of available information on Canary Rockfish in preparation for a re-assessment by COSEWIC; the pre-COSEWIC assessment is awaiting translation before appearing on the CSAS website. A new full stock assessment by DFO is planned for 2021/22.

Silvergray Rockfish

Silvergray Rockfish were last assessed in 2014. The assessment is publicly available on the CSAS website (Research Document 2016/042; SAR 2014/028).

Yellowmouth Rockfish

In 2010, Yellowmouth Rockfish along the Pacific coast of Canada was designated as ‘Threatened’ by COSEWIC, with commercial fishing identified as the primary threat. In 2011, a stock assessment and recovery potential assessment was published (Research Document 2012/095; Science Advisory Report 2011/060). The estimated spawning biomass in 2011was 0.614 (0.431, 0.829) of the unfished equilibrium spawning biomass (B_0), and 1.606 (2.685, 4.573) of the spawning biomass at maximum sustainable yield (B_{MSY}), which is above the upper reference point for a healthy stock in the Sustainable Fisheries Framework (DFO 2009). A revised stock assessment will be conducted in 2021.

Shortraker Rockfish

Shortraker Rockfish were last assessed in 1998. There is currently no new assessment planned.

Redbanded Rockfish

The last assessment for Redbanded Rockfish was attempted in 2014; however, no model was found that was able to produce reliable results, so researchers were unable to provide specific quantitative advice to fisheries management. The Research Document (Research Document 2017/058) is available on the CSAS website.

Darkblotched Rockfish

In 2009, Darkblotched Rockfish along the Pacific coast of Canada was designated as Special Concern by COSEWIC. There is currently no stock assessment planned.

3. Management

i) Inshore Rockfish

Inside and Outside Yelloweye Rockfish still fall under a rebuilding plan that is documented in Appendix 9 of the 2020 IFMP (https://waves-vagues.dfo-mpo.gc.ca/Library/40765167.pdf). Most inshore rockfish are managed with Total Allowable Catches under the Individual Transferable Quota system.

Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

Recreationally, the retention of Yelloweye Rockfish in inside and outside waters is prohibited. In outside waters, recreational fishers are limited to 3 rockfishes daily, only 1 of which may be a China, Tiger or Quillback Rockfish; possession limits are twice the daily limits, and the season runs from April 1 – November 15. In inside waters (4B), recreational fishers can take 1 rockfish daily, possession limits are twice the daily limit and the season runs from May 1 – October 1. A condition of the recreational license is that: “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.”

ii) Offshore Rockfish

Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

I. Thornyheads

1. Research

Data collection continued in 2020 through trawl and longline surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling.

2. Assessment

Longspine Thornyhead was designated 'Special Concern' by COSEWIC in 2007. An assessment has been requested but not yet scheduled.

Shortspine Thornyhead was assessed in 2015 (Research Document 2017/015; Science Advisory Report 2016/016).

3. Management

Longspine and Shortspine Thornyhead are both IVQ species. Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

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, non-target species, and Sensitive Benthic Areas.

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 2020 included the continuation 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 2019 primary research activities towards this goal included contributing to a synthesis of life history characteristics across the Sablefish range (Kapur et al. 2020), analyses to identify and develop range-wide indices of abundance and the evaluation of time- and size-varying movement within and among regions (e.g., Alaska, British Columbia and the US West Coast).

Collection of biological data continued in 2020 through trawl and trap surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling after March 2020.

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 misspecification 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 2019 (DFO 2019). Based on the 2019 assessment, the current point estimate of Sablefish spawning stock biomass in Canada is 16,300 t. This spawning biomass is at the transition from the Cautious to Healthy zones under the DFO FPA Framework (i.e., $B_{2018}/B_{MSY} = 0.8$). The updated stock status of Canadian Sablefish depended on the absolute size of the 2015-year class the raw estimate of this which was about eight times the historical average. This created the impression of the largest recorded recruitment from one of the lowest spawning biomasses ever observed in Canada. However, this estimated recruitment is highly uncertain, and both the timing and magnitude of the year-class size should be better estimated as several more years of fishery and survey data accumulate.

In 2019 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. These feedback simulations showed that the current MP (no limits on at-sea releases) meets biological objectives but ranked near the bottom in terms of catch performance and revenues compared to MPs with at-sea release management measures. A no size limit (i.e., full retention) MP performed best for both biological and fishery objectives, followed by MPs that included caps on sub-legal releases. These simulations also showed that the largest conservation risk is tuning the maximum target harvest rate in MPs assuming large 2015 recruitment, but then it fails to materialize.

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 (Hanselman 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.

The next scheduled update to the BC Sablefish operating model is 2022/23, with a simulation-evaluation of management procedures based on the updated operating model scheduled for 2023/24.

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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.

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Kapur, M., M. Haltuch, B. Connors, L. Rogers, A. Berger, E. Koontze, J. Cope, K. Echavef, K. Fenske, D. Hanselman, and A.E. Punt. 2020. Oceanographic features delineate growth zonation in Northeast Pacific sablefish. Fisheries Research. https://doi.org/10.1016/j.fishres.2019.105414

3. Management

The MP that is currently in place for the Canadian Sablefish fishery was last evaluated in 2019 through the Sablefish MSE (see Assessment section above). 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 3-year phased-in period to a new maximum target harvest rate of 5.5% in 2022.

Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

K. Lingcod

1. Research

Data collection continued in 2020 through trawl and longline surveys and recreational creel surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling. Additional biological samples (length, weight, sex, maturity and fins for ageing) were collected on the Outside HBLL S survey done in collaboration with industry. We are currently preparing fins for aging in order to inform survey selectivity in our next stock assessment.

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. Fins collected on the IPHC, trawl surveys and Outside HBLL surveys are currently being processed. Inside Lingcod were last assessed in 2014.

3. Management

Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2019 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

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, Southern Rock Sole, Dover Sole, and English Sole continued in 2020 through surveys. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling after March 2020.

2. Assessment

Arrowtooth Flounder

Arrowtooth Flounder was last assessed in 2016. The final assessment was finalized and published through the Canadian Science Advice Secretariat (CSAS) in 2017. The research document and science advisory report are available at http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2017/2017_025-eng.html and https://waves-vagues.dfo-mpo.gc.ca/Library/365131.pdf.

Concerns expressed by industry participants regarding localized depletion on several the historic fishing grounds have led to a request from fisheries management for an updated assessment. Efforts are underway to deliver that assessment by the fall of 2021.

Petrale Sole

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 2020. Planning is currently underway to deliver an updated assessment in 2021/22.

Southern Rock Sole

Southern Rock sole was last assessed in 2013. No request for updated advice has been received, but aging of otoliths was undertaken in 2019 in anticipation of an updated assessment sometime in 2022/23.

Dover Sole

Dover sole was last assessed in 1999. Aging of otoliths was completed in 2020 in anticipation of an updated assessment in 2022.

English Sole

English sole was also last assessed in 2007. No request for updated advice has been received, but aging of otoliths is scheduled for 2021/22 in anticipation of an updated assessment sometime in 2022/23.

3. Management

Arrowtooth Flounder, Petrale Sole, Southern Rock Sole, Dover sole, and English Sole are all managed by annual coastwide or area specific TACs and harvested primarily by the IVQ multi-species bottom trawl fishery. Commercial TACs and landings for 2020 are provided in Appendix 2. To support groundfish research and account for unavoidable mortality incurred during the 2020 Groundfish surveys, research catches are allocated before defining the TAC. See Appendix 2 for details.

N. Pacific Halibut & IPHC Activities

Pacific halibut caught incidentally by Canadian groundfish trawlers are typically 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. With the suspension of the At Sea Observer program due to COVID-19, there was no commercial sampling after March 2020.

Commercial TACs and landings for 2020 are provided in Appendix 2.

O. Other Groundfish Species

Nothing to report at this time.

V. Ecosystem Studies

A. Data-limited Species

The Fisheries and Oceans Canada (DFO) Sustainable Fisheries Framework (DFO 2009) lays the foundation for an ecosystem-based and precautionary approach to fisheries management that enables continued productivity of Canada's fisheries.

In recent decades, DFO groundfish stock assessments have focused on data-rich species, resulting in a subset of stocks with full stock assessments, while many stocks with less informative data remain unassessed. Consequently, quotas assigned to rarely assessed or unassessed stocks may result in catch rates that are too high, may restrict harvesting opportunities to catch target species, or may result in failure for fisheries to meet seafood certification standards.

Starting in 2015, work was initiated to address this gap. Instead of a tiered approach as is used in other jurisdictions around the world, the approach eventually adopted for BC groundfish stocks considers data-richness on a continuous scale and focuses on simulation testing multiple management procedures on a stock-by-stock basis to choose an approach that best meets fisheries risk objectives.

Groundfish Data Synopsis

The first phase consisted of a groundfish data synopsis, as described in the 2019 TSC report. The synopsis provides a visual snapshot of temporal trends and spatial distributions of commercial catches and survey indices, growth and maturity characteristics, and data availability for over 100 BC groundfish stocks. The synopsis was peer reviewed through a Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) process in 2018 and published in 2019 as a Research Document (Anderson et al. 2019). An article describing the approach will be featured in 2020 in the AFS Fisheries Magazine (Anderson et al. in press).

Management Procedure Framework

The second phase is the development of a framework for applying a management-procedure (MP) approach to data-limited groundfish stocks in British Columbia. (Data-limited stocks are defined here as those with insufficient data to reliably estimate stock status or estimate abundance or productivity with conventional stock assessment methods such as statistical catch-at-age models.) The MP framework was reviewed through a CSAS RPR process in June 2020. Specifically, the MP framework tests the performance of a suite of data-limited management procedures against conservation and fishery objectives. This is done using an existing closed-loop simulation framework that includes building appropriate operating models, testing suites of management procedures, and determining management procedures that best meet conservation and fishery objectives for one or more case-study stocks. The framework uses the open source R package DLMtool (Carruthers and Hordyk 2018), developed at the University of British Columbia, in partial partnership with DFO.

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VI. Other related studies

Nothing to report at this time.

VII. Publications

A. Primary Publications

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Appendix 1: Details of Fisheries and Oceans, Canada Pacific Region Groundfish Surveys in 2020

Overview

The Fisheries and Oceans, Canada (DFO) Groundfish section of the Stock Assessment and Research Division includes a surveys program. The program includes a suite of fishing 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 10). 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 randomized surveys, a fixed-station longline hook survey targeting North Pacific Spiny Dogfish in the Strait of Georgia is completed every three years. The Groundfish section also routinely participates in the Canadian portion of the Joint Canada US Hake Acoustic Survey, collects groundfish information from a DFO Small-Mesh Bottom Trawl Survey, and funds an additional technician during the International Pacific Halibut Commission (IPHC) Setline Survey (Figure 11).

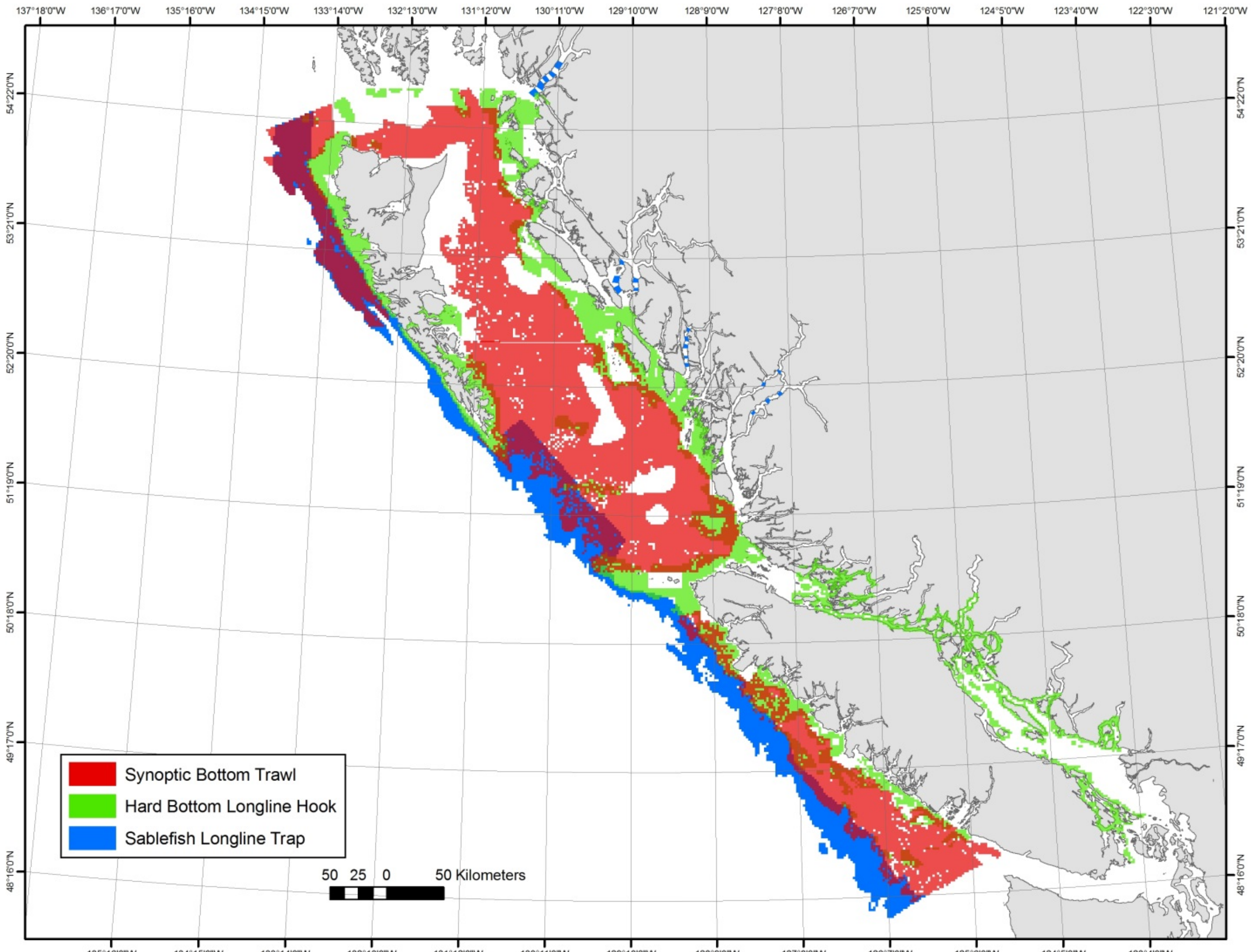

Figure 8. Random depth-stratified survey coverage.

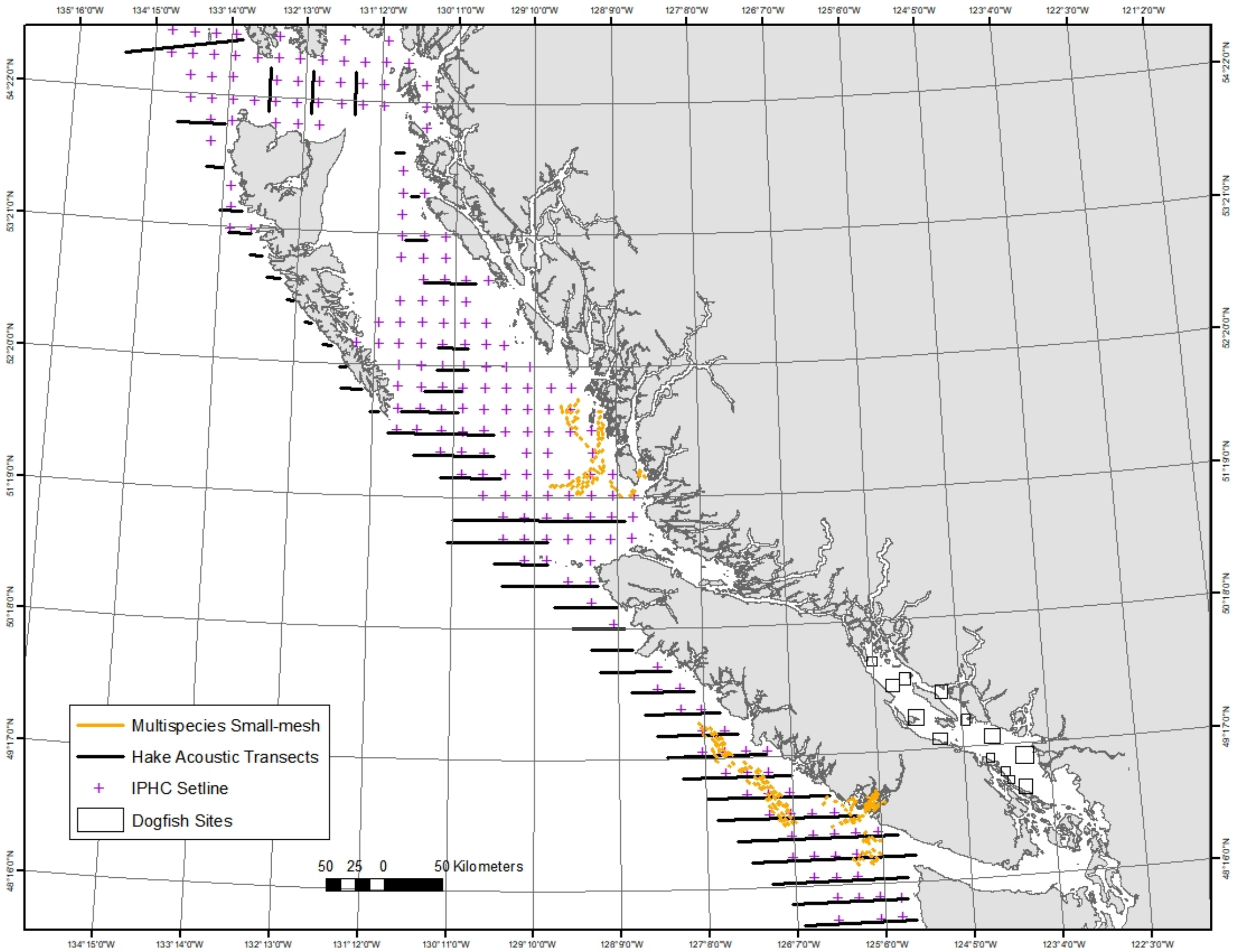

Figure 9. Non-random depth-stratified surveys that form part of the Groundfish surveys program including the Multispecies Small-mesh Bottom Trawl Survey, the Pacific Hake Acoustic Survey, and the International Pacific Halibut Commission (IPHC) Setline Survey.

Each year, two or three area-specific random depth-stratified bottom trawl surveys known as Multispecies Synoptic Bottom Trawl Surveys are conducted. The commercial trawl industry provides the vessel for one survey while the other survey is conducted onboard a Canadian Coast Guard research trawler. Surveys are conducted with a combination of DFO staff and industry-hired sea-going technicians. These bottom trawl surveys provide coast-wide coverage of most of the trawlable habitat between 50 and 500 meters depth.

In addition to the annual bottom trawl surveys, two area-specific random depth-stratified longline hook surveys known as Hard Bottom Longline Hook (HBLL) Surveys are conducted. The commercial longline hook industry contracts vessels and sea-going technicians for a survey of “outside” waters (not between Vancouver Island and the mainland) while a separate longline hook survey of “inside” waters (between Vancouver Island and the mainland) is conducted by DFO staff onboard a Canadian Coast Guard research vessel. These longline hook surveys provide coast-wide coverage of most of the non-trawlable habitat between 20 and 220 meters depth that is not covered by the bottom trawl surveys.

The final randomized survey conducted each year is a coast-wide longline trap survey targeting Sablefish, known as the Sablefish Research and Assessment Survey. The commercial

Sablefish industry supplies the chartered commercial fishing vessel and the survey is conducted with a combination of DFO staff and industry-hired sea-going technicians. This survey covers the depth range of 150 m to 1250 m for the entire outer BC coast as well as a number of central coast inlets.

The suite of annual randomized bottom trawl, hook and line, and trap surveys is bolstered by a longline hook survey targeting North Pacific Spiny Dogfish conducted every three years and a hydroacoustic survey targeting Pacific Hake conducted each year. The Strait of Georgia Dogfish Longline Hook Survey follows a fixed-station design and is intended to provide biological, catch, and effort data. The Hake Acoustic Survey is conducted as part of the Pacific Whiting Treaty and typically alternates year to year between research and assessment activities. Both of these surveys are conducted aboard Canadian Coast Guard research vessels by DFO staff.

Each year, Groundfish section staff also participate in the Multispecies Small-mesh Bottom Trawl Survey onboard the Canadian Coast Guard research trawler. This survey follows a fixed-station design and visits commercially important shrimp grounds off the west coast of Vancouver Island and in eastern Queen Charlotte Sound. Groundfish program staff participate in the survey to provide assistance in enumerating the catch while also collecting biological samples from selected fish species.

During their annual survey, the International Pacific Halibut Commission (IPHC) only fully enumerates the catch for, and collects biological samples from, Pacific Halibut. In an effort to acquire more data on groundfish species intercepted by this survey, particularly rockfish, the commercial longline fishing industry provides an additional technician aboard each of the IPHC chartered survey vessels. The extra technician fully enumerates the catch of all species and collects biological samples from selected inshore species of rockfish as well as Lingcod. Although the IPHC survey went ahead in 2020, the program to provide an extra technician was in hiatus in 2020.

This appendix summarizes the 2020 surveys (Figure 12). The COVID-19 pandemic resulted in the suspension of many field activities and several planned surveys were deferred by one year. Some of the surveys that did go ahead were conducted with adjusted objectives and reduced staff. The surveys in 2020 included a Multispecies Synoptic Bottom Trawl survey conducted off the West Coast of Haida Gwaii, the Hard Bottom Longline Hook Survey conducted in the southern part of “outside” waters and the coast-wide Sablefish Research and Assessment Survey. The Pacific Hake Hydroacoustic Survey was a research program in 2020 and the results are not included in this report.

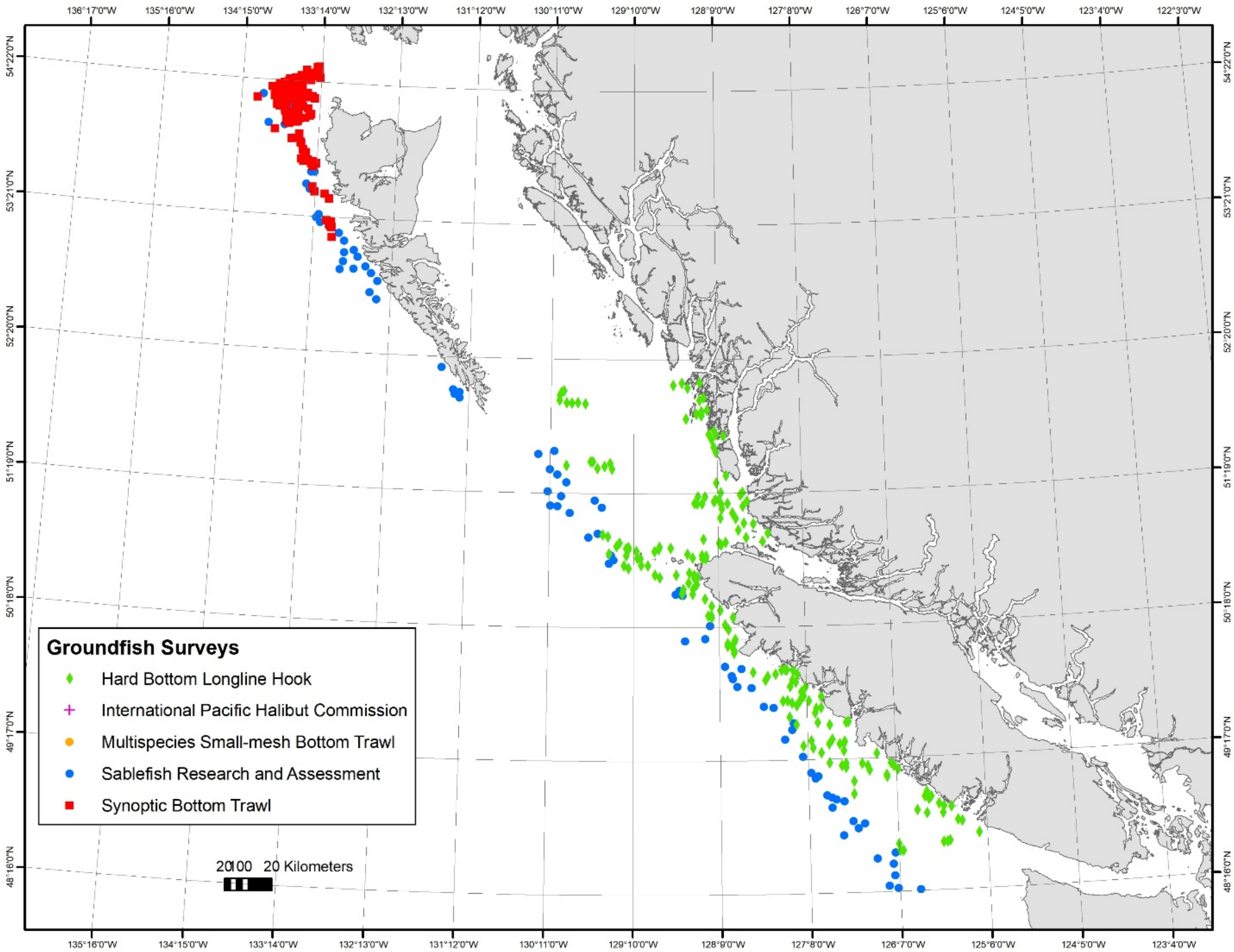

Figure 10. Fishing locations of the 2020 Groundfish surveys.

Multispecies Synoptic Bottom Trawl Surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive multispecies bottom trawl survey strategy that covers most of the BC coast. The objectives of these surveys are to provide fishery independent abundance indices of as many benthic and near-benthic fish species available to bottom trawling as is reasonable while obtaining supporting biological samples from selected species. The abundance indices and biological information are incorporated into stock assessments, status reports, and research publications.

All of the synoptic bottom trawl surveys along the British Columbia coast have followed the same random depth-stratified design. Each survey area is divided into 2 km by 2 km blocks and each block is assigned one of four depth strata based on the average bottom depth in the block. The four depth strata vary between areas. For each survey and in each year, blocks are randomly selected within each depth stratum. If a survey block is not fishable for any reason it will be abandoned and the vessel will proceed to the next block.

There are four core synoptic bottom trawl surveys, two of which are conducted each year. The Hecate Strait survey and the Queen Charlotte Sound survey are conducted in odd-numbered years while the West Coast Vancouver Island survey and the West Coast Haida Gwaii (formerly Queen Charlotte Islands) survey are conducted in even-numbered years (Figure 13).

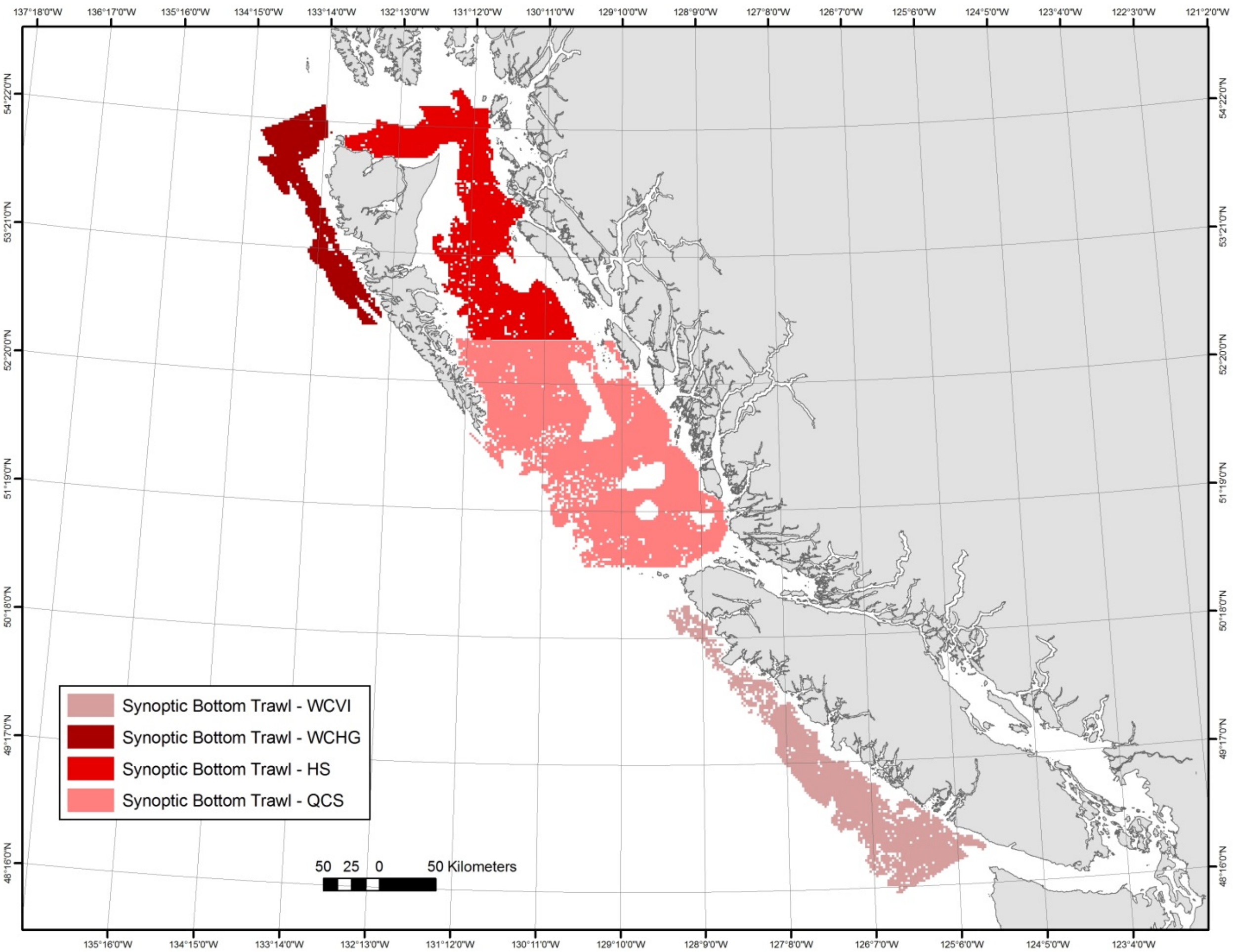

Figure 11. Multispecies Synoptic Bottom Trawl Survey coverage.

In addition to the four core surveys, a Strait of Georgia survey was initiated in 2012 with the intention of repeating the survey every 3 years. The first scheduled repeat of the survey was in 2015 but it was not possible to conduct the survey during March. Nonetheless, research vessel time was available during May and it appeared that the time period would remain available in future years. However, due to changes in department priorities, the May time period was actually not available in subsequent years. As such, the plan in 2017 was to revert back to the original time frame for the Strait of Georgia survey and complete a survey in March. The survey would continue biennially, in odd numbered years. Unfortunately the research vessel was not operational in 2017 so no survey was completed and the survey is now on hiatus due to staffing constraints.

The synoptic bottom trawl surveys are conducted on both chartered commercial vessels and government research vessels. The Hecate Strait survey, the West Coast Vancouver Island survey, and the Strait of Georgia survey are all conducted on a Canadian Coast Guard research trawler while the Queen Charlotte Sound survey and the West Coast Haida Gwaii are conducted on chartered commercial fishing vessels.

The four core synoptic surveys (Hecate Strait, Queen Charlotte Sound, West Coast Vancouver Island, and West Coast Haida Gwaii) are all fished using an Atlantic Western IIA bottom trawl. In contrast, the Strait of Georgia survey is fished using a much smaller Yankee 36 bottom trawl. The decision to use the smaller trawl makes direct comparisons between the areas difficult but allowed us to cover the survey area in the available days. The use of the smaller trawl allows more blocks to be fished each day as the net is faster to deploy and retrieve and catches tend to be smaller.

In 2020 the West Coast of Vancouver Island survey scheduled for May and June was canceled due to the COVID-19 pandemic. The intent is to complete the survey in 2021. The West Coast Haida Gwaii survey scheduled for the late summer and early fall of 2020 was conducted on a chartered commercial vessel but was not staffed with DFO personnel. As a result, the electronic data acquisition system that directly logs and records information into a database was not used. Instead, this survey was conducted using paper data forms.

The survey objectives were focused on the main goal of the survey design which is catch rate indices. As such, ancillary data collection such as the oceanographic data loggers typically attached to the trawl net were not used and the biological sampling requirements were reduced. The workload for the science staff was reduced because using paper forms is slower and less efficient than the direct electronic capture. The workload was also reduced to avoid burnout for the single science crew who were onboard for the duration of the survey.

West Coast Haida Gwaii Multispecies Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multispecies Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between August 25 and September 23, 2020. A total of 120 blocks were assessed (Table 1, Figure 14). Of the 112 total tows conducted, 96 were successful and 16 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 192,758 kg. The mean catch per tow was 1785 kg with an average of 20 different species of fish and invertebrates. The most abundant fish species encountered were Pacific Ocean Perch (*Sebastes alutus*), Silvergray Rockfish (*Sebastes brevispinis*), the Rougheye/ Blackspotted Rockfish complex (*Sebastes aleutianus/melanostictus*), Yellowmouth Rockfish (*Sebastes reedi*), Sharpchin Rockfish (*Sebastes zacentrus*), and Redstripe Rockfish (*Sebastes proriger*). The number of tows where the species was captured and total catch weight from usable tows as well as the estimated biomass and relative survey error for the 25 most abundant species are shown in Table 2. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 5,500 individual fish of 28 different species (Table 3).

Table 1. 2020 West Coast Haida Gwaii Multispecies Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-assessed blocks (due to other reasons such as tide, weather, or other vessels in the area) by stratum.

Depth Stratum (m)	Rejected Prior	Rejected Inspected	Failed	Success	Not Assessed	Total
180 to 330 m	0	5	2	65	5	77
330 to 500 m	0	6	0	26	1	33
500 to 800 m	0	7	1	3	0	11
800 to 1300 m	1	2	0	2	6	11
Total	**1**	**20**	**3**	**96**	**12**	**132**

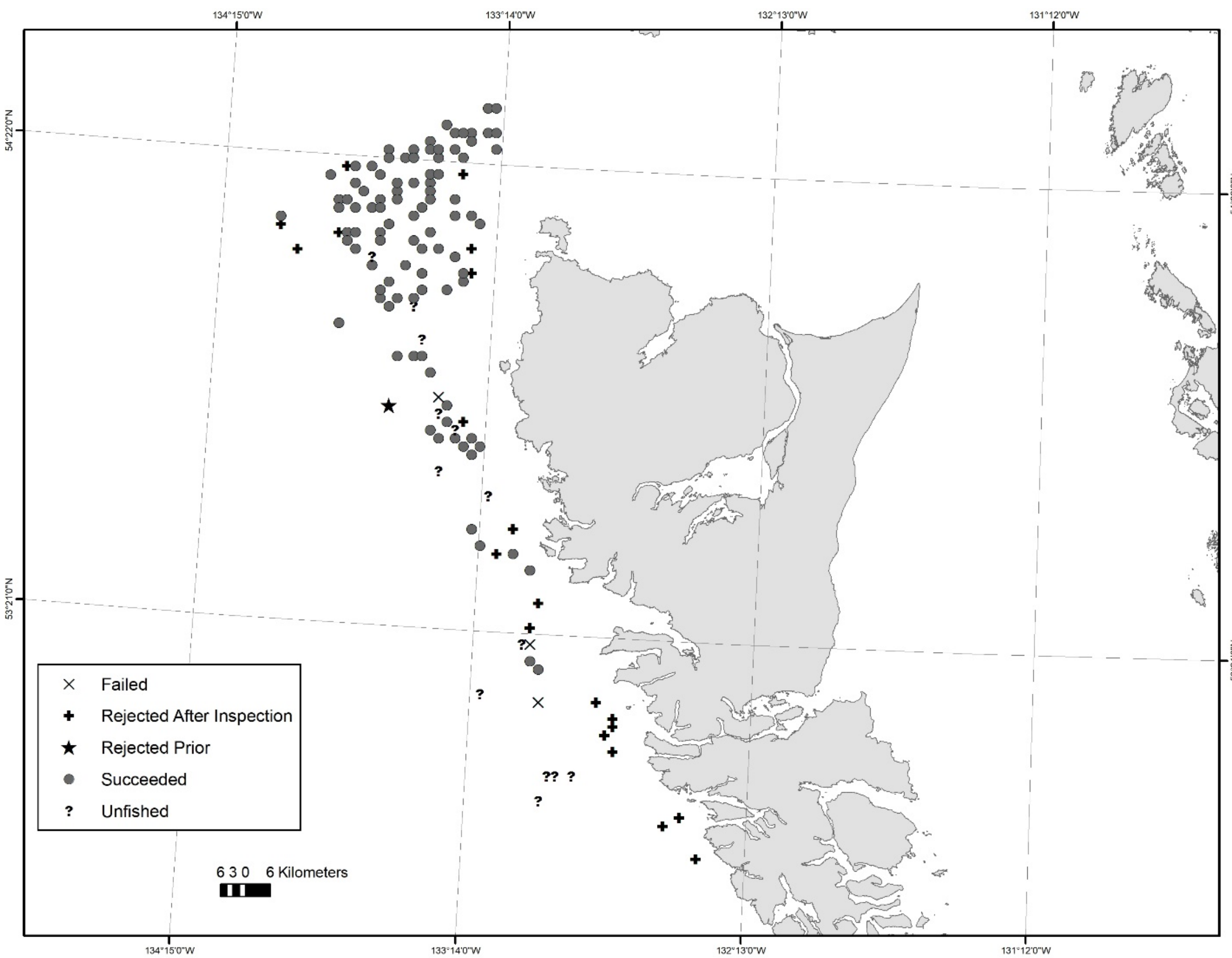

Figure 12. Final status of the allocated blocks for the 2020 West Coast Haida Gwaii Multispecies Synoptic Bottom Trawl Survey.

Table 2. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2020 West Coast Haida Gwaii Multispecies Synoptic Bottom Trawl Survey.

Species	Scientific Name	Number of Tows	Catch (kg)	Biomass (t)	Relative Error
Pacific Ocean Perch	*Sebastes alutus*	91	110358	21190	0.21
Silvergray Rockfish	*Sebastes brevispinis*	74	13823	1705	0.26
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	47	9987	3543	0.34
Sharpchin Rockfish	*Sebastes zacentrus*	63	7918	1053	0.35
Yellowmouth Rockfish	*Sebastes reedi*	33	7685	898	0.49
Redstripe Rockfish	*Sebastes proriger*	43	7094	798	0.40
Shortspine Thornyhead	*Sebastolobus alascanus*	88	4558	1731	0.08
Arrowtooth Flounder	*Atheresthes stomias*	85	2482	351	0.35
Sablefish	*Anoplopoma fimbria*	78	1797	1663	0.17
Splitnose Rockfish	*Sebastes diploproa*	27	1352	168	0.75
Canary Rockfish	*Sebastes pinniger*	11	1122	134	0.48
Dover Sole	*Microstomus pacificus*	79	923	436	0.11
Rex Sole	*Glyptocephalus zachirus*	89	861	204	0.19
Rosethorn Rockfish	*Sebastes helvomaculatus*	67	847	153	0.20
Redbanded Rockfish	*Sebastes babcocki*	73	845	148	0.24
Widow Rockfish	*Sebastes entomelas*	32	808	99	0.42
Pacific Hake	*Merluccius productus*	38	705	290	0.34
Bocaccio	*Sebastes paucispinis*	22	439	54	0.37
Shortraker Rockfish	*Sebastes borealis*	19	434	139	0.24
Pacific Halibut	*Hippoglossus stenolepis*	31	412	56	0.22
Lingcod	*Ophiodon elongatus*	32	405	57	0.21
Pacific Cod	*Gadus macrocephalus*	40	364	45	0.24
Longnose Skate	*Raja rhina*	23	329	65	0.25
Spotted Ratfish	*Hydrolagus colliei*	62	165	30	0.15
Walleye Pollock	*Gadus chalcogrammus*	38	147	20	0.21

Table 3. Number of fish sampled for biological data during the 2020 West Coast Haida Gwaii Multispecies 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**
Skate	*Bathyraja* sp.	4	0	0
Aleutian Skate	*Bathyraja aleutica*	3	0	0
Arrowtooth Flounder	*Atheresthes stomias*	29	29	0
Bocaccio	*Sebastes paucispinis*	214	214	0
Canary Rockfish	*Sebastes pinniger*	118	118	0
Dover Sole	*Microstomus pacificus*	29	29	0
Lingcod	*Ophiodon elongatus*	19	19	0
Longnose Skate	*Raja rhina*	43	0	0
Longspine Thornyhead	*Sebastolobus altivelis*	65	65	0
Pacific Cod	*Gadus macrocephalus*	91	91	0
Pacific Grenadier	*Coryphaenoides acrolepis*	57	0	0
Pacific Hake	*Merluccius productus*	28	0	0
Pacific Halibut	*Hippoglossus stenolepis*	56	0	0
Pacific Ocean Perch	*Sebastes alutus*	1873	1873	0
Redbanded Rockfish	*Sebastes babcocki*	485	485	0
Redstripe Rockfish	*Sebastes proriger*	255	255	0
Rex Sole	*Glyptocephalus zachirus*	50	0	0
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	650	650	649
Roughtail Skate	*Bathyraja trachura*	7	0	0
Sablefish	*Anoplopoma fimbria*	80	80	0
Sandpaper Skate	*Bathyraja interrupta*	18	0	0
Sharpchin Rockfish	*Sebastes zacentrus*	160	0	0
Shortraker Rockfish	*Sebastes borealis*	53	53	0
Shortspine Thornyhead	*Sebastolobus alascanus*	491	373	0
Silvergray Rockfish	*Sebastes brevispinis*	473	456	0
Splitnose Rockfish	*Sebastes diploproa*	32	0	0
Yelloweye Rockfish	*Sebastes ruberrimus*	19	19	0
Yellowmouth Rockfish	*Sebastes reedi*	98	98	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 boundary between the northern and southern regions of the outside area was adjusted in 2010 to better align with the boundaries between the Queen Charlotte Sound and Hecate Strait Synoptic Bottom Trawl surveys. At total of 164 survey blocks in the vicinity of McInnes Island were moved from the southern region to the northern region. As a result, some of the work that was conducted in 2007 and 2009 which was originally part of the southern region is now considered part of the northern region.

The northern region of the outside area was surveyed during even numbered years from 2006 to 2012 and the southern region was surveyed in odd years from 2007 to 2011. The survey had a one year hiatus in 2013 but resumed in 2014 in the southern region. The current schedule is to survey the northern region in odd numbered years and the southern region in even numbered years.

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

Both Hard Bottom Longline surveys include detailed hook by hook enumeration of the catch. Up until the 2018 survey, the DFO Inside survey also recorded catch weights but in 2019 this activity was suspended in favor of spending time completing more detailed biological sampling. The catch rate indices from both surveys are calculated using the hook by hook data only, so not recording catch weights had no impact on the main goal of the survey. Further, by not spending time and effort weighing the catch, it was possible to incorporate gut contents analysis as part of the biological sampling.

In 2020 the southern region of the outside area was surveyed. The scheduled survey of the southern region of the inside area was canceled due to the COVID-19 pandemic. The intent is to cover both the northern and southern regions of the inside area in 2021.

Outside (Pacific Halibut Management Association, PHMA) Survey

The 2020 Outside Hard Bottom Longline Hook Survey was conducted in the southern region. Two commercial hook and line vessels where chartered in August and together completed a total of 196 sets (Figure 15). The F/V Borealis 1 surveyed the mainland coast and Queen Charlotte Sound and completed a total of 66 sets from July 31 to August 19, 2020. The F/V Banker II surveyed the West Coast of Vancouver Island and completed a total of 130 sets from August 1 to September 22, 2020.

The most common species captured during the 2020 Outside Longline Survey was Yelloweye Rockfish (*Sebastes ruberrimus*), followed by Pacific Halibut (*Hippoglossus stenolepis*), Sablefish (*Anoplopoma fimbria*), and Quillback Rockfish (*Sebastes maliger*) (Table 4). Table 5 and Table 6 show the catch of all species by each vessel. Table 7 provides an annual summary of the total catch in the southern region.

During the Outside Longline Survey, detailed biological samples including ageing structures are collected from 50 rockfish in each set with a focus on Yelloweye Rockfish (*Sebastes ruberrimus*). If time permits, Lingcod and additional rockfish will be sampled. Table 8 provides an annual summary by species of the number of fish that were sampled for biological data during the Outside Longline Survey in the southern region. A total of 4884 individual fish were sampled for biological data in 2020. On the Borealis 1, biological data were collected from a total of 1599 individual fish (Table 9) while on the Banker II, biological data were collected from a total of 3285 individual fish (Table 10).

A temperature depth recorder was attached to most of the sets during the 2020 Outside Longline Survey.

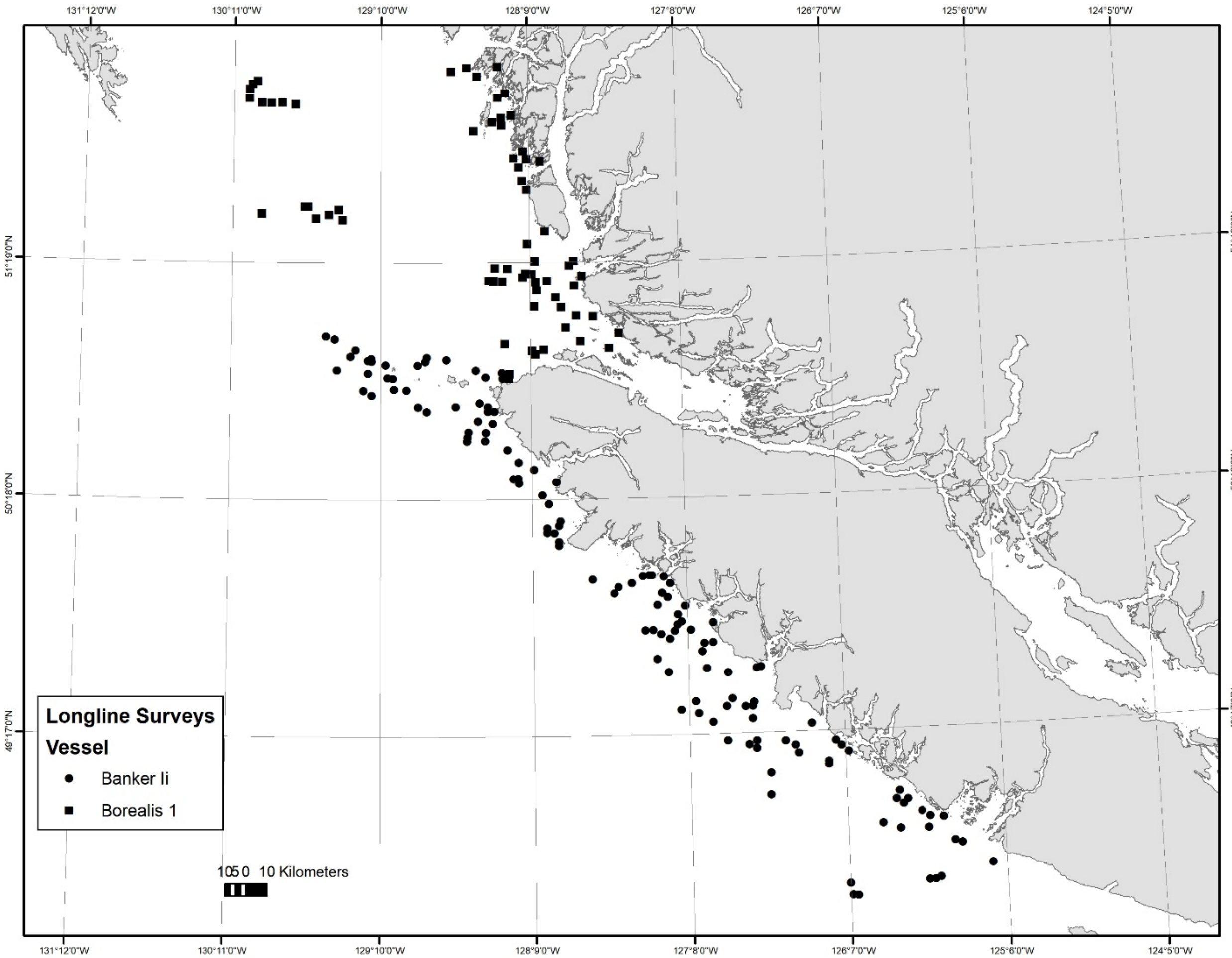

Figure 13. Longline set locations of the 2020 Outside Hard Bottom Longline Hook Survey.

Table 4. Number of sets, catch (piece count), and proportion of the total fish caught of the top 25 fish species (by piece count) from the 2020 Outside Hard Bottom Longline Hook Survey.

Species	Scientific Name	Number of Sets	Catch (count)	Proportion of Total Catch (%)
Yelloweye Rockfish	*Sebastes ruberrimus*	108	2427	15.07
Pacific Halibut	*Hippoglossus stenolepis*	175	2128	13.22
Sablefish	*Anoplopoma fimbria*	59	1987	12.34
Quillback Rockfish	*Sebastes maliger*	91	1673	10.39
Lingcod	*Ophiodon elongatus*	152	1323	8.22
Redbanded Rockfish	*Sebastes babcocki*	28	691	4.29
Spotted Ratfish	*Hydrolagus colliei*	123	684	4.25
Canary Rockfish	*Sebastes pinniger*	78	602	3.74
Longnose Skate	*Raja rhina*	122	588	3.65
North Pacific Spiny Dogfish	*Squalus suckleyi*	119	533	3.31
Pacific Cod	*Gadus macrocephalus*	57	476	2.96
Arrowtooth Flounder	*Atheresthes stomias*	58	418	2.60
Copper Rockfish	*Sebastes caurinus*	32	324	2.01
China Rockfish	*Sebastes nebulosus*	29	321	1.99
Greenstriped Rockfish	*Sebastes elongatus*	45	313	1.94
Cabezon	*Scorpaenichthys marmoratus*	36	284	1.76
Silvergray Rockfish	*Sebastes brevispinis*	53	254	1.58
Big Skate	*Beringraja binoculata*	53	180	1.12
Rosethorn Rockfish	*Sebastes helvomaculatus*	49	178	1.11
Petrale Sole	*Eopsetta jordani*	45	109	0.68
Yellowtail Rockfish	*Sebastes flavidus*	23	106	0.66
Tiger Rockfish	*Sebastes nigrocinctus*	31	75	0.47
Pacific Sanddab	*Citharichthys sordidus*	23	51	0.32
Rockfishes	*Sebastes*	3	48	0.30
Vermilion Rockfish	*Sebastes miniatus*	20	48	0.30

Table 5. Total catch (piece count) by species for the 2020 Outside Hard Bottom Longline Hook Survey sets completed by the Borealis 1.

Species	Scientific Name	Total Catch (count)
Quillback Rockfish	*Sebastes maliger*	920
Pacific Halibut	*Hippoglossus stenolepis*	845
Sablefish	*Anoplopoma fimbria*	654
Yelloweye Rockfish	*Sebastes ruberrimus*	589
Spotted Ratfish	*Hydrolagus colliei*	411
Canary Rockfish	*Sebastes pinniger*	232
Pacific Cod	*Gadus macrocephalus*	171
Lingcod	*Ophiodon elongatus*	168
North Pacific Spiny Dogfish	*Squalus suckleyi*	155
Longnose Skate	*Raja rhina*	123
Arrowtooth Flounder	*Atheresthes stomias*	91
China Rockfish	*Sebastes nebulosus*	87
Silvergray Rockfish	*Sebastes brevispinis*	77
Copper Rockfish	*Sebastes caurinus*	74
Yellowtail Rockfish	*Sebastes flavidus*	68
Rosethorn Rockfish	*Sebastes helvomaculatus*	47
Redbanded Rockfish	*Sebastes babcocki*	46
Greenstriped Rockfish	*Sebastes elongatus*	44
Tiger Rockfish	*Sebastes nigrocinctus*	38
Red Irish Lord	*Hemilepidotus hemilepidotus*	30
Cabezon	*Scorpaenichthys marmoratus*	29
Sandpaper Skate	*Bathyraja interrupta*	17
Petrale Sole	*Eopsetta jordani*	15
Big Skate	*Beringraja binoculata*	15
Southern Rock Sole	*Lepidopsetta bilineata*	14
Vermilion Rockfish	*Sebastes miniatus*	13
Shortspine Thornyhead	*Sebastolobus alascanus*	12
Blue Shark	*Prionace glauca*	11
Yellowmouth Rockfish	*Sebastes reedi*	8
Kelp Greenling	*Hexagrammos decagrammus*	6
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	6
Buffalo Sculpin	*Enophrys bison*	4
Dover Sole	*Microstomus pacificus*	2
Redstripe Rockfish	*Sebastes proriger*	2
Black Rockfish	*Sebastes melanops*	2
Wolf Eel	*Anarrhichthys ocellatus*	2
Skates	*Rajidae*	2
English Sole	*Parophrys vetulus*	1
Flathead Sole	*Hippoglossoides elassodon*	1
Pacific Hake	*Merluccius productus*	1
Unknown Fish	Unknown fish	1
Starfish	*Asteroidea*	169
Sponges	*Porifera*	21
Anemone	*Actiniaria*	10
Bivalve Molluscs	*Bivalvia*	8
Barnacles	*Cirripedia*	5
Sea Urchins	*Echinacea*	4
Red Rock Crab	*Cancer productus*	3
Octopus	*Octopus*	3
Sea Cucumbers	*Holothuroidea*	2

Species	Scientific Name	Total Catch (count)
Unknown	*Unknown*	1
Sea Pen	*Ptilosarcus gurneyi*	1
Inanimate Object(s)	*Inanimate object(s)*	1

Table 6. Total catch (piece count) by species for the 2020 Outside Hard Bottom Longline Hook Survey sets completed by the Banker II.

Species	Scientific Name	Total Catch (count)
Yelloweye Rockfish	*Sebastes ruberrimus*	1838
Sablefish	*Anoplopoma fimbria*	1333
Pacific Halibut	*Hippoglossus stenolepis*	1283
Lingcod	*Ophiodon elongatus*	1155
Quillback Rockfish	*Sebastes maliger*	753
Redbanded Rockfish	*Sebastes babcocki*	645
Longnose Skate	*Raja rhina*	465
North Pacific Spiny Dogfish	*Squalus suckleyi*	378
Canary Rockfish	*Sebastes pinniger*	370
Arrowtooth Flounder	*Atheresthes stomias*	327
Pacific Cod	*Gadus macrocephalus*	305
Spotted Ratfish	*Hydrolagus colliei*	273
Greenstriped Rockfish	*Sebastes elongatus*	269
Cabezon	*Scorpaenichthys marmoratus*	255
Copper Rockfish	*Sebastes caurinus*	250
China Rockfish	*Sebastes nebulosus*	234
Silvergray Rockfish	*Sebastes brevispinis*	177
Big Skate	*Beringraja binoculata*	165
Rosethorn Rockfish	*Sebastes helvomaculatus*	131
Petrale Sole	*Eopsetta jordani*	94
Pacific Sanddab	*Citharichthys sordidus*	51
Rockfishes	*Sebastes*	48
Yellowtail Rockfish	*Sebastes flavidus*	38
Tiger Rockfish	*Sebastes nigrocinctus*	37
Vermilion Rockfish	*Sebastes miniatus*	35
Blue Shark	*Prionace glauca*	33
Sandpaper Skate	*Bathyraja interrupta*	26
Bocaccio	*Sebastes paucispinis*	19
Yellowmouth Rockfish	*Sebastes reedi*	16
Spinyhead Sculpin	*Dasycottus setiger*	10
Kelp Greenling	*Hexagrammos decagrammus*	8
Pacific Ocean Perch	*Sebastes alutus*	8
Shortspine Thornyhead	*Sebastolobus alascanus*	7
Wolf Eel	*Anarrhichthys ocellatus*	7
Skates	*Rajidae*	7
Southern Rock Sole	*Lepidopsetta bilineata*	6
Dover Sole	*Microstomus pacificus*	3
Black Rockfish	*Sebastes melanops*	2
Starry Flounder	*Platichthys stellatus*	1
Bigmouth Sculpin	*Hemitripterus bolini*	1
Red Irish Lord	*Hemilepidotus hemilepidotus*	1
Buffalo Sculpin	*Enophrys bison*	1
Widow Rockfish	*Sebastes entomelas*	1
Bluntnose Sixgill Shark	*Hexanchus griseus*	1
Fish-Eating Star	*Stylasterias forreri*	204
Starfish	*Asteroidea*	161

Species	Scientific Name	Total Catch (count)
Anemone	*Actiniaria*	31
Giant Pacific Octopus	*Enteroctopus dofleini*	9
Long-Armed Sea Star	*Orthasterias koehleri*	9
Sea Pen	*Ptilosarcus gurneyi*	9
Sunflower Starfish	*Pycnopodia helianthoides*	8
Sea Whip	*Balticina septentrionalis*	7
Sea Urchins	*Echinacea*	6
Sea Cucumbers	*Holothuroidea*	5
Box Crabs	*Lopholithodes*	2
Inanimate Object(s)	*Inanimate object(s)*	2
Bivalve Molluscs	*Bivalvia*	1
Sea Pens	*Pennatulacea*	1
Bubble Gum Coral	*Paragorgia arborea*	1

Table 7. Annual summary of the total catch (piece count) for the top 25 species (by total piece count over all years) for the Outside Hard Bottom Longline Hook Survey southern region. Catch from 2007 and 2009 has been adjusted for sets that were originally in the southern region that were moved to the northern region when the survey areas were realigned to match the synoptic bottom trawl survey boundaries.

Species	2007	2009	2011	2014	2016	2018	2020	Total
North Pacific Spiny Dogfish	7867	4727	5854	1457	779	1268	533	22485
Yelloweye Rockfish	3679	3447	4079	2523	2444	3805	2427	22404
Pacific Halibut	2661	1725	1808	2881	2303	2218	2128	15724
Quillback Rockfish	1530	949	1718	1463	1477	2557	1673	11367
Sablefish	990	1209	912	534	1128	1641	1987	8401
Lingcod	1177	598	494	767	474	1045	1323	5878
Redbanded Rockfish	785	1112	647	507	529	1157	691	5428
Spotted Ratfish	958	255	1188	400	941	719	684	5145
Longnose Skate	1300	570	698	621	429	698	588	4904
Canary Rockfish	749	524	593	469	820	1087	602	4844
Pacific Cod	456	463	552	725	1249	456	476	4377
Arrowtooth Flounder	735	812	682	402	616	519	418	4184
Silvergray Rockfish	580	685	294	96	137	345	254	2391
China Rockfish	446	78	419	304	277	499	321	2344
Copper Rockfish	242	133	235	197	127	394	324	1652
Greenstriped Rockfish	122	126	226	122	176	167	313	1252
Rosethorn Rockfish	106	108	252	111	137	191	178	1083
Big Skate	92	134	118	93	209	203	180	1029
Cabezon	42	16	28	51	8	154	284	583
Vermilion Rockfish	92	11	80	55	32	148	48	466
Yellowtail Rockfish	30	30	61	43	58	98	106	426
Yellowmouth Rockfish	115	84	28	37	85	38	24	411
Petrale Sole	30	13	46	20	28	78	109	324
Tiger Rockfish	41	21	30	17	23	58	75	265
Sandpaper Skate	24	6	15	8	31	39	43	166

Table 8. Annual summary of the number of fish sampled for biological data during the Outside Hard Bottom Longline Hook Survey in the southern region. Totals from 2007 and 2009 have been adjusted for sets that were originally in the southern region that were moved to the northern region when the survey areas were realigned to match the synoptic bottom trawl survey boundaries.

Species	2007	2009	2011	2014	2016	2018	2020	Total
Yelloweye Rockfish	2653	2508	3072	1939	1899	2591	1917	16579
Quillback Rockfish	1256	765	1296	1449	1107	1732	1312	8917
Redbanded Rockfish	412	590	265	355	413	416	348	2799
Canary Rockfish	236	319	192	445	426	29	0	1647
China Rockfish	224	65	228	308	266	237	226	1554
Copper Rockfish	221	133	221	192	130	338	287	1522
Lingcod	0	0	0	0	0	324	741	1065
Silvergray Rockfish	74	193	104	93	23	1	0	488
Greenstriped Rockfish	35	84	72	125	74	27	0	417
Rosethorn Rockfish	32	18	92	113	85	0	0	340
Vermilion Rockfish	27	3	16	54	32	5	0	137
Tiger Rockfish	23	5	22	17	23	15	25	130
Pacific Cod	0	0	0	119	0	0	0	119
Yellowtail Rockfish	4	15	22	41	11	0	0	93
Black Rockfish	4	1	26	8	0	4	4	47
Yellowmouth Rockfish	0	5	2	36	2	0	0	45
Shortspine Thornyhead	5	6	8	16	0	0	0	35
Bocaccio	5	11	5	1	0	1	6	29
Blue Shark	0	0	0	0	0	13	12	25
Rougheye/Blackspotted Rockfish Complex	3	6	1	3	1	2	6	22
Deacon Rockfish	6	0	0	0	14	0	0	20
Redstripe Rockfish	0	1	5	0	0	0	0	6
Southern Rock Sole	0	0	5	0	0	0	0	5
Widow Rockfish	0	0	2	0	0	0	0	2
Dusky Rockfish	0	1	0	0	0	0	0	1
Chilipepper	0	0	1	0	0	0	0	1
Sharpchin Rockfish	0	0	0	1	0	0	0	1
Shortraker Rockfish	0	0	0	1	0	0	0	1
Pacific Ocean Perch	0	0	1	0	0	0	0	1

Table 9. Number of fish sampled for biological data during the 2020 Outside Hard Bottom Longline Hook Survey on the Borealis 1 showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Black Rockfish	*Sebastes melanops*	2	2	0
China Rockfish	*Sebastes nebulosus*	86	86	0
Copper Rockfish	*Sebastes caurinus*	61	61	0
Lingcod	*Ophiodon elongatus*	102	102	0
Quillback Rockfish	*Sebastes maliger*	714	716	0
Redbanded Rockfish	*Sebastes babcocki*	42	42	0
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus complex*	6	6	6
Tiger Rockfish	*Sebastes nigrocinctus*	19	19	0
Yelloweye Rockfish	*Sebastes ruberrimus*	567	567	0

Table 10. Number of fish sampled for biological data during the 2020 Outside Hard Bottom Longline Hook Survey on the Banker II showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected	DNA Tissue Collected
Black Rockfish	*Sebastes melanops*	2	2	0
Blue Shark	*Prionace glauca*	12	0	12
Bocaccio	*Sebastes paucispinis*	6	6	0
China Rockfish	*Sebastes nebulosus*	140	141	0
Copper Rockfish	*Sebastes caurinus*	226	225	0
Lingcod	*Ophiodon elongatus*	639	496	0
Quillback Rockfish	*Sebastes maliger*	598	579	0
Redbanded Rockfish	*Sebastes babcocki*	306	305	0
Tiger Rockfish	*Sebastes nigrocinctus*	6	6	0
Yelloweye Rockfish	*Sebastes ruberrimus*	1350	1154	0

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 16). Each spatial stratum was further divided into 2 km by 2 km blocks and each block was assigned to one of 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.

Recent Sablefish Research and Assessment surveys have been comprised of two main components:

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 17). 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, recent surveys have also 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. In earlier years of the program, autonomous, trap-mounted cameras were used to also collect images of the sea floor but their use was suspended following the 2017 survey.

As with all the other surveys in 2020, COVID 19 affected the Sablefish survey. DFO staff were not on board during the survey and the science complement was reduced. The objective for 2020 was the core survey goal of providing an abundance index that is used to determine the fishery total allowable catch. As such, the target number of offshore randomized tagging program sets was maintained while the inlets program were dropped. The electronic data acquisition system that is typically used was not deployed and instead all data were collected using paper data forms. The workload for the science staff was reduced by removing any ancillary data collection including the data recorders usually deployed as part of the benthic impacts research project as well as lower priority biological samples.

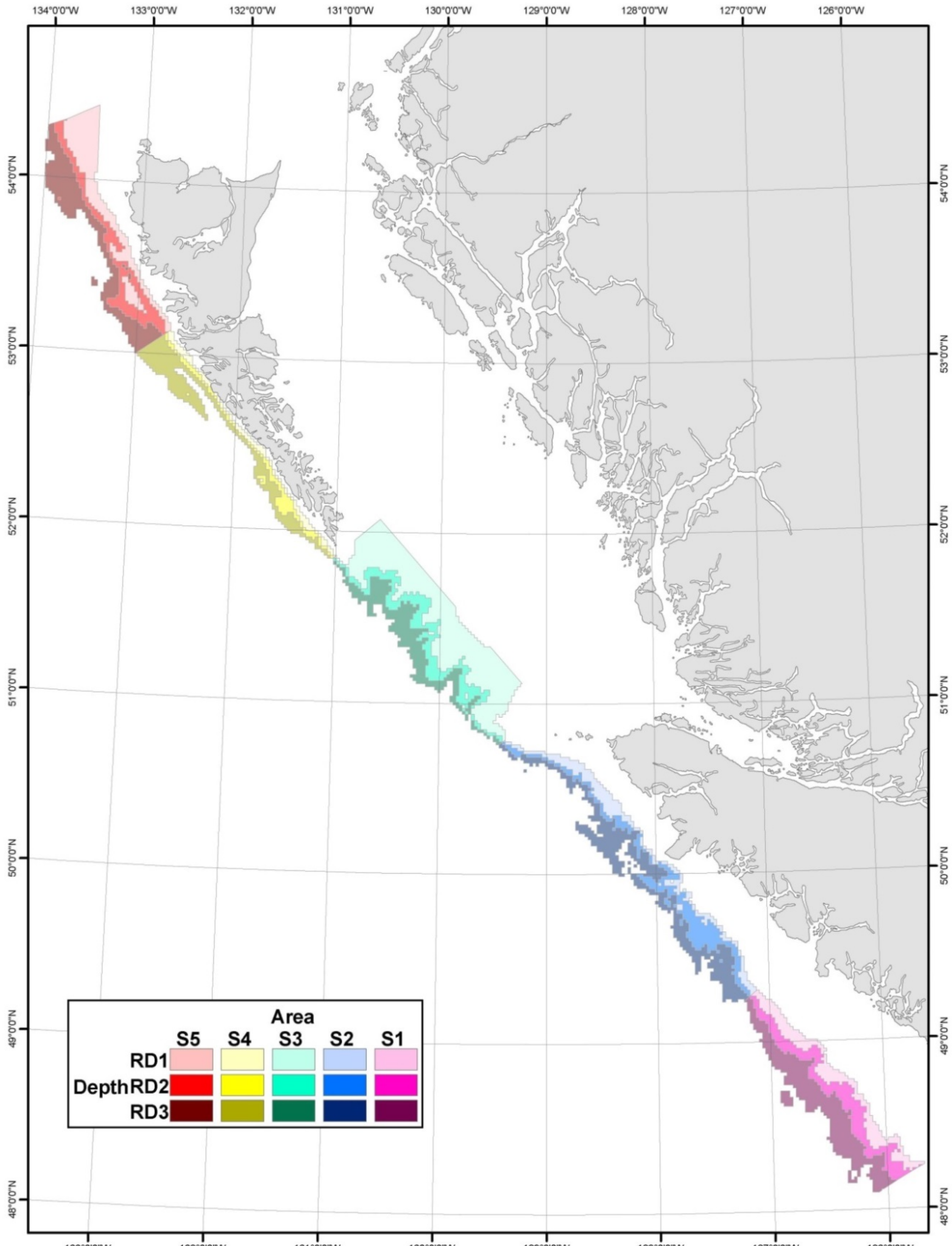

Figure 14. Sablefish Research and Assessment Survey randomized tagging program design showing the boundaries of each of the spatial and depth strata.

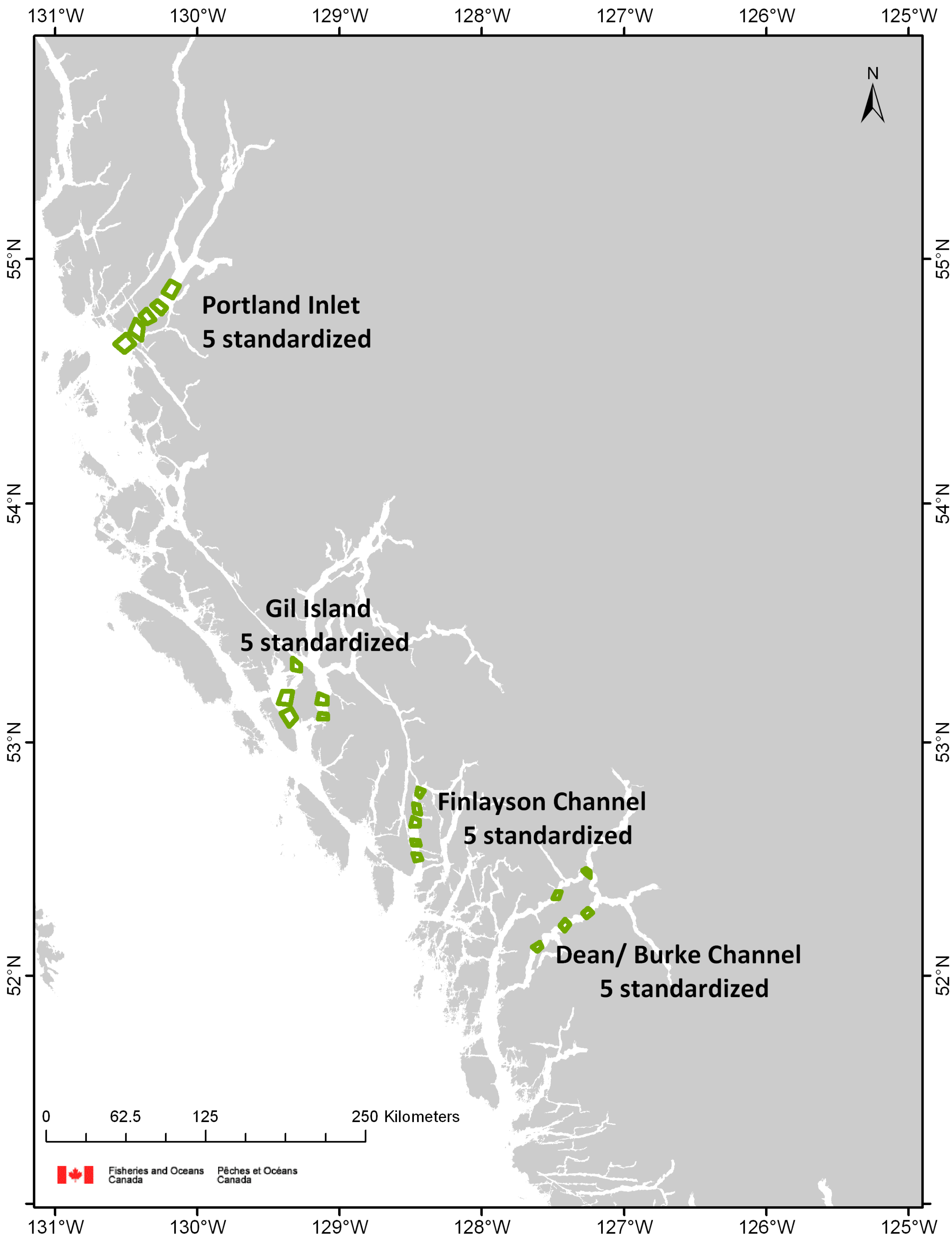

Figure 15. Sablefish Research and Assessment Survey Inlets program locations.

The 2020 Sablefish Research and Assessment Survey was conducted on the Pacific Viking from October 7 to November 21, 2020. A total of 87 Randomized Tagging Program sets were completed (Figure 18, Table 11).

The total catch of the survey was 98,180 kg (Table 12) and the average catch per set was 1128 kg. The most abundant fish species encountered by weight were Sablefish (*Anoplopoma fimbria*), followed by Pacific Halibut (*Hippoglossus stenolepis*), Lingcod (*Ophiodon elongatus*), North Pacific Spiny Dogfish (*Squalus suckleyi*), 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 13. Annual summaries of catch for common species are shown for the Randomized Tagging Program in Table 14. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 12,068 individual fish of 2 different species (Table 15). An annual summary of the number of fish sampled for biological data during the Randomized Tagging Program is shown in Table 16.

Table 11. Summary of sets completed during the 2020 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)	7	6	4	17
S4 (South West Coast Haida Gwaii or SWCHG)	4	6	5	15
S5 (North West Coast Haida Gwaii or NWCHG)	6	7	5	18
Total	**29**	**34**	**24**	**87**

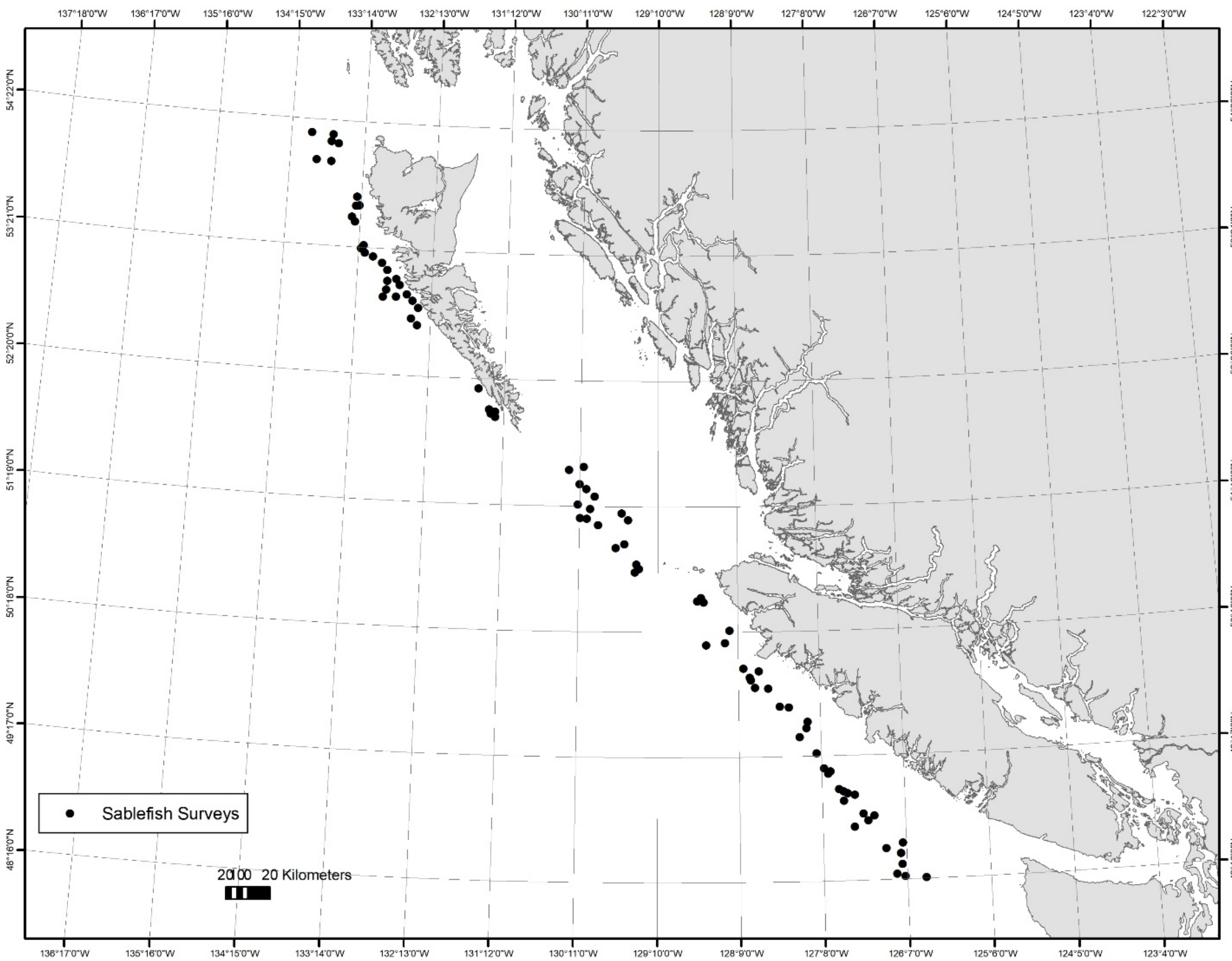

Figure 16. Set locations of the 2020 Sablefish Research and Assessment Survey.

Table 12. Total catch for the top 35 species (by weight) captured during the 2020 Sablefish Research and Assessment Survey.

Species	Scientific Name	Total Catch (count)	Total Catch (kg)
Sablefish	*Anoplopoma fimbria*	48092	92169
Pacific Halibut	*Hippoglossus stenolepis*	180	1554
Lingcod	*Ophiodon elongatus*	168	1522
North Pacific Spiny Dogfish	*Squalus suckleyi*	337	1121
Yelloweye Rockfish	*Sebastes ruberrimus*	85	302
Redbanded Rockfish	*Sebastes babcocki*	158	287
Arrowtooth Flounder	*Atheresthes stomias*	125	286
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus complex*	130	221
Giant Grenadier	*Albatrossia pectoralis*	48	218
Pacific Grenadier	*Coryphaenoides acrolepis*	227	200
Grooved Tanner Crab	*Chionoecetes tanneri*	286	117
Shortraker Rockfish	*Sebastes borealis*	17	64
Shortspine Thornyhead	*Sebastolobus alascanus*	44	55
Dover Sole	*Microstomus pacificus*	10	10
Pacific Cod	*Gadus macrocephalus*	3	6
Brown Box Crab	*Lopholithodes foraminatus*	23	6
Oregontriton	*Fusitriton oregonensis*	213	6
Rosethorn Rockfish	*Sebastes helvomaculatus*	11	4
	Paralomis multispina	12	3
Fragile Urchin	*Allocentrotus fragilis*	32	2
	Lithodes couesi	6	2
Octopus	*Octopus*	1	2
Petrale Sole	*Eopsetta jordani*	1	2
Jellyfish	*Scyphozoa*	1	1
Pacific Flatnose	*Antimora microlepis*	1	1
Walleye Pollock	*Gadus chalcogrammus*	1	1
Pink Snailfish	*Paraliparis rosaceus*	2	1
Prawn	*Pandalus platyceros*	7	0
Fish-Eating Star	*Stylasterias forreri*	5	0
Papillose Sea Cucumber	*Synallactes challengeri*	1	0
Golden King Crab	*Lithodes aequispinus*	1	0
	Solaster	1	0
Longspine Thornyhead	*Sebastolobus altivelis*	2	0
	Myxoderma sacculatum	1	0
	Mediaster tenellus	1	0

Table 13. 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 count) captured during the 2020 Sablefish Research and Assessment Survey Randomized Tagging Program sets. Species that were only captured once have been omitted from the table.

Species	**Scientific Name**	**Number of Sets**	**Catch (count)**	**Proportion of Total Catch (%)**	**3C**	**3D**	**5A**	**5B**	**5E**
Sablefish	*Anoplopoma fimbria*	87	48092	96.88	13983	10047	4844	3835	15383
North Pacific Spiny Dogfish	*Squalus suckleyi*	23	337	0.68	20	33	79	22	183
Pacific Grenadier	*Coryphaenoides acrolepis*	15	227	0.46	11	32	14	2	168
Pacific Halibut	*Hippoglossus stenolepis*	30	180	0.36	12	27	29	15	97
Lingcod	*Ophiodon elongatus*	18	168	0.34	4	2	121	1	40
Redbanded Rockfish	*Sebastes babcocki*	23	158	0.32	11	3	80	22	42
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	20	130	0.26	9	17	4	43	57
Arrowtooth Flounder	*Atheresthes stomias*	22	125	0.25	14	51	15	10	35
Yelloweye Rockfish	*Sebastes ruberrimus*	6	85	0.17	0	0	71	0	14
Giant Grenadier	*Albatrossia pectoralis*	16	48	0.10	4	13	1	0	30
Shortspine Thornyhead	*Sebastolobus alascanus*	27	44	0.09	2	15	12	1	14
Shortraker Rockfish	*Sebastes borealis*	8	17	0.03	0	2	2	8	5
Rosethorn Rockfish	*Sebastes helvomaculatus*	7	11	0.02	0	0	2	3	6
Dover Sole	*Microstomus pacificus*	8	10	0.02	1	3	3	1	2
Pacific Cod	*Gadus macrocephalus*	2	3	0.01	1	0	0	0	2
Longspine Thornyhead	*Sebastolobus altivelis*	2	2	0.00	0	0	0	0	2

Table 14. Annual summary of the total catch (piece count) for the top 10 species (by total piece count over all years) for the Sablefish Research and Assessment Survey Randomized Tagging Program sets. Data from 2003 through 2007 have been omitted from this table.

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sablefish	20326	15529	17375	22568	16845	18095	14266	25428	18073	36604	46808	60965	48092
Arrowtooth Flounder	1163	1787	553	1037	921	414	864	610	427	686	336	100	125
Pacific Grenadier	608	829	676	742	715	254	534	686	627	276	346	200	227
North Pacific Spiny Dogfish	162	565	414	868	966	386	287	365	699	158	964	567	337
Rougheye/Blackspotted Rockfish Complex	513	418	406	266	941	223	488	320	386	257	177	290	130
Pacific Halibut	125	224	172	256	342	99	447	444	283	165	323	223	180
Redbanded Rockfish	257	150	131	244	208	127	241	295	217	287	219	221	158
Lingcod	109	93	97	165	71	88	92	121	154	106	192	200	168
Giant Grenadier	146	179	118	105	195	80	87	206	72	67	106	46	48
Yelloweye Rockfish	58	60	21	106	34	13	17	81	97	22	311	49	85

Table 15. Number of fish sampled for biological data during the 2020 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
Sablefish	*Anoplopoma fimbria*	8277	11968	3587	0
Rougheye/Blackspotted Rockfish Complex	*Sebastes aleutianus/melanostictus* complex	0	126	126	126

Table 16. 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 through 2007 have been omitted from this table.

Species	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Sablefish	11059	9331	10270	12463	10486	10118	8204	12094	9910	15841	13094	13721	11942
Rougheye/Blackspotted Rockfish Complex	282	289	266	240	393	179	373	270	270	183	144	195	126
Pacific Grenadier	461	562	378	471	380	188	0	0	0	0	0	0	0
Arrowtooth Flounder	441	379	245	400	656	140	0	0	0	0	0	0	0
North Pacific Spiny Dogfish	0	219	326	440	674	207	0	0	0	0	0	0	0
Redbanded Rockfish	224	145	131	243	204	113	0	0	0	29	0	0	0
Giant Grenadier	129	141	111	99	195	79	0	0	0	0	0	0	0
Pacific Halibut	0	2	60	5	15	0	0	0	0	158	261	216	0
Yelloweye Rockfish	55	60	21	106	32	12	0	75	58	21	150	49	0
Shortraker Rockfish	53	65	73	18	59	18	13	10	59	26	24	11	0
Pacific Flatnose	18	39	27	17	24	11	0	0	10	0	0	0	0
Shortspine Thornyhead	1	9	26	22	53	34	0	0	0	0	0	0	0
Lingcod	0	27	36	1	3	1	0	0	0	0	0	0	0
Rosethorn Rockfish	8	6	2	23	7	3	0	0	0	0	0	0	0
Dover Sole	3	1	3	13	18	3	0	0	0	0	0	0	0
Rosy Snailfish	30	0	0	1	0	0	0	0	0	0	0	0	0

Appendix 2: British Columbia commercial groundfish TACs, landings, and research allocations for 2020.

Table 1. British Columbia Groundfish Total Allowable Catch (TAC) and commercial landings in metric tonnes (t) for 2020. Except where noted, TACs are from the 2020 Groundfish Integrated Fisheries Management Plan (https://waves-vagues.dfo-mpo.gc.ca/Library/40935218.pdf). Landings are the published quota sector summaries (https://www.pac.dfo-mpo.gc.ca/fm-gp/groundfish-poissons-fond/publications-eng.html) and may not yet be complete for 2020.

Species or Species Group	Trawl Sector (t)		Combined Line Sectors (t)		Total (t)	
	TAC	Landings	TAC	Landings	TAC	Landings
Sharks And Skates						
North Pacific Spiny Dogfish	4,480	309	9,520	53	14,000	362
Big Skate	914	114	118	15	1,032	129
Longnose Skate	195	92	263	72	458	164
Pacific Cod	1,450	481	0	0	1,450	481
Walleye Pollock	4,935	6,516	0	0	4,935	6516
Pacific Hake [1]	7,000 gulf & 104,480 offshore	94,280	0	0	111,480	94,280
Rockfishes						
Rougheye/Blackspotted Rockfish Complex	636	TBD	484	TBD	1,120	TBD
Pacific Ocean Perch	5,192	2,618	1	0	5,193	2,618
Redbanded Rockfish	295	129	284	141	579	270
Shortraker Rockfish	126	17	111	79	237	96
Silvergray Rockfish	1,945	1,423	254	24	2,199	1,447
Widow Rockfish	2,500	1,987	46	0	2,546	1,987
Yellowtail Rockfish	5,440	3,315	60	0	5,500	3,315
Quillback Rockfish	4	0	151	58	155	58
Bocaccio	300	290	0	0	300	290
Canary Rockfish	965	596	135	7	1,100	603
Redstripe Rockfish	1,550	35	43	0	1,593	35
Yellowmouth Rockfish	2,364	1,154	78	0	2,442	1,154
Yelloweye Rockfish	3	6	113	73	116	79
Copper, China, And Tiger Rockfish	1	1	63	47	64	48

Table 1. Continued.

Species or Species Group	Trawl Sector (t)		Combined Line Sectors (t)		Total (t)	
	TAC	Landings	TAC	Landings	TAC	Landings
Thornyheads						
Shortspine Thornyhead	736	142	34	83	770	225
Longspine Thornyhead	405	21	20	0	425	21
Sablefish	257	88	2680	2,420	2,937	2,508
Lingcod	2572	306	1168	547	3,740	853
Flatfishes						
Arrowtooth Flounder	5000	1,954	0	0	5,000	1,954
Petrale Sole	900	416	0	0	900	416
Southern Rock Sole	1,552	170	0	0	1,552	170
Dover Sole	3,073	1,313	0	0	3,073	1,313
English Sole	822	354	0	0	822	354
Pacific Halibut [2,3]	454	135	2,299	2,198	2,753	2,333

[1] *Hake TAC provided by Chris Grandin*

[2] *Halibut weights are dressed, head-off, where dressed, head-off weight = round weight * 0.75.*

[3]*The groundfish trawl fishery has a bycatch mortality cap of 454 tonnes that is not part of the allocated commercial TAC. Halibut caught while fishing under the authority of a groundfish trawl licence cannot be retained and must be returned to the water as quickly as possible*

Table 2. British Columbia Groundfish research allocations in metric tonnes (t) for 2020. Except where noted, research allocations are deducted from the fish available to the commercial fishery by sector prior to the definition of commercial TACs. Values are copied from the 2020 Groundfish Integrated Fisheries Management Plan (https://waves-vagues.dfo-mpo.gc.ca/Library/40935218.pdf).

Species or Species Group	Trawl surveys (t)	Longline surveys (t)	Sablefish surveys (t)	Total (t)
Sharks And Skates				
North Pacific Spiny Dogfish	12.1	--	--	12.1
Big Skate	0.2	--	--	0.2
Longnose Skate	1.2	--	--	1.2
Pacific Cod	2.6	--	--	2.6
Walleye Pollock	1.2	--	--	1.2
Pacific Hake	4.6	--	--	4.6
Rockfishes				
Rougheye/Blackspotted Rockfish Complex	16.1	23.7	--	39.8
Pacific Ocean Perch	99.9	--	--	99.9
Redbanded Rockfish	1.7	11.6	--	13.3
Shortraker Rockfish	0.9	5.4	--	6.3
Silvergray Rockfish	12.2	12.7	--	24.9
Widow Rockfish	0.8	--	--	0.8
Yellowtail Rockfish	6.5	2.0	--	8.5
Quillback Rockfish	0.1	5.8	--	5.9
Bocaccio	0.5	--	--	0.5
Canary Rockfish	6.2	6.5	--	12.7
Redstripe Rockfish	13.7	--	--	13.7
Yellowmouth Rockfish	7.2	3.0	--	10.2
Yelloweye Rockfish	0.2	15.8	--	13.0
Copper, China, And Tiger Rockfish	0.0	2.8	--	2.8
Thornyheads				
Shortspine Thornyhead	6.6	0.9	--	7.5
Longspine Thornyhead	0.5	--	--	0.5

Table 2. Continued.

Species or Species Group	Trawl surveys (t)	Longline surveys (t)	Sablefish surveys (t)	Total (t)
Sablefish	12.1	1.0	60	73.1
Lingcod	2.0	5.7	--	7.7
Flatfishes				
Arrowtooth Flounder	20.7	--	--	20.7
Petrale Sole	1.5	--	--	1.5
Southern Rock Sole	0.5	--	--	0.5
Dover Sole	6.1	--	--	6.1
English Sole	2.6	--	--	2.6
Pacific Halibut [1]	1.6	27.2	--	28.8

[1] The halibut poundage for the groundfish trawl survey is part of the trawl fishery's halibut bycatch mortality cap. The groundfish trawl fishery has a bycatch mortality cap of 454 tonnes that is not part of the allocated commercial TAC.

TSC Agency Reports – IPHC 2021

Contents

I. Agency Overview

Management of the Pacific halibut resource and fishery has been the responsibility of the International Pacific Halibut Commission (IPHC) since its creation in 1923, see Figure 1 for a map of the IPHC Convention Area. 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.

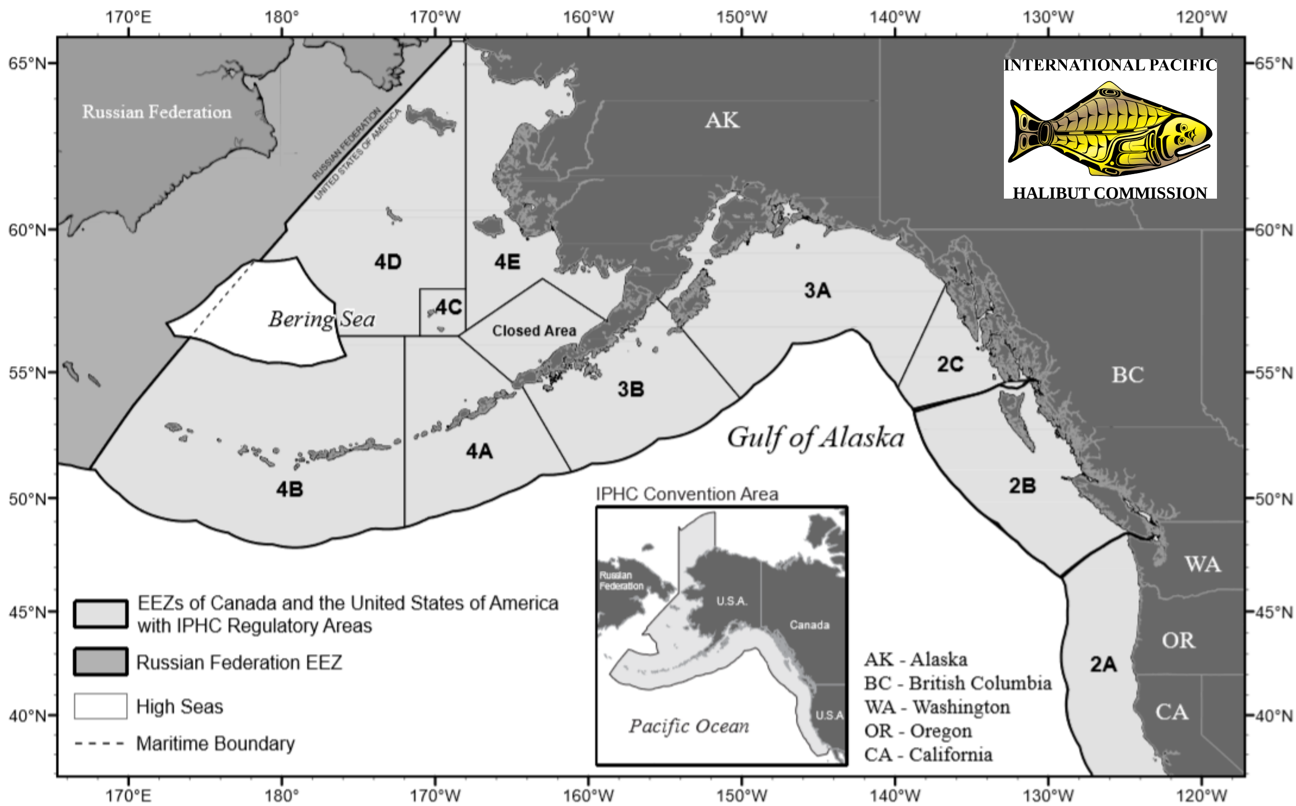

Figure 1. Map of the IPHC Convention Area and IPHC Regulatory Areas.

Staffing Updates: see https://www.iphc.int/locations/map

II. Fishery-Independent Setline Survey (FISS)

BACKGROUND

The International Pacific Halibut Commission's (IPHC's) Fishery-Independent Setline Survey (FISS) 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 directed 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.

For details on FISS work conducted in 2020, please refer to the following paper: IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2020

III. Reserves – N/A

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

A. Pacific halibut and IPHC activities

1. Research

The primary biological research activities at the IPHC that follow Commission objectives and selected for their important management implications are identified and described in the Five-Year Research Plan for the period 2017-21:

Overview of research activities in 2020 and planned for 2021

1. Migration. Knowledge of Pacific halibut migration throughout all life stages is necessary in order to gain a complete understanding of stock distribution and the factors that influence it.

    1.1. Larval distribution and connectivity between the Gulf of Alaska and Bering Sea. Knowledge of the dispersal of Pacific halibut larvae and subsequent migration of young juveniles has remained elusive because traditional tagging methods are not effective on these life stages due to the small size of the fish. This larval connectivity project, in cooperation with NOAA EcoFOCI, used two recently developed modeling approaches to estimate dispersal and migration pathways in order to better understand the connectivity of populations both within and between the Gulf of Alaska (GOA) and Bering Sea (BS) (Sadorus et al., 2021). In brief, to improve current understanding of larval dispersal pathways and migrations of young fish within and between GOA and BS, investigations were conducted to (1) examine pelagic larval dispersal and connectivity between the two basins using an individual-based biophysical model (IBM), and (2) track movement of fish up to age-6 years using annual age-based distributions and a spatio-temporal modeling approach. IBM results indicate that the Aleutian Islands constrain connectivity between GOA and BS, but that large island passes serve as pathways between these ecosystems. The degree of connectivity between GOA and BS is influenced by spawning location such that up to 50-60% of simulated larvae from the westernmost GOA spawning location arrive in the BS with progressively fewer larvae arriving proportional to distance from spawning grounds further east. There is also a large degree of connectivity between eastern and western GOA and between eastern and western BS. Spatial modeling of 2-6 year old fish shows ontogenetic migration from the inshore settlement areas of eastern BS towards Unimak Pass and GOA by age 4. The pattern of larval dispersal from GOA to BS, and subsequent post-settlement migrations back from BS toward GOA, provides evidence of circular, multiple life-stage, connectivity between these ecosystems, regardless of temperature stanza or year class strength..

    1.2. Wire tagging of U32 Pacific halibut. The patterns of movement of Pacific halibut among IPHC Regulatory Areas have important implications for management of the Pacific halibut fishery. The IPHC Secretariat has undertaken a long-term study of the migratory behavior of Pacific halibut through the use of externally visible tags (wire tags) on captured and released fish that must be retrieved and returned by workers in the fishing industry. In 2015, with the goal of gaining additional insight into movement and growth of young Pacific halibut (less than 32 inches [82 cm]; U32), the IPHC began wire-tagging small Pacific halibut encountered on the NOAA-Fisheries groundfish trawl survey and, beginning in 2016, on IPHC's FISS. In 2019, a total of 821 Pacific halibut were tagged and released during the GOA trawl survey and 885 tags were released during the BS trawl survey. Through 2019, a total of 6,536 tags have been released in the NOAA-Fisheries groundfish trawl survey and, to date, 52 tags have been recovered. No U32 tagging on the NOAA-Fisheries groundfish trawl survey occurred in 2020 due its cancellation as a result of COVID-19. On the IPHC FISS, a total of 3,980 U32 Pacific halibut have been wire tagged are released and 74 of those have been recovered to date. In 2020, 868 U32 fish were wire-tagged and released: 321 fish in Regulatory Area 2B and 547 fish in Regulatory Area 3A. The distance traveled by recaptured fish from the release location was under 10 nm for 35% of the fish and between 11 and 50 nm for 25% of the fish. For example, of the 2,005 fish released in Reg Area 3A between 2015 and 2019, 31 of 32 recovered fish were recovered in the same area of release and within the first three years at liberty.

1.3. Tail pattern identification. In order to complement studies on the movement patterns of Pacific halibut through conventional external wire tags, the IPHC Secretariat is investigating whether natural tail markings can be used for individual fish identification after recapture. Beginning with a pilot project conducted in the IPHC FISS in 2017, a total of 1,206 sublegal (< 32 inches fork length) Pacific halibut have been photographed and wire tagged to date. Of these, 14 fish have been recaptured and pictures of the tails were provided. A database of tail images is being created and different pattern-recognition software packages are being tested to allow for pattern matches.

2. Reproduction. Efforts at IPHC are currently underway to address two critical issues in stock assessment for estimating the female spawning biomass: the sex ratio of the commercial landings and maturity estimations.

2.1. Sex ratio of the commercial landings. The sex ratio of the commercial fishery catch represents an extremely important source of uncertainty in the Pacific halibut annual stock assessment (Stewart and Hicks, 2020). The IPHC has generated sex information of the entire set of aged commercial fishery samples collected in 2017 and in 2018 (>10,000 fin clips per year) using genetic techniques based on the identification of sex-specific single nucleotide polymorphisms (SNPs) (Drinan et al., 2018) using TaqMan qPCR assays conducted at the IPHC's Biological Laboratory. Therefore, for the first time, direct estimates of the sex-ratio at age for the directed commercial fishery have been available for stock assessment. Genetic analyses of commercial samples from 2017 showed that the proportion of females coastwide was high (82%), ranging from 65% to 92% depending on the biological region. Data from the 2018 commercial samples showed almost identical patterns, with females comprising 80% of the coastwide commercial landings (by number). Given that the sex-ratio data constitutes one of the two most important contributors to estimates of both population trend and scale, the inclusion of this information in the 2019 stock assessment resulted in higher spawning biomass. The IPHC Secretariat has recently completed the processing of genetic samples from the 2019 commercial landings and the results indicate that the percentage of females coastwide in the commercial catch is 78%, showing a continuous decline since 2017.

2.2. Maturity estimations. Recent sensitivity analyses have shown the importance of changes in spawning output due to skip spawning and/or changes in maturity schedules for stock assessment (Stewart and Hicks, 2020). These results highlight the need for a better understanding of factors influencing reproductive biology and success for Pacific halibut. In order to fill existing knowledge gaps related to the reproductive biology of female Pacific halibut, research efforts are devoted to characterize female maturity in this species. Specific objectives of current studies include: 1) accurate description of oocyte developmental stages and their use to classify female maturity stages; 2) comparison of macroscopic (based on field observations) and microscopic (based on histological assessment) maturity stages and revision of maturity criteria; 3) revision of current estimates of female age-at-maturity; and 4) investigation of fecundity and skip-spawning in females.

The IPHC Secretariat has described for the first time the different oocyte stages that are present in the ovary of female Pacific halibut and how these are used to classify females histologically to specific maturity stages (Fish et al., 2020). In brief, eight different oocyte developmental stages have been described, from early primary growth oocytes until preovulatory oocytes, and their size and morphological characteristics established. Maturity classification was determined by assigning maturity status to the most advanced oocyte developmental stage present in ovarian tissue sections and seven different microscopic maturity stages were established. Analysis of oocyte size frequency distribution among the seven different maturity stages provided evidence for the group-synchronous pattern of oocyte development and for the determinate fecundity reproductive strategy in female Pacific halibut. The results of this study will allow us to establish a comparison of the microscopic/histological and macroscopic/field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment. The results of this study set the stage for and in-depth study on temporal changes in maturity that is currently underway through histological assessment of ovarian samples collected over an entire annual reproductive cycle. Furthermore, the IPHC Secretariat is establishing a comparison of the microscopic (e.g. histological) and macroscopic (e.g. visual) maturity classification criteria to determine whether field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment needs to be revised in light of the improved knowledge on ovarian development.

The IPHC Secretariat is also conducting temporal and spatial analyses of female maturity schedules through the collection of ovarian samples in the IPHC's FISS.

For the temporal analysis of maturity, ovarian samples have been collected in the Portlock region (central Gulf of Alaska) during the same period (June-July) for 30 females (>90 cm length) for four consecutive years: 2017, 2018, 2019 and 2020. These ovarian samples have been processed for histology and microscopic maturity staging will be conducted to compare the maturity status over that time period. Furthermore, for the spatial analysis of maturity, ovarian samples from 30 females (>90 cm length) have been collected in the FISS in 5 different regions in the Gulf of Alaska in order to obtain preliminary information on potential spatial differences in maturity.

3. Growth. Recent stock assessments conducted by the IPHC Secretariat have indicated that the Pacific halibut stock experienced a continuous coastwide decline from the late 1990s until approximately 2012 largely due to a decrease in size-at-age (SAA) (Stewart and Hicks, 2020). Current low values of SAA combined with low recruitment of cohorts spawned at the time of the initial decrease in SAA in the 1990s have contributed to a decrease in exploitable Pacific halibut biomass. Although the decrease in SAA has been hypothesized as being attributed to several potential causes, including environmental effects such as temperature or food availability, as well as ecological or fishery effects, our knowledge on the actual factors that influence SAA of Pacific halibut is still scarce. The IPHC Secretariat has conducted studies aimed at elucidating the drivers of somatic growth leading to the decline in SAA by investigating the physiological mechanisms that contribute to growth changes in the Pacific halibut. The two main objectives of these studies are: 1) the identification and validation of physiological markers for somatic growth; and 2) the use of growth markers for evaluating growth patterns in the Pacific halibut population and the effects of environmental factors on somatic growth. In order to pursue these objectives, the IPHC Secretariat has investigate on the effects of temperature variation on growth performance, as well as on the effects of density, hierarchical dominance and handling stress on growth in juvenile Pacific halibut in captivity. These studies have been funded by a grant from the North Pacific Research Board to the IPHC and the Alaska Fisheries Science Center (NPRB #1704). At this time, results from studies investigating the effects of temperature on growth physiological indicators are being prepared for publication in a peer-reviewed journal (Planas et al., in preparation). In brief, juvenile Pacific halibut were subjected to temperature-induced growth manipulations, whereby somatic growth was suppressed by low temperature acclimation and stimulated by temperature-induced compensatory growth. Physiological signatures of growth suppression and growth stimulation were identified by a comparative transcriptomics and proteomics approach that identified genes and proteins, respectively, which experienced expression changes in response to the two growth manipulations. The identified genes and proteins could potentially represent useful markers for growth in skeletal muscle. Currently, assays are being developed to test the validity of the identified molecular markers for growth on skeletal muscle samples from age-matched adult Pacific halibut of different size categories.

   In addition to temperature-induced growth manipulations, the IPHC Secretariat is conducting similar studies to identify physiological growth markers that respond to density and stress-induced growth manipulations. On one hand, changes in SAA in

Pacific halibut have been hypothesized, among other potential causes, to be the result of changes in population dynamics of the Pacific halibut stock due to a density effect, whereby high population densities would negatively affect growth. On the other hand, we hypothesize that stress responses associated with capture and release of discarded Pacific halibut may affect feeding and growth in the wild, therefore, addressing potential growth consequences related to capture and handling stress. Investigations related to the effects of density and stress exposure are currently underway.

4. Discard Mortality Rates (DMRs) and Survival Assessment. Information on all Pacific halibut removals is integrated by the IPHC Secretariat, providing annual estimates of total mortality from all sources for its stock assessment. Bycatch and wastage of Pacific halibut, as defined by the incidental catch of fish in non-target fisheries and by the mortality that occurs in the directed fishery (i.e. fish discarded for sublegal size or for regulatory reasons), respectively, represent sources of mortality that can result in significant reductions in exploitable yield in the directed fishery. Given that the incidental mortality from the commercial Pacific halibut fisheries and bycatch fisheries is included as part of the total removals that are accounted for in stock assessment, changes in the estimates of incidental mortality will influence the output of the stock assessment and, consequently, the catch levels of the directed fishery. For this reason, the IPHC Secretariat is conducting investigations on the effects of capture and release on survival and on providing experimentally-derived estimates of DMRs in the directed longline and guided recreational Pacific halibut fisheries.

4.1. Evaluation of the effects of **hook release techniques** on injury levels and association with the physiological condition of longline-caught Pacific halibut. In order to better estimate post-release survival of Pacific halibut caught incidentally in the directed longline fishery, the IPHC Secretariat is conducting investigations to understand the relationship between fish handling practices and fish physical and physiological condition and survival post-capture as assessed by accelerometer tags. Currently, the IPHC assigns a 3.5% DMR to Pacific halibut released from longline gear with only minor injuries and a 16% DMR to the total estimated volume of U32 discards generated by the target fishery. The former was experimentally derived between 1958 and 1961, and the latter is a result of tagging studies in which the baseline DMR was used as a parameter in tag-recovery models that were used to estimate DMRs for fish returned to the water in relatively poorer condition than “minor”. As such, if the 3.5% is mis-specified, the subsequent rates that rest upon that value will be inaccurate, as will be our estimates of total discard mortality within the fishery. The baseline rate was generated from at-sea captive holding studies that reported that observed mortality patterns were, at least in part, due to fluctuating environmental conditions from which the fish could not escape, and for which they attempted to compensate analytically. Ambiguity therefore exists regarding the degree to which the baseline rate is accurate, necessitating additional studies in order to resolve this issue. For this reason, the IPHC Secretariat, with partial funding by a grant from the Saltonstall-Kennedy NOAA Grant Program (NA17NMF4270240), conducted studies to evaluate the effects of hook release techniques on injury levels, their association with the physiological condition of captured Pacific halibut and, importantly, generated experimentally-derived estimates of DMR in the directed longline fishery, as depicted in the workflow shown below:

As part of this study, injury profiles and release viabilities for different release techniques (careful shake, gangion cutting, and hook stripping) have been developed. The results obtained indicate that injury patterns were similar for careful shake and gangion cutting, with most injuries being a small puncture to the cheek, and greater than 70% of the released fish were classified to be in excellent viability. The hook stripper produced more severe physical injuries with significantly greater numbers of fish classified as moderate or poor in viability condition upon release. Physiological stress indicators in the blood (glucose, lactate, and cortisol) from all fish released have been measured and the results obtained to date are suggestive of a trend towards lower glucose and higher lactate blood levels in fish classified as dead in terms of the release condition. Cortisol levels do not show a significant trend across the release condition categories. Results on glucose, lactate, and cortisol plasma levels in fish according to physical injury code show a fair amount of variation within groups. The relationship of blood glucose, lactate, and cortisol levels to other measured parameters in discarded fish (fat levels, condition index, time out of water, temperature exposure, etc.) is currently under investigation.

4.2. Discard mortality rates of Pacific halibut in the charter recreational fishery. The IPHC initiated in 2019 a research project aimed at experimentally deriving DMRs from the charter recreational fishery for the first time. This project has received funding from the National Fish and Wildlife Foundation (Project # 61484) and from the North Pacific Research Board (NPRB #2009). As an initial step in this project, information from the charter fleet on types of gear and fish handling practices used was collected through stakeholder meetings and on dock interviews with charter captains and operators. Results show that the guided recreational fleet predominantly uses circle hooks (75-100%), followed by jigs. Predominant hook release methods included reversing the hook (54%), or twisting the hook out with a gaff (40%), and the fish were generally handled by supporting both the head and tail (65%), while other common techniques included handling by the operculum (10%) or by the tail alone (10%). These results will inform the design of the experimental test fishing that will take place in late Spring/early Summer of 2021 and in which injury levels, fish condition and stress parameters will be evaluated to identify best practices intended to minimize discard mortality in this fishery and to provide direct estimates of discard survival as assessed by accelerometer tags.

5. Genetics and genomics. The IPHC Secretariat is conducting studies to increase the genomic resources for Pacific halibut and apply them to improve our current

understanding of population structure and of Pacific halibut movement and distribution.

5.1. Sequencing of the Pacific halibut genome. The IPHC Secretariat has recently completed conducting a project aimed at generating a first draft sequence of the Pacific halibut genome, the blueprint for all the genetic characteristics of the species. This project was conducted in collaboration with the French National Institute for Agricultural Research (INRA, Rennes, France). Briefly, the Pacific halibut genome has a size of 586 Mb and contains 24 chromosomes- covering 98.6% of the complete assembly with a N50 scaffold length of 25 Mb at a coverage of 91x. The Pacific halibut genome sequence has been submitted to the National Center for Biological Information (NCBI) with submission number SUB7094550 and with accession number JABBIT000000000. Furthermore, the Pacific halibut genome has been annotated and is available in NCBI as NCBI *Hippoglossus stenolepis* Annotation Release 100. The generated genomic resources will greatly assist current studies on the genetic structure of the Pacific halibut population, on the application of genetic signatures for assigning individuals to spawning populations and for a detailed characterization of regions of the genome or genes responsible for important traits of the species.

5.2. Investigate the genetic structure of the Pacific halibut population in the North-eastern Pacific Ocean. Understanding population structure is imperative for sound management and conservation of natural resources. Pacific halibut in Canadian and USA waters are managed by the International Pacific Halibut Commission (IPHC) as a single coastwide unit stock since 2006. The rationale behind this management approach is based on our current knowledge of the highly migratory nature of Pacific halibut as assessed by tagging studies (Webster et al., 2013) and of past analyses of genetic population structure that failed to demonstrate significant differentiation in the North-eastern Pacific Ocean population of Pacific halibut by allozyme and small-scale microsatellite analyses. However, more recent studies have reported slight genetic population structure on the basis of genetic analysis conducted with larger sets of microsatellites suggesting that Pacific halibut captured in the Aleutian Islands may be genetically distinct from other areas (Drinan et al., 2016). These findings of subtle genetic structure in the Aleutian Island chain area are attributed to limited movement of adults and exchange of larvae between this area and the rest of the stock due to the presence of oceanographic barriers to larval and adult dispersal (i.e. Amchitka Pass) that could represent barriers to gene flow. Unfortunately, these genetic studies were conducted using a relatively limited set of microsatellite markers and, importantly, using genetic samples collected in the summer (i.e. non-spawning season) that may not be representative of the local spawning population. With the collection of winter (i.e. spawning season) genetic samples in the Aleutian Islands by the IPHC in early 2020, a collection of samples from spawning aggregations in five different geographic areas across the North-eastern Pacific Ocean (i.e. British Columbia, Central Gulf of Alaska, Bering Sea, Central and Western Aleutian Islands) is now available to re-examine the genetic structure of the Pacific halibut population. Importantly, novel, high-throughput and high-resolution genomics approaches are now available for use, such as low-coverage whole genome resequencing, in order to describe with unprecedented detail the genetic structure of the Pacific halibut population. The recently sequenced Pacific halibut genome will constitute an essential resource for the success of the whole genome resequencing approach. The results from the proposed genomic studies will provide important information on spawning structure and, consequently, on the genetic baselines of source populations.

5.3. Analysis of genetic variability among juvenile Pacific halibut in the Bering Sea and the Gulf of Alaska. The aim of this study is to evaluate the genetic variability among juvenile Pacific halibut in a given ocean basin in order to infer information on the potential contribution from fish spawned in different areas to that particular ocean basin. We hypothesize that genetic variability among juvenile Pacific halibut captured in one particular ocean basin (e.g. eastern Bering Sea) may be indicative of mixing of individuals originating in different spawning grounds and, therefore, of movement. By comparing the genetic variability of fish between two ocean basins (i.e. eastern Bering Sea and Gulf of Alaska), we will be able to evaluate the extent of the potential contribution from different sources (e.g. spawning groups) in each of the ocean basins and provide indications of relative movement of fish to these two different ocean basins. The use of genetic samples from juvenile Pacific halibut collected in the NMFS trawl survey in the eastern Bering Sea and in the Gulf of Alaska, aged directly or indirectly through the length-age key, will allow us to provide genetic information from fish that are at or near their settlement or nursery grounds. These studies will provide the ability to assign individual juvenile Pacific halibut to source populations and genetic information on movement and distribution of juvenile Pacific halibut.

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 directed commercial fishery data collection program. Ongoing data collections projects include the following:

IPHC Secretariat 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 trawl 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 directed 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 FISS or directed commercial fishery.

Sampling of directed commercial landings

The IPHC positions Secretariat to sample the directed 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. The collected otoliths provide age composition data and the tissue samples provide sex composition. Lengths and weight data, in combination with age data and sex data, provide size-at-age analyses by sex. Mean weights are combined with final landing weights to estimate catch in numbers. Logbook information provides weight per unit effort data, fishing location for the landed weight, and data for research projects. Finally, tags are collected to provide information on migration, exploitation rates, and natural mortality.

In addition to sampling the catch, other objectives include collecting recovered tags, and copying information from fishing logs along with the respective landed weights, for as many Pacific halibut trips as possible throughout the entire season.

2. Assessment

The 2020 stock assessment produced the following scientific advice regarding the Pacific halibut stock:

*"**Sources of mortality**: In 2020, total Pacific halibut mortality due to fishing was down to 35.50 million pounds (16,103 t) from 39.87 million pounds (18,086 t) in 2019. Of that total, 84% comprised the retained catch, up from 81% in 2019."*

*"**Stock status (spawning biomass)**: Current (beginning of 2021) female spawning biomass is estimated to be 192 million pounds (87,050 t), which corresponds to a 41% chance of being below the IPHC trigger reference point of $SB_{30\%}$, and less than a 1% chance of being below the IPHC limit reference point of $SB_{20\%}$. Relative female spawning biomass at the beginning of 2021 was estimated to be at 33% of the unfished state, with a 41% chance of being below the IPHC trigger reference point of $SB_{30\%}$, and less than a 1% chance of being below the IPHC limit reference point of $SB_{20\%}$. Therefore, the stock is considered to be '**not overfished**' ($SB_{2021} > SB_{20\%}$). Projections indicate that mortality consistent with the interim management procedure reference fishing intensity ($F_{43\%}$) is likely to result in further declining biomass levels in the near future."*

*"**Fishing intensity**: The 2020 mortality corresponded to a point estimate of SPR = 48%; there is a 38% chance that fishing intensity exceeded the IPHC's current reference level of 43%. The Commission does not currently have a coastwide fishing intensity limit reference point. However, given that the stock is above the spawning biomass limit reference point, the stock is by default classified as '**not subject to overfishing**'."*

*"**Stock distribution**: The proportion of the coastwide stock represented by Biological Region 3 has been decreasing since 2004, and increasing in Biological Regions 2 and 4. However, there was an increase in Biological Region 3 in 2020*

and a decrease in Biological Region 2. Biological Region 4 is near the historical high estimated for 2019, and has shown an increasing trend since the early 1990s."

*"**Outlook.** The stock is projected to decrease with at least a 51% chance over the period from 2021-23 for all TCEYs greater than the "3-year surplus" of 24.4 million pounds (~11,068 t), corresponding to a projected SPR of 58% (credible interval 39-76%). At the status quo TCEY (36.6 million lb, (~16,600 t)), the probability of spawning biomass decline is 62% and 61% for one and three years, respectively. At the reference level (a projected SPR of 43%) the probability of spawning biomass declining to 2022 is 65%, decreasing to 63% in three years, as the 2011 and 2012 cohorts mature. The one-year risk of the stock dropping below $SB_{30\%}$ ranges from 35% (at the 3-year surplus level) to 41% at the reference TCEY. Over three years these probabilities range from 29% to 44% depending on the level of mortality."*

For more information on the 2020 stock assessment and the fishery status, please refer to paper IPHC-2021-AM097-08 at the IPHC website.

3. Management

The International Pacific Halibut Commission (IPHC) completed the 97th Session of the IPHC Annual Meeting (AM097) on 29 January 2021 with decisions on total mortality limits, fishery limits, fishing period dates, and other fishery regulation changes. A total of 270 individuals attended the meeting via the electronic platform.

Meeting documents, presentations, recordings of the sessions, and the report of the meeting are available on the AM097 meeting page at the IPHC website: 97th Session of the IPHC Annual Meeting (AM097) | IPHC. Decisions arising from this meeting, including management decisions, are documented in the following report: Report of the 97th Session of the IPHC Annual Meeting (AM097)

Other Actions

Harvest Strategy Policy: https://www.iphc.int/the-commission/harvest-strategy-policy

Commercial Fishing Period: The Commission recommended that further consultations between Contracting Parties and fishery stakeholders on the administrative and policy implications of a year round fishery would support the decision process for the 98th Session of the IPHC Annual Meeting (AM098; January 2022) on potential further extensions of the directed commercial fishing period.

V. Ecosystem Studies

[See details in the Research section on ongoing IPHC data collection projects above.]

VI. Publications

Drinan DP, Galindo HM, Loher T, and Hauser L (2016) Subtle genetic population structure in Pacific halibut Hippoglossus stenolepis. J Fish Biol 89: 2571-2594.

Drinan DP, Loher T, and Hauser L (2018) Identification of Genomic Regions Associated With Sex in Pacific Halibut. J Hered 109: 326-332.

Fish T, Wolf N, Harris BP, Planas JV (2020) A comprehensive description of oocyte developmental stages in Pacific halibut, Hippoglossus stenolepis. J Fish Biol 97: 1880-1885. doi: 10.1111/jfb.14551

International Pacific Halibut Commission. 2020. Annual Report 2020.

https://www.iphc.int/uploads/pdf/ar/iphc-2021-ar2020-r.pdf Sadorus L, Goldstein E, Webster R, Stockhausen W, Planas JV, Duffy-Anderson J (2021) Multiple life-stage connectivity of Pacific halibut (Hippoglossus stenolepis) across the Bering Sea and Gulf of Alaska. Fish Oceanogr 30:174-193. doi: https://doi.org/10.1111/fog.12512

Stewart I, Hicks A (2020). Assessment of the Pacific halibut (Hippoglossus stenolepis) stock at the end of 2019. Meeting Doc. IPHC-2020-SA-01, 32 p. Int. Pac. Halibut Comm., Seattle, Washington, USA. [Available from https://iphc.int/uploads/pdf/sa/2020/iphc-2020-sa-01.pdf]

Webster RA, Clark WG, Leaman BM, and Forsberg JE (2013) Pacific halibut on the move: a renewed understanding of adult migration from a coastwide tagging study. Can. J. Fish.Aquat. Sci., 70:642-653

NMFS Southwest Fisheries Science Center

DRAFT

Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2021

Edited by Melissa Monk

With contributions from John Field, Tom Laidig, Nick Wegner, Sabrina Beyer and Joe Bizzarro

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 John Crofts is the Deputy Director. All SWFSC divisions support 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. David Weller), and the Fisheries Resources Division (led by Dr. Annie Yau). 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 three of the four research branches conduct studies focused on groundfish. The FED recently underwent a reorganization due to supervisor retirements and new hires. Dr. Steve Lindley is currently the acting supervisor of the Fisheries Economics team. The Molecular Ecology team (led by Dr. Carlos Garza) studies the molecular ecology and phylogeny salmonids and groundfish. Dr. John Field now oversees a larger Fisheries Assessment Group with three teams, Fisheries and Ecosystem Oceanography (led by Dr. John Field), Habitat and Groundfish Ecology (led by Dr. E.J. Dick) and Fisheries Assessment Modeling (led by Dr. Michael O'Farrell).

All of the teams within the Fisheries Assessment Group support the needs of NMFS and the Pacific Fishery Management Council, one of which is groundfish stock assessment. 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. Dr. Xi He from FED was the most recent SWFSC representative to the Pacific Council's Groundfish Management Team, however that seat is currently vacant since Dr. He's retirement earlier in 2021. Several scientists from the Fisheries Ecology Division in Santa Cruz currently serve on the Pacific Council's Scientific and Statistical Committee.

There is also much collaboration among the three teams within the Fisheries Assessment Group. The Fisheries Assessment Modeling team primarily conducts stock assessments for both groundfish and salmon, focusing on research to advance fisheries assessment methods. The Habitat and Groundfish Ecology team utilizes a number of survey tools, e.g., visual surveys conducted with remotely operated vehicles (ROV), human-occupied submersibles, autonomous underwater vehicles (AUV), scuba, hook-and-line fishing and captive rearing, to study deep-water demersal communities and groundfish ecology. The Fisheries and Ecosystem Oceanography team within the group is responsible for leading the annual pelagic juvenile rockfish recruitment and ecosystem assessment survey along the West Coast.

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)
Larval Rockfish Investigators: Andrew Thompson, William Watson

During the past seven years (2013-2020), the ichthyoplankton and molecular ecology laboratories at the SWFSC, La Jolla, built species-specific larval rockfish time-series by genetically sequencing individual larvae from winter CalCOFI samples between 1998 and 2013. Results of this work are currently published in a master's thesis and two peer-reviewed scientific publications, and time-series from blue rockfish (*Sebastes mystinus*) were used by the Pacific Fisheries Management Council to inform the status of this stock.

In 2019-2020 we are continuing to analyze this data. For example, a SIO master's student (Jessica Freeman) is utilizing nonparametric multivariate and Bayesian analyses to better understand drivers of larval rockfish dynamics. In addition, a postdoctoral researcher (Noah Ben-Aderet) removed otoliths from a subset of six species collected between 1998 and 2013. He has completed measuring otolith core width as a proxy for maternal investment and outer band width as a proxy for growth rate. He is currently conducting analyses to test whether environmental conditions during parturition affect maternal investment and if maternal investment and/or environmental conditions impact rate of growth. The ultimate goal of this project is to identify mechanisms that impact rockfish recruitment and determine if larval condition can predict recruitment success.

In 2019-2020, we initiated another genetics project seeking to identify rockfishes in CalCOFI samples. Rather than sequencing individual larvae, we extracted DNA from the ethanol in which CalCOFI samples are stored. We then used metabarcoding techniques similar to those used for environmental DNA analysis to sequence DNA from all fishes in a sample. It turned out that the traditional primers used for fish metabarcoding (MiFish 12S) discriminated poorly among rockfish species. Hence, we designed rockfish-specific metabarcode primers within the cytochrome *b* gene. We metabarcoded DNA from four stations per year between 1998 and 2019 and used recently developed bioinformatics pipelines to quantify the number of DNA reads for each species in a sample. Initial results demonstrate that we are able to identify most rockfish species from ethanol preservative. The metabarcoding work is led by Zachary Gold, a Ph.D. student from UCLA. The metabarcode work will be one of the chapters of his dissertation thesis. Zack is graduating in 2020 and a manuscript on this effort should be ready for submission to a peer-reviewed journal in late 2020.

We began in 2019-2020 a collaboration with the NWFSC to explore larval rockfish dynamics before, during, and after the 2014-2016 Marine Heatwave. We obtained from Ric Brodeur and Toby Auth rockfish larvae collected annually off the Newport Hydrological Line from 2013-2019. Prior to the closure of the SWFSC due to the coronavirus pandemic, we completed tissue extractions from all larvae (approximately 1800) and sequenced and identified approximately 1000. We were on track to complete identification by the end of April, but had to postpone lab work due the closure of the Center. Once the SWFSC reopens, we should be able to complete the identifications in about a month if we can work at our pre-shutdown pace.

Finally, we continued to update larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from July 1961 through December 2015, and samples collected during the primary rockfish reproductive seasons, winter and spring, of 2016-2019. This provides a 58-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

Contact: John Field (john.field@noaa.gov)

Since 1983 the SWFSC has conducted a Rockfish Recruitment and Ecosystem Assessment Survey in late Spring surveys for pelagic young-of-the-year (YOY) rockfish using a modified Cobb midwater trawl. The survey supports the development of recruitment indices for stock assessments of many winter-spawning rockfish (e.g., chilipepper, bocaccio, and widow rockfishes), and a suite of fisheries and ecosystem oceanography studies. Although the planned 2020 on the NOAA ship Reuben Lasker was cancelled due to COVID 19, the SWFSC managed to complete a small charter survey in the core (Central California) survey area. SWFSC staff joined the charter vessel crew for one night of fishing to train them on basic survey protocols, and for the remaining nights of the charter SWFSC staff would meet fishermen at the dock every 1-2 days to receive catches, where they were returned to the SWFSC lab for processing. Temperature/depth recorders attached to the trawl were used to confirm that the net was fishing at the right depth and for the appropriate duration.

The results of the 2020 survey indicated that total pelagic y indices for total rockfish and sanddab (Citharichthys spp.) were the second lowest on record and continued a decline from record high abundance levels observed during the 2014-2016 marine heatwave (Fig. 1) (25-26). YOY Pacific hake, myctophids, juvenile market squid and pelagic octopus catches were also below average. In contrast, the 2020 index for adult northern anchovy continued a multi-year period of persistently high abundance. A 2021 survey will take place on the NOAA ship Reuben Lasker, beginning in late April 2021. Although the sampling was sparse, with only 15 trawls successfully completed (the average number of trawls conducted in the core area between 1983 and 2019 was 60), the results were rigorously evaluated with model-based estimation approaches, and compared to alternative sources of information, such as seabird diets on the Southeast Farallon Islands, to ensure that catches were consistent with other ecosystem observations (Santora et al. in review). Uncertainty was greater for abundance indices of most taxa in 2020 due to the sparseness of sampling, and a rigorous evaluation of the trade-off between sampling intensity and index uncertainty was developed as part of the evaluation of 2020 data (Santora et al. in review).

The RREAS survey data have been pooled with data from NWFSC pelagic juvenile cruises, including the PWCC/NWFSC survey from 2001-2009 and the NWFSC Pre-recruit survey from 2011 through 2019. One effort in progress has pooled data from these surveys to describe the variability in the temporal and spatial abundance and distribution patterns of YOY rockfishes along the U.S. West Coast. This analysis indicates that over the scale of the California Current, while there is considerable spatial coherence in these relative abundance patterns over broad spatial scales, there are many years in which abundance patterns are very heterogeneous, particularly to the north and south of major promontories such as Cape Mendocino and Point Conception (Field et al. in review). Results also confirm that the high abundance levels of YOY rockfish observed during the 2014-2016 large marine heatwave were largely coastwide events.

The results of this work will help to inform future pelagic YOY surveys and future indices of recruitment strength used to inform stock assessment models.

C. BY SPECIES, BY AGENCY

C1. Nearshore rockfish stock assessments

C2. Shelf Rockfish

Drs. Melissa Monk and E.J. Dick are currently leading the development of stock assessments for the vermillion/sunset rockfish complex southern and central/northern California to support PFMC management efforts. The stock assessment review panel for these assessments will take place in late June (the NWC will lead development of models for Oregon and Washington). Two models for California waters will be developed, north and south of Point Conception, as there appears to be more mixing of vermillion and sunset in the southern region, while in the northern region vermillion rockfish are more frequently encountered. Far more data are available in the southern area (index and compositional data from the NWFSC hook and line survey will likely be key indices in the southern model) relative to the central/northern California area, where data are more sparse. This assessment represents the first large-scale effort to age vermilion rockfish, and as several aging laboratories are involved, the labs have initiated an official CARE (Center for Age Reading Experts) exchange, with each lab providing 60 fish that are subsequently aged by each lab involved in the age determination effort. The results will provide robust information on ageing error among the aging labs.

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 in La Jolla continues to evaluate the effects of capture and barotrauma on rockfishes (*Sebastes* spp.) following release in recreational fisheries. This work focuses in three major areas: 1. Acoustic telemetry tagging studies to document the survival rates and sublethal effects of catch and release and barotrauma on important management species such Cowcod (*S. levis*) and Bocaccio (*S. paucispinis*) (Fig A), 2. Laboratory studies examining the sensitivity of rockfishes to hypoxia both before and immediately following laboratory induced barotrauma using hyperbaric chambers, and 3. Working with the recreational fishing community in California to measure the effectiveness and angler preference for different types of commercially available descending devices used to release rockfishes suffering from barotrauma.

Analysis of acoustic tagging work to date has shown species-specific long-term survival rates of 50.0% for Cowcod (n=46, CI= 35.7-70.5%) and 89.5% for Bocaccio (n=41, CI 80.2-99.8%). For

Cowcod (which showed much lower survival rates), fish length, sea surface temperature, and dissolved oxygen levels at depth all significantly affected survival. For fish that survived, general additive models (GAMs) of post-release behavior showed that capture and barotrauma affected Cowcod and Bocaccio for at least 30 days post release. Dissolved oxygen also significantly affected post-release behavior. The modeled impact of dissolved oxygen on both survival rate and post-release behavior have led to on-going laboratory-based studies to examine the effects of hypoxia on Cowcod and Bocaccio behavior and physiology. Specifically, this work is examining behavioral avoidance to low oxygen using a custom-built shuttle-box system, and determining the effects of hypoxia on metabolism through respirometry trials. Better understanding how low levels of dissolved oxygen contribute to mortality and rockfish behavior will allow for refinement of the catch-and-release process and the implementation of release guidelines that maximize survival. In addition, such work can provide insight into limits on rockfish suitable habitat.

Research testing the effectiveness of descending devices released 2,275 rockfish from 32 species. 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. These 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. This work was recently published in *Fisheries Research* (Bellquist et al. 2019)

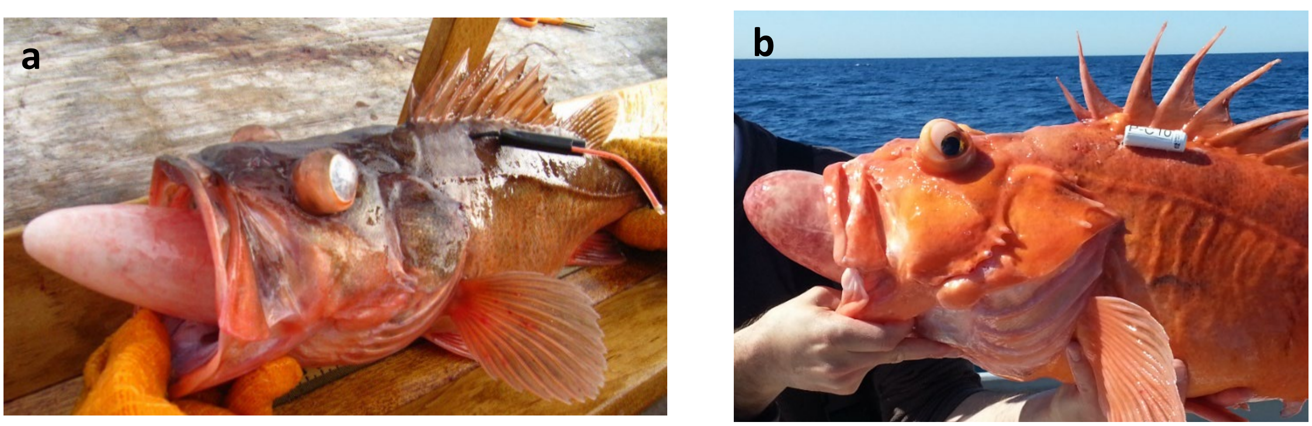

Figure A: Acoustic transmitter attachment and external barotrauma indicators for a) 47.5 cm FL Bocaccio tagged with a V9 single-anchored transmitter displaying a bloated body, everted esophagus, exophthalmia, and ocular emphysema. b) 64.0 cm Cowcod tagged with a double anchored V13 transmitter showing a bloated body, everted esophagus, exophthalmia, and the first onset of ocular emphysema (anterior-dorsal portion of eye).

D. OTHER RELATED STUDIES

D1. SWFSC FED Habitat and Groundfish Ecology Team 2019-20 Research on California Demersal Communities

Contact: EJ Dick (edward.dick@noaa.gov) FED HAGE Investigators: Joe Bizzarro, Tom Laidig, Melissa Monk, Diana Watters

The SWFSC/FED Habitat and Groundfish Ecology Team (HAGE) completes stock assessments on groundfish species and conducts research focused on deep-water California demersal communities. The goal for the deep-water component 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 groundfish 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 HAGE 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 HAGE 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 EXpanding Pacific Research and Exploration of Submerged Systems (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 4 research expeditions in 2020 including the 10-day deep-sea coral cruise aboard the E/V *Nautilus* (see D3 below). Three EXPRESS expeditions are currently planned for 2021.

D3. FY19 NMFS Deep-sea coral EXPRESS expedition, 1 Oct-7 Nov 2019
Contact: Tom Laidig (tom.laidig@noaa.gov)

A 10-day deep-sea coral expedition was conducted 17 Oct - 26 Oct, 2019 off the coast of California. The expedition was supported by NOAA's Marine Sanctuary Program, and staffed by NOAA personnel (CINMS, SWFSC, SWFSC). The cruise was planned through the EXPRESS campaign (See D2 above) with experts from CINMS, SWFSC, NWFSC, USGS, BOEM and MBARI. 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 information on corals, sponges, fishes, and sea floor habitats at sites around CINMS and Santa Lucia Bank, 2) Survey potential wind energy sites off Santa Lucia Bank, 3) Revisit a previously documented potential petrale sole spawning site on Santa Lucia Bank, 4) Create 3-D maps of high coral density areas for CINMS outreach activities, 5) Collect samples to help in identifying west coast corals and sponges. The expedition used two underwater remotely operated vehicles (ROVs), *Hercules* and *Argus*, in tandem. The ROVs were launched from the support vessel E/V Nautilus. Working from home, the science team narrated throughout dives, and directed quantitative transect surveys and specimen collections via telepresence technologies, which also provided live video and audio transmission to the public. Over one hundred hours of video were recorded and analysts are currently reviewing these files for identification and abundances of organisms. Many species of deep-sea corals, sponges and fishes were observed (Figure X). The Petrale sole spawning area was rediscovered but the dive ended too soon (due to travel time to next location) to map the entire aggregation site (Figure XX). A vast, previously unknown reef of dead *Farrea* sponges was discovered just south of Santa Cruz Island (Figure XXX). Additional surveys are being planned to map the extent of this reef. Many samples were collected for identification, however, due to Covid-19 restrictions to laboratory access, they have not been analyzed.

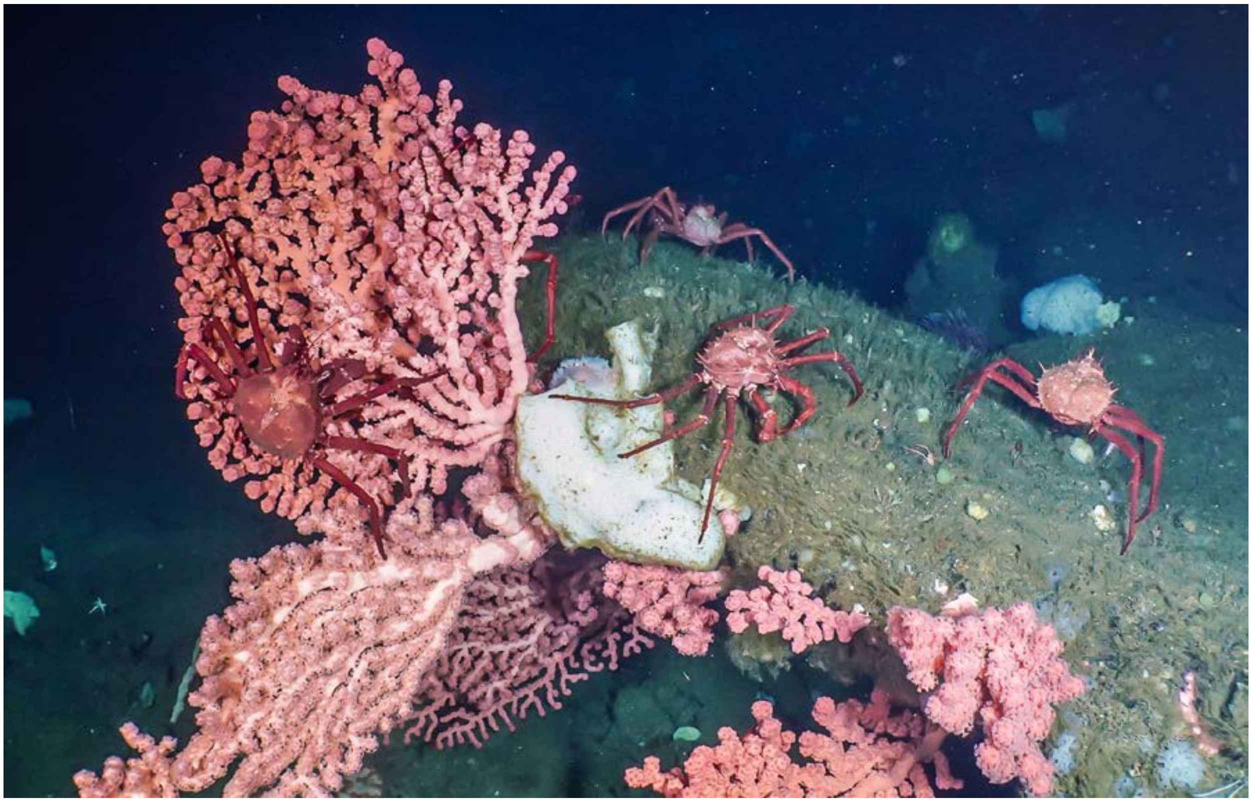

Figure X. Bubblegum corals (*Paragorgia pacifica*) and scarlet king crabs (*Lithodes cousei*) at Santa Lucia Bank.

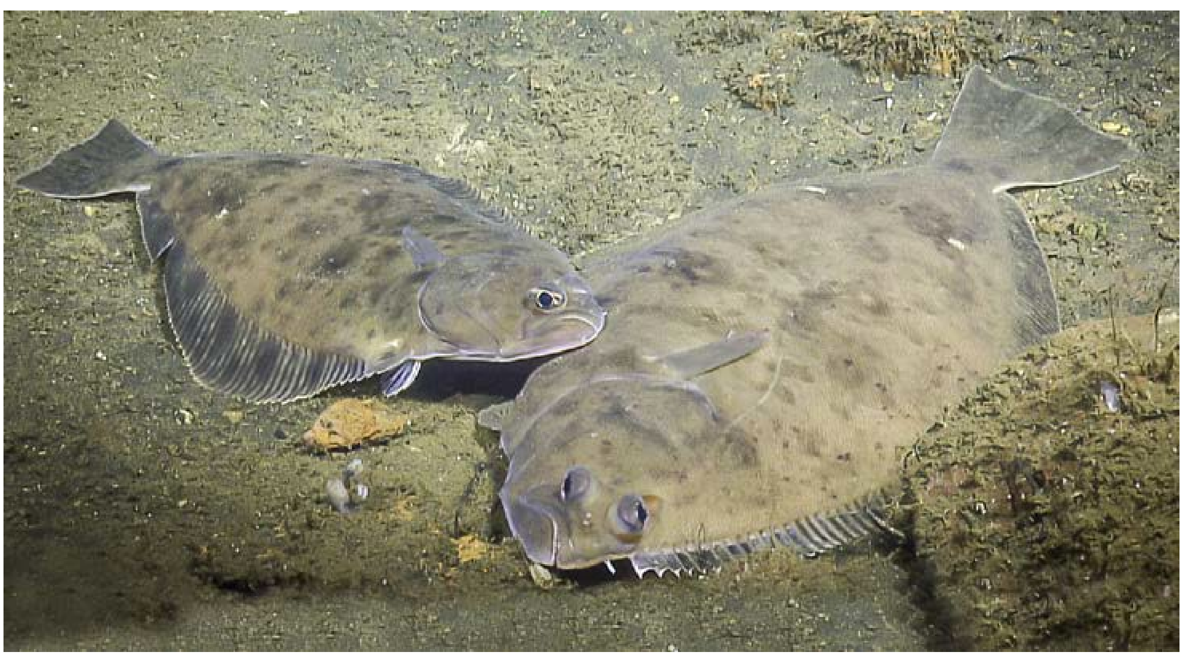

Figure XX. A smaller, presumed male petrale sole (*Eopsetta jordani*) laying on a larger female waiting to spawn.

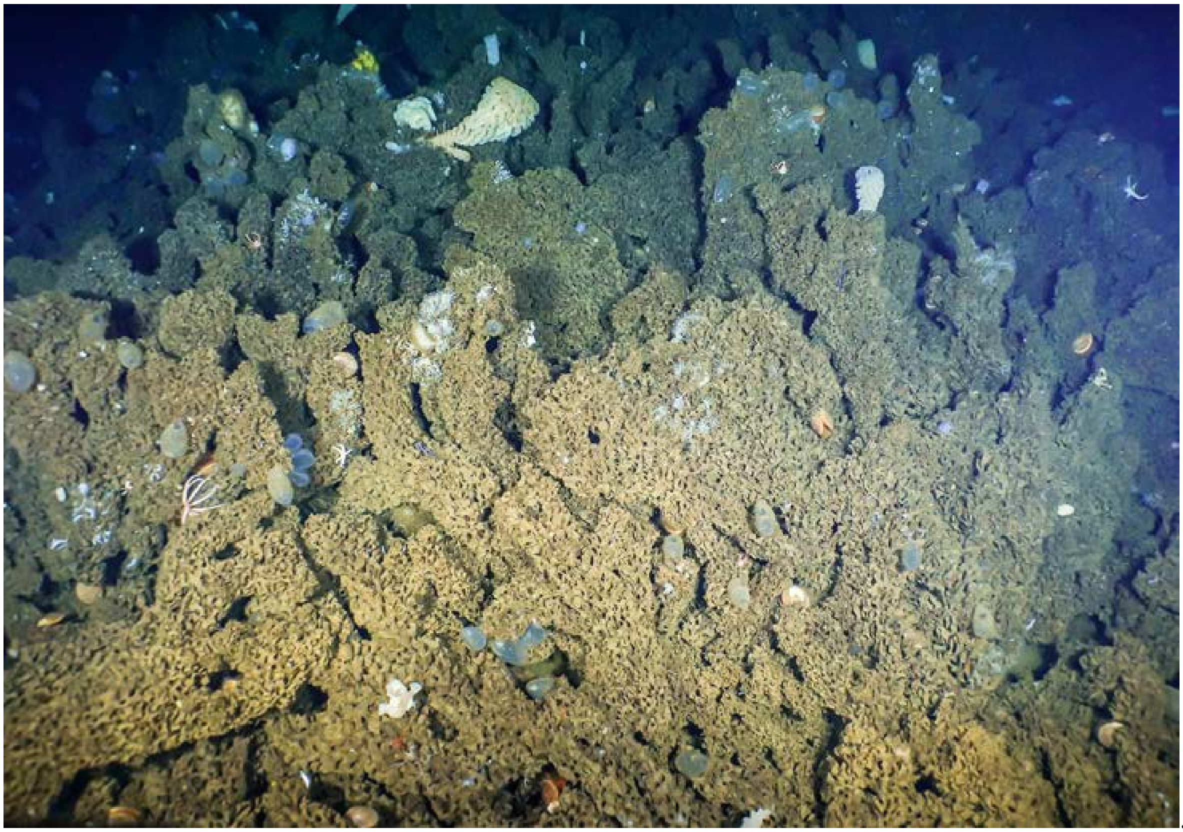.

Figure XXX. Large reef of dead sponge (thought to be *Farrea* spp.) found southeast of Santa Cruz Island at ca. 575 meters depth in Footprint Marine Reserve.

D4. The importance of corals and sponges as groundfish habitat off Central and Southern California

Contact: Tom Laidig (tom.laidig@noaa.gov)
FED HAGE Investigators: Joseph J. Bizzarro, Rebecca Miller, Tom Laidig, Diana Watters

The overall goal of this project is to investigate the utilization of corals and sponges as habitat for groundfishes by analyzing extensive, long-term video data sets collected in central and southern California. Fish densities, sizes, diversity, and assemblage structure will be compared among similar seafloor habitat types with varying amounts and types of corals and sponges. Comparisons will be made within and between central and southern California study sites to assess the amount of spatial variability in fish-coral associations. Successful completion of this project will result in quantitative estimates of the relative importance of corals as habitat for a variety of commercially and ecologically significant groundfishes and the spatial consistency of these associations.

The project was initiated during early 2020, with the first year devoted to database standardization, video review, data editing, and new data collection. Using digital seafloor video data collected during human occupied submersible dives, we completed video review and data collection for 110 dive-transects from Central California at depths of 30–320, and 43 dive-transects from Southern California at depths of 44–320. To date, we have documented 402 associations between fishes and corals and 570 associations between fishes and sponges at a distance of < 1 body length and 1521 and 957 associations, respectively, at a distance of < 3 m. There were 64 fishes within 1 body length of a coral or sponge. Species commonly observed with sponges or corals include early juvenile stages of Squarespot, Pygmy, and Halfbanded Rockfishes, and older juvenile and adult Bank, Rosethorn, and Starry Rockfishes. Data collection is nearing completion, and analysis (towards a peer-reviewed publication) will commence during the summer of 2021.

D5. 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.

D6. Rockfish Reproductive Ecology Laboratory and Field Studies

Contact: sabrina.beyer@noaa.gov (Affiliate)/ **sbeyer@ucsc.edu**

Ongoing studies at the SWFSC Fisheries Ecology Division in partnership with the University of California Santa Cruz highlight spatiotemporal variability in reproductive output, including fecundity and the production of multiple annual larval broods in California rockfishes (*Sebastes* spp). Laboratory work continued in 2020 to process egg and larval samples collected in Central California in order to document interannual variability in reproductive effort correlated with oceanographic conditions in a range of economically important rockfishes. Samples of gravid Chilipepper (*S. goodei*), Bocaccio (*S. paucispinis*), Yellowtail (*S. flavidus*) and Widow (*S. entomelas*) rockfishes will be incorporated into a nearly three-decade time-series of fecundity data dating back to the 1980s and 1990s and spanning a range of environmental conditions in the Central region of the California Current to better understand environmental drivers of reproductive plasticity and maternal reproductive effort. The autodiametric method of fecundity analysis was developed, tested and implemented for more rapid processing of unfertilized oocytes in Chilipepper, Yellowtail and Rosy rockfish (*S. rosaceus*). The autodiametric method, on average, was five times faster than the traditional gravimetric counting method for unfertilized stages in rockfishes and will increase the efficiency of reproductive data collection.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2020– PRESENT

E1. Primary Literature Publications

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. *Fish. Res.* 215:44-52.

Beyer, S.G., Alonzo, S.H., Sogard, S.M. In press. Zero, one or more broods: Reproductive plasticity in response to temperature, food, and body size in the live-bearing Rosy Rockfish (Sebastes rosaceus). Marine Ecology Progress Series.

Bizzarro, J.J., Gilbert-Horvath, E.A., Dick, E.J., Berger, A.M., Schmidt, K.T., Pearson, D., Petersen, C., Kautzi, L.A., Miller, R.R., Field, J.C., and Garza, J.C. 2020. Genetic identification of blue rockfish (*Sebastes mystinus*) and deacon rockfish (*S. diaconus*) to enable life history analyses for stock assessment. Fishery Bulletin 118:37-50.

Chaumel, J., Schotte, M., Bizzarro, J.J., Zaslansky, P., Fratzl, P., Baum, D., and Dean, M.N. 2020. Co-aligned chondrocytes: zonal morphological variation and structured arrangement of cell lacunae in tessellated cartilage. *Bone* 134: 115264.

Duncan, E., Wooninck, L., Laidig, T., Clarke, E., Powell, A., Whitmire, C., Cochrane, G. and Caldow, C. California Streaming: Exploring Deep-Sea Coral and Sponge Assemblages in Sunny Southern California. 2021. In Raineault, N.A., J. Flanders, and E. Niiler, eds. New frontiers in ocean exploration: The E/V *Nautilus*, NOAA Ship *Okeanos Explorer*, and R/V *Falkor* 2020 field season. *Oceanography* 34(1), supplement, 78 pp

Field, J.C. R.R. Miller, R.R., Santora, J.A., Tolimieri, N., Haltuch, M.A., Brodeur, R.A., Auth, T.D.,Dick, E.J., Monk, M.H., Sakuma, K.M., and Wells, B.K. In review. Spatiotemporal patterns of variability in the abundance and distribution of winter-spawned pelagic juvenile rockfish in the California Current. PLOS One.

Henderson, M.J., Huff, D.D., and Yoklavich, M.M. 2020. Deep-sea coral and sponge taxa increase demersal fish diversity and the probability of fish presence. Frontiers in Marine Science 7:593844 (19 p.).

Lyons, K., Adams, D.H., and Bizzarro, J.J. *In press*. Evaluation of muscle tissue as a non-lethal proxy for liver and brain organic contaminant loads in an elasmobranch, the Bonnethead Shark. *Marine Pollution Bulletin*.

Matich, P., Bizzarro, J.J., and Shipley, O.N. *In press*. Are stable isotope ratios appropriate for suitable for describing niche partitioning and individual variation? *Ecological Applications*.

Mattiasen, E.G., Kashef, N.S., Stafford, D.M., Logan, C.A., Sogard, S.M., Bjorkstedt, E.P., and Hamilton, S.L. 2020. Effects of hypoxia on the behavior and physiology of kelp forest fishes. Global Change Biology 26(6):3498-3511.

Santora, J.A., T.L. Rogers, T.L., Cimino, M.A., Sakuma, K.M., Hanson, K.D., Dick, E.J., Jahncke, J., Warzybok, P., and Field, J.C. In Review. Diverse integrated ecosystem approach overcomes pandemic related fisheries monitoring challenges. Nature Communications.

Shipley, O.N., Kelly, J.B., Bizzarro, J.J., Olin, J.A., Cerrato, R.M., Power, M., and Frisk, M.G. 2021. Evolution of realized Eltonian niches across Rajidae species. *Ecosphere* 12: e03368.

Sosa-Nishizaki, O., García-Rodríguez, E., Morales-Portillo, C.D., Pérez-Jiménez, J.C., Rodríguez-Medrano, M.C., Bizzarro, J.J., and Castillo-Géniz, J.L. 2020. Fisheries interactions and the challenges for target and nontargeted take on shark conservation in the Mexican Pacific, p. 39–62. In: Advances in Marine Biology Vol. 85. Sharks in Mexico: research and conservation, part B (Larson, S, and Lowry, D., eds.). Elsevier. Amsterdam, Netherlands.

E2. Other Publications

Mamula, A., Thomas-Smyth, A., Speir, C., Kosaka, R., and Pearson, D. 2020. Matching Vessel Monitoring System data to trawl logbook and fish ticket data for the Pacific groundfish fishery. NOAA Technical Memorandum NMFS-SWFSC-623. 76 p.

Poti, M., Henkel, S.K., Bizzarro, J.J., Hourigan, T.F., Clarke, M.E., Whitmire, C.E., Powell, A., Yoklavich, M.M., Bauer, L., Winship, A.J., Coyne, M., Gillett, D.J., Gilbane, L., Christensen, J., and Jeffrey, C.F.G.. 2020. Cross-shelf habitat suitability modeling: characterizing potential distributions of deep-sea corals, sponges, and macrofauna offshore of the U.S. West Coast. U.S. Department of the Interior, Bureau of Ocean Energy Management, Camarillo, CA. OCS Study BOEM 2020-021. 267 p.

STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2020

Prepared for the Sixty-first Annual Meeting of the Technical Subcommittee
of the Canada-United States Groundfish Committee

With contributions from:
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April 2021

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION of COMMERCIAL FISHERIES & DIVISION of SPORT FISH
Capital Office Park
1255 W. 8th Street
Juneau, AK 99802-5526

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STATE OF ALASKA GROUNDFISH FISHERIES AND ASSOCIATED INVESTIGATIONS IN 2020

I. Agency Overview

A. 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, except for Pacific halibut, 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) FMPs. 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. ADF&G personnel are listed in Appendix I by division and region. 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.

1. Southeast Region

The **Southeast Region** Commercial Fisheries groundfish staff are in Sitka, Juneau, and Petersburg. Sitka staff is comprised of the project leader, one fishery biologist, and one full-time fishery technician. Staff in Juneau includes one full-time fishery biologist and one seasonal fishery technician, 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 typically 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 inseason management of the groundfish resources. Inseason 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 2020. The ADF&G research vessel *R/V Medeia* is home ported in Juneau and is used to conduct the annual sablefish marking survey.

2. Central Region

The **Central Region** commercial fisheries groundfish management and research staff are primarily located in Homer. The management staff in Homer consists of an area management biologist, an assistant area management biologist (serves as regional port sampling and age reading project leader), a research analyst (processes fish tickets and manages databases), a fisheries biologist (serves as lead port sampler and age reader), and two seasonal fisheries technicians (samplers stationed in Seward and Homer with travel to Whittier); additional seasonal technicians are utilized in Homer and Cordova as funding allows for sampling, observing, and age reading. The area management biologist serves as a member of the Council's GOA Groundfish Plan Team. The research staff in Homer consists of a Groundfish research project lead, a fishery biologist, and a research analyst. Commercial Fisheries groundfish staff are supported by regional staff in Anchorage.

Commercial fisheries groundfish staff are responsible for the research and management of groundfish species harvested in Central Region, which includes state waters of Cook Inlet and Prince William Sound (PWS) areas, as well as federal waters for lingcod, and black, deacon, and dark rockfishes. Within Central Region, groundfish species of primary interest include sablefish, Pacific cod, walleye pollock, lingcod, rockfishes, skates, sharks, and flatfishes. Management staff collect harvest data through commercial groundfish sampling, fishermen interviews, logbooks, and onboard observing. 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 are collected and entered into local databases to provide additional information, including catch composition, catch per unit effort (CPUE), depth, and location data. Research staff produce relative abundance estimates from bottom trawl surveys conducted in Kachemak Bay and in the inside waters of PWS. Bottom trawl surveys in PWS are conducted by ADF&G research vessel R/V *Solstice*, which is based in the port of Cordova.

3. Westward Region

The **Westward Region** Groundfish management and research staff are 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 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).

4. 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 like 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 inseason 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 (NMFS, 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 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 2020, ADF&G AKFIN personnel processed 12,952 groundfish fish tickets, collected 23,642 groundfish biological samples and measured 20,029 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 2020

ADF&G Region	Total fish tickets
1 - Southeast	3,303
2 - Central	1,823
4 - Westward; Kodiak, Chignik, AK Pen.	6,555
4 - Westward; BSAI	1,271
Total	12,952

Groundfish Biological Data Collection - Calendar Year 2020

ADF&G Region	AWL samples collected	Age estimates produced by regional personnel	Age estimates produced by the ADU lab
1 - Southeast	5,862	n/a	6,792
2 - Central	7,384	4,160	5,163
4 - Westward	10,396	3,914	n/a
Total	23,642	8,074	11,955

b. Interagency Electronic Reporting System - eLandings (Contact Carole Triem)

ADF&G maintains a commercial harvest database, based on landing report receipts – fish tickets. These data are comprehensive for 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 CFEC, 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 (Figure 1). The web-based reporting component of this system is eLandings (Figure 2). The application for the at-sea catcher processor fleet is seaLandings. Vessels using the seaLandings application upload landing and production reports to the centralized database. 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 IERS has been successfully operated in Alaska's commercial fisheries since August 2005. To date, approximately 1.5 million landing reports have been submitted to the eLandings repository database. More than 99% of all groundfish landings are submitted electronically.

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 2020 salmon season, 96% percent of all salmon landings were submitted electronically.

Implementation of statewide electronic reporting of shellfish and herring fisheries is a goal; however, this ambitious undertaking has been delayed. Development resources have been focused on completing the Processor HTML5 application, to improve the reporting experience for processor users. Turnover at all three agencies have contributed to the delays. Due to the complexity of the eLandings system, training new staff requires up to two years before he/she can act without review.

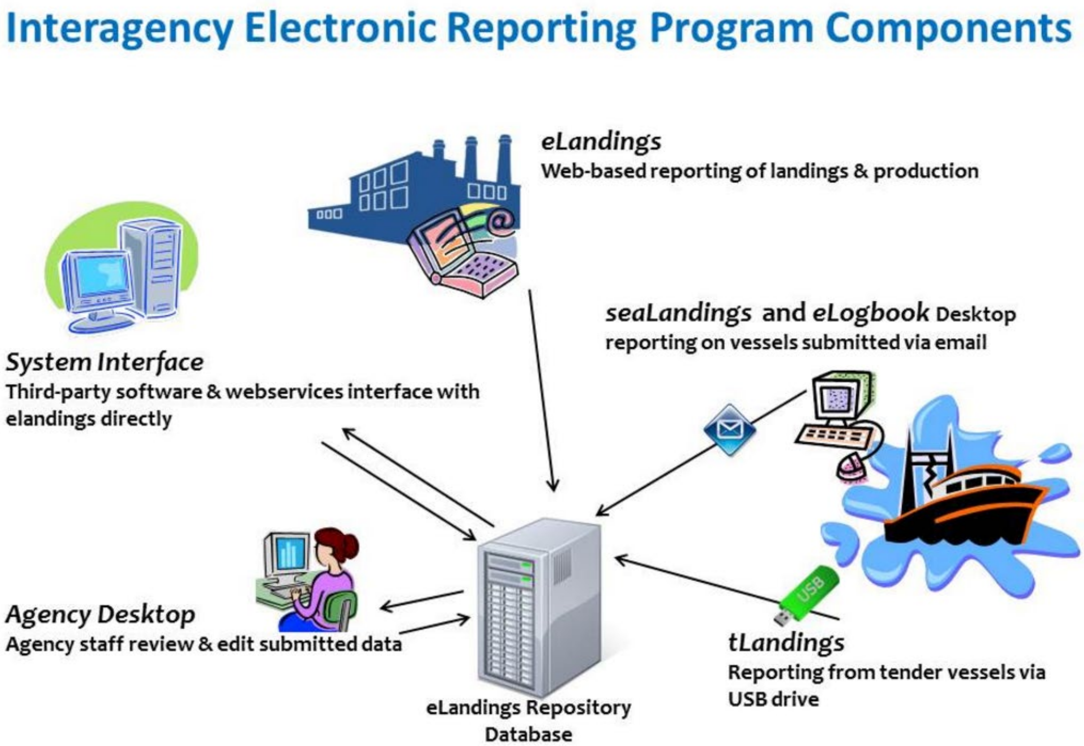

Figure 1.–Data are reported by the seafood industry using eLandings web, seaLandings and tLandings. Agency staff review, edit and verify landing and production reports within the eLandings agency desktop tool. Industry can pull harvest data for their company from the database using the eLandings system interface tools.

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 2020, the IERS recorded 163,627 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 is provided by ADFG and NMFS staff, who monitor the eLandings Help Desk email address. IFQ reporting support is provided by the NOAA Fisheries Data Technicians.

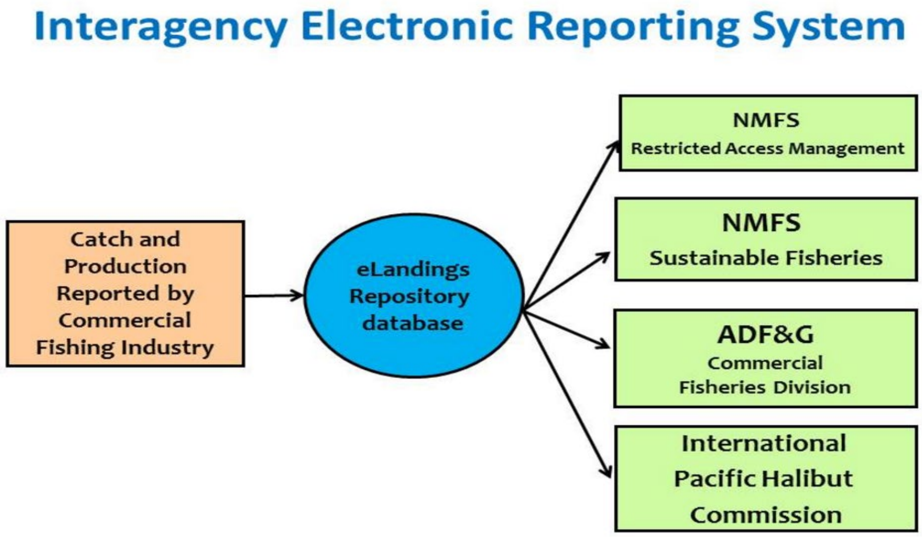

Figure 2.–Interagency staff have established methods to pull data from the repository database into their databases of record. The ADF&G fish ticket records are pulled into the commercial fisheries fish ticket database once data verification has occurred.

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.

5. Gene Conservation Laboratory

The ADF&G Gene Conservation Laboratory (GCL) is a statewide program located in Anchorage. The mission of the GCL is to protect genetic resources and provide genetic information and advice to department staff, policy makers, and the public to support management of resources.

In the past, the GCL collected genetic information on black, yelloweye, light and dark dusky rockfish, and pollock (a list of *Sebastes* and pollock tissue samples stored at GCL can be found in

Appendix III). The GCL used traditional genetic markers, such as allozymes, mitochondria DNA, and microsatellites, to identify larval and juvenile rockfish (Seeb and Kendall 1991), to study population structure of black rockfish in the Gulf of Alaska (Seeb 2004), and to investigate spatial and temporal genetic diversity in walleye pollock from Gulf of Alaska, eastern Bering Sea, and eastern Kamchatka (Olsen et al. 2002).

In 2019, the GCL developed an operational plan with Division of Sport Fish to sample and analyze yelloweye and black rockfish from inside and outside waters of Prince William Sound, North Gulf of Alaska, and Southeast Alaska (Howard et al. 2019a-c). The GCL used Restriction site Associated DNA Sequencing (RAD-Seq) to develop a new set of Single Nucleotide Polymorphism (SNP) genetic markers and has genotyped the black and yelloweye rockfish for the genetic population structure. The data are currently being analyzed.

6. 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 2020, the ADU received 7,566 otolith sets from central and southeast Alaska commercial and survey sampling (representing eight groundfish species). The ADU produced 13,560 ages and distributed 11,955 ages to region managers, including data from samples received in previous years but processed in 2020. 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 2020, quality control procedures resulted in an additional 9,574 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 3,795 age estimates. Given production, quality control, and training procedures, the ADU recorded 26,929 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 (15,915 otoliths in 2020, representing 13 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 size-at-age values were developed from Ludwig 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 2020, ADU personnel participated in age structure exchanges to address agency and TSC concerns, prepared CARE documents for the TSC meeting, and participated in virtual meetings. The ADU contributed to a sablefish exchange with the Alaska

Fisheries Science Center in Seattle, WA (AFSC), Northwest Fisheries Science Center in Newport, OR NWFSC, and Fisheries and Oceans Canada (DFO); a rougheye exchange with AFSC; a lingcod otolith exchange with ADF&G Homer-Sport; and a yelloweye rockfish exchange with ADF&G Homer.

The ADU is funded by the State of Alaska, AKFIN, and special project support. In fiscal year 2020, approximately 54% of funding was provided by the State of Alaska, 30% by AKFIN, and 15% from research grants. During 2020, the ADU employed 9 people (approximately 41-man months) to age, process samples, enter data, maintain sample archives, measure samples, and complete other support tasks for both groundfish and invertebrates.

B. 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, except for the sport halibut fishery which is managed by the IPHC and NMFS. 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, lingcod, and sablefish; the primary bottomfish species targeted by the sport fishery. Statewide data collection programs include an annual mail survey (Statewide Harvest Survey, SWHS) that estimates overall catch and 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 and release of selected species including halibut, rockfish (pelagic, yelloweye, or other nonpelagic), lingcod, sablefish, and salmon shark 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.

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 is funded through sport fishing license sales, 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.

1. 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 regional research coordinator, project leader, and the project research analyst are based in Juneau. The project biometrician is stationed in Anchorage. Since 2014, the area management biologists in Yakutat, Juneau, Sitka, Petersburg/Wrangell, Ketchikan, and Craig have been responsible for the onsite daily supervision of the field technicians. A total of 25-30 technicians work at the major ports in the Southeast region, where they interview anglers and charter operators and collect data from sport harvests of halibut and groundfish while also collecting data on sport harvests of salmon. In 2020, an Action Plan was developed which guided the collection of data during onsite surveys to minimize impacts of COVID to staff and sport anglers. Low sport fishing license sales in 2020 due to travel restrictions in combination with COVID-related extraction plans resulted in elimination of staffing the port of Elfin Cove in the Southeast region harvest assessment project.

Biological data collected included lengths of halibut, rockfish, lingcod, and sablefish, sex of lingcod, sex and age of black rockfish at Sitka, and genetic information of black rockfish; technicians also collect other basic data including the sport fishery sector (charter or unguided) and the statistical areas fished. Otoliths were collected from black rockfish landed at Sitka for estimation of age composition in 2016–2020. Genetic information was collected from black rockfish in 2020. Data summaries were provided to the Alaska BOF, other ADF&G staff (especially through the Statewide Rockfish Initiative), 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/Skagway, Sitka, Juneau, Petersburg/Wrangell, 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.

2. 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 consists 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 is based in the Homer office, consisting of a project leader, project assistant, and six technicians. Seasonal technicians collected data from the sport harvest at six major ports in the region. Low sport fishing license sales in 2020 due to travel restrictions resulted in funding cuts to the Southcentral region harvest assessment project. One technician position was not filled, but the data collected by this technician were collected by other project personnel.

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 length, age, and sex of halibut, rockfishes, lingcod, and sharks; sablefish, Pacific cod, and other infrequently harvested sport bottomfish species may also be sampled opportunistically. 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 are responsible for management of groundfish fisheries, except halibut, in state and federal waters. In addition, staff provide sport halibut harvest statistics to the IPHC and the Council, assist in development and analysis of the statewide charter logbook program and SWHS, provide information to the BOF, advisory committees, and local fishing groups, draft and review proposals for sport groundfish regulations, and disseminate information to the public.

II. Surveys

Fishery surveys, where applicable, are addressed in research sections by species.

III. Marine Reserves

Nothing to report for 2020.

IV. Groundfish Research, Assessment, and Management

A. Hagfish

1. Research

In 2016, the **Southeast Region** began an opportunistic survey for hagfish *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 on 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 742 hagfish have been sampled with the largest length recordings for *E. deani* at 770 mm for females and 620 mm for males (Figure 3; Contact Rhea Ehresmann).

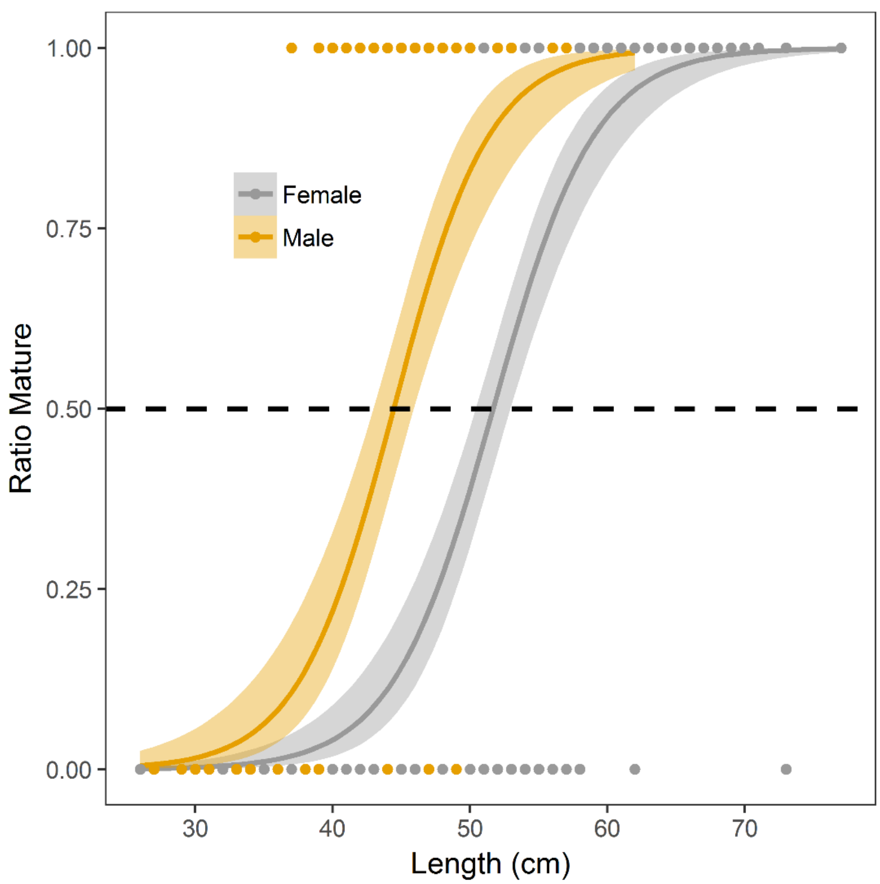

Figure 3.–.Preliminary size at 50% maturity with 95% confidence intervals for male (44.4 cm, n=182) and female (51.6 cm, n=269) *E. deani* in southern Southeast Alaska.

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 2020, one commissioner's permit was issued for directed fishing of hagfish in the **Southeast Region**. There has been an increase in interest in this fishery with several fishermen requesting information in 2020 with the anticipation of obtaining permits in 2021.

4. Fisheries

The directed fishery for hagfish in the Southeast region has a total guideline harvest level (GHL) of 77.1 mt for 2020, which was a 22.7 mt increase from the 2019 GHL. In 2020 a total of 55.5 mt of hagfish were harvested in the directed fishery. 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.

B. Dogfish and other sharks

1. 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 1,979 boat-trips and 8,757 angler-days of effort targeting or harvesting groundfish species in 2020. Interviewed anglers caught seven salmon sharks and kept six, caught one sleeper sharks and did not retain any, and caught 359 spiny dogfish and kept five. Biological data were obtained from two salmon sharks (Contact Martin Schuster).

2. Assessment

There are no stock assessments for dogfish or sharks.

3. 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 the **Central Region**, bycatch had historically been set at 20% of the round weight of the target species on board a vessel, the maximum allowable retention amount in regulation; however, from 2014 through 2020, allowable bycatch levels of all shark species in aggregate (includes spiny dogfish) were set at 15% by emergency order (EO).

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 overharvest, 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 2020.

4. Fisheries

No applications for commissioner's permits were received in 2020, and no permits have been issued in **Central Region** since 2006. During 2020, there was no commercial harvest of spiny dogfish as bycatch in Cook Inlet Area with 4.3 mt harvested in PWS.

Estimates of the 2020 sport harvest of sharks are not yet available, but harvest in 2019 was estimated at 115 sharks of all species in Southeast Alaska and 157 sharks in Southcentral Alaska. The precision of these estimates was relatively low; the Southeast estimate had a CV of 39% and the Southcentral estimate had a CV of 31%. The statewide charter logbook program also required reporting of the number of salmon sharks kept in the charter fishery. In 2019, 6 salmon sharks were harvested by charter anglers in Southeast, 15 were harvested in Southcentral, and 1 in Western Alaska. Charter anglers are believed to account for most of the sport salmon shark harvest.

C. Skates

1. Research

A population abundance index from the PWS bottom trawl survey is generated annually for three skate species (Figure 4). The survey occurs in Eastern PWS; the time series begins in 1999 for big and longnose skates and 2001 for Bering skate. The 2020 PWS survey was conducted in a new survey area and was not part of the historical index survey. Aleutian skates are also captured in the survey, but their occurrence is too low to estimate abundance. Bering skate CPUE has increased from 2007 to 2019 and is presently above the long-term survey average. Big skate CPUE has generally increased since 2001 and has been above the long-term average since 2014. Longnose skate CPUE fell to a survey low in 2017 but was near a survey high in 2019 (Contact Wyatt Rhea-Fournier).

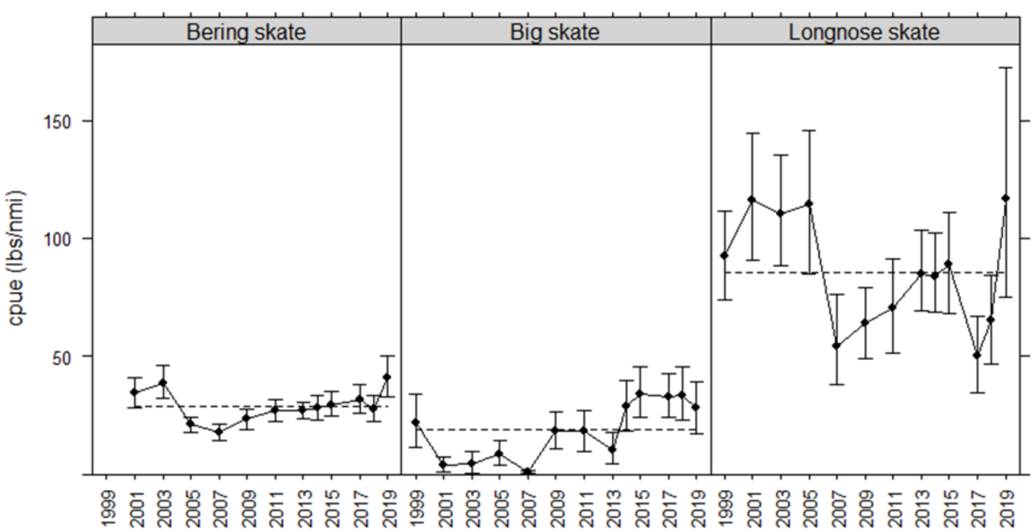

Figure 4.–PWS trawl survey CPUE estimates for skates with 90% confidence intervals. Dotted line represents the long-term survey average.

2. Assessment

There are no stock assessments for skates in state waters but the PWS trawl survey biomass time series as well as biomass time series from other Central Region trawl surveys in Kachemak and Kamishak Bays in Cook Inlet have recently been included in the federal stock assessment of the skate stock complex in the GOA (Ormseth 2019).

3. Management

A commissioner's permit is required before a directed commercial 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 the **Central Region**, skates are harvested commercially as bycatch up to 5% of target species; this allowable bycatch level is set by EO to align with the NMFS maximum retainable allowance (MRA) for skates in the GOA.

A directed fishery in 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 included a logbook requirement.

In the Cook Inlet Area, there was no harvest of skates in 2020. In PWS, skate harvest was 7.9 mt in 2020, an increase from 5.7 mt in 2019. Due to bycatch limits set as a percentage of the targeted species, harvest levels of the target species may affect the amount of bycatch harvested. In 2020, federal Pacific cod fisheries were closed, and state-waters Pacific cod fisheries set at lower harvest levels, which decreased the amount of bycatch caught, particularly with longline gear.

Over the last ten years, in **Southeast Region**, skate landings in internal waters of Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) fluctuated with a low harvest in 2011 of 1.5 mt and a high in 2014 of 18.7 mt. In 2020, a total of 3.6 mt of skates were landed. Skate harvest fluctuates with current market value.

D. Pacific cod

1. Research

Commercial landings in the **Southeast Region**, **Central Region**, and the **Westward Region** are sampled for length, weight, age, sex, and stage of maturity. 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.

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 the coefficient of variation (CV) ranging from 0.16 to 0.54 and averaging 0.28. The survey occurs in Eastern PWS and the Pacific cod time series begins in 1991. Estimated CPUE dropped substantially in 2017 and remained low in 2019 (Figure 5).

In the Central Region, skipper interviews and biological sampling of commercial Pacific cod deliveries from Cook Inlet and PWS areas during 2020 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).

The **Division of Sport Fish—Southcentral Region** creel sampling program also collects data on Pacific cod catch by stat area (on a vessel-trip basis) through dockside interviews, and lengths of sport-caught Pacific cod, though this is a secondary objective and there are no sample size targets. Interviewed anglers caught 1,504 Pacific cod in 2020, of which 1,132 were retained. Biological data were collected from 132 Pacific cod in Southcentral Region. No information is collected in the Southeast Region creel survey program on the Pacific cod sport fishery.

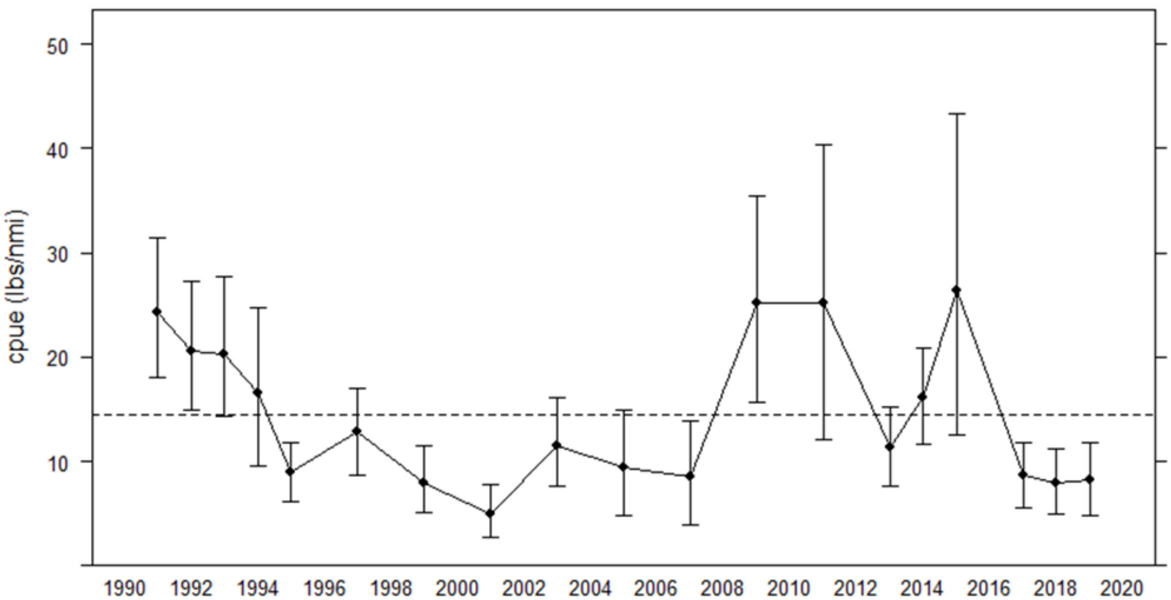

Figure 5.–PWS trawl survey CPUE estimates for Pacific cod with 90% confidence intervals. Dotted line represents the long-term survey average.

2. Assessment

No stock assessment programs were active for Pacific cod during 2020.

3. Management

The 2020 federal/parallel fisheries in the Gulf of Alaska (GOA) were closed and state-waters season opening dates were coordinated with the federal closure to allow for orderly and manageable fisheries. In some areas, the state-waters guideline harvest levels (GHLs) were based on a 35% reduction from the maximum prescribed harvest limits in regulation. This GHL reduction provided the opportunity for limited fisheries in state waters while recognizing the need for conservative fishery management at current Pacific cod stock levels.

The internal waters of the **Southeast Region** are comprised of two areas, NSEI and SSEI Subdistricts. 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 inseason 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; however, the federal fisheries, and subsequently the state parallel fisheries in Southeast state outer coast waters were closed in 2020.

In the GOA, Pacific cod Management Plans are 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 high level of interest from the longline gear group. Guideline harvest levels are further allocated by gear type.

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. Most CGOA state-waters fisheries open after the respective gear sector closure in the federal Pacific cod A season, generally late winter through early spring. A 58-foot overall length (OAL) vessel size limit is in place for the Chignik and South Alaska Peninsula Areas. The Cook Inlet and Kodiak Areas have a harvest cap for vessels larger than 58-ft OAL that limits harvest to a maximum of 25% of the overall GHL. If the GHL is not fully harvested, the fishery management plans allow removal of area exclusivity, vessel size restrictions, and gear limits later in the season to increase harvest to promote achievement of GHL.

In the **Bering Sea/Aleutian Islands area**, a Pacific cod Management Plan for an exclusive Aleutian Islands Subdistrict, 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 35% of the Aleutian Islands ABC for Pacific cod and may not exceed 15 million lbs.

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. During the 2020 season, new regulations adopted at the January Board of Fisheries meeting became effective on February 28. These new regulations closed the state-waters fishery for trawl vessels over 60 feet OAL and pot vessels over 100 feet OAL on February 17 at 11:59pm Alaska time. All state waters west of 170° W long reopened for trawl vessels 100 feet or less OAL and pot vessels 125 feet or less OAL on March 15 at 12:00 noon Alaska time.

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 9 percent of the Bering Sea ABC for Pacific cod in 2020. 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. Additionally, there is a Pacific cod season open to vessels 58 feet or less OAL using jig gear. The fishery GHL is set at 100,000 pounds which is subtracted from the overall Bering Sea ABC for Pacific cod. The season opens May 1.

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 SWHS.

4. Fisheries

Most of the Pacific cod harvested in the **Southeast Region** are taken by longline gear in the NSEI Subdistrict during the winter months. 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, the Pacific cod harvest has been largely sold for human consumption. A total of 193 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2020 with 177 mt harvested from the directed fishery (Figure 6).

For **Central Region** Pacific cod fisheries, the dominant gear type has been pot gear in Cook Inlet Area and longline gear in PWS fisheries. In the **Cook Inlet**, **Kodiak**, **Chignik**, and **South Alaska Peninsula** state-waters Pacific cod fisheries, pot gear vessels are allocated 70% of the GHL and jig gear vessels are allocated 30% of the GHL; however, pot gear vessels often harvest a larger percentage if GHLs are not on track to be met and gear and exclusivity restrictions are lifted. In the **Dutch Harbor Subdistrict** state-waters Pacific cod fishery, pot and jig gear are legal gear types however each gear has a separate allocation. In the **Aleutian Islands Subdistrict** state-waters fishery, trawl, jig, longline, and pot are all legal gear types. Pot, trawl, and longline vessels participated in 2020; however, harvest by gear type is confidential due to the number of processors and vessels.

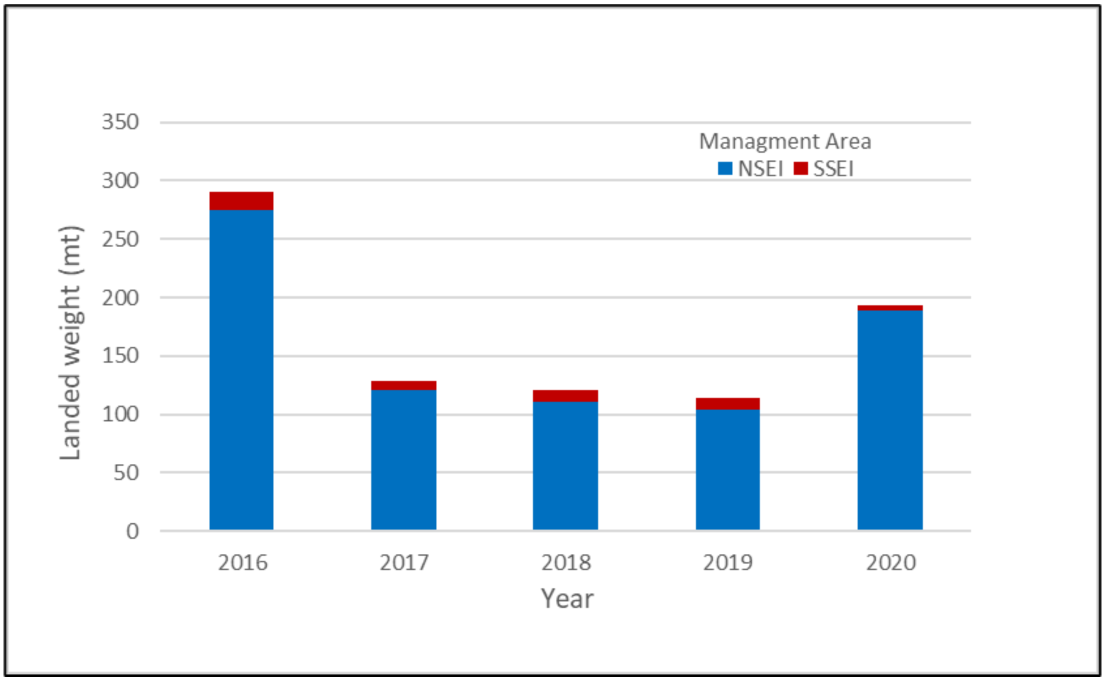

Figure 6.–Annual harvest of Pacific cod in the Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) management areas in Southeast Alaska from 2016–2020 for the directed and bycatch fisheries.

In the **Central Region**, the Cook Inlet Area state-waters fishery GHL is based on 3.75% of the federal CGOA Pacific cod ABC and the PWS GHL is based on 25% of the EGOA ABC. The 2020 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and PWS areas of the Central Region were 206 mt and 198 mt, respectively. The Cook Inlet Area GHL was a decrease of 29% from 2019 and in PWS the decrease was even greater, at a 53% reduction. This follows a decrease of approximately 80% from 2017 to 2018 following a sharp decline in abundance observed in the NMFS survey and a subsequent decline from 2018 to 2019 in both areas.

Pacific cod harvest in 2020 from the state-waters seasons was 192 mt from Cook Inlet Area and 196 mt from PWS. In Cook Inlet Area, the GHL is allocated 85% to pot gear and 15% to jig gear; pot vessels achieved their allocation; however, jig vessels only harvested 27% of their allocation. For PWS, the GHL is allocated 85% to longline gear and 15% to jig and pot gear combined; longline achieved their allocation; pot and jig vessels harvested 10% of their allocation in 2020.

In the **Westward Region**, the Kodiak Area state-waters Pacific cod GHL is based on 12.5% of the annual CGOA Pacific cod ABC, the Chignik Area GHL is based on 8.75% of the annual CGOA ABC, and the South Alaska Peninsula Area GHL is 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 2020 Pacific cod GHLs were 687 mt in the Kodiak Area, 481 mt in the Chignik Area and 963 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik, and South Alaska Peninsula was 689 mt, 445 mt, and 930 mt, respectively. Pot gear vessels took approximately 77% of the total 2020 catch in these state-waters Pacific cod fisheries. In the Aleutian Islands Subdistrict state-waters Pacific cod 2020 GHL 6,804 mt. Legal gear is limited to nonpelagic trawl, pots, longline and jig gear during state-waters the Pacific cod fishery. The 2020 total state-waters Pacific cod catch for the Aleutian Islands Subdistrict was 6,762 mt. The **Dutch Harbor Subdistrict** state-waters Pacific cod 2020 GHL for pot gear is based on 9% of the annual Bering Sea Pacific cod ABC. In 2020, the total state-waters catch for the Dutch Harbor Subdistrict pot gear fishery was 14,029 mt. The Dutch Harbor Subdistrict state-waters Pacific cod GHL for jig gear is 45 mt, which is subtracted from the annual Bering Sea Pacific cod ABC. The 2020 harvest for this fishery is confidential due to limited participation.

Estimates of the 2020 sport harvest of Pacific cod are not yet available from the SWHS, but the 2019 estimates were 13,762 fish in the **Southeast Region** and 11,802 fish in the **Southcentral Region**. The estimated annual harvests for the recent five-year period (2015-2019) averaged 12,222 fish in Southeast Alaska and 20,190 fish in Southcentral Alaska. Statewide Pacific cod harvest peaked at over 60,000 fish in 2014 and in 2018 was at the lowest level since 2003.

E. Walleye Pollock

1. Research

In the **Central Region** skipper interviews and biological sampling of PWS commercial trawl pollock deliveries during 2020 occurred in 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 and aged by Homer staff (Contact Elisa Russ).

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 ranging from 0.15 to 0.67 and averaging 0.26. The survey occurs in Eastern PWS and the pollock series begins in 1994. Estimated CPUE was down in 2014 to a survey low, and 2019 was well below the long-term average (Figure 7).

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).

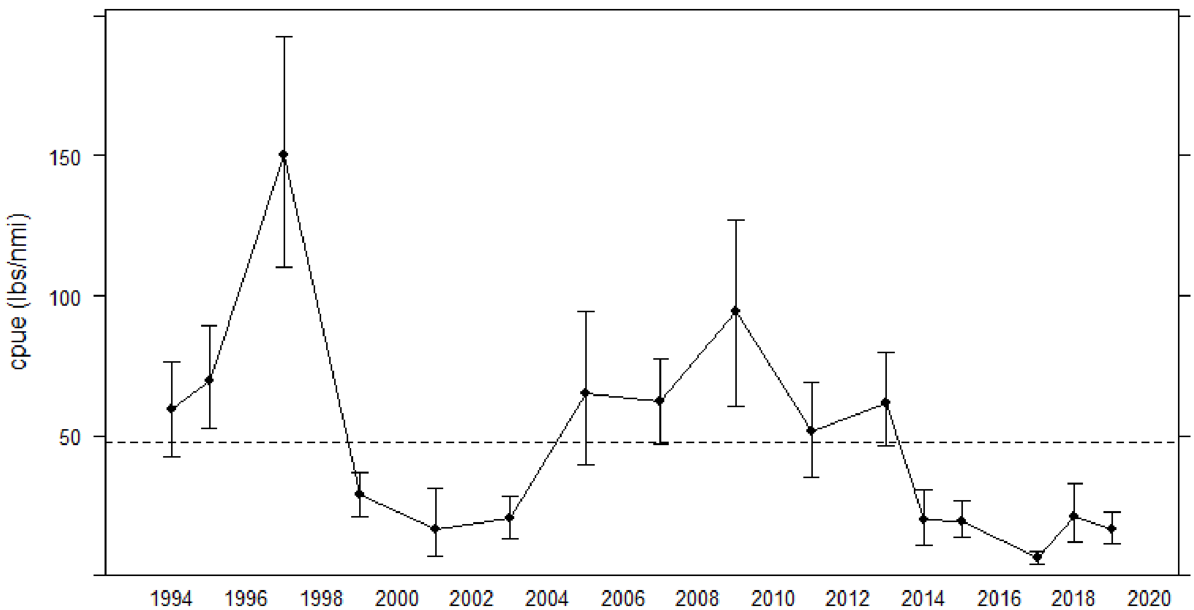

Figure 7.–PWS trawl survey CPUE estimates for Walleye pollock with 90% confidence intervals. Dotted line represents the long-term survey average.

2. Assessment

No stock assessment work was conducted by the department on pollock in 2020.

3. 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 an ADF&G 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).

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.

4. Fisheries

The 2020 PWS pollock pelagic trawl fishery opened January 20 and closed February 29. There were 27 landings made by 14 vessels with a total harvest of 2,731 mt, or 100% of the 2,712 mt GHL, which included harvest from the test fishery; interest in the fishery was high because of low Pacific cod abundance and corresponding harvest levels. Rockfish bycatch during the fishery totaled 7.9 mt, below the 11.5 mt allowed as bycatch to the pollock harvested. Other bycatch limits were achieved and exceeded. The harvest bycatch cap for salmon was 0.92, with a harvest of 1.02 mt. In addition, the squid harvest cap was 69.1 mt and the fleet harvested 69.8 mt. In the Cook Inlet Area, no seine pollock commissioner's permits were issued in 2020. Pollock was harvested in **Central Region** as bycatch to other groundfish fisheries at low levels; in 2020, 0.02 mt was harvested in Cook Inlet Area and 0.28 mt in PWS (Contact Jan Rumble).

F. Pacific Whiting (hake)

1. Research

There was no research conducted on Pacific whiting (hake) in 2020.

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 2020. Currently in **Central Region** and **Southeast Region** Pacific whiting (hake) are grouped with the "other groundfish" assemblage and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

G. Grenadiers

1. Research

There was no research conducted on grenadiers in 2020.

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 2020. Currently in the **Central Region** and **Southeast Region** grenadiers are considered part of the "other groundfish" assemblage and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

H. Rockfishes

Commercial rockfish fisheries are managed under three assemblages: DSR, pelagic shelf rockfish (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.

1. Research

In the **Southeast Region**, biological samples of rockfish are collected from the directed commercial DSR fishery; however, 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 most groundfish fisheries. The logbook program is designed to obtain detailed information regarding specific harvest location. In 2020, length, weight and age structures were collected from 244 yelloweye rockfish caught in the halibut commercial longline fisheries. There were no yelloweye rockfish sampled from the directed fishery due to the directed fishery closure in 2020.

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2020 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 DSR and slope species. The directed jig fishery in the Cook Inlet Area that targets PSR opens July 1 and historically has been the focus of rockfish sampling during the last half of the year. Sample data collected includes date and location of harvest, species, length, weight, sex, gonad condition, and otoliths. Homer staff determine ages of PSR and DSR otoliths; otoliths from slope and thornyhead rockfish species are 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; tissue samples were collected in 2018 and 2019 with genetic analysis to follow. Additionally, ovaries were collected from both species of rockfish in 2019 and 2020 for maturity and fecundity studies. An age structure exchange was also conducted on yelloweye rockfish between commercial and sport age reading staff in Homer. The genetics and gonad collections, and age structure exchange, were conducted as collaborative interdivisional research as part of the ADF&G Statewide Rockfish Initiative (SRI) initiated in 2017 (Contact Elisa Russ).

Funding for **Central Region** DSR and lingcod ROV surveys ended in 2016 and surveys have not been conducted since then. Rockfishes are captured in Central Region bottom trawl surveys for Tanner crab. All rockfish are sampled for length, weight, sex, and age structures. Rougheye/blackspotted rockfish composed >90% of the rockfish catch by weight in all years. A population abundance index from the PWS bottom trawl survey is estimated for rougheye/blackspotted rockfish each year of that survey with CV estimates ranging from 0.16 to 0.40 and averaging 0.25. The survey occurs in Eastern PWS and the time series begins in 1991. Estimated CPUE has been below the long-term survey average since 2014 and was the lowest in the time series in 2019 (Figure 8; Contact Mike Byerly or Wyatt Rhea-Fournier).

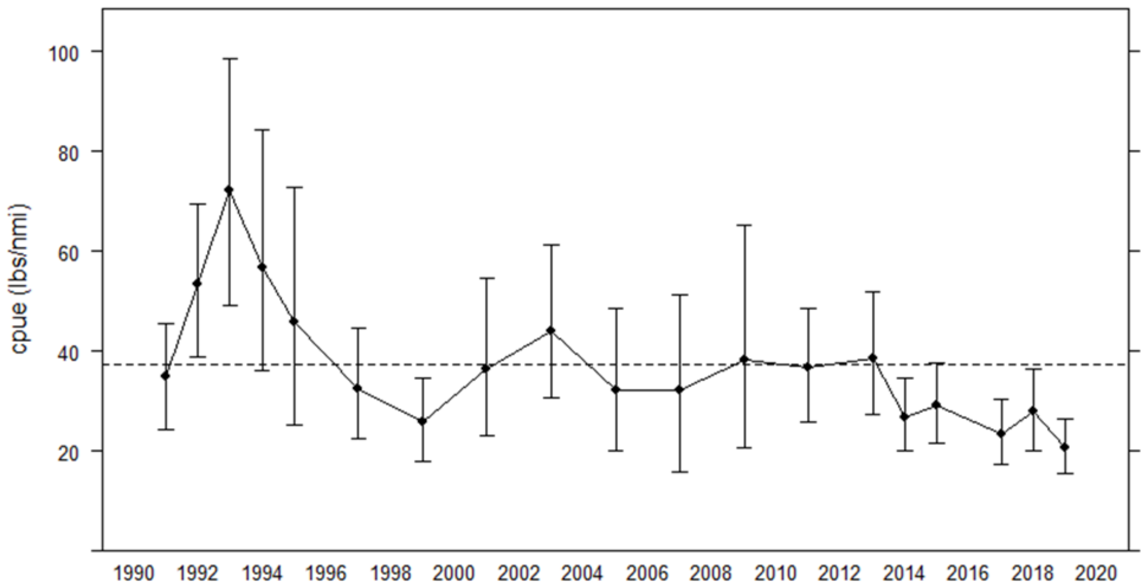

Figure 8.–PWS trawl survey CPUE estimates for rougheye/blackspotted rockfish with 90% confidence intervals. Dotted line represents the long-term survey average.

The **Westward Region** continued port sampling of several commercial rockfish species in 2020. 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 have completed aging black rockfish otoliths through the 2020 season. The Westward Region also continued to conduct hydroacoustic surveys of black and dark rockfish in the Northeast, Afognak, Eastside, and Southeast districts of the Kodiak Management Area in 2020 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 2021. As one of ADF&G's SRI research priorities, a black rockfish maturity study was initiated in 2019 and collections continued through 2020 with the goal of updating the maturity parameters for black rockfish in the Kodiak Area (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 ports. Rockfish objectives included estimation of: 1) species composition, 2) length composition and average weight, as derived from a length-weight regression relationship, 3) age and sex composition of black rockfish at Sitka, 4) genetic composition of black and yelloweye rockfish (no yelloweye rockfish genetic samples were collected in 2020 due to a closure in all SEAK waters that extended to all DSR species) from inside and outside ports, and 5) biomass of total sport removals (harvest and release mortality). Primary species harvested in Southeast Alaska included yelloweye, black, copper, silvergray, and quillback rockfish. A total sample size of 3,001 rockfish was obtained from the sport harvests at Ketchikan, Craig, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2020 (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 2020 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, Central Cook Inlet, and Homer was 3,550 rockfish (Contact Martin Schuster). The Division of Sport Fish conducted research in PWS on the ability of six 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 2022 (Contact Brittany Blain-Roth or Jay Baumer). In addition, a University of Alaska, Fairbanks Graduate Student/ADF&G Biologist collected life history information on yelloweye rockfish to improve estimates of maturity, fecundity and skip-spawning between Prince William Sound and Northern Gulf of Alaska (Arthur 2020; Contact Brittany Blain-Roth or Donald Arthur). Similar data are currently being collected from black rockfish in the same area.

The **Age Determination Unit** continued the North Pacific Research Board funded project 1803: Reconstructing reproductive histories of yelloweye rockfish through opercular hormone profiles. ADF&G personnel sampled opercula and otoliths from female yelloweye rockfish along with black rockfish and other representative species. Ages were estimated using otoliths and corresponding bands were identified on opercula. Sampled opercula material was sent to Baylor University to analyze progesterone, cortisol, and ecdysteroid concentrations (Figure 9). Lifetime reproductive and stress hormone profiles were constructed for 13 female yelloweye rockfish and individual profiles were used to estimate age of sexual maturity and annual spawning frequency. Preliminary results suggest the onset of sexual maturity for female yelloweye rockfish is between 8 and 20 years and mean spawning frequency could be as low as 40%. Also, there was little evidence supporting reproductive senescence in female yelloweye rockfish. Yelloweye and black rockfish operculum samples paired with blood and ovary samples are being processed to validate results (Contact Dion Oxman).

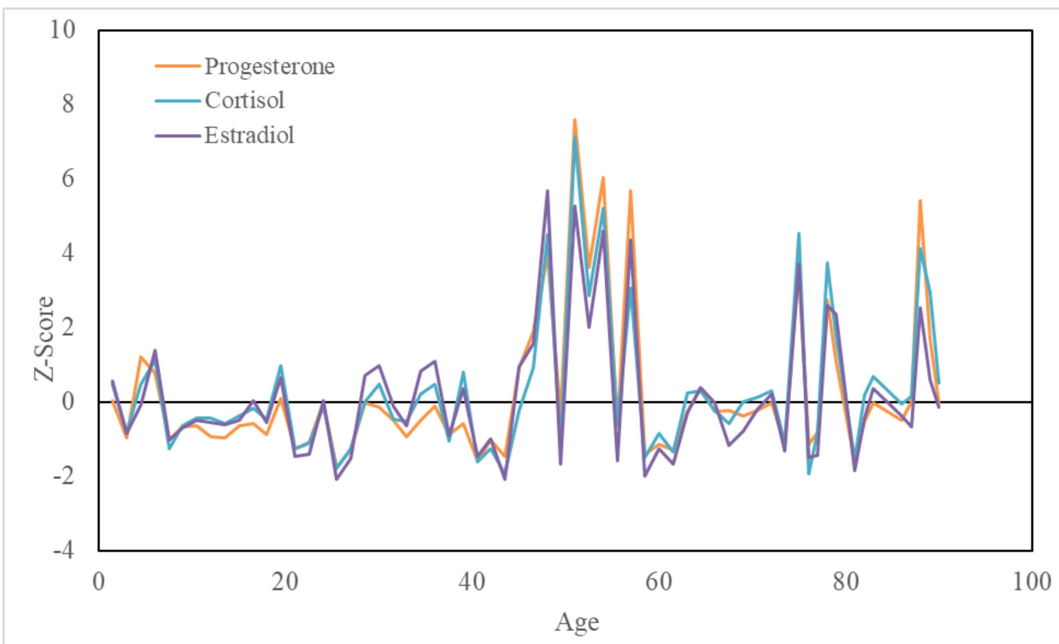

Figure 9.–Normalized progesterone, cortisol, and estradiol concentrations recovered from annual growth increments within the operculum of a 90-year-old female yelloweye rockfish via immunoassay extraction. Hormone concentrations were normalized based on concentrations prior to the first peak, assuming this were estimates of non-reproductive levels.

2. 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 no deeper than 180 m, and the average weight of yelloweye rockfish. 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 SEO is set by multiplying the lower bound of the 90% confidence interval of total biomass for yelloweye rockfish by the natural mortality rate (M = 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 (2.0 to 4.0%). However, starting in 2015, the non-yelloweye DSR biomass estimate has been calculated from catch data from 2010–2014 recreational, commercial, and subsistence fisheries and 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 surveys for non-DSR species (e.g., black rockfish) have not been conducted since 2002.

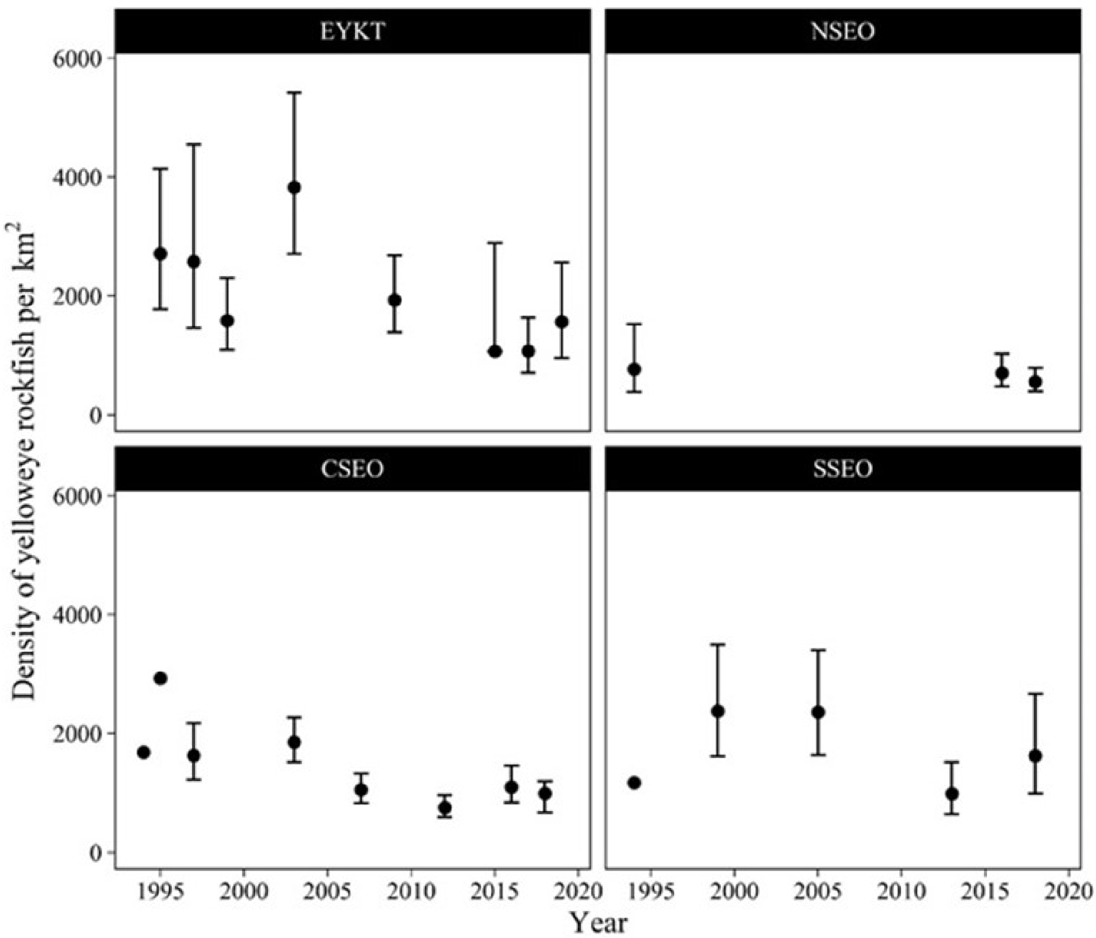

Figure 10.–Density estimates of yelloweye rockfish with 90% confidence intervals in the Eastern Gulf of Alaska management areas.

Prior to 2012, line transect surveys were conducted using a manned submersible. Since 2012, visual surveys have been conducted using a remotely operated vehicle (ROV). The last submersible surveys were conducted in 2020 in the Southern Southeast Outside (SSEO) section, 2019 in the Eastern Yakutat (EYKT) section, and 2018 in the SSEO, Central Southeast Outside (CSEO) and Northern Southeast Outside (NSEO) sections. Density estimates were derived from each of these surveys except for the SSEO management area where the data analyzation is in progress (Figure 10). Density estimates by area for the most recent submersible surveys ranged from 553–1,562 yelloweye rockfish per km^2 with CV estimates of 14–25%. The most recent density estimates for EYKT in 2019 was 1,562 yelloweye rockfish per km^2 (CV = 25%), SSEO in 2018 was 1,624 yelloweye rockfish per km^2 (CV = 25%), CSEO in 2018 was 897 yelloweye rockfish per km^2 (CV = 14%), and NSEO in 2018 was 544 yelloweye rockfish per km^2 (CV = 18%). In addition, fish lengths for yelloweye rockfish, lingcod, black rockfish, and halibut are measured from ROV video data using stereo camera imaging software (SeaGIS, Ltd; Contact Rhea Ehresmann).

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; however, assessment surveys have not been conducted in recent years (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, and Southeast districts of the Kodiak Management Area (Contact Carrie Worton).

3. 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 in the winter, prior to 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 2020 ABC for DSR was 238 mt, which resulted in a TAC of 231 mt with allocations of 194 mt to commercial fisheries and 37 mt to sport fisheries. Estimated subsistence harvest for 2020 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 Rhea Ehresmann).

In the **Central Region**, commercial rockfish fisheries in 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 PSR species. At the spring 2000 BOF meeting, the BOF closed directed rockfish fishing in PWS 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 PSR. 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 PSR fishery. In addition, logbooks are required during the Cook Inlet Area 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 PWS 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 2020, 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 52 mt. The Chignik and South Alaska Peninsula area GHLs were 45 mt and 34 mt, respectively. In the South Alaska Peninsula Area, the 2020 black rockfish harvest was confidential due to low participation and harvest, 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. In 2020, less than 1 mt of black and 9.2 mt of dark rockfish were harvested incidental to other groundfish species.

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*.

Beginning in 2020, a functioning deepwater release mechanism was required on all vessels sport fishing in Alaskan saltwater, and all rockfish not harvested were required to be released at depth of capture or at a depth of 100 feet.

For the 2020 season, the **Southeast Region's** sport bag and possession limit for pelagic rockfish was five fish per day, 10 in possession. The sport fishery in Southeast outside waters is allocated a portion of the TAC (16%) for demersal shelf rockfish. By emergency order, all Southeast Alaskan waters were closed to nonpelagic rockfish retention from January 1, 2020, through January 31, 2021. A second emergency order was subsequently issued allowing for retention of slope rockfish in Southeast waters from April 3, 2020, through January 31, 2021. There was a bag and possession limit of one slope rockfish in all waters of Southeast Alaska during that time; waters remained closed to retention of DSR species. For the entire Southeast Alaska region, charter operators and crew members were not allowed to retain nonpelagic rockfish (except species from the slope assemblage) while clients were on board the vessel.

As in Southeast Alaska, sport rockfish regulations in the **Southcentral Region** largely rely on bag limits for regulating effort and are more restrictive for nonpelagic species to account for their lower natural mortality rates. The open season for rockfish was year-round in all areas. In 2020, the bag limit in Cook Inlet was five rockfish daily, only one of which could be a nonpelagic species; the possession limit was two bag limits. The bag limit in PWS was four rockfish per day, with a possession limit of eight rockfish; only one per day and one in possession could be a nonpelagic species. The bag limit in the North Gulf Coast area was four rockfish per day, only one of which could be a nonpelagic species; the possession limit was two bag limits. The bag limit for Chiniak and Marmot Bay areas off Kodiak was three rockfish, no more than two of which could be nonpelagic and 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 nonpelagic species, and no more than one of the nonpelagic species could be a yelloweye. The bag limit in the Alaska Peninsula and Aleutian Islands was 10 rockfish per day. For all areas off Kodiak, the Alaska Peninsula, and the Aleutian Islands, the possession limit was two bag limits.

In 2017 the department began the SRI, 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.

4. Fisheries

Directed fisheries for only black rockfish occurred in the **Southeast Region** in 2020. The directed fisheries for DSR in SEO and inside waters were closed in 2020 due to stock health concerns. DSR was taken as bycatch with 98.5 mt harvested in SEO and 19.6 mt in internal waters. Harvest in the directed black rockfish fishery in Southeast Outside District (SEO) was 6.2 mt and black rockfish bycatch harvest in all groundfish, halibut, and salmon troll fisheries in SEO was 3.5 mt. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 51.2 mt harvested in 2020.

For **Central Region** commercial rockfish fisheries, 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 2020, the total rockfish harvest was 17.9 mt, a decrease from 30.0 mt in 2019. In Cook Inlet Area, the PSR harvest and other rockfish were similar, 9.2 mt and 8.7 mt. A majority of the PSR harvest came from the directed jig fishery, at 99%. The other rockfish were harvested as bycatch in longline groundfish fisheries (4.8 mt), and jig fisheries (3.9 mt). In PWS, rockfish are only harvested as bycatch, as there is no directed fishery. The harvest of 37.3 mt in 2020 was an increase of ~14% from 2019, although still well below the GHL. The majority of rockfish bycatch in PWS was caught by longline gear (75%) followed by trawl gear (25%) with the minimal remaining harvested by jig gear.

Sport harvest (guided and unguided) is estimated primarily through the SWHS (all species combined). Charter vessel logbooks provide reported harvest for the guided sector in three categories - pelagic, yelloweye, other nonpelagic. Additionally, species-specific data are available only from creel surveys.

Harvest reporting areas for these programs are different than commercial reporting areas, making direct comparisons difficult. Methods were recently developed to estimate sport harvest in numbers of fish for black and yelloweye rockfish in the same geographic reporting areas as used in commercial fisheries. Results are expected to be published by the end of 2021. Additional methods are being developed to estimate sport removals by weight and for other rockfish species.

Sport rockfish harvest is typically estimated in numbers of fish. Estimates of the 2020 harvest are not yet available from the SWHS, but the 2019 estimates for all species combined were 156,368 fish in Southeast and 174,105 fish in Southcentral Alaska. The average annual harvest estimates for the recent five-year period (2015–2019) were 166,156 rockfish in Southeast Alaska and 153,311 fish in Southcentral Alaska. Rockfish harvest in the sport fishery has increased substantially in recent years, likely in response to more restrictive limits for other sport caught fish.

I. Thornyhead rockfish

1. Research

There was no research conducted on thornyhead rockfish in 2020.

2. Assessment

There are no stock assessments for thornyhead rockfish.

3. Management

There is no directed fishery for thornyhead rockfish, and they may only be harvested as bycatch in halibut and other groundfish fisheries.

4. Fisheries

In **Central Region** thornyhead rockfish 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 thornyhead rockfish and other rockfish in aggregate may be retained. Proceeds from bycatch overages are forfeited to ADF&G.

In **Southeast Region**, thornyhead were retained as bycatch, based on the round weight of the target species, of up to 15% in aggregate with other rockfish. For pot gear only, 5% thornyhead bycatch was permitted in the sablefish and Pacific cod fisheries. Any bycatch overages that occurred in state waters were forfeited to ADF&G.

J. Sablefish

1. Research

In 2020, sablefish longline surveys were conducted for both the NSEI and SSEI areas in the **Southeast Region**. 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 2020 three permit holders participated in the surveys and could sell their Personal Quota Share (PQS), thus, reducing the impact on the quota for fish harvested and sold by the state. The department plans to allow permit holders to harvest their PQS aboard future NSEI longline surveys.

In addition to longline surveys, an annual mark-recapture survey has been conducted using longlined pots since 2000. This survey has used the state research vessel *Medeia* since 2012. During the 21-day NSEI survey that took place in May 2020, 29 longlined pot sets were made, and 7,916 sablefish were marked and released. Sablefish were targeted by statistical area in proportion to the commercial catch using logbook data from the three previous years. The mark-recapture results serve as a component of the NSEI stock assessment. The tagging survey is not scheduled for 2021 due to budgetary constraints (Contact Rhea Ehresmann).

In **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 fish, 318 fish, 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.

Sablefish 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 the catch composed of predominantly 1 and 4-yr old fish. Precision in the estimates is generally poor with CV values ranging from 0.17 to 0.86 and averaging 0.42. The survey occurs in Eastern PWS and the sablefish series begins in 1994. Estimated CPUE declined sharply in 2007 and has remained very low though has been increasing in the last two surveys as a larger cohort moves through the population (Figure 11; Contact Wyatt Rhea-Fournier).

In **Central Region**, skipper interviews and biological sampling in 2020 occurred in Whittier and Seward. Data collected included date and location of harvest, length, weight, sex, gonad condition, and otoliths. Otoliths were 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).

The Division of Sport Fish—Southeast Region collects catch, harvest, and biological data from sablefish as part of a marine harvest survey program. Ports sampled in 2020 included Juneau, Sitka, Craig, Petersburg/Wrangell, Gustavus, Yakutat, and Ketchikan. Length data were collected from 217 sablefish in 2020, primarily from the ports of Sitka, Ketchikan, and Juneau (Contact Mike Jaenicke). Port sampling of sablefish is opportunistic in **Southcentral Region** and is not a primary objective of the program; port samplers in Southcentral Alaska measured only one sablefish from the sport harvest in 2020, reflecting the relatively low harvests. Interviewed anglers in Southcentral Region retained 38 of 69 sablefish caught in 2020).

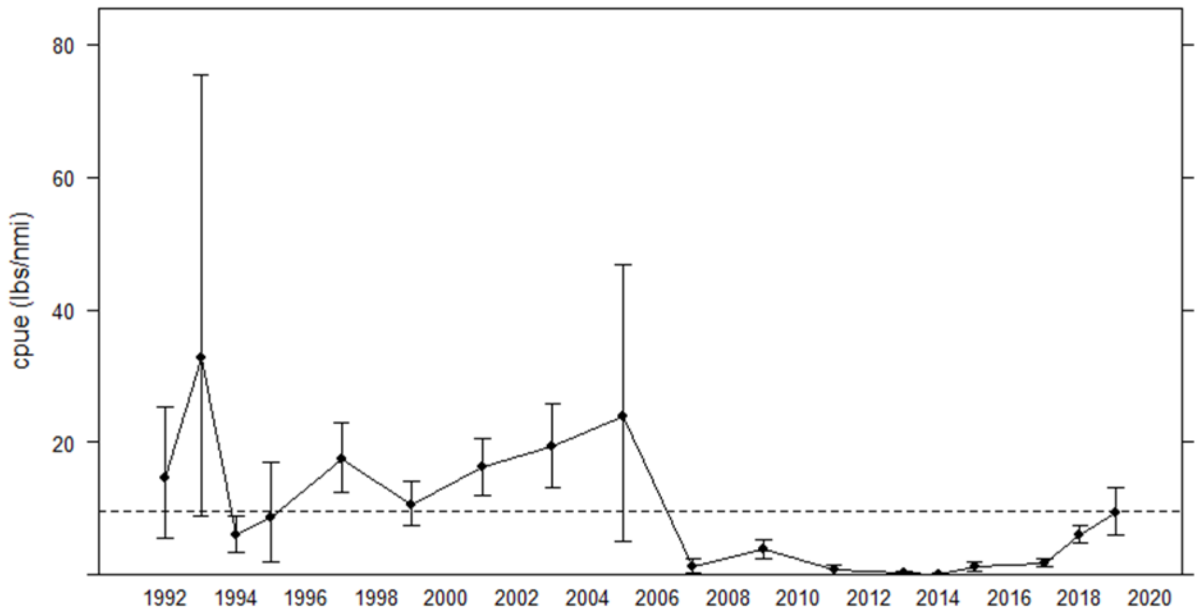

Figure 11.–PWS trawl survey CPUE estimates for sablefish with 90% confidence intervals. Dotted line represents the long-term survey average.

The **Age Determination Unit** worked with the AFSC, Auke Bay Laboratories to investigate the use of age-0 lapillar and sagittal otoliths to infer daily growth in juvenile sablefish in the Gulf of Alaska. Otoliths from rhinoceros auklet bill-load samples from 1978 to present, survey samples, and samples from laboratory reared juvenile sablefish were removed and prepared. The external and internal structure of otoliths collected from bill-load samples were significantly damaged due to storage and were not useful for modeling size nor daily growth. Focus was shifted to samples included in growth trials conducted at Auke Bay Laboratories. Otolith size and daily increment width was measured using image analysis. The relationships between lapillar and sagittal otolith increment width, comparison of total increment count on both structures, otolith size to fish size, temperature and feeding ration were modeled. Evaluations of survey and laboratory reared juvenile sablefish found close agreement in daily age between otoliths, strong linear relationships between otolith size and fish size, and peak otolith increment width in both structures between 14°C and 18°C and at maximum feed rations. These findings support current and previous studies, and investigators plan to publish methods and findings (Contact Kevin McNeel).

2. Assessment

In the **Southeast Region**, the department uses 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. 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 the NSEI Subdistrict, the 2020 recommended ABC was 551.9 mt, a 15% increase from the 2019 ABC. This ABC was generated using a new statistical catch-at-age (SCAA) model that replaced past methodology that partitioned a mark-recapture abundance estimate using fishery age compositions. This new model reduces reliance on the annual mark-recapture project by integrating multiple indices of abundance and biological data (catch, mark-recapture abundance estimates, survey and fishery CPUE, and survey length and age composition data). The 2020 recommended ABC is less than the SCAA model's maximum permissible ABC of 580.8 mt, as management decision was implemented to constrain recommended ABCs to a maximum 15% annual change. Consequently, the 2020 recommended ABC was held to 551.9 mt (15% increase from 2019) rather than 580.8 mt (a 21% increase). This management procedure has been shown to increase fishery stability, maximize catch, and achieve biological goals in long-term simulations.

In the SSEI Subdistrict, the 2020 annual harvest objective (AHO) was set at 259.7 mt, a 3% reduction from 2019. For SSEI, 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. There were several negative indicators that contributed to the reduction in AHO, including decreased survey and fishery CPUE, truncation of the population age structure, and suppressed spawning stock biomass (Contact Rhea Ehresmann).

3. 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. 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 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. 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. In 2018, the BOF also approved the use of pots in the personal use sablefish fishery with a limit of two pots per person, 8 pots per vessel.

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.

In **Central Region**, the Cook Inlet Area sablefish GHL is set using a 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 1.8 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 NMFS and ADF&G indicate that sablefish populations throughout the GOA including PWS 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 2020. PWS fishery management developed through access limitation and in 2003 into a shared quota system wherein permit holders are allocated shares of the GHL. 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; new season dates of April 15–August 31 were also adopted. The new season opening date, one month later than in previous years, was adopted to reduce the opportunity for whale 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 register and fill out logbooks provided by ADF&G. In 2013, the BOF changed the season opening and closing dates reverting them back to coincide with the federal IFQ season.

The **Southeast Region sport fishery** for sablefish was regulated for the first time in 2009. Sport limits in 2020 were four fish of any size per day, four in possession, with an annual limit of eight fish applied to nonresidents. The sablefish sport fishery in the remainder of Alaska has no limits.

4. Fisheries

In the **Southeast Region**, the 2020 NSEI quota was set at 502 mt of sablefish. The fishery is managed by equal quota share with each permit holder allowed 6.7 mt. The 2020 NSEI sablefish fishery opened August 15 and closed November 15 by regulation. The 75 permit holders landed a total of 500 mt. The SSEI quota was set at 260 mt with an equal quota share of 11.8 mt for each of the 19 permit holders for longline/pot gear and three permit holders for pot gear. The 2020 SSEI sablefish fishery season allowed longline/pot gear permits to fish from June 1–November 15. The 22 permit holders landed a total of 179 mt of sablefish (Contact Rhea Ehresmann).

In the **Central Region,** the 2020 Cook Inlet Area sablefish fishery opened at noon July 15 with a GHL of 34.9 mt and closed by regulation on December 31; no effort or harvest occurred in 2020. Harvest and effort have been steadily decreasing in the Cook Inlet Area fishery and 2020 marked the first time that there was zero harvest. The 2020 PWS sablefish fishery opened April 15 with a GHL of 75.7 mt. Because of COVID-19 complications, some of the fleet requested an extension of the season to December 31 (from the regulatory closure of August 31), which was granted. PWS sablefish harvest totaled 43.2 mt, a slight increase from 2019; harvest has been steadily increasing since the 7.7 mt historical low in 2015, although still not achieving the GHL. There has been an increase in the use of pot gear in the fishery in recent years in response to excessive orca depredation on sablefish in PWS, but longline gear still dominated in 2020 harvesting 72% and 28% 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 2020 Aleutian Island fishery opened concurrent with the IFQ season, on March 14 with pot, longline, jig and hand troll gear allowed. The GHL was set at 195.0 mt for the state-waters fishery. The harvest from the 2020 Aleutian Islands sablefish fishery was 180.4 mt. The season remained open until the November 15 closure date (Contact Asia Beder).

The most recent sablefish sport harvest estimates from the SWHS are for 2019. The estimated harvest was 18,376 fish in Southeast Alaska and 7,426 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 15,612 sablefish in Southeast Alaska and 2,133 sablefish in Southcentral Alaska in 2019 (Contact Bob Chadwick, Jason Dye).

K. Lingcod

1. Research

In the **Southeast Region**, dockside sampling of lingcod caught in the commercial fishery continued in 2020 in Sitka with 1,051 fish sampled for biological data. Otoliths were sent to the ADU in Juneau for age determination (Contact Rhea Ehresmann).

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; however, evidence of sex (vent/papilla) was required by EO to remain intact on lingcod by having fishermen cut one inch forward of the vent when gutting fish (Contact Elisa Russ). Funding for Central Region lingcod ROV surveys ended in 2016 and no surveys have been conducted in recent years (Contact Mike Byerly).

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 some ports. Data collected in the program include statistics on effort, catch, and harvest of lingcod taken by Southeast Alaska sport anglers. Ports sampled in 2020 included Juneau, Sitka, Craig, Petersburg/Wrangell, Gustavus, Yakutat, and Ketchikan. Length and sex data were collected from 986 lingcod in 2020, primarily from the ports of Sitka, Ketchikan, Craig, Gustavus, 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 556 lingcod from the sport harvest at Seward, Valdez, Whittier, Kodiak, and Homer in 2020. These ports account for most of the sport lingcod harvest in Southcentral Alaska (Contact Martin Schuster).

2. 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 2020 (Contact Mike Byerly or Wyatt Rhea-Fournier).

3. Management

Management of commercial lingcod fisheries in the **Southeast Region** 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. The 27-inch 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 BOF established a super-exclusive directed fishery registration for lingcod permit holders fishing in the IBS area.

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 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 the **Southeast Region**, 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 2020 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 limits or annual limits. 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 and 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 inches in length and one must be at least 55 inches in length;

(2) In the Southern Southeast area, nonresidents were allowed one fish daily and 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.

(3) In the Yakutat area, nonresidents were allowed one fish daily and in possession, the fish must be 30–50 inches in length or at least 55 inches or greater in length, and the annual limit was two fish, of which one must be 30–50 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 and protect 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 and possession limits in 2020 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 Jason Dye or Matt Miller). The bag limit in Kodiak, the Alaska Peninsula, and the Aleutian Islands was two lingcod with a possession limit of four fish. There were no size limits in these areas.

4. Fisheries

Lingcod are the target of a "dinglebar" troll fishery in the **Southeast Region**. Dinglebar troll gear is power troll gear modified to fish for groundfish. Additionally, lingcod are landed as significant bycatch in the DSR longline, halibut longline, and salmon troll fisheries. The directed fishery landed 137 mt of lingcod in 2020. An additional 39 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. The 2020 lingcod GHL was 23.8 mt in Cook Inlet Area, and the fishery closed November 13 when the GHL was achieved; increases in lingcod effort and harvest in recent years began in 2017 with similar harvest levels in 2017, 2018, and 2019. In PWS, lingcod harvest in 2020 was 11.7 mt in PWS, down slightly from 2019. Approximately 92% of the lingcod harvest from Cook Inlet Area was from the directed lingcod jig fishery and the remainder was harvested as bycatch primarily with longline gear. In PWS, the lingcod harvest was split evenly between longline gear (49.5%) and jig gear (49.5%) with a minimal amount harvested with pot gear; 7.3 mt or 62% of total harvest was from the directed fishery (Contact Jan Rumble).

In the **Westward Region**, no directed lingcod effort occurred during 2020. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2020 harvest totaled 17 mt in the Kodiak Area, 1.5 mt in the Chignik area, and <1 mt in the South Alaska Peninsula and Aleutian Islands – Bering Sea Areas combined.

Sport lingcod harvest estimates from the SWHS for 2019 (the most recent year available) were 14,055 lingcod in Southeast Alaska and 14,288 lingcod in Southcentral Alaska. The average estimated annual harvest for the recent five-year period (2015-2019) was 13,077 fish in Southeast Alaska and 13,455 fish in Southcentral Alaska.

L. Atka Mackerel

1. Research

There was no research on Atka mackerel during 2020.

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 2020. Currently in the **Central Region** and **Southeast Region** Atka mackerel are considered part of the "other groundfish" assemblage and are allowed up to 20% as bycatch in aggregate in directed fisheries for groundfish.

M. Flatfish

1. Research

There was no research on flatfish during 2020.

2. Assessment

There are no stock assessments for flatfish.

3. Management

Trawl fisheries for flatfish are allowed in four small areas in the internal waters of the **Southeast Region** 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.

In **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.

4. Fisheries

No effort has occurred in the **Southeast Region** fishery in recent years. Since 2000, only one vessel has applied for a commissioner's permit to participate in this fishery; this vessel made a single flatfish landing in 2014. 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 2020, one commissioner's permit to catch flatfish was issued in the Cook Inlet Area and none in PWS. The purpose of the Cook Inlet Area permit was to test the viability of pot gear; however, there was limited success.

N. Pacific Halibut and IPHC Activities

The sport halibut fishery is monitored by the **Division of Sport Fish**. Data on sport fishery effort and harvest are collected through port sampling in Southeast and Southcentral Alaska, the SWHS, and charter vessel logbooks. 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 the **Southeast Region**. 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 the **Southeast Region,** several projects are funded through test fish funds, notably the sablefish longline assessments and mark-recapture work, the herring fishery, and some salmon assessments.

VII. Publications

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Beder, A., and J. Shaishnikoff. 2020. Annual management report for groundfish fisheries in the Bering Sea-Aleutian Islands Management Area, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 20-25-, Anchorage.

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http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps

Age Determination Unit: http://mtalab.adfg.alaska.gov/ADU/

Gene Conservation Laboratory Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishinggeneconservationlab.main

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APPENDICES

Appendix I. Alaska Department of Fish and Game staff (updated 04/09/2021).

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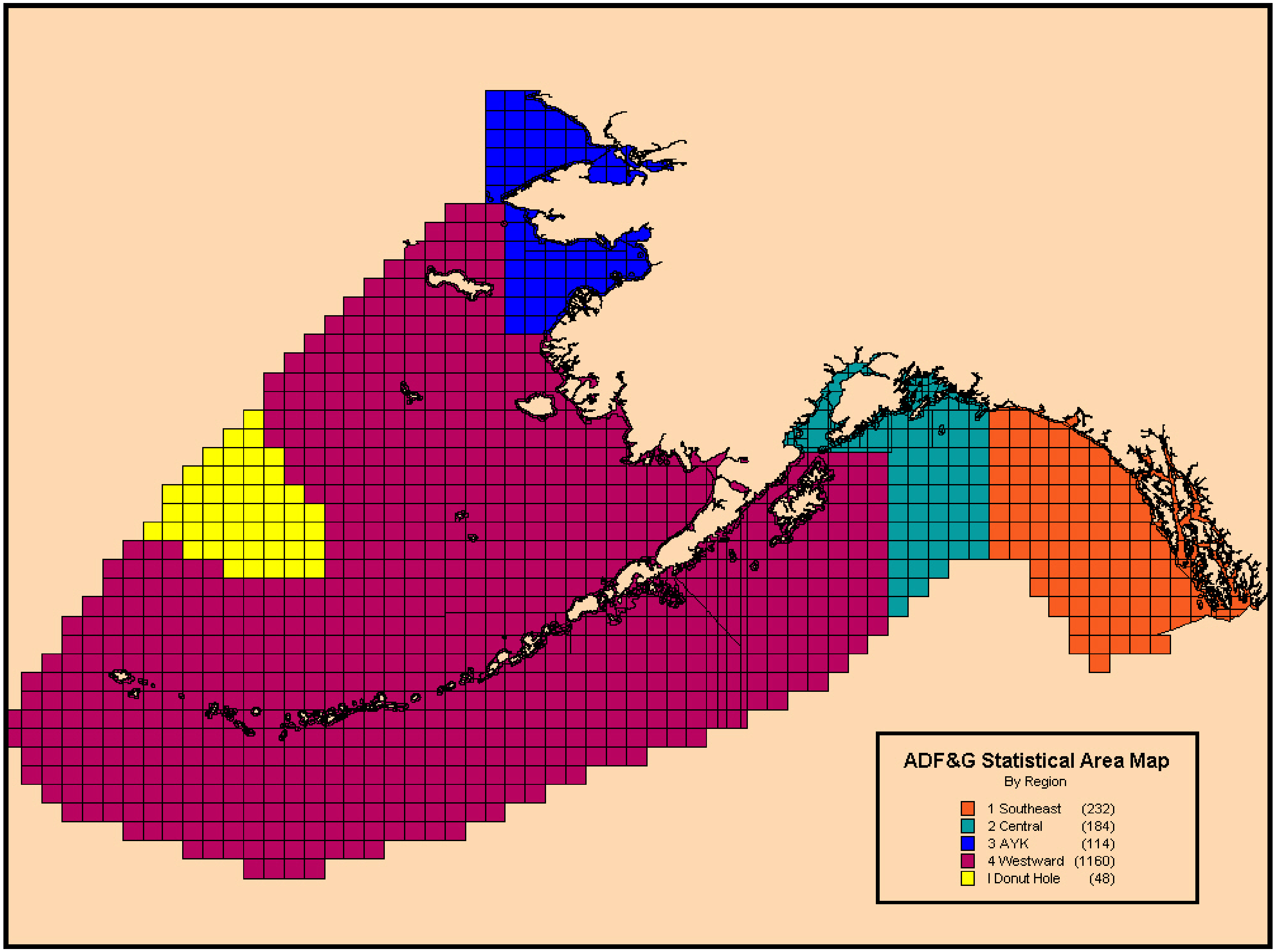
Appendix II. Map depicting State of Alaska commercial fishery management regions.



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
	Port Gravina	2008	61	fin
	Prince William Sound - inside	2018	71	fin
	Prince William Sound Marine	2018	121	fin
	Eastern North Gulf Coast	2019	51	fin
	Kodiak	2019	10	fin
	North Gulf Coast	2019	123	fin
	Prince William Sound	2019	110	fin
	Prince William Sound	2019	175	fin
	Sitka, Craig	2019	467	fin
	Sitka, Craig, Petersburg	2019	396	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
	Eastern North Gulf Coast	2019	34	fin
	Gustavas to Ketchikan	2019	719	fin
	Kachemak Bay	2019	50	fin

North Gulf Coast	2019	125	fin
Prince William Sound	2019	319	fin
Sitka, Craig	2019	31	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 2021

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Contents

I. Agency Overview

Within the California Department of Fish and Wildlife (CDFW), the Marine Region is responsible for protecting and managing California's marine resources under the authority of laws and regulations created by the State Legislature, the California Fish and Game Commission (CFGC) and the Pacific Fishery Management Council (PFMC). The Marine Region is unique in the CDFW because of its dual responsibility for both policy and operational issues within the State's marine jurisdiction (0 – 3 miles). It was created to improve marine resources management by incorporating fisheries and habitat programs, environmental review and water quality monitoring into a single organizational unit. In addition, it was specifically designed to be more effective, inclusive, comprehensive and collaborative in marine management activities.

The Marine Region has adopted a management approach that takes a broad perspective relative to resource issues and problems. This ecosystem approach considers the values of entire biological communities and habitats, as well as the needs of the public, while ensuring a healthy marine environment. The Marine Region employs approximately 140 permanent and 100 seasonal staff that provide technical expertise and policy recommendations to the CDFW, CFGC, PFMC, and other agencies or entities involved with the management, protection, and utilization of finfish, shellfish, invertebrates, and plants in California's ocean waters.

Groundfish project staff are tasked with managing groundfish and providing policy recommendations to the CDFW, CFGC, and PFMC. Other staff work indirectly on groundfish, such as our California Recreational Fisheries Survey (CRFS) staff that sample our recreational fisheries and our Marine Protected Areas (MPA) 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

Scientists from CDFW's Groundfish and MPA Management Projects continued analysis of ROV survey data collected from 2014 to 2016 to develop methods for estimating fish density and total expanded biomass for select species using design and model-based approaches. In January 2020, these methods were evaluated for use in stock assessments by the PFMC's Scientific and Statistical Committee (SSC). An evaluation of the methods was performed by a committee formed by the SSC and two independent reviewers from the Center of Independent Experts. In February, the reviewers met in person and received presentations from CDFW. In addition, ROV methods developed by the Oregon Department of Fish and Wildlife were evaluated and presented in parallel with CDFW's. The proceedings of the evaluations were presented for approval by the full SSC at the June 2020 PFMC meeting and were approved for use in management.

As a test case, Gopher Rockfish (*Sebastes carnatus*) was modeled and results indicate that depth, latitude and seafloor terrain attributes provide a suitable model fit. The seafloor mapping data was used as a basis for expansion of modeled Gopher Rockfish abundance and biomass. The estimates derived from the model-based approach are comparable to design-based estimates derived from the same data. CDFW will develop similar models with the 2014-2016 statewide survey data to inform upcoming stock assessments of Copper (*S. caurinus*) and Vermilion (*S. miniatus*) rockfish in 2021.

In addition, density by depth and length frequency by depth are being considered relative to depth restrictions to inform selectivity and catchability parameters informing fully parameterized stock assessments in Stock Synthesis. ROV data collected in 2020 and 2021, as part of long-term MPA monitoring, will also be incorporated into the models where feasible.

The estimates of density and biomass from these models may also be used to measure MPA performance. Preliminary results indicate differences in length compositions and density inside and outside MPAs as a result of site selection or accumulation of biomass in long established locations with protections. Two area models reflecting these differences may provide more representative estimates of status and scale if incorporated in assessments currently only reflecting data from openly fished areas. Future surveys may provide a time series to examine long term trends in abundance to inform fishery and MPA management. Until then, absolute estimates of abundance can be used to inform the scale of the integrated stock assessments in Stock Synthesis.

Contributed by John Budrick (John.Budrick@wildlife.ca.gov) and Michael Prall (michael.prall@wildlife.ca.gov)

III. Reserves

Marine Protected Areas Research and Monitoring

Completed in 2012, California's Marine Protected Area (MPA) Network spans the entire California Coast including offshore islands and is comprised of 124 MPAs. 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 Program takes a two-phased approach to monitoring: Phase 1, regional baseline monitoring, which concluded in 2018, and Phase 2, statewide long-term monitoring, which is ongoing.

To manage Phase 2, the State developed a MPA Monitoring Action Plan (Action Plan), which prioritizes key measures and metrics, habitats, sites, species, human uses, and management questions to target for long-term monitoring. In 2019, seven projects were funded to monitor six habitats and human uses. Monitoring activities will span 2019-2021 and reports will be submitted in 2021.

In 2022, the first comprehensive review of the MPA Management Program including an evaluation of the MPA Network performance will take place. Monitoring data from Phase 1 and Phase 2 will be analyzed using a before-after, control-impact approach to measure the effects of protection on the prioritized indicators identified in the Action Plan.

To further inform aspects of the review, the state has convened two external working groups of the Ocean Protection Council's Science Advisory Team. The Climate Resiliency Working Group examined MPA resiliency to climate change and provided recommendations on how to best manage the state's natural resources and leverage the MPA Network under a new climate change regime. The Decadal Evaluation Working Group refined and prioritized Action Plan Network evaluation questions, defined the MLPA goals in scientifically tractable terms, and provided recommendations on how to integrate data streams and fill in knowledge gaps to address Network evaluation for the 2022 review and beyond. Informed by these recommendations, the Department will work closely with monitoring principal investigators and partners at the National Center for Ecological Analysis and Synthesis, or NCEAS, on the integration and synthesis of MPA monitoring data and other data streams for the 2022 review.

To receive updates about the MPA Management Program and other Department programs, click here; archived MPA stories are available here.

Contributed by Sara Worden (sara.worden@wildlife.ca.gov)

IV. Review of Agency Groundfish Research, Assessment and Management

A. Hagfish

There are four species of hagfish that exist off California: Black Hagfish (*Eptatretus deani*), Pacific Hagfish (*E. stoutii*), Shorthead Hagfish (*E. mcconnaugheyi*) and Whiteface Hagfish (*Myxine circifrons*). Of the four, the Pacific Hagfish (hagfish) is the preferred species for California's primarily export-only fishery. Using traps, fishermen land hagfish in live condition. Exporters keep hagfish alive dockside until packed for live export to South Korea where they are sold live for human food. There is a small domestic market for live and fresh, dead hagfish. Considered scavengers, hagfish are found over deep, muddy habitat.

1. Assessment
Little is known about the status or biomass of 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 (2007), ending 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 examined to determine spawning status by sex and length frequency. In 2020, CDFW staff sampled hagfish at the ports of Moss Landing, Morro Bay, and Port San Luis.

For the period 2010-2020, landings have fluctuated between 360 and 967 metric tons (0.8 and 2.1 million pounds) annually with an average of 668 mt. The annual ex-vessel value for this period ranged from $565,000 to $1.84 million with an average of $1.2 million. In 2020 there were 558 metric tons landed with an ex-vessel value of $1.08 million. Typically fishing effort and export demand are market driven by the South Korean economy and fishing activities of Washington and Oregon fishermen. Additional influences on fishing effort include the price and availably of bait, fuel costs, and other fisheries that may be available to hagfish fishermen. In 2020, the COVID-19 pandemic forced market closures and reduced market demand due to additional limits placed on export goods. The pandemic also caused restrictions to be placed on California fishermen and dock infrastructure.

2. Management

The commercial hagfish fishery is open access; all fishery participants are required to have a commercial fishing license and a general trap permit. 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 per vessel is 200 bucket, 500 Korean, or 25 barrel traps. Fishermen must choose one trap type and may not combine hagfish trap types or have non-hagfish traps onboard when fishing with a chosen hagfish trap. To assist in enforcing vessel trap limits, the vessel commercial registration number must be on the trap buoy. 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 hagfish traps must have a CDFW approved destructive device and all holes, except for the entrance, 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. 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. 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
   Yelloweye Rockfish and Lingcod

   In 2020, CDFW 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 2020, state and county health advisories and stay at home orders in response to the COVID-19 pandemic impacted the ability of the CRFS program to collect Yelloweye Rockfish from anglers and resulted in a much lower number of specimens collected in 2020.

   Similarly, collection of carcasses of lingcod (*Ophiodon elongatus*) as well as several other recreationally important species of rockfish were impacted by the pandemic. CDFW shifted efforts to processing and drying over 400 samples of lingcod fin rays for aging. The lingcod fin ray samples were collected during previous years from both the recreational and commercial fisheries and the resulting age data will help inform future lingcod stock assessments.

   CDFW intends to resume field sampling in 2021, as conditions permit.

   Contributed by Andrew Klein (Andrew.Klein@wildlife.ca.gov)

   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; depth-

based fishing closures) while avoiding overfished rockfish species (e.g. Canary (*S. pinniger*), Yelloweye, and Bocaccio Rockfish (*S. paucispinis*)) from the Oregon/California border to Point San Pedro. The goal of this study has been 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 2020 indicate that the gear is successfully targeting healthy stocks such as Yellowtail and Widow (*S. entomelas*) Rockfish, and now Canary Rockfish, while avoiding overfished species. Canary Rockfish and Bocaccio have since been rebuild (in 2016 and 2019, respectively), and are currently allowed to be retained and sold under this EFP. Prior to the rebuilding of Canary Rockfish and Bocaccio catch of these species was minimal, and catch of Yelloweye Rockfish continues to be minimal.

In 2015, the geographic extent of the EFP was expanded south to Point Conception and additional vessels were added to allow for additional data collection in more southerly areas. Currently, fishing occurs between 40° 10' N. lat. near Cape Mendocino and Point Conception.

Contributed by Melissa Mandrup (Melissa.Mandrup@wildlife.ca.gov)

3. Assessment
The CDFW contributed to length-based stock assessment efforts for Copper, Squarespot (*Sebastes hopkinsi*) and Quillback (*S. maliger*) Rockfish in 2020 in collaboration with National Marine Fisheries Service (NMFS) assessment authors. Staff also contributed data from CRFS, ROV and historical CDFW data bases for Lingcod, Vermilion/Sunset rockfish (Sunset = *S. crocotulus*), and Spiny Dogfish (*Squalus acanthias*) assessments. CDFW staff will contribute to the 2021 stock assessments as contributing authors, Stock Assessment Review panel members, and reviewers.

   Contributed by John Budrick (John.Budrick@wildlife.ca.gov)

4. 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 recommended by the PFMC and implemented by NMFS.

5. Commercial Fishery Monitoring
CDFW has collected commercial fisheries statistics since 1916 using paper fish tickets. Beginning July 1 2019, CDFW began requiring the submission of electronic fish tickets via PSMFC's E-Tix system instead of the paper fish tickets. 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 Marine Landings Database System. Outside funding also enables California fishery data to be routinely incorporated into regional databases such as Pacific Coast Fisheries Information Network.

Commercial sampling is conducted by PSMFC staff and 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.

In 2020, state and county health advisories and stay at home orders in response to the COVID-19 pandemic impacted PSMFC's ability to conduct commercial sampling in California. These orders varied by date and location until the initial statewide stay at home order was issued on March 19, 2020. While commercial fishing was designated an essential business and could continue operations, initially groundfish samplers stayed home per orders. As restrictions eased, staff were allowed back in the field with new safety measures in place (i.e., physical distancing requirements and personal protective equipment), although the actual sampling methods were unchanged. By May 2020, sampling had resumed at all ports.

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.

Contributed by Andre Klein (Andrew.Klein@wildlife.ca.gov) and Traci Larinto (Traci.Larinto@wildlife.ca.gov

6. Recreational Fishery Monitoring
As with the commercial groundfish fishery, the COVID-19 pandemic impacted CRFS ability to collect recreational fisheries data in 2020. While the public was told to stay home, outdoor recreational activities, including recreational fishing were allowed in most locations. CRFS interviews with anglers were initially discontinued until safety procedures were developed. In an effort to stay aware of trends in recreational activities, CRFS implemented statewide effort checks at fishing sites, with more than 500 sites surveyed at a distance

to document status (open or closed to the public) and to gauge relative effort. In May when California's party/chart boat fleet began operating under new COVID-19 health guidelines, CRFS resumed tracking the fleet's activities. CRFS resumed sampling in July under newly developed sampling guidelines to comply with COVID-19 health advisories and best practices. The new guidelines reduced CRFS' efficiency at intercepting anglers, but methods were employed to compensate for the loss included doubling the number of party/charter boat dockside surveys, and streamlining the angler interview process at launch ramps, piers, breakwaters and jetties. This allowed CRFS to resume production of monthly estimates, with only a break from April through June.

Contributed by David Hernandez (David.Hernandez@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 2020 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.

   Once the federal regulations are adopted, the state can then take action 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.

3. Commercial Fishery Monitoring
   The directed commercial fishery for Pacific Halibut is managed under a coastwide (Washington, Oregon and California) quota and operates as a derby fishery. The fishery opened on June 26 and beginning in 2020, is structured based on 56-hour openers that are spaced two weeks apart. The fishery operates on this schedule until the coastwide quota has been met. California effort in this fishery continued in 2020 with six vessels participating in the fishery; landings totaled 2,848 dressed kilograms (6,274 dressed pounds).

4. Recreational Fishery Monitoring

The 2020 recreational Pacific halibut fishery in California was open May 1-August 11 and closed for the year on August 11 at 11:59 p.m., due to projected attainment of the 17,690 net kilogram (39,000 net pound) quota. The California Department of Fish and Wildlife's (CDFW) 2020 preliminary season catch estimate is 29,078 net kilograms (64,107 net pounds), or 164 percent of the quota.

CDFW tracks recreational catch of Pacific halibut on a weekly basis during the open season. For the week ending July 26, projected catch was 38 percent of the quota. The following week of July 27-August 2, an unprecedented 256 Pacific halibut were reported as kept by anglers and catch projections through August 2 indicated the quota had been exceeded. This is a record-high weekly value for California and set new monthly high records as well. Prior to this event, the record monthly high total sampled fish was 198 fish sampled in July 2014. Adding to the unusual nature of this event, in 2019 the California recreational fishery attained only 7,911 net kilograms (17,440 net pounds) of its 17,690 net kilogram (39,000 net pound) quota.

Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

V. Publications

Budrick, J, Ryley, L, Prall, M. 2020. Methods for using remotely operated vehicle survey data in assessment of nearshore groundfish stocks along the California coast. 89 p. Available at: ftp://ftp.pcouncil.org/pub/2019%20Nearshore%20ROV%20Surveys%20Methodology%20Review/CA%20Survey/.

April 2021

OREGON’S GROUNDFISH INVESTIGATIONS IN 2020

Marine Resources Program
Oregon Department of Fish and Wildlife

2040 SE Marine Science Drive
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OREGON'S GROUNDFISH INVESTIGATIONS IN 2020

OREGON DEPARTMENT OF FISH AND WILDLIFE
2021 TSC AGENCY REPORT

Edited by: Alison Whitman

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Agency Overview

MRP Program Manager: *Dr. Caren Braby*
Resource Management and Assessment: *Dave Fox*
Fishery Management: *Maggie Sommer*
Technical and Data Services: *Justin Ainsworth*

The Oregon Department of Fish and Wildlife's Marine Resources Program (MRP) is responsible for assessing, monitoring, and managing Oregon's marine habitat, biological resources, and fisheries. The MRP'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. Funding levels have been relatively stable over recent years.

ODFW staff place rockfish with barotrauma in a recompression cage during an at-sea survey.

Contents

Surveys

Recreational Fisheries Monitoring and Sampling

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2020, but with some modifications due to COVID-19 precautions and restrictions. Starting in November 2005, major ports were sampled year-round and minor ports for peak summer-fall season. We continue to estimate catch during un-sampled time periods in minor ports based on the relationship of effort and catch relative to major ports observed during summer-fall periods when all ports are sampled. Lingcod (*Ophiodon elongatus*), multiple rockfish species (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus*) and kelp greenling (*Hexagrammos decagrammus*) are the most commonly landed species.

The ORBS program continued collecting information on species composition of landed groundfish species at Oregon coastal ports during 2020; however, fish lengths and weights were not collected due to agency-prescribed COVID safety protocols. 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, with some modifications in 2020 due to COVID safety protocols. 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; however, that sampling was suspended in 2020, again due to COVID safety protocols. Beginning in 2003, the recreational harvest of several groundfish species is monitored inseason for catch limit tracking purposes.

Other ODFW management activities in 2020 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 2021.

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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 inseason monitoring and as a primary commercial data source for federal stock assessment. In 2020, preparations continued to add fixed gear fishery logbooks to the PacFIN clearinghouse. Species composition sampling of rockfish and biological sampling of commercially landed groundfish continued in 2020 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. All sampling in 2020 was conducted following ODFW-prescribed COVID-19 safety protocols. While the commercial groundfish sampling rate decreased in 2020 because of the need to avoid fish plants with active COVID-19 outbreaks, adequate sampling of all sectors was accomplished.

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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 2020. More information is available on the Oregon Marine Reserves website at http://oregonmarinereserves.com/

Management

Site Management Plan

ODFW released the Cape Perpetua Marine Reserve Site Management Plan in 2020. The Plan outlines the state's marine reserve mandates and describes management, outreach, and community engagement strategies developed for the Cape Perpetua Marine Reserve. The Plan also highlights the local communities' interests in additional activities and research, above and beyond what is being carried out by ODFW.

Human Dimensions Research Reports

Several marine reserve human dimensions research reports were released in 2020. These projects were conducted as collaborations between ODFW and academic researchers.

- 2017-19 Qualitative Evaluation of Impacts of Marine Reserves on Commercial and Charter Fishers: Understanding the Big Picture (OSU Cascades 2020)
- Understanding Oregonians' Coastal Values and Priorities through Participatory GIS Mapping (PSU 2020)
- Cape Perpetua Visitor Surveys (Epperly et al. 2020)

Infographics

ODFW produced several infographics, highlighting some of the initial findings from ongoing marine reserves human dimensions research.

- Coastal Residents' Perspectives of Marine Reserves
- Fishermen's Perspectives of Marine Reserves
- Building and Maintaining Relationships in Marine Resource Management
- Information, Perceptions, and Communication

Monitoring

Ecological monitoring includes 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. Despite the challenges of COVID-19, the marine reserve ecological monitoring team successfully conducted oceanographic and intertidal monitoring in 2020 at the following reserves:

- Cape Falcon Marine Reserve: temperature, oxygen and salinity data gathered in the reserve and its comparison area at Cape Meares. Data reveal similar oceanographic conditions between the two sites and no hypoxia (low oxygen conditions) while moorings were deployed July – Sept.
- Cascade Head Marine Reserve: Intertidal monitoring for sea stars and community musselbed surveys were successfully conducted following modified COVID-19 fieldwork protocols. Temperature, oxygen and salinity data were gathered from this reserve and reveal several points of hypoxia (low oxygen conditions) while moorings were deployed July – Sept.
- Otter Rock Marine Reserve: Intertidal monitoring for sea stars and community musselbed surveys were successfully conducted following modified COVID-19 fieldwork protocols.
- Cape Perpetua Marine Reserve: Collaborators with the Partnership for Interdisciplinary Study of Coastal Oceans (PISCO) successfully collected, temperature, salinity, oxygen, and pH data from the marine reserve.

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Research

Nothing new to report in 2020.

REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENT AND MANAGEMENT

Hagfish

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 2020 were down to 1.2 million pounds, or 75.6% of state harvest guideline of 1.6 million pounds after 99.2% attainment the year prior. No major hagfish management actions were taken by ODFW in 2020.

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Dogfish and Other Sharks

Nothing to report in 2020.

Skates

Nothing to report in 2020.

Pacific Cod

Nothing to report in 2020.

Walleye Pollock

Nothing to report in 2020.

Pacific Whiting

Management

The US (and Canadian) whiting total allowable catch (TAC) and catch continues to be near record high levels. The new assessment does continue the trend of decreased abundance as the very strong 2010 and 2014 cohorts begin to leave the population. In April 2020, the Pacific Fishery Management Council (PFMC) recommended and National Marine Fisheries Service implemented an emergency rule to allow an at-sea Pacific whiting processing platform to operate as both a mothership and a catcher-processor within the same calendar year. This action was taken to allow for mitigation of risk associated with the COVID-19 pandemic and impacts associated with current processing limitations in these two sectors (i.e., to better ensure a processor would be available to take fish from catcher vessels in the mothership sector, given the potential for COVID-19 outbreaks to disrupt processing operations). Increasing the whiting mothership utilization of their allocation has been a recent focus at the PFMC, with the adoption of a Purpose & Need statement in September 2020.

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Grenadiers

Nothing to report in 2020.

Rockfish

Research

Depth-associated variability of Deacon Rockfish (*Sebastes diaconus*) age, growth and maturity parameters in Oregon waters and their effect on stock status. In press.

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 during late 2016 and throughout 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 we combined the nearshore and offshore samples.

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 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 finding may indicated 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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Habitat use and activity patterns of Deacon Rockfish (*Sebastes diaconus*) at seasonal scales and in response to episodic hypoxia. In press.
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*), become 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 mo), 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.

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Sex identification PCR-RFLP assay tested in eight species of *Sebastes* rockfish. Published.

The phenotypic identification of sex in *Sebastes* rockfish is difficult and often impractical from a management perspective, and the genetic basis of sex determination in the genus is currently uncertain. We tested a previously developed sex identification polymerase chain reaction restriction fragment length polymorphism (PCR-RFLP) assay on 8 species of *Sebastes* rockfish. Results indicated that restriction is species dependent rather than sex dependent in most species.

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Operationalizing a survey of Oregon's nearshore semi-pelagic rockfish. Ongoing.

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 nearness to the ODFW offices 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 3 times on locations with either large schools of rockfish or rocky reef habitat. For each video drop we collected a minimum of 2 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 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 this summer 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.

A statewide survey was planned for September 2019 however problems with contracting resulted in this work not being operationalized. Therefore we were going to operationalize the survey in fall 2020. However, covid-19 delayed this implementation. The new hope is to conduct the survey in fall of 2021. The vessel is contracted and sea trials have begun. 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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Inter-Reef Movement of Yelloweye Rockfish. Ongoing.

Yelloweye Rockfish, *Sebastes ruberrimus*, continue to constrain catch of multiple healthy shelf stocks. One tool that has been used to manage the take of Yelloweye Rockfish is spatial area management through the establishment of places like Yelloweye Rockfish Conservation Areas. A key aspect of effective spatial fisheries management is an understanding of population connectivity. Highly migratory species ultimately may not receive as much protection from spatial closures if they migrate out of closed areas into fished areas. While many rockfish species characteristically have small home ranges making them effective candidates for spatial fisheries management, more data are needed for Yelloweye Rockfish. To answer this question, the ODFW Marine Fisheries Research Project used standard acoustic telemetry techniques, tagged Yelloweye Rockfish in 2005, 2012 and 2013 to understand home range size (Rankin 2019). In all of these studies, the researchers found that some Yelloweye remained in the acoustic array at Stonewall Bank and had a small home range while others left only to return 6+ months later. They also found that some individuals moved up into the water column for a few hours each day before descending back to the bottom. The goal of the proposed project is to understand 1) where do these other Yelloweye Rockfish travel 2) to ascertain if only certain sexes or sizes of fish make these perceived large scale movements and 3) understand the daily movement dynamics of the species.

While standard acoustic telemetry methods often work well for species with small home ranges they are not effective for species that make large movements. Further, standard passive tags aren't effective when a species is not actively targeted in fisheries. Pop-up satellite tags are an effective tool for this kind of study and have been proven to be effective at monitoring the movement of Rockfish (Rodgveller et al. 2017). We propose to use a chartered fishing boat (paid for with dedicated research funds) to collect Yelloweye Rockfish at Stonewall Bank using hook and line gear. A small fin clip will be collected from the fish to provide both population genetics and sex data. These fish will then be recompressed in barrels for 24 hours on the seafloor. Doing so minimizes the effects of barotrauma on the fish during subsequent tagging. After 24 hours the fish will be recovered, tagged with Desert Star SeaTag-GEO tags and released. Tags will be set to release after 6 months at which point they broadcast their data to a satellite and back to the office. When tags indicate they have popped off the fish we will also go out on a boat and attempt to recover the tag using a directional listening device in order to hopefully obtain the much higher resolution data only located on the tag. Regardless which data we use, these data will provide, at minimum, location data where the tag popped off (ideally more) and extensive data on the daily movement dynamics of the fish. These data will provide insight into the inter-reef movement of this important constraining species as well as insight into the daily behavior of the species.

The tags for this project have been purchased. We are working with the state of Oregon and Argos to allow us to retrieve the data from their website. The vessel to tag the fish is contracted and we have the LOA from NOAA.

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Susceptibility of five species of rockfish to hydroacoustic and bottom trawl survey gears inferred from high resolution behavioral data. In review.

Fisheries independent surveys are an important data input for stock assessments. However, these surveys are expensive to conduct and require precise, well thought out planning to be effective. Although the amount of money allocated to a survey is often dictated by factors beyond the control of the survey development team, surveys must incorporate their understanding of the biology of the focal species or species group into the survey design. Acoustic telemetry data can provide a high-resolution dataset to answer some of these questions. In this study, we reanalyze past acoustic telemetry studies on Black Rockfish (*Sebastes melanops)*, Copper Rockfish (*Sebastes caurinus*), Deacon Rockfish (*Sebastes diaconus*), Quillback Rockfish (*Sebastes maliger*) and Yelloweye Rockfish (*Sebastes ruberrimus*) in order to apply these data to future survey development. We combined the telemetry data with multibeam bathymetry data to 1) understand how the height off bottom of each species changed throughout a day and 2) simply define the habitat utilized by each species. We found, on average, Black, Deacon and Yelloweye Rockfish were all more than 1 m off bottom, whereas Copper and Quillback remained on, or near the bottom throughout the day. Deacon Rockfish were associated with the most rugose bottom, followed by Yelloweye. Black, Copper and Quillback all utilized low relief habitats. In general, we hypothesize that Black and Deacon Rockfish are good candidates for survey by hydroacoustics, whereas, Copper and Quillback appear to be good candidates for survey by bottom trawl. Surprisingly, due to the habitat they reside in, Yelloweye Rockfish were available to hydroacoustics, and likely not available to bottom trawl. However, Yelloweye Rockfish have variable behaviors, as reported by the original work, and as such, we are wary to suggest that hydroacoustics are an appropriate survey tool. We do, however, propose that Yelloweye potentially contribute to backscattering values of acoustic surveys conducted for midwater rockfish, and that bottom trawls are likely not an effective survey tool for Yelloweye Rockfish.

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Assessment

ODFW staff participated on three Stock Assessment Teams (STAT) for copper, quillback and vermilion rockfish federal stock assessments during 2020. Staff provided data and consulted with lead assessors on modeling decisions for all three assessments. Additionally, for vermilion rockfish, ODFW staff assisted federal assessors with base model development and sensitivities. ODFW will be continuing to assist with assessment documentation and participation in the Stock Assessment Review (STAR) panels for these species in 2021.

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Management

Federal Nearshore Management Activities

Additional access to nearshore areas was provided as part of the 2021-22 biennial harvest specifications and management measures. During the June 2020 meeting, the PFMC adopted multiple NT-RCA boundary changes in California and allowed for the use of hook and line gear between 30 and 40 fathoms in the area between 40° 10′ N. lat. and 46° 16′ N. lat. Pots/traps, bottom longline, and dinglebar gear were excluded north of 40° 10′ N. lat., due to potential habitat impacts in areas primarily accessed using hook and line gear (see Agenda Item F.1.a, Supplemental GMT Report 4, June 2020 for further details).

For the past two years, the midwater trawl gear type has increased to about 110,000 metric tons.

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Fixed-Gear Nearshore 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 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 fresh fish products.

Landings are regulated through bimonthly trip limits, minimum size limits, and annual harvest guidelines (HG). Landings from 2019 commercial nearshore fishing, logbook compliance, economic data, and biological data were published in the 2019 Commercial Nearshore Fishery Data Update (Rodomsky *et al.* 2020). Weekly updates on landings and model projections allow MRP staff to effectively manage the fishery in-season. In 2020 during COVID-19, overall effort started slow and landings across all species groups except for Other Nearshore Rockfish ran low. In period 3, initial in-season increases of 600 pounds were made to each Black Rockfish bimonthly trip limit for periods 4 through 6. After Black Rockfish catch remained low in period 4, an additional 600 pounds was added to Black Rockfish period 5 and 6 trip limits (1,200 pounds in total to those last two periods) to maximize fisher opportunity and HG attainment. Blue and Deacon Rockfish trip limits were not adjusted up as they do not limit landings. Other Nearshore Rockfish landings ran high late into period 5 so the period 6 trip limit was lowered to 45 pounds and a daily trip limit of 15 pounds was implemented 9/23 to slow landings. In retrospect, this last decrease was too restrictive. End of the year attainment of the Black Rockfish state HG was 82.2%, was 90.5% for Other Nearshore Rockfish and was 29.8% for Blue and Deacon Rockfish. For Cabezon and Greenling management specifics see the Other Groundfish section.

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Federal Non-nearshore Commercial Fishery

During 2020, trip limits were increased in both the limited entry fixed gear and open access fisheries north of 40º 10' N lat. Limited entry fixed gear (LEFG) limits of minor slope rockfish & darkblotched rockfish were raised from 6,000 lbs. to 8,000 lbs. per two months. LEFG limits of minor shelf rockfish, shortbelly and widow rockfish increased to 800 lbs. per month from 200 lbs. per month. Yellowtail rockfish limits in the LEFG program increased to 3,000 lbs. per month from 1,000 lbs. The Canary rockfish LEFG limit increased from 300 lbs. to 3,000 lbs. every 2 months.

Open access (OA) trip limits were also increased for many species. Minor slope rockfish and darkblotched rockfish increased from 500 lbs. to 1,000 lbs. OA trip limits increased from 200 lbs to 800 lbs. for minor shelf rockfish, shortbelly and widow Rockfish. Yellowtail and canary rockfish also increased, from 500 to 1,500 lbs. per month for yellowtail and an increase to 1,000 lbs from 300 lbs. every two months for canary. These trip limit adjustments do not change the projected impacts compared to impacts evaluated in the PFMC's 2019-2020 groundfish harvest specifications analysis, because that analysis assumed the entire ACL would be harvested whereas the projected impacts are still below the ACL even with the increased trip limits.

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Recreational Fishery

Black rockfish (*Sebastes melanops*) remains the dominant species caught in the recreational ocean boat fishery; however the black rockfish harvest limit continued to decrease by 2-5% through 2020 due to the most recent stock assessment (2015) and applying the time varying sigma to the output of that assessment. With blue and deacon rockfish taken out of the nearshore rockfish complex beginning in 2019, the harvest guideline for that complex was greatly reduced. The retention of yelloweye rockfish (*S. ruberrimus*) was prohibited year-round, as it has been since the early 2000s. In order to remain within the yelloweye rockfish impact cap (via discard mortality), the recreational groundfish fishery was restricted pre-season to inside of 40 fathoms from June 1 to August 31. Black rockfish and nearshore rockfish species have become as much of a limiting factor as yelloweye rockfish. The fishery season structure and regulations, such as bag limits (species specific sub-bag limits) and depth restrictions, attempted to balance impacts, as what reduces impacts on one species may increase impacts to the other. Even with those efforts the nearshore rockfish complex harvest guideline was reached in late July, at which time ODFW required anglers to release those species. 2020 was another high effort year, even with COVID-19 closures and restrictions it had the third highest effort, with just over 103,000 bottomfish angler trips.

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Outreach

ODFW staff did have to reduce in person outreach activities in 2020 due to COVID restrictions and safety protocols. However, we continued to work with anglers via webinars, and online materials.

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 17,000 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 continue to be successful. Prior to the campaign, fewer than 40 percent of anglers reported using descending devices. Since the campaign began, the percentage of anglers reporting use 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 angler reported usage rates to approximately 95 percent in most ports and months. Additional outreach efforts include: videos online that show fish successfully swimming away after release with a device, rockfish barotrauma flyers, and videos on how to use the various descending devices. 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. ODFW staff are planning to continue the outreach and education efforts.

Additionally, ODFW has been educating anglers on a relatively 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 bloat above the hooks, to keep the line vertical in the water column. ODFW has produced informational handouts with the gear specifics, species allowed, and other associated regulations.

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Thornyheads

Nothing to report in 2020.

Sablefish

Management

Sablefish is the most economically valuable species in the West Coast bottom trawl and fixed gear fisheries. Sablefish prices were depressed due to market saturation before COVID-19, and market perturbations caused by the pandemic are leading to even more disruption. In 2020, the PFMC recommended and NMFS implemented an emergency rule to temporarily allow an extension in the primary sablefish tier fishery from October 31, 2020 to December 31, 2020. The issue of "gear-switching", or using non-trawl gear to harvest sablefish in the trawl individual fishing quota (IFQ) fishery continues to be prioritized by the PFMC, which will consider an analysis of a range of maximum gear switching levels at its April 2021 meeting. The gear-switching issue arose during the first 5-year review of the trawl IFQ program, and is centered on concerns by trawl fishermen that fixed gear participation has led to higher sablefish quota lease rates and reduced their ability to catch co-occurring stocks. Gear-switching participants are concerned that limits adopted now could undermine significant investments already made to fish in the IFQ fishery with non-trawl gear, under a legal provision of the program. There has also been an initiation of a periodic review of the Limited Entry Fixed Gear Permit Stacking Program that will continue into the future (https://www.pcouncil.org/documents/2020/08/d-2-attachment-2-program-review-planning-limited-entry-fixed-gear-permit-stacking.pdf/). The introductory workshop in a Management Strategy Evaluation (MSE) process for sablefish is scheduled for April 27-28, 2021 (https://www.pcouncil.org/events/sablefish-management-strategy-evaluation-workshop-to-be-held-online-april-27-28-2021/).

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Lingcod

Assessment

ODFW staff participated in the STAT for the federal lingcod stock assessment. Staff provided data and advice on modeling decisions. Major model development is planned for spring 2021. Additionally, ODFW staff provided substantial coordination and logistical support to aging efforts for lingcod in 2020 and continuing into 2021. Commercial lingcod samples were sent to be aged at WDFW in 2020, and recreational lingcod samples were mounted and sent to NWFSC for aging in late 2020 and will continue into 2021.

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Management

Commercial Fishery

Trip limits increased for lingcod in both the limited entry fixed gear and open access fisheries North of 40º 10′ N lat. In the limited entry fleet trip limits were increased from 2,600 to 4,000 lbs. every 2 months. In the open access fleet trip limits were increased from 1,200 lbs. to 2,000 lbs. per month. In 2020, the commercial fleets in Oregon landed 294.4 metric tons of lingcod, which was down from 397.1 mt in 2019, likely due to market limits and other factors related to the COVID-19 pandemic.

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Recreational Fishery

Lingcod (*Ophiodon elongates*) is a popular target in the Oregon recreational bottomfish fishery. Many anglers especially like to target lingcod during the months when the fishery is open to all-depths, as larger lingcod are thought to occur in deeper offshore waters. Lingcod have their own daily bag limit (2 per angler per day), separate from the other bottomfish. There is also a minimum size limit of 22 inches. In 2020, anglers landed just over 53,000 lingcod, totaling 162 mt.

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Atka Mackerel

Nothing to report in 2020.

Pacific Halibut

Management

Oregon's recreational fishery for Pacific halibut continues to be a popular, high profile fishery requiring International Pacific Halibut Commission (IPHC), federal, and state technical and management considerations. In 2020, the recommended an annual catch limit for Area 2A (Oregon, Washington, and California) was 1.5 million pounds which the IPHC Commissioners indicated would be in place for four years, until 2022. The recreational fishery for Pacific halibut is managed under three subareas with a combination of all-depth and nearshore quotas. In 2020, the Columbia River subarea quota was 18,494 pounds, the Central coast subarea quota was 271,592 pounds, and the Southern coast subarea quota, was 8,000 pounds. Landings in the sport Pacific halibut fisheries are monitored weekly for tracking landings versus catch limits. The majority of halibut continue to be landed in the central coast subarea, with the greatest landings in Newport followed by Garibaldi or Pacific City. Total 2020 recreational landings in the Central coast subarea was 157,887 pounds, 58 percent of the quota. Landings in the Southern subarea were 7,381 pounds (92% of the quota) and in the Columbia River subarea, landings were 5,619 pounds (50 %). Fishing in the Central Coast Subarea was restricted by weather for part of May, June, and much of August and September. Due to COVID restrictions, the Columbia River Fishery did not open until August, rather than the usual early May. Anglers reported a lot of small fish, in the 24-28 inch size range, many of which were released at sea. The average size of landed fish in 2020 was down by approximately 4 pounds net weight from 2019. This low average size was the main contributor to the low quota attainment, as there were more fish landed in 2020 than in previous years, just less poundage.

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Other Groundfish

Kelp Greenling

Management – Commercial Fishery

The commercial Greenling harvest guideline (HG) for 2020 was 118.3 metric tons. Greenling are targeted by very few commercial fishers regardless of the relatively high HG and price per pound paid for live fish. The bimonthly trip limit in 2020 was 1,000 pounds per period set after considering public input, markets and local depletion concerns. Greenling landings ended the year at 10.1% of the HG attained. Barring changes in targeted effort catch rates and markets, Greenling attainment is likely to continue to remain low.

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Cabezon
Management – Commercial Fishery
The commercial harvest guideline (HG) for Cabezon in 2020 was again 30.2 metric tons. Cabezon catch in the fishery ran low in 2020 for first time a few years. To increase opportunity and attainment, ODFW doubled the initial 2020 bimonthly trip limit to 2,000 pounds for periods 5 and 6. Final commercial fishery attainment was 67.3% after in-season adjustments.

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Management – Recreational Fishery
Cabezon (*Scorpaenichthys marmoratus*) is another popular target for some recreational bottomfish anglers. Cabezon have a one-fish sub-bag limit as part of the general marine bag limit, and a 16 inch minimum size, additionally the season does not open until July 1. The cabezon harvest guideline has remained relatively constant over the last ten years. Even with the average angler catching less than one per day, the quota goes very quickly. In each of the last several years, the quota has been met in six weeks, at which time ODFW prohibits retention. Fishing is prohibited January through June as that is the time that cabezon generally spawn and nest guard. Prohibiting fishing during those months, is intended to protect cabezon during that time.

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Ecosystem Studies

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. 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 5 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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Untrawlable habitat survey in partnership with NWFSC and AFSC

Survey biologists with NOAA Fisheries in Seattle and Newport are interested in partnering with the commercial and sportfishing industries in the Pacific Northwest to improve stock assessments for lingcod and shelf rockfish. We are planning to charter one commercial and one sportfishing vessel to conduct a study comparing the effectiveness of four different methods for collecting abundance and biological data for groundfish species found in rocky, high-relief habitats. The four methods are:

- Hook and line gear deployed by rod and reel
- Stereo video imagery from a small, stationary lander
- Stereo still camera imagery from a semi-moored housing
- Environmental DNA (eDNA) collected from water samples near the seafloor

The research was conducted from late October –early November in 2019 off the Oregon coast between Cascade Head and Heceta Bank in a depth range of 20 –125 fathoms and will target a variety of banks, reefs, and other rocky habitats. Results from this study will help determine the most effective and efficient gear to use in designing a larger, more comprehensive monitoring program for groundfish in the untrawlable habitats of the Pacific Northwest. Sampling was conducted in fall of 2019 and video review is undergoing.

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Aging Activity

Production Aging

In 2020, emphasis was placed on species up for assessment in 2021. Initially, it was believed that there might be a full assessment on Oregon Copper Rockfish, so ODFW produced break-and-burn age estimates for 363 Copper Rockfish from the commercial fishery (73 tested; captured from 2002-2019) and 2298 from the recreational fishery (459 tested, captured from 2005-2019). These ages ended up being used to inform an externally estimated growth curve for a data-moderate assessment.

Due to some uncertainty over the next species to focus on for 2021 assessments, ODFW moved to aging Black Rockfish in preparation for a 2023 assessment. Break-and-burn age estimates were generated for 648 Black Rockfish (0 tested) captured in the 2017 commercial fishery.

In September 2020, ODFW began generating ages for a full 2021 Vermilion Rockfish assessment. To that end, staff produced break-and-burn estimates for 896 Vermilion Rockfish from the commercial fishery (180 tested; captured from 2004-2020) and 621 from the recreational fishery (0 tested; captured from 2009-2019). Aging of samples from the recreational fishery would continue into 2021.

Aging activities affected by COVID-19 in 2020 included the preparation of Lingcod fin ray sections. Typically, agers from PSMFC cut and mount fin ray sections from our recreational catch. Standard practice requires the use of a fume hood for mounting the sections to slides with Cytoseal. Due to COVID-19, PSMFC agers were not able to access their lab, so sections were cut by ODFW personnel and affixed to slides using Crystalbond (a non-toxic thermoplastic resin), and nail polish was used to elucidate annual marks. This method produced clear sections that were able to be read and served as a good alternative to the standard mounting method described in the CARE aging manual.

Age Validation

The 2015 stock assessment for California, Oregon, and Washington stocks of Black Rockfish identified the need for validation and verification of annuli as a recommended avenue for research in order to improve upon future assessments. In May 2020 we began a collaborative study with the Canadian Centre for Isotopic Analysis at the University of Alberta to validate annuli on otoliths of Black Rockfish (a semi-pelagic rockfish), Cabezon (a difficult-to-age sculpin), and Copper Rockfish (a demersal rockfish) using secondary ion mass spectroscopy to measure oxygen isotope ratios in otoliths over the lifespan of the fish. Because an otolith is acellular, metabolically inert, and grows throughout the life of the fish, any elements or compounds accreted onto its surface are permanently retained. Otoliths therefore contain a complete record of the temperature and chemical composition of the ambient water a fish experienced over its lifespan. A known inverse relationship exists between water temperature and $\delta^{18}O$, so our goal is to relate peaks in the $\delta^{18}O$ signal (corresponding to cold water temperatures) to annual marks on the otolith.

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Remotely operated vehicle (ROV) video survey methodology review for nearshore groundfish abundance estimation

Since 2000, ODFW's Marine Resources Program has conducted remotely operated vehicle (ROV) video transect surveys of untrawlable nearshore rocky reefs to assess the distribution and density of demersal fishes and invertebrates as well as their associated benthic habitat structures. Meanwhile, the Research and Data Needs sections of many recent stock assessments for nearshore and other stocks have included recommendations for a fishery-independent survey in untrawlable habitats. Reports by Stock Assessment Review Panels and the Center for Independent Experts have echoed these recommendations, noting the need to adequately survey populations (or portions thereof) that are not available to the current survey sampling gear in order to understand scale and trends in abundance, and to avoid reliance on fishery-dependent Catch Per Unit Effort (CPUE) indices. To date, data informing the scale of nearshore population sizes is lacking.

In 2020, ODFW and California's DFW jointly participated in a formal methodology review of ROV-based fishery-independent visual surveys for nearshore groundfish species conducted by the Pacific Fishery Management Council's Scientific and Statistical Committee (SSC). The in-person review was conducted over three days in February 2020 in Santa Cruz, CA. The purpose of the review was to determine whether results produced using the data acquisition, compilation, and analysis methods used independently by each of the two states' agencies can be used in future stock assessment models. The data and methods evaluated focus on providing fishery-independent estimates of total abundance for select coastal benthic fish species, with the primary purpose of informing scale in stock assessments. For species with insufficient data to generate robust estimates of absolute abundance, these methods may still produce useful indices of relative abundance. Following positive recommendations from the SSC and review by the full PFMC, in September 2020 the ROV data and methods for both states were endorsed for use by stock assessors for a select list of species, subject to the considerations identified by the SSC for appropriate data usage.

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Publications

Vaux, F., Rasmuson, L., Kautzi, L., Rankin, P., Blume, M., Lawrence, K., Bohn, S., O'Malley, K. 2019. Sex matters: Otolith shape and genomic variation in Deacon Rockfish (*Sebastes diaconus*). Evolutionary Applications 9: 13153-13173

Washington Department of Fish and Wildlife Contribution to the 2021 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2020-April 2021

April 20th-21st, 2021

Edited by:
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Contributions by:
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Contents

I. 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. Two primary work units deal with marine fish research within the Fish Management Division. The Toxics-focused Biological Observation System for the Salish Sea (TBiOS) (formerly Puget Sound Ecosystem Monitoring Program or PSEMP) conducts considerable marine forage fish and groundfish research in Puget Sound, but focuses on the accumulation of toxic contaminants in these species. The unit is led by Jim West and also consists of Sandy O'Neill, Dr. Louisa Harding, Mariko Langness, and Rob Fisk. A second and larger work unit within the Fish Management Division is the Marine Fish Science (MFS) Unit, which itself is broadly separated into three groups that deal with distinct geographic regions and/or species assemblages (Puget Sound Groundfish, Marine Forage Fish, and Coastal Marine Fish), though there is some overlap of senior staff. The entire MFS Unit is overseen by Dr. Theresa Tsou, while Lisa Hillier oversees the Unit budget, manages the Washington Conservation Corps (WCC) survey group, and assists with stock assessments both on the coast and in Puget Sound. Dr. Dayv Lowry was the lead of the Puget Sound Groundfish Unit until September 2020, but the position is currently vacant; Phill Dionne leads statewide marine forage fish research and management; and Lorna Wargo leads the Coastal Unit for groundfish, coastal pelagic species, and shrimp management, fishery monitoring, and research.

Puget Sound Marine Fish Science (PSMFS) Unit ~ Groundfish

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. 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.

In addition to Dr. Dayv Lowry (lead, until Sept. 2020), staff of the PSMFS Unit during the reporting period included Robert Pacunski, Larry LeClair, Jennifer Blaine, Andrea Hennings, Mark Millard, Ian Craick, and Katie Kennedy. Since December of 2016 and until his departure from WDFW, Dr. Lowry 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. In 2018 Lisa Hillier was added to the NPFMC Groundfish Plan Teams for both the Bering Sea and Gulf of Alaska.

Marine Forage Fish (MFF) Unit

Forage fish in Washington are managed under the auspices of the Forage Fish Management Plan (Bargmann 1998) and managed by members of the statewide Marine Forage Fish (MFF) Unit, which works primarily in Puget Sound. Together with Phill Dionne, the MFF Unit is composed of Dr. Todd Sandell, Adam Lindquist, Patrick Biondo, Kate Olson, Eric Bruestle, Aidan Coyle (until Sept. 2020), and Stephanie Lewis. 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).

Primary Contacts – Puget Sound, Forage Fish, and TBiOS:
Groundfish Monitoring, Research, and Assessment – *Contact: Robert (Bob) Pacunski 425-379-2314, robert.pacunski@dfw.wa.gov; Dr. Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov.*
Forage Fish Stock Assessment and Research – *Contact: Phill Dionne 360-902-2641, phillip.dionne@dfw.wa.gov; Dr. Todd Sandell 425- 379-2310, todd.sandell@dfw.wa.gov.*
Toxics-focused Biological Observation System for the Salish Sea (TBiOS) (formerly Puget Sound Ecosystem Monitoring Program or PSEMP) – *Contact: Dr. Jim West 360-902-2842, james.west@dfw.wa.gov).*
For complete staff contact information see section VIII of this report.

Coastal Marine Fish Science (CMFS) Unit

In addition to Lorna Wargo, staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Rob Davis, Donna Downs, Kristen Hinton, Jamie Fuller, Michael Sinclair, and Tim Zepplin. Unit tasks are supported through a combination of state general and federal funds. Long-standing activities of the unit include the assessment of groundfish populations off the Washington coast, the monitoring of groundfish commercial and recreational landings, coastal rockfish research projects, and the monitoring and management of ocean pink shrimp. In the last two years, the coastal unit has expanded to also include the monitoring and management of coastal pelagic species (CPS), including finfish and squid species, through collaborative research projects with federal and industry partners.

Groundfish and CPS on the Washington coast are subject to state regulatory and policy authority as well as to federal management under the Magnuson-Stevens Fishery Conservation and Management Act and the PFMC's fishery management plans for groundfish and CPS. The Department's Forage Fish Management Plan also guides management of coastal fishery resources in state waters. The

MFS Unit contributes fishery policy and scientific support for federal West Coast groundfish and CPS management via participation on the Coastal Pelagic Species Management Team (CPSMT, Lorna Wargo) and the Scientific and Statistical Committee (SSC, Dr. Theresa Tsou), of the Pacific Fishery Management Council (PFMC). Landings and fishery management descriptions for PFMC are summarized annually in the Stock Assessment and Fishery Evaluation (SAFE) documents.

Additional West Coast fishery management support is provided by the Intergovernmental Ocean Policy Unit, which consists of a currently vacant lead (previously Michele Culver), Corey Niles, Heather Hall, Whitney Roberts, and Victoria Knorr. Whitney also serves on the PFMC's Groundfish Management Team (GMT), as does Erica Crust of the Fish Program's Ocean Sampling Program. Further support is provided to the PFMC by Randi Thurston, who serves on the Habitat Committee.

Primary Contacts – Coastal MFS Unit:
Groundfish Management, Monitoring, Research, and Assessment – *Contact: Dr. Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Lorna Wargo 360- 249-1221 lorna.wargo@dfw.wa.gov; Corey Niles, 360-902-2733, corey.niles@dfw.wa.gov (Coastal Marine Policy Lead).*
Coastal Pelagic Species /Forage Fish Management, Monitoring, Research, and Assessment – *Contact: Lorna Wargo 360- 249-1221 lorna.wargo@dfw.wa.gov; Phill Dionne 360-902-2641, phillip.dionne@dfw.wa.gov.*
For complete staff contact information see section VIII of this report.

II. Surveys

A. 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 the mouth of the Sekiu River in the Strait of Juan de Fuca – that have provided invaluable long-term, fisheries-independent indicators of population abundance for benthic organisms 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; Blaine et al. 2020). Surveys in 1987, 1989, and 1991 were semi-stratified random surveys of the majority of Puget Sound. From 1994-97 and 2000-07, surveys were annual, stratified-random surveys focusing on individual sub-basins (WDFW unpublished data; Palsson et al. 1998; Blaine et al. 2020). 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 key species, size distribution data and various biological samples are collected from a subset of individuals from each sampling location. 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). A total of 51 fixed index stations throughout the study area are sampled each spring (late April-early June) (Figure 1).

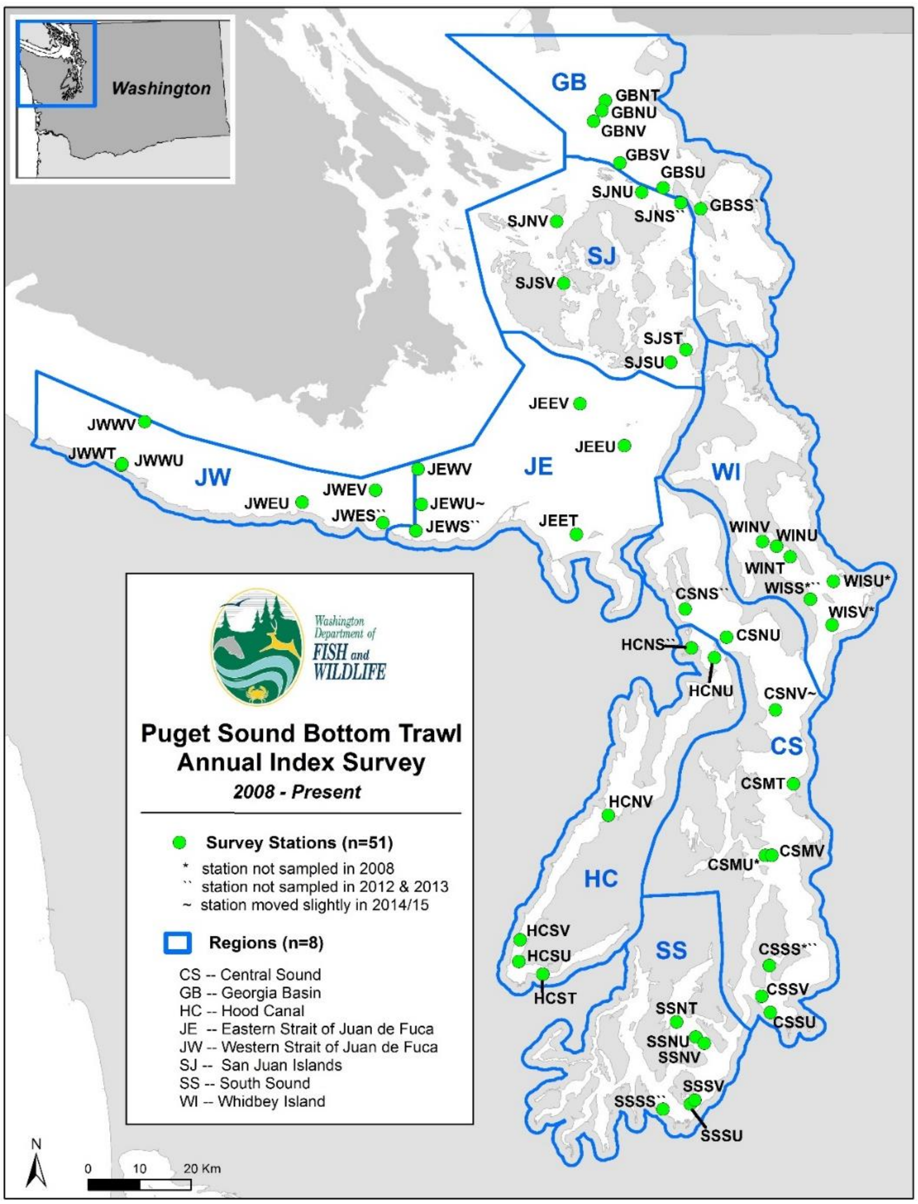

Figure 1. Trawl site locations for the index survey, sampled 2008-19.

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 were moved slightly to accommodate concerns raised by fiber-optic cable companies.

The trawling procedure of the survey has remained largely consistent throughout the historical survey period 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.

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 a live data feed regarding the net's depth, proximity to the bottom, and opening height.

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. Data from the bottom trawl survey will also become a cornerstone of the Puget Sound Partnership's new vital sign indicator "groundfish and benthic invertebrates."

The 2020 Index bottom trawl survey was unfortunately cancelled due to the COVID-19 pandemic, but the 2021 survey is scheduled to occur April 19-May 14, 2021. *For more information about the bottom trawl survey, please contact: Jen Blaine (Jennifer.blaine@dfw.wa.gov).*

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B. Annual Pacific Herring Assessment in Puget Sound

Consistent with previous years, Pacific herring stocks in Puget Sound (southern Salish Sea) were assessed by WDFW staff through spawn deposition field surveys from January through June using the established methods of Stick et al. (2014) and Sandell et al. (2019). WDFW staff based in the Olympia, Mill Creek, and Port Townsend offices attempted 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, fecundity, etc. of the herring stocks). Stock biomass assessment activities for the 2021 spawning season are in progress.

WDFW recognizes 21 different herring stocks in Puget Sound and two coastal stocks (Willapa Bay and Grays Harbor), based primarily on the timing and location of spawning activity. Historically there were three distinct genetic groupings (Cherry Point, Squaxin Pass, and the "all other stocks" complex). However, recent research focusing on SNP sequencing has determined that, at present, only the Cherry Point and Elliott Bay stocks are unique; the remaining stocks now comprise the "Other Stocks" grouping (Petrou et al., 2021). Within this "Other Stocks" grouping, research has identified differences in stock timings that include an "Early Winter" (Jan-Feb), "Late Winter" (Feb-March), and "Spring" (April and later) stock groupings. Only five of the stocks have been sequenced to date, and we await further genetic analysis results from our collaborators at the University of Washington (Drs. Lorenz Hauser and Eleni Petrou).

In 2020, spawn deposition field surveys began on January 2nd but were suspended on March 16th due to the COVID-19 pandemic; boat-based work resumed on May 18th, and a total of 134 surveys were completed (as opposed to 225 in 2019). Surveys included the primary spawning areas of 12 of the 21 Puget Sound herring stocks (nine stocks had inadequate or no coverage). In spite of this, 2020 was a dramatic year for herring in Washington state, with an overall increase in estimated spawning biomass (ESB) to 18,559 metric tons, the highest since the 1980s and clearly an underestimate given the limited sampling effort (in 2019, the total ESB was 7,891 mt). The biggest increases occurred at Purdy (884 mt; South Sound), Quilcene Bay (7,118 mt; Hood Canal) and Port Orchard-Port Madison (7,077 mt; Central Basin); these were the largest spawning events ever recorded at these sites. However, the genetically distinct, late-spawning Cherry Point stock ESB was 274 mt in 2020, down from 290 mt in 2019, though surveys there were incomplete.

Coastal surveys were heavily impacted by the pandemic with very limited coverage of Willapa Bay and Grays Harbor. Only one survey was conducted in Grays Harbor on 2/5/20, with no spawn detected, and no surveys were carried out in Willapa Bay. In general, herring spawning biomass for these areas is relatively small compared that of Puget Sound.

Given the fluidity of our genetic stock groupings, we now consider the basin of spawning activity (Figure 2) as the preferred method of biomass reporting; Figure 3 shows the marked shift from a broadly based spawn deposition (heaviest in the North) towards the dominance of the few stocks mentioned above. Overall this is excellent news for the southern Salish Sea and bodes well for the higher trophic levels, including ESA-listed fish, seabirds, and marine mammals, that depend on herring for food, but the declines in certain regions, particularly South Puget Sound, remain a cause for concern.

For more information about the Pacific Herring assessment, please contact: Todd Sandell (todd.sandell@dfw.wa.gov).

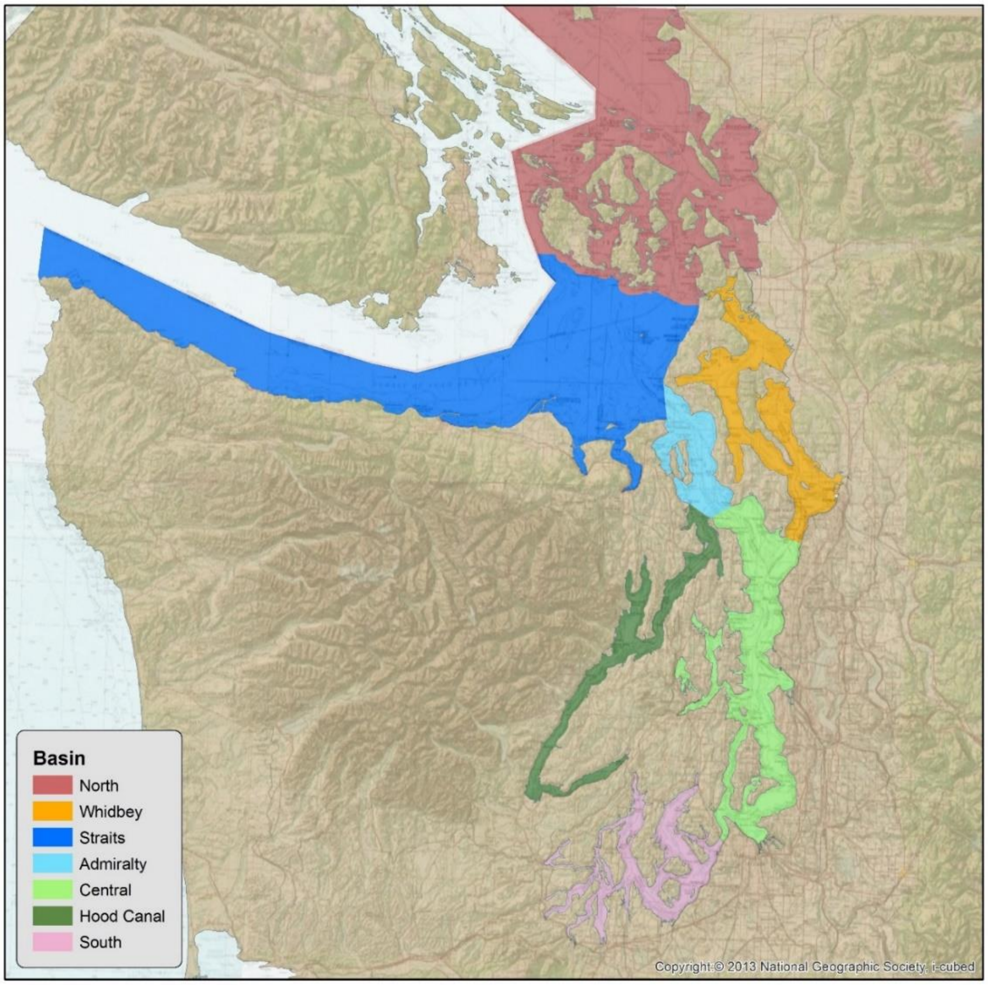

Figure 2: Basin map for herring regions in the southern Salish Sea

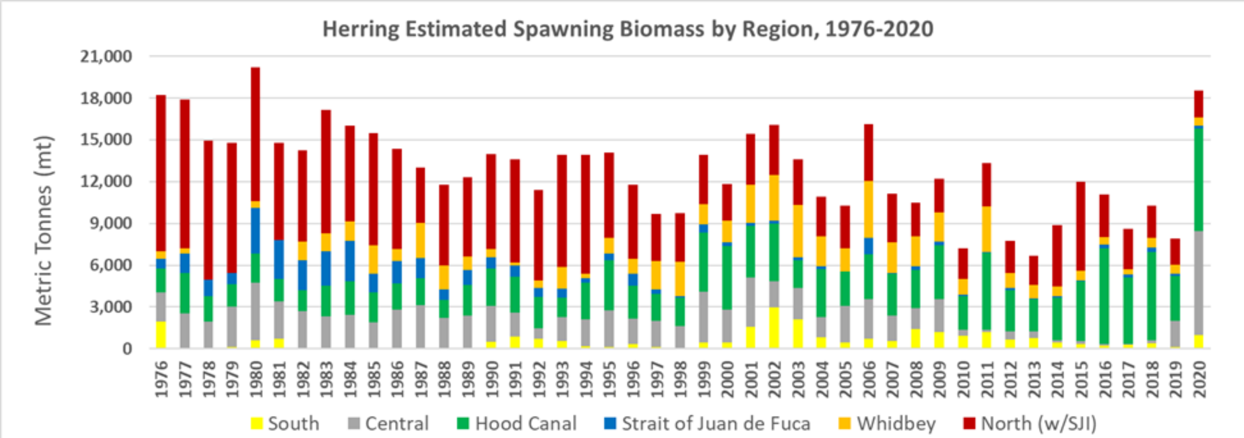

Figure 3. Pacific Herring spawning biomass estimates by Basin in the southern Salish Sea

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Stick, K., A. Lindquist, and D. Lowry. 2014. 2012 Washington State herring stock status report. Washington Department of Fish and Wildlife, SS FPA 14-09. 106 p.

C. 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.

A standardized rod-and-reel survey designed to describe relative changes in population abundances of nearshore rockfish species and other associated groundfish species along the entire Washington Coast over time was implemented in 2018. 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. This effort was continued in 2019 with adjustments to survey methods addressing some standardization concerns.

In the spring of 2019, 125 specific GPS coordinates located at rocky reefs along the Washington coast were chosen as unique survey index stations for the Black Rockfish Survey. Stations were chosen roughly relative to the amount of known rockfish habitat by Marine Area and depth, and to include both marginal and superior habitat locations based on catch rates from previous WDFW rod-and-reel surveys. The coordinates of seven of these stations were adjusted in the fall of 2019 to avoid hazards and to align spring and fall stations in close proximity. Fishing locations span 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 include all coastal Marine Areas. Location depths are limited to under 40 fathoms, which includes the extent of the typical depth range for Black Rockfish and all locations where the WDFW rod-and-reel surveys have previously encountered Black Rockfish. All 125 of these fixed stations were scheduled to be surveyed in the spring of 2020 at the GPS locations defined in 2019.

The Black Rockfish spring survey is scheduled annually in March, April, and May. The start date for this survey is typically chosen as the day after the Washington recreational groundfish season opens to avoid any possible differences in catch rates due to varying fishing pressure before and after the season. To alleviate vessel availability constraints in the spring of 2020, however, one charter day was fulfilled on March 9th, before the season opened, at remote locations that are unlikely to be fished recreationally at any time during the survey season. Due to restrictions put in place to mitigate the COVID-19 pandemic, 2020 survey operations were terminated on March 23. Two stations in Marine Area 1 and 44 stations in Marine Area 2 were surveyed before the cessation of operations (**Error! Reference source not found.**4). The remaining 22 stations in Marine Area 2 and all 57 stations located on the northern Washington coast (Marine Areas 3 and 4) were not surveyed.

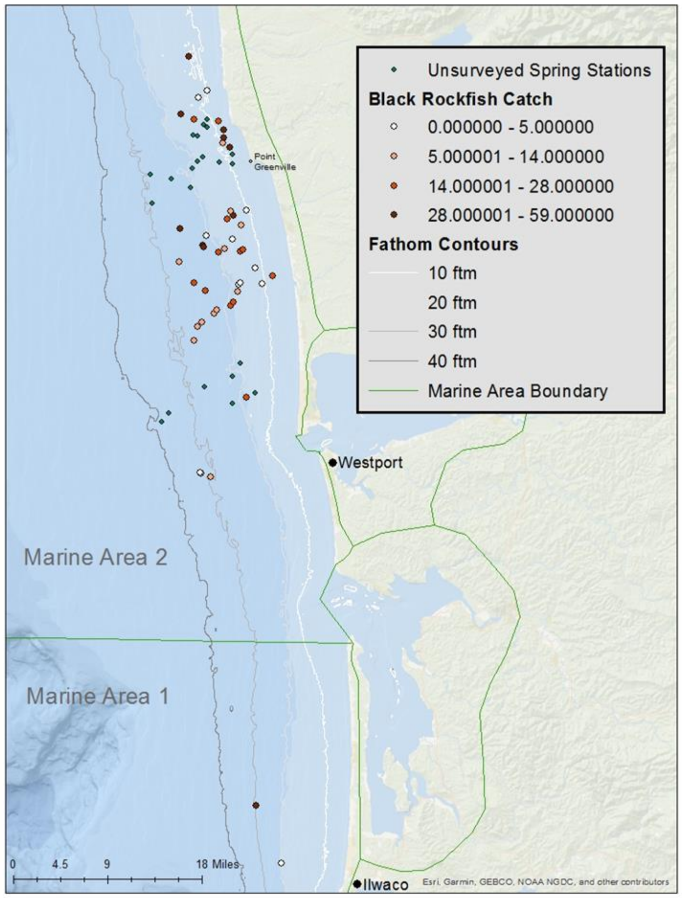

Figure 4. Spring index stations in Marine Areas 1 and 2 with the associated total catch of Black Rockfish in the spring of 2020 by number of individuals. "Unsurveyed Spring Stations" were scheduled but not surveyed in 2020.

Survey operations are conducted on recreational charter vessels staffed with five hired anglers and three to four WDFW scientific staff. All contracted skippers have at least eight years of professional captain experience fishing for rockfish on the Washington Coast, and each angler deployed has over 10 years of experience fishing for rockfish on the Washington Coast. Fishing rods, reels, and terminal tackle are kept consistent across all stations surveyed. Terminal tackle consists 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 is chosen by the vessel's captain after taking into consideration depth and weather conditions but are kept consistent among anglers for each drift.

All fishing effort is conducted during daylight hours and charter days typically range from 8-11 hours. Cells to be visited on any given charter day are chosen before leaving port by the lead biologist after consultation with the vessel's captain and considering ocean conditions. Fishing effort at each station consists of four eight-minute fishing drifts that began within 50 yards of the station's GPS position. At each station, captains take time to scout for fish aggregations and hard bottom/high relief areas near the station coordinates before setting up each drift. A fishing "drift" is defined as any consecutive time span that is spent fishing, beginning when the first angler's hook enters the water and ending when the last angler's hook leaves the water for any reason. Depending on weather conditions, the vessel either drifts or anchors over the target area, but vessel disposition is kept constant for each individual station. For recordkeeping purposes, each anchored fishing event is recorded as a drift.

Five anglers fish for the total fishing time at each station surveyed, and the same five anglers fish all stations each charter day. Before fishing begins at each survey station, anglers are randomly assigned to a standard fishing position on the vessel for all drifts at that station. These standard angler fishing positions are established on either the port or starboard side of the vessel, depending on the captain's preference, and are evenly spread out along the vessel from bow to stern.

For each drift, anglers start and end fishing at the same time but are allowed to retrieve their gear as many times as necessary during the drift to land catch or maintain gear. Individual angler times per drift are recorded as the total time hooks are in the water, which excludes any time that fishing gear is out of the water either to land a fish or work on the gear. Anglers are allowed to fish anywhere in the water column that they expected to catch the most fish, and captains are encouraged to describe the depths of fish aggregations to them.

Effort information collection includes station number, GPS location of the start and end of each drift, depth, disposition of vessel (anchored or drifting), drift speed and direction, number of anglers, total fishing time per station, and terminal tackle gear type. The intensity and direction of weather conditions including tide, wind, and swell are also recorded. Fishing time, catch by species, gear loss, and fishing depth (benthic or pelagic) are recorded by angler. Catch is identified to species, measured (fork length), and scanned for previously implanted tags. Fish that are not chosen for age structure sampling are released at capture location, with a descending device when necessary. Released Yelloweye Rockfish are tagged with both an internal PIT tag and an external Floy tag. Released China, Copper, Deacon, Quillback, Tiger, and Vermilion Rockfish, as well as Cabezon and Kelp Greenling, are tagged with a Floy tag and released.

Over 8 charter days in the spring of 2020, 46 stations were successfully surveyed in Marine Areas 1 and 2 before survey operations were canceled due to state and agency safety restrictions. Recreational fishing effort in the survey area, which is typically significant over the survey season, was abnormally low from self-imposed precautionary measures including the cancelation of all Westport charter trips after March 16th and many private anglers opting to stay home. Five to seven stations were surveyed each charter day dependent on the distance of target locations from port. Average drift speeds at each station ranged from 0 to .9 knots and all stations were fished while drifting. Total angler rod hours at surveyed stations ranged from 2.5 to 2.9.

Most stations that typically produce highly diverse catch are found in Marine Areas 3 and 4, which were not surveyed in 2020. Because of this, and the overall limited total fishing effort, the diversity of catch in the 2020 Black Rockfish survey was abnormally low. Seven different species were still encountered (**Error! Reference source not found.**), with Black Rockfish the most predominant species captured across both Marine Areas (**Error! Reference source not found.**). Other high-catch species included Lingcod and Canary Rockfish.

Table 1. Catch by number of all species per Marine Area and depth bin in the 2020 spring survey.

Species	Marine Area 1	Maring Area 2				Grand Total
	21-30 Fathoms	0-10 Fathoms	11-20 Fathoms	21-30 Fathoms	31-40 Fathoms	
Black Rockfish	38	195	288	257	1	779
Brown Irish Lord					1	1
Canary Rockfish			1	8	27	36
Deacon Rockfish				2		2
Kelp Greenling		1				1
Lingcod		3	11	18	4	36
Yellowtail Rockfish				8	2	10
Grand Total	38	199	300	293	35	865

Favorable ocean conditions and the early spring timing of the Black Rockfish Survey allowed the completion of 36.8% of the scheduled index sites in 2020 before COVID-19 restrictions were put in place that effectively ended the survey. The limited data collected are a viable portion of this survey's time series and will be available to groundfish stock assessors. However, some of the particular constraints of the survey year should be considered when interpreting this year's data, including the restricted geographic coverage and the historic species compositions and catch rates of unsurveyed stations relative to stations completed in 2020. The 2021 Black Rockfish Survey is scheduled to begin on March 10th with no significant changes to survey methods or station locations.

For more information about the Black Rockfish survey, please contact: Rob Davis (Robert.davis@dfw.wa.gov).

D. Coastal Nearshore Demersal Groundfish Rod and Reel Survey

The Demersal Groundfish Survey component of WDFW's multispecies nearshore rod-and-reel survey efforts is conducted annually in the fall. This survey describes relative changes in population abundances of Washington's nearshore demersal groundfish species that are typically found individually or in small groups directly on or near rocky substrate. The target demersal species include China, Copper, Quillback, Tiger, Vermilion, and Yelloweye Rockfish, as well as Kelp Greenling and Cabezon.

The locations of the Demersal Groundfish Survey span the Washington Coastal Marine Areas 2, 3 and 4, in depths from subtidal to 40 fathoms. Marine Area 1 has little known habitat containing demersal species and is not included in this survey. Similar to the Black Rockfish Survey, “stations” consist of a single GPS position at the center of rocky substrate. Sixty-four fixed stations were selected for the Demersal Groundfish Survey in the fall of 2019. Based on catch rates from previous WDFW rod-and-reel surveys, stations were selected to include both marginal and prime habitat locations for each target demersal species. All of these fixed stations were scheduled to be surveyed in the fall of 2020 at the locations defined in 2019.

Methods of the fall survey are identical to those described in the spring Black Rockfish Survey with a few key methodology changes to better represent demersal species. These adjustments include not targeting schools of fish in the water column; restricting all angler fishing effort to on or near the bottom; and changing the terminal tackle to salmon mooching rigs baited with white worms. All other data collection and fishing effort methods are kept consistent with the spring survey described above.

The Demersal Groundfish Survey was cancelled in 2020 as a result of the COVID-19 pandemic. This survey provides the only source of fishery-independent data on many of Washington’s coastal nearshore groundfish species. For many of the demersal groundfish species that are the focus of this survey, sufficient life history or biological data is lacking, and little data exists to develop relative indices of abundance, making this research particularly critical. The data collected by this survey inform state and federal scientists in stock assessments, which in turn inform the status and management of multiple groundfish species. The absence of the 2020 data will likely increase scientific uncertainty in these groundfish assessments, although the effect of this loss will be somewhat mitigated with the continuation of this survey going forward. The 2021 Demersal Groundfish Survey is scheduled to occur in September and October with no significant changes to survey methods or design.

For more information about the Demersal Groundfish Survey, please contact: Rob Davis (Robert.davis@dfw.wa.gov).

E. Nearshore Coastal Pelagic Species Acoustic Trawl Methodology Survey of the California Current off Washington and Oregon

In 2019, the WDFW Marine Fish Science unit placed biologists onboard the F/V LISA MARIE in a collaborative survey conducted by the NOAA/Southwest Fishery Science Center (SWFSC), the West Coast Pelagic Conservation Group (WCPCG) – a commercial fishery industry coalition, and the WDFW. The work accomplished in 2019 was a continuation of a “proof of concept” study initiated by industry in 2017 to extend acoustic surveying and sampling of the coastal pelagic species (CPS) assemblage to the nearshore, complementing the offshore NOAA/SWFSC California

Current Ecosystem survey (CCES). The CCES acoustic trawl methodology survey conducted annually by the NOAA Southwest Fisheries Science Center (SWFSC) is a critical tool for understanding the abundance and distribution of Coastal Pelagic Species (CPS) such as Pacific Sardine, Northern Anchovy, Pacific Herring, Pacific Mackerel, Jack Mackerel, and mesopelagic fishes. The WCPCG had applied for a federal Saltonstall-Kennedy grant to continue and expand the effort in 2020; however, this survey was cancelled due to the COVID-19 pandemic. *For more information about the CPS survey, please contact: Lorna Wargo (Lorna.wargo@dfw.wa.gov).*

III. Fishery Monitoring

A. Puget Sound Port Sampling/Creel Surveys of Recreational Fisheries

Estimates are made for the recreational harvest of bottomfish, Pacific Halibut, salmonids, and other fishes caught in Puget Sound 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) and phone surveys. Staffing for angler intercept surveys, contracting of the phone surveys, and all estimation procedures are the responsibility of the Fish Program. *For more details, please contact Anne Stephenson (Puget Sound; Ann.stephenson@dfw.wa.gov) or Eric Kraig (estimation; Eric.kraig@dfw.wa.gov).*

B. Ocean/Coastal Port Sampling/Creel Surveys of Recreational and Commercial Fisheries

WDFW supports groundfish stock assessments and management of fisheries through multiple interrelated groups that collect and process biological and catch data: the Fish Program's Ocean Sampling Program, and the Coastal Marine Fish Science (CMFS) Unit's commercial fishery sampling group and recreational fishery sampling group.

Ocean Sampling Program for Recreational Fisheries – The Ocean Sampling Program (OSP) is responsible for catch estimation of ocean salmon and groundfish recreational fisheries. OSP uses port exit counts, primarily, and dockside angler interviews of recreational landings at Ilwaco-Chinook, Westport, La Push, and Neah Bay to track quota attainment for Chinook and Coho Salmon, and to estimate catch of groundfish species. In addition, dockside samplers collect biological and tag data from salmon, and length data from groundfish. *For more details, please contact Wendy Beeghley (Wendy.beeghley@dfw.wa.gov).*

CMFS Unit Commercial Fishery Sampling – Data on commercial groundfish, CPS, and Hagfish fisheries are collected by CMFS group technicians at all primary coastal ports: Westport, Ilwaco, Chinook, Bellingham, Blaine, Neah Bay, and La Push. The commercial sampling team has two major objectives: (1) to collect biological data – such as sizes, otoliths, and gonads – from commercially landed groundfish to support research and stock assessments; and (2) to collect groundfish catch data via commercial fisheries logbooks, fish receiving tickets, and species composition sampling of mixed-species market categories, which support fisheries monitoring and in-season management decision making.

The CMFS Unit produces periodic reports intended to inform fishery managers and fishery assessment authors by describing the biological and catch data collection methods and an inventory of data collected. Descriptions of port and fishery dynamics offer context for the changes to data collection methods. Collectively the series of reports serve to document changes in fishery monitoring and sampling goals, and approaches and procedures in response to evolving fishery management science and management needs. The most recent report, published June 2020, summarizes activities and accomplishments from 2015 through 2018 (Downs et al. 2020).

References cited

Downs, D., K. Hinton, J. Fuller, T. Zepplin, K. Lawson, L. Wargo, T.S. Tsou. 2020. Washington Coastal Commercial Groundfish Fisheries Monitoring Program: Progress Report 2015-2018. Washington Department of Fish and Wildlife. Fish Program Report Number FPA 20-07.

The CMFS Unit also monitors commercial coastal pelagic fishery landings in support of stock assessments and fishery management at Ilwaco and Westport. The only active fishery during the reporting period was the baitfish fishery, which harvests Northern Anchovy from the northern subpopulation (NSNA) distributed off Washington, Oregon, and northern California coasts. The NSNA are subject to management under the Pacific Fishery Management Council Coastal Pelagic Species Fishery Management Plan. NSNA have never been formally assessed, primarily due to the extremely low level of catch; thus, the status of the subpopulation is unknown. Biological sampling of landings was started in 2014 to provide time series data for potential assessment in the future as the need arises. Samples of 100 fish are collected weekly during the fishery season (roughly May to September). Fewer samples were collected in 2020 due to reduced fishing activity associated with the COVID-19 pandemic. Table 2 presents an inventory of the number of fish sampled and data collected as annual mean weight and length.

Table 2. An inventory of biological data and annual mean weight and length for Northern Anchovy sampled in the coastal bait fish fishery.

Year	Number sampled Length/Weight/Maturity	Number Aged	Mean Weight (g)	Mean Length (mm)
2015	1150	129	23	129
2016	1126	649	20	118
2017	931	929	14	111
2018	950	792	15	114
2019	1799	1790	16	112

2020	500		13	106

CMFS Unit Recreational Fishery Sampling – The CMFS Unit's recreational groundfish sampling program (RGSP) has two major objectives. The primary objective is to scan recreational groundfish catch at Westport in order to recover tag information and biological data from fish tagged and released during at-sea surveys. The secondary objective of the RGSP is to directly support research and stock assessment by collecting biological data from untagged recreationally caught groundfish species at La Push and Neah Bay. This biological information enhances data collection efforts of the WDFW Ocean Sampling Program previously described.

IV. 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, with the exception of the synthesis report of LeClair et al (2018). No monitoring activities were conducted in 2020; however, the PSMFS Unit is currently collaborating with the Seattle Aquarium and Point Defiance Zoo and Aquarium to resume dive surveys in 2021/22.

References Cited

LeClair, L., R. Pacunski, L. Hillier, J. Blaine, and D Lowry. 2018. Summary of findings from periodic scuba surveys of bottomfish conducted over a sixteen-year period at six nearshore sites in central Puget Sound. Washington Department of Fish and Wildlife Technical Report. Olympia, WA. FPT 18-04. 189 pp.

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

A. Hagfish

The Washington Hagfish Commercial Fishery, which opened in 2005 under developmental regulations, is small in scale, exporting hagfish for both frozen and live-fish food markets in Korea. Hagfish are caught in long-lined barrels constructed from olive oil or pickle barrels modified with an entrance tunnel and dewatering holes (Figure 5). Fishing occurs on soft, muddy habitat along the entire outer coast of Washington and northern Oregon. The fishery operates, by rule, only in offshore waters deeper than 50 fathoms and is open access. Licensed Washington fishers can fish federal waters off of 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 predominantly catches Pacific Hagfish, but Black Hagfish are landed incidentally. A few trips attempting to target Black Hagfish were successful in the recent past, and a small-scale market is developing for the frozen product. Pacific Hagfish predominate from 50-80 fa, while Black Hagfish have been targeted with deeper sets, up to 300 fa; Pacific and Black Hagfish ranges appear to overlap between 80 and 100 fathoms. Currently, however, fish ticket landing data cannot distinguish between species, as only one species code exists. The median CPUE is about 4.5 pounds, but instances of high CPUE are not uncommon, as evidenced by reports of "plugged" barrels.

Biological sampling data collected from Pacific and Black Hagfish consist of length, weight, maturity, and egg counts for females at maturity stages 4 through 7; however, only Pacific Hagfish data are reported here. Male and female hagfish present similar size distributions (Figure 6). The largest specimen sampled was a 67-cm female, and the smallest a 24-cm specimen, sex unknown. An evaluation of maturity suggests year-round spawning. Fecundity is low, with the number of eggs in females at maturity stages 6 & 7 (Table 3) averaging 25 eggs per female. Few females with developed eggs have been sampled; the 2017-2020 sample contained 13% mature females.

Management of the 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 – including logbooks, fish receiving tickets, and biological sampling of catch – have been developed to inform management. 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). Interest remains in conducting a study similar to research completed in California to evaluate escapement relative to barrel dewatering-hole size, but funding sources have not yet been identified.

For more information about the Hagfish fishery, please contact: Lorna Wargo (Lorna.wargo@dfw.wa.gov).

Figure 5. Barrels used in the WA commercial hagfish fishery.

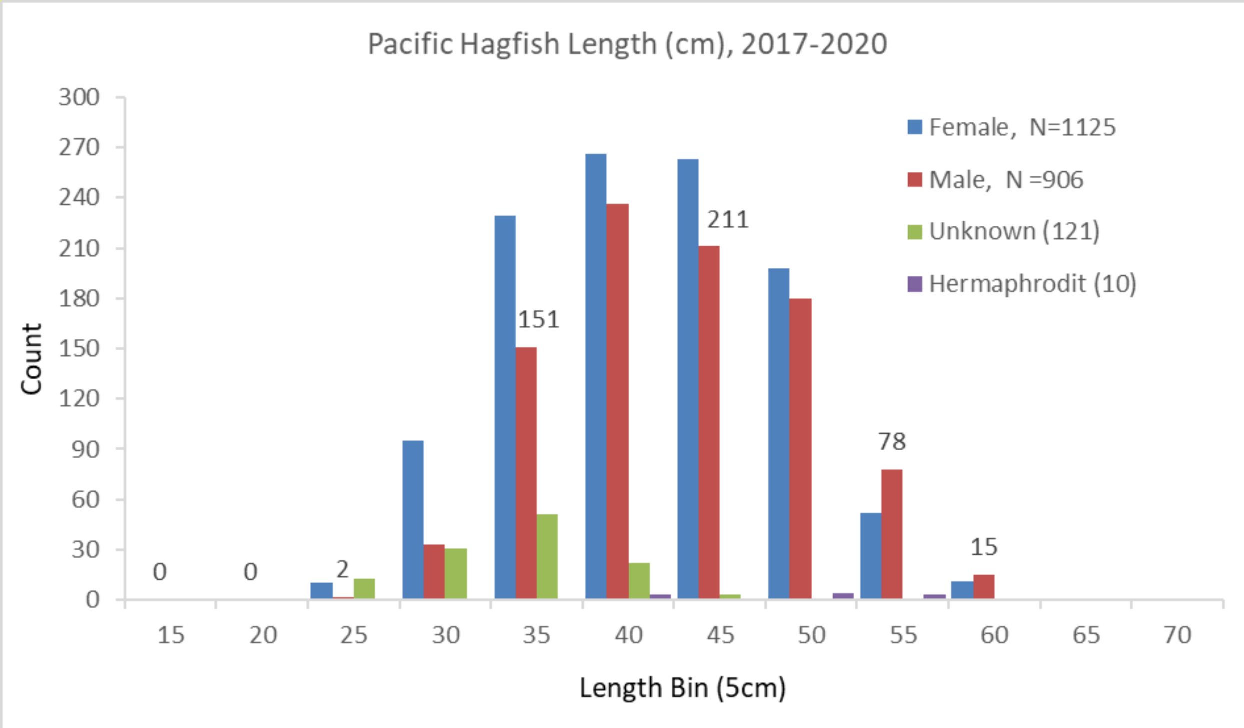

Figure 6. Length (cm) of male and female Pacific hagfish, 2017-2020.

Table 3. Average egg count per mature female Pacific Hagfish collected from Washington landings during 2017-2020.

Pacific Hagfish	Sample Count	Egg count minimum	Egg count maximum	Egg count average
Maturity stage 6	129	9	49	25
Maturity stage 7	16	5	39	19
Total	145			25

B. North Pacific Spiny Dogfish and other sharks

No specific, directed research or management to report. Spiny Dogfish are regularly seen in ROV videos and caught in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured; a tissue plug for genetics is also taken from select individuals. Other shark species occasionally encountered include Brown Catsharks and Sixgill Sharks.

C. Skates

No specific, directed research or management to report. Longnose and Big Skates are regularly seen in ROV videos and caught in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured. Sandpaper skates are also occasionally encountered.

D. Pacific Cod

No specific, directed research or management to report. Pacific Cod are regularly caught (primarily in the Strait of Juan de Fuca) in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured; otoliths for age analysis are also taken from moribund individuals.

E. Walleye Pollock

No specific, directed research or management to report. Walleye Pollock are regularly seen in ROV videos and caught in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured. Rough population estimates are produced as part of the survey analysis.

F. Pacific Whiting (Hake)

No specific, directed research or management to report. Pacific Hake are regularly seen in ROV videos and caught in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured. Rough population estimates are produced as part of the survey analysis.

G. Grenadiers

No specific, directed research or management to report.

H. Rockfishes

Research: 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 most 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. At least 57 Yelloweye rockfish were identified during video review, but no Bocaccio were observed during the survey. Video review has been completed, and the data are undergoing final QA/QC prior to 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 comparisons 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 14 fish observed on 9 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. Video review has been completed and the data are undergoing final QA/QC prior to analysis.

In October 2018, the WDFW partnered with DFO Canada to conduct a 14-day survey of the **Canadian waters of 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 in 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 observed. Reviews of the transect videos were completed in early 2020, and those data have been passed off to DFO along with the associated tracking data for analysis.

In August 2019 the WDFW PSMFS unit initiated an ROV survey focused on benthic rockfishes, Lingcod, and Kelp Greenling within the **interior marine waters of Washington** using a two-stage survey design. Within the Yelloweye Rockfish and Bocaccio DPSs, the survey design was based on the results of a MaxEnt habitat suitability model. Due to a lack of reliable bathymetry coverage for the waters of the Strait of Juan de Fuca west of the western DPS boundary, the MaxEnt approach could not be implemented, and the survey design was based on an evaluation of known and suspected habitats identified during previous drop-camera and ROV surveys. After 450 stations were randomly selected (Figure 8), the survey began on August 6 but was suspended on September 26th due to an equipment failure on the support vessel *R/V Molluscan*. Because the WDFW was already in the process of purchasing a replacement vessel for the *Molluscan*, they opted not to replace the failed equipment in order to apply those funds to the purchase of the new vessel. The new vessel, the *R/V Salish Rover* (Figure 7), was acquired in December 2019, with retrofitting and needed maintenance completed in June 2020. Due to the COVID-19 pandemic, WDFW protocols prevented the survey from restarting until November 2020, but equipment problems with the ROV system and poor weather conditions only allowed for several days of sampling to be conducted in November and December 2020. Four days of sampling were conducted in February 2021, 10 days were conducted in March, and 4-12 more days of sampling are slated for May-June. Given the delays and setbacks to the survey schedule, the PSMFS Unit has revised and narrowed the scope of the survey to focus on only those stations inside of Admiralty Inlet (Figure 9).

Figure 7: WDFW's new vessel for ROV (and other) operations, the R/V *Salish Rover*. The "*Rover*" is 58 feet long and has a full galley, settee area, head, and 3 staterooms with 2 bunks each.

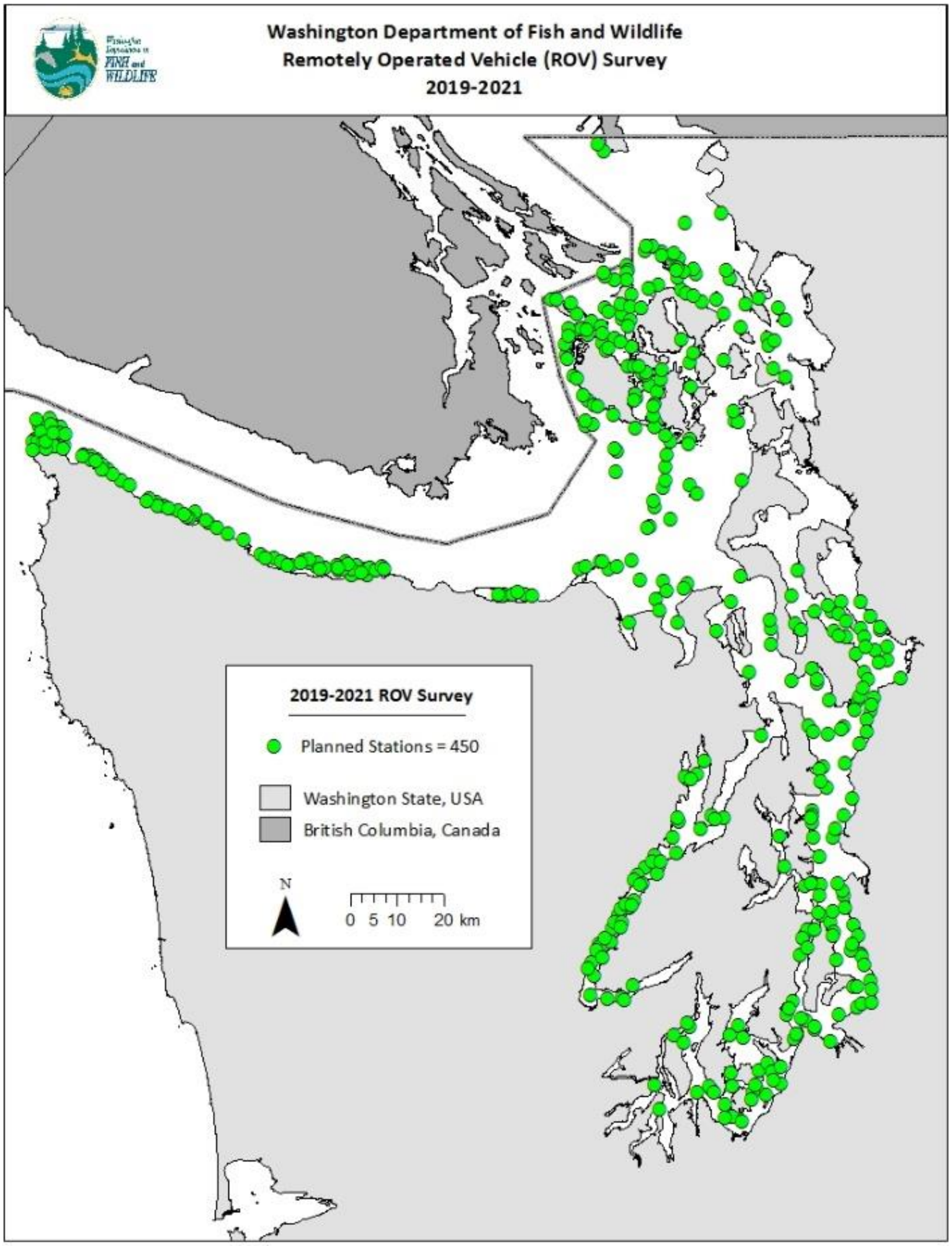

Figure 8. Randomly selected stations (n=450) for the 2019-21 ROV survey. Stations all far within the highly suitable stratum predicted by the MaxEnt model based on prior ROV survey data.

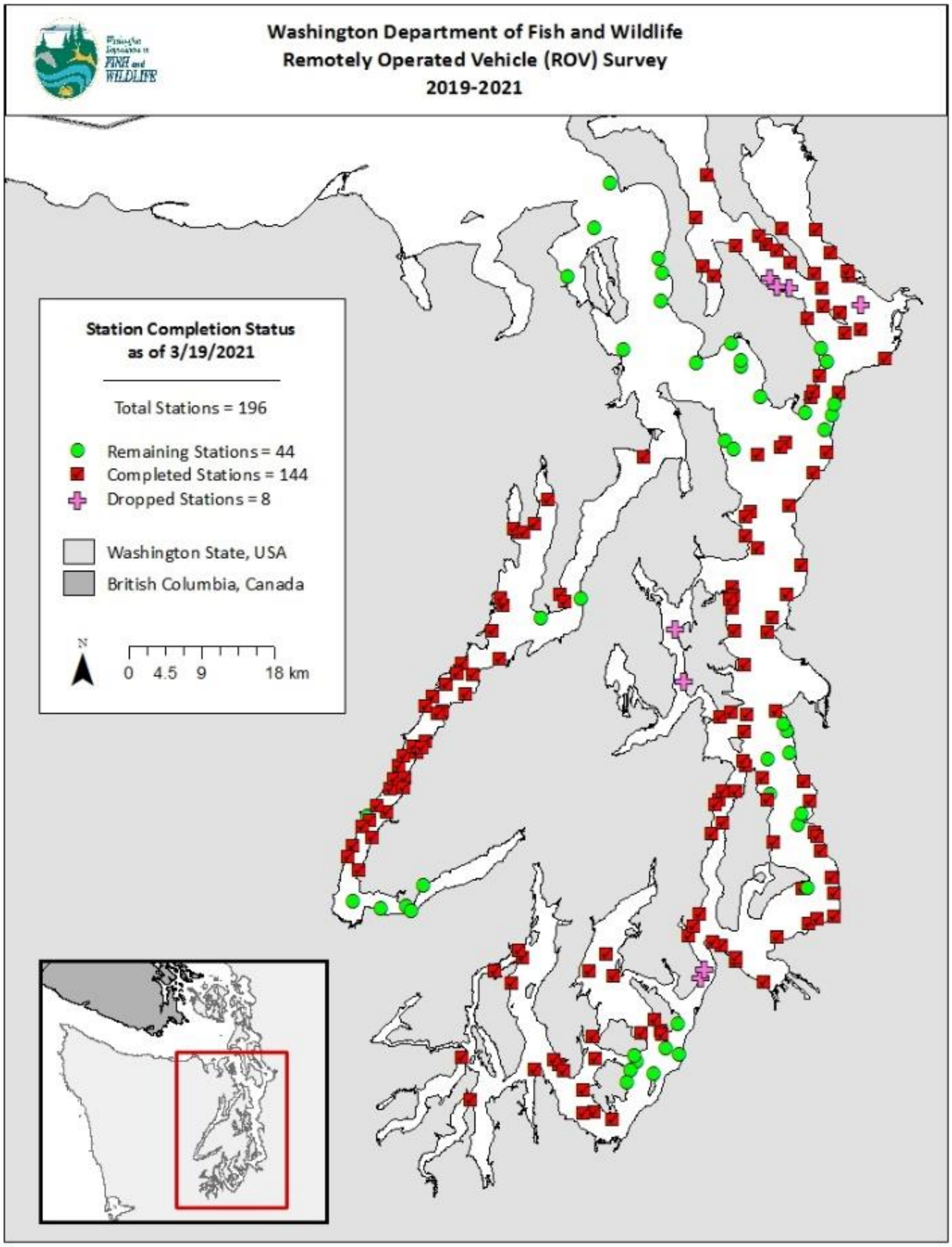

Figure 9. Revised scope of the 2019-2021 ROV survey due to scheduling setbacks from COVID-19 and the new vessel acquisition. Station status is current as of 3/19/2021.

Management – In 2012, NOAA issued a 5-year incidental take permit (ITP) to WDFW that provided for a limited take of ESA-listed rockfish in Puget Sound recreational fisheries and commercial shrimp trawls. Renewal documents were submitted to NOAA in mid-2016, which included an additional request for take coverage in the recreational and commercial shrimp pot fisheries, but due to a disagreement with NOAA resulting from a change in fishery regulations in the Pacific Halibut fishery that allowed for take of lingcod within the DPSs that could potentially impact listed rockfish, the permit review process was halted until the disagreement was resolved in late 2019. However, since the submission of the renewal documents in 2016, a new recreational shrimp fishery has emerged that requires updating the Fishery Conservation Plan that accompanies the ITP application. The FTP is now being updated by the WDFW Shellfish unit and will be resubmitted to NOAA in the near future.

For more details on the ROV program, please contact Bob Pacunski (Robert.pacunski@dfw.wa.gov).

I. Thornyheads

No specific, directed research or management to report.

J. Sablefish

No specific, directed research or management to report. While Sablefish used to be caught regularly – albeit in small numbers – in the Puget Sound bottom trawl survey, they were not encountered from 2011-2016, despite the annual survey efforts. Starting in 2017, however, the survey has begun to encounter them again: 8 were caught in 2017, 2 in 2018, and 8 in 2019.

K. Lingcod

Lingcod Age Structure Processing Lab – The Coastal Marine Fish Science Unit processes lingcod fins collected from Washington (coastal and Puget Sound) commercial and recreational fisheries, and periodically Oregon fisheries by contract. Lingcod fins are processed for ageing using the fin cross-section method. The process includes four steps: drying, gluing, sectioning, and mounting. Each dried and glued fin is secured in a sectioning saw (Beuhler Isomet 1000), and seven to ten cross-sections (2.0 mm) are cut. The sections are mounted onto microscope slides with Cytoseal, dried for at least 24 hours, and sent to age readers. Sectioned fins are aged using the surface-read method. During the reporting period, the lab processed 6,500 fins.

Formal Stock Assessment in Puget Sound – Over the past several 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 has completed an evaluation of 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 finalized, managers will be able to use the output from the Stock Synthesis model to inform management decisions for Lingcod in Puget Sound. Finalization of the report is expected in fall 2021.

Pre-season Lingcod Rod-and-Reel Test Fishing Survey– In April 2019, the PSMFS Unit conducted a four-day test fishing survey targeting Lingcod in Marine Catch Area 7 (San Juan Islands) prior to the opening of the recreational Lingcod fishing season. This was a pilot study with a primary goal of obtaining basic catch per unit effort (CPUE) and length frequency data for Lingcod under simulated recreational fishery conditions for potential use in a Puget Sound Lingcod stock assessment, and to evaluate the claim made by several recreational anglers that "no more legal sized fish are around." Secondary goals included documenting bycatch and obtaining genetic samples from select fish species to inform demographic models of Puget Sound bottomfish. A second, more comprehensive pre-season survey that included additional sites in Central and Sound Puget Sound was planned for April 2020 but was prevented due to the COVID-19 pandemic. This effort is slated to resume with an April 2021 survey.

L. Atka mackerel

No specific, directed research or management to report.

M. Flatfishes

No specific, directed research or management to report. Several species of flatfish are regularly seen in ROV videos, and eighteen species have been caught in the Puget Sound Bottom Trawl Survey, where they are counted, weighed, and measured. Rough population estimates are produced as part of the survey analysis. The most dominant flatfish species throughout Puget Sound is English Sole, which has been encountered at all depths and in all regions; the 2019 trawl survey estimate for English Sole throughout Puget Sound was 11,500 mt.

N. Pacific halibut & IPHC activities

Sampling Directed Halibut Landings – The 2020 2A Pacific Halibut Non-Tribal Directed Commercial Fishery consisted of 58-hour fishing periods (beginning at 0800 on Monday thru 1800 on Wednesday) starting the 4th week in June and occurring every two weeks until the quota was attained. There was a total of five openers in 2020, beginning on June 22nd and closing on August 19th. The CMFS Unit was asked by the International Pacific Halibut Commission (IPHC) to assist in collecting dockside Pacific Halibut samples for the 2020 fishery. The IPHC typically provides samplers for each directed halibut opener, but due to strict COVID-19 protocols and staff shortages, they were unable to provide samplers for landings in the southern Washington ports. The CMFS Unit provided sampling coverage for three of the five openers at the ports of Ilwaco and Chinook. Biological data consisting of length, weight, otoliths, and fin clips were collected following the IPHC sampling protocols, and a total of 114 fish were sampled.

O. Other groundfish and forage fish work

Anchovy – Northern Anchovy (northern subpopulation) fisheries in Washington are conducted to provide live bait for recreational and commercial fisheries, and packaged bait for retail to recreational fishermen. Distinguished by gear type, fisheries for anchovy include a lampara-gear fishery and a seine-gear fishery. The lampara-gear fishery is primarily comprised of Albacore Tuna fishers that catch and hold anchovy in onboard live-wells to meet their own bait needs. The purse-seine fishery harvests and holds live bait in dockside net pens for retail sale to recreational and commercial fishers. The fishery occurs in federal waters (3-200 miles), inside three miles (state waters) on the southern Washington coast, as well as within the estuaries of Grays Harbor and Willapa Bay, and in the lower Columbia River. Participation in the fishery is not limited. The northern subpopulation of Northern Anchovy has never been formally assessed through a model-based method, as historically the WDFW did not monitor baitfish landings. To build a time series in support of potential assessment, in 2014 the CMFS Unit began monitoring the commercial baitfish fishery at both Westport and Ilwaco, although the majority of sampling occurs at Westport. An inventory of samples collected and mean length and weight data are presented in Table 4. More complete reporting of these data can be found in an agency technical report in process (contact Lorna Wargo for details).

Table 4. Number of samples, number aged and mean weight and length of Northern Anchovy sampled from the commercial baitfish fishery, 2015 – 2020.

Year	Number sampled Length/Weight/Maturity	Number Aged	Mean Weight (g)	Mean Length (mm)
2015	1150	129	23	129
2016	1126	649	20	118
2017	931	929	14	111
2018	950	792	15	114
2019	1799	1790	16	112
2020	500		13	106

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. Results currently show no population differentiation at any observable geographic scope. Further analysis and processing of additional samples will require additional funding that has not yet been secured.

Smelt – While there are no estimates of biomass or established indices of abundance for smelt in Puget Sound, there are both commercial (purse seine) and recreational (dip net, jigging) fisheries that primarily target surf smelt. Since 2014, the recreational fishery has been limited to the hours between 6am and 10pm, has been open only five days a week, and has a daily bag limit of 10 pounds per person. The commercial fishery has also been limited to the hours between 6am and 10pm, has been open only four days a week, has region specific seasons and closures (Figure 10), and has had an annual quota of 60,000 pounds that is reset on January 1 of each year. Since the commercial quota was established in 2014, it has been reached – and the fishery subsequently closed – by mid-October each year. The only exception to this was in 2020 when the quota was not reached, and the total landings for the year was only 30,876 pounds. This decrease in landings is most likely due to reduced demand due to the COVID-19 pandemic and the departure of one of the primary commercial harvesters.

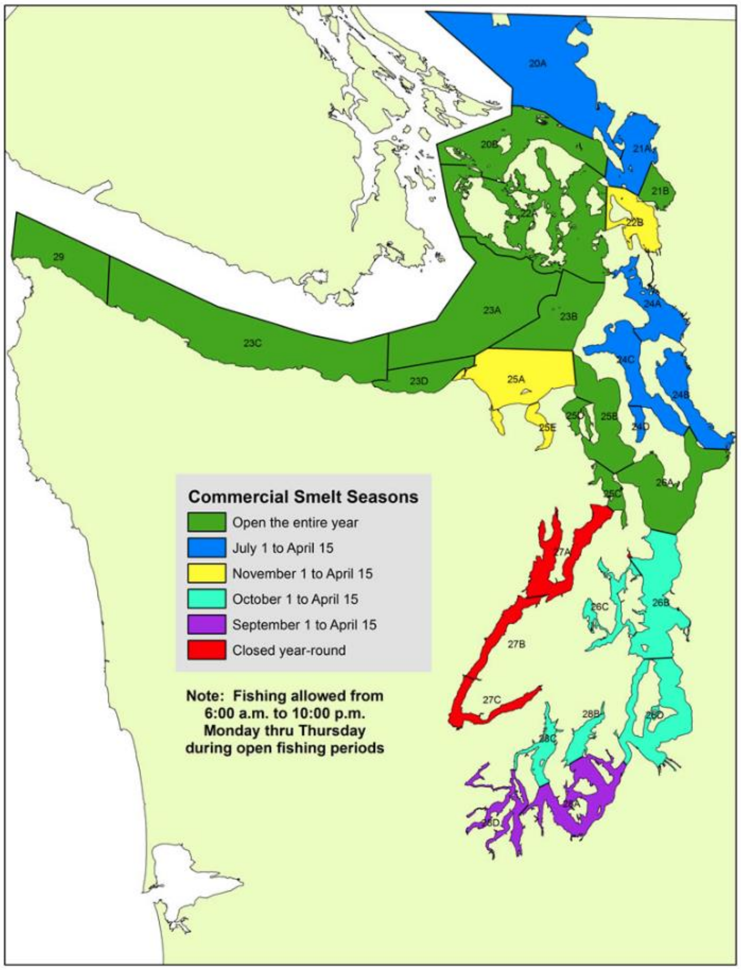

Figure 10: Map of commercial smelt fishery management regions and respective season openings.

Historical Groundfish Fishery Compendium and Catch Reconstructions – 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 year. Additionally, significant progress has been made on a report documenting the history of the fishery, fishing technology, and harvest patterns for groundfish in Puget Sound. A definitive compendium on the topic is anticipated to be complete by the end of 2022.

VI. 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 food-web indicator) in 2016, and 2018, and 2020. 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 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 the early 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 four, Puget Sound-wide assessments of contaminants using transplanted (i.e. caged) mussels over the winters of 2012/13, 2015/16, 2017/18, and 2019/20. 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, including an account of PBDE (flame retardants) contamination in seaward-migrating juvenile Chinook Salmon in the Snohomish River, linking the contamination with a wastewater effluent source. 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 (james.west@dfw.wa.gov).*

United States Navy Drydock Salmon Entrainment Study – Puget Sound Naval Shipyard at Naval Base Kitsap Bremerton (NAVBASE Bremerton) contains six extensive dry docks that are used to clean, inspect, and service ships ranging from small submarines to aircraft carriers (Figure 11). 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.

In January 2020 the PSMFS Unit was contracted to conduct a salmon entrainment study in the drydocks at NAVBASE Bremerton. Although salmon are the primary focus of the study, data will also be collected on other entrained fish species. At the time of this reporting, four sampling events have been conducted in three drydocks; DD5 was sampled on 03 June 2020, DD3 was sampled both on 02 September 2020 and 18 September 2020, and DD6 was sampled on 09 March 2021.

In total, 38 Chinook and 4 Coho have been encountered. The majority of these salmon have been juveniles, with a median length of 165 mm; however, the overall range in lengths is 80-620 mm. Of the Chinook, 13 were hatchery-origin while 25 were wild. Every effort was made to release all salmon quickly and alive. A secondary target species group after salmonids is forage fish, of which 3 primary species have been encountered: Northern Anchovy, Pacific Herring, and Pacific Sand Lance. Of these, Pacific Herring have been the most numerous and frequently encountered species, as they have been present in each of the sampling events thus far, ranging vastly in total counts: 130 fish were caught in DD5 on 6/3/20, 39 in DD3 on 9/2/20, an estimated almost 19,000 in DD3 on 9/18/20, and 125 in DD6 on 5/6/21. Other species regularly encountered include a variety of sculpins and perch, as well as a few flatfish and rockfish (non-ESA) species. At least four more sampling events should occur before the end of the contract period in February 2022.

For more details on the Naval Dry Dock survey, please contact Jen Blaine (Jennifer.blaine@dfw.wa.gov).

Figure 11: Locations of the six service dry docks at Naval Base (NAVBASE) Bremerton on the Kitsap Peninsula in central Puget Sound.

VII. Publications

In 2020-21 staff of the MFS Unit published the documents indicated below.

Blaine, J., D. Lowry, and R. Pacunski. 2020. 2002-2007 WDFW scientific bottom trawl surveys in the southern Salish Sea: species distribution, abundance, and population trends. Fish Program Technical Report No. 20-01. Washington Department of Fish and Wildlife, Olympia, WA. 237 pp.

Burger, M., T. Sandell, C. Fanshier, A. Lindquist, P. Biondo, and D. Lowry. 2020. Findings of the 2016-17 southern Salish Sea acoustic mid-water trawl survey. Fish Program Technical Report No. 20-03. Washington Department of Fish and Wildlife, Olympia, WA. 48 pp.

Davis, R., and L. Wargo. 2020. Enhanced Sampling of the Washington Coast Recreational Groundfish Fishery 2014-2017. Washington Department of Fish and Wildlife. Technical Report No. FPT 20-05.

Downs, D., K. Hinton, J. Fuller, T. Zepplin, K. Lawson, L. Wargo, T.S. Tsou. 2020. Washington Coastal Commercial Groundfish Fisheries Monitoring Program: Progress Report 2015-2018. Washington Department of Fish and Wildlife. Fish Program Report Number FPA 20-07.

Lowry, D, R. Pacunski, E. Kraig, V. Tribble, and T.S. Tsou. 2020. Conservation Plan for reducing the impact of selected fisheries on ESA-listed species in Puget Sound, with an emphasis on bocaccio and yelloweye rockfish. Washington Department of Fish and Wildlife, Olympia, WA. 100 pp.

Pacunski, R., D. Lowry, J. Selleck, J. Beam, A. Hennings, E. Wright, L. Hillier, W. Palsson, and T.S. Tsou. 2020. Quantification of bottomfish populations, and species-specific habitat associations, in the San Juan Islands, WA employing a remotely operated vehicle and a systematic survey design. Washington Department of Fish and Wildlife. Technical Report No. FPT 20-07.

VIII. Conferences and Workshops

In 2020-21, 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. Most meetings and events were cancelled due to the COVID-19 pandemic.

PFMC ROV Survey and Statistical Methods Review Panel. Santa Cruz, CA, February, 2020. Theresa Tsou (panel member), Bob Pacunski (panel member), and Dayv Lowry (invited observer) attended.

IX. Complete Staff Contact Information

WDFW permanent marine fish management and research staff include (updated 4/2021):

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Committee of Age Reading Experts

2021 Committee Report

Prepared for the Sixty-first Annual Meeting of the

Technical Subcommittee of the Canada-USA Groundfish Committee

April 20 – 21, 2021

Prepared by
Delsa Anderl
2019-2022 CARE Chair

National Oceanic Atmospheric Administration
National Marine Fisheries Service
Resource Ecology and Fisheries Management
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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, 2020 – April 6, 2021. This interim reporting period was prepared by current CARE Chair Delsa Anderl. Current officers through June 30, 2022 (elected at April CARE 2019 Meeting) are:

- Chair – Delsa Anderl (AFSC-Seattle)
- Vice-Chair – Andrew Claiborne (WDFW-Olympia)
- Secretary – Nikki Atkins (NWFSC-Newport)

3. CARE Conference

CARE meets biennially for a conference that usually lasts three days. However, with prior approval from the current TSC Chair to bring the matter to a vote, CARE membership voted to postpone the April 2021 CARE conference until April 2022 due to COVID-19 concerns and restrictions. CARE biennial meetings will thereafter be held on even-numbered years. 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.

i. CARE Check-in

In place of a CARE meeting, a 2-hr virtual check-in was held on April 6. Forty-seven members participated and 9 agency leads provided summary reports that included their ageing lab status under pandemic restrictions.

The list of recommendations outlined by the TSC to CARE, CARE to CARE, and CARE to TSC were not addressed at the check-in but will be addressed at the April 2022 meeting. This list of recommendations can be found in the CARE 2020 report to the TSC.

ii. Agency Reports:

A. Alaska Department of Fish & Game (ADF&G) – (Kevin McNeel)

There are four main groundfish age programs within the Alaska Department of Fish and Game that operate autonomously: the Kodiak ADF&G Age Lab, the Homer Commercial and Homer Sport Age Labs, and the Age Determination Unit (ADU, based in Juneau).

ADF&G-Kodiak

Sonya El Mejjati supervises the ADF&G-Kodiak Age Lab, which is made up of three age readers: Mike Knutson, Jessica Horn (started 2020) and herself. The lab mainly processed Pacific Cod as well as Black and Dark Rockfish during their three to four-month production ageing season.

Working through the pandemic, they wear masks anytime there is more than one person in the lab. They try to have no more than two people in the lab and Mike was able to telework. Mike came in every 2-3 weeks to resolve age discrepancies.

If any personnel traveled, they would quarantine for 5 days and take a COVID-19 test before returning to the lab (following the borough school district travel protocols for returning students).

ADF&G-Homer Sport

Martin Schuster supervises the ADF&G-Homer Sport Age Lab, but Marian Ford attended the CARE update meeting to represent the lab. Their lab is made up of three age readers: Martin, Tim Blackmon, and Marian. The lab has focused on Black, Yelloweye, Dark, and Dusky Rockfish otoliths and Lingcod fin rays.

To produce ages during the pandemic, Marian has been successfully teleworking from home for the majority of the time, and Martin and Tim processed Black Rockfish at the office. While in the office, they used vacant offices to maintain social distance and wore masks.

ADF&G- Age Determination Unit (ADU, Juneau)

Kevin McNeel supervises the ADU and their lab is made up of three groundfish age readers: Chris Hinds, Cathy Mattson, and himself. Jodi Neil and Mollie Dwyer processed samples in 2020, but Jodi has a separate, full-time position and Mollie just accepted another position this month (April 2021). During this past fall and winter, the ADU was supported by technicians from the other Mark Tag and Age Lab programs to process samples and estimate ages. During the last year, the lab focused on Sablefish, mixed rockfish, Pacific Cod, and Lingcod.

To continue work during the pandemic, Chris and Cathy have moved to teleworking and at-home age reading was available for people that quarantined. The lab also made use of empty offices and space for people in the building, supported social distancing, and enforced quarantine schedules as well as mask/cleaning mandates. Age resolutions, training, and exchange work were done remotely through screensharing apps (Microsoft Teams), images, and live-microscope cameras.

The ADU recently participated in a Sablefish exchange with AFSC, CDFO, and NWFSC, two Lingcod otolith/fin ray exchanges with WDFW and ADFG-Homer-Sport, a Rougheye Rockfish exchange with AFSC, and a Yelloweye Rockfish exchange with ADF&G-Homer Commercial.

In terms of age-related research, the ADU is continuing work on a Prince William Sound (PWS) Shortraker Rockfish chronology and is starting a chronology for PWS Yelloweye Rockfish. The ADU is finishing a North Pacific Research Board funded project on reconstructing reproductive histories of Yelloweye Rockfish (as well as other species) through hormone profiles extracted from bone. Further, the ADU is collaborating with other labs to compare age criteria for Lingcod fin rays and otoliths to evaluate and support methods.

B. **Alaska Department of Fish & Game Commercial – (Elisa Russ)**

In 2020 the Homer ADF&G Commercial Groundfish Age Lab had three age readers:

Elisa Russ (project leader), Andrew Pollak (primary production reader), and Kerri Foote (Black Rockfish). The port sampling program collects biological samples including age structures (primarily otoliths) from state managed groundfish and shellfish species harvested in Cook Inlet and Prince William Sound management areas (Central Region). Sampling goals are 550 otoliths collected from primary groundfish species – Pacific Cod, Sablefish, Lingcod, Walleye Pollock, and Rockfish. Groundfish sampling occurs in the ports of Homer, Seward, Whittier, Cordova, Kenai, and Kodiak.

Groundfish species aged in Homer include demersal shelf rockfish (primarily Yelloweye and Quillback), pelagic shelf rockfish (primarily Black Rockfish), and Walleye Pollock. In 2020, in response to an ADF&G Statewide Rockfish Initiative (SRI) focusing on assessment of keystone species Black and Yelloweye Rockfish, the Homer Age Lab accelerated age work on those two species in order to catch up on a backlog of unread otoliths. A total of 4,160 ages were produced in 2020, with age data current through 2019 for Black and Yelloweye Rockfish. As part of the SRI, a Yelloweye Rockfish exchange was done between the Homer Commercial and Sport Fish (Martin Schuster – lead) Age Labs.

Precision testing is done on 20% of all samples and on 100% of samples that are aged by new readers. All differences beyond 1 year are resolved, unless there is bias and then all differences are resolved. Otoliths are stored dry, cut using an Isomet saw, and baked; burning is used during precision testing to refresh otoliths and reduce pattern-obscuring glazing that may occur following preservation in storage media after the initial baking. Morphometric measurements (otolith length, width, and weight, excluding crystalized or broken otoliths) have been collected for all species since 2018. This information is analyzed to help identify outliers and errors in the age, species ID, or data entry.

The onset of COVID-19 in March 2020 in Alaska created new challenges for the ADF&G project, as it did for everyone. All travel to other ports (primarily Seward and Whittier) was halted during spring and early summer due to severe outbreaks of COVID-19 in seafood processing companies. All port sampling and age reading staff voluntarily submitted to regular testing and any exposure was handled using State of Alaska protocols similar to CDC guidelines for quarantining. Safety vests stating to keep a distance of 6 feet and masks were ordered and worn by port sampling staff. Most staff at ADF&G Homer office began teleworking and for those who continued to work in the office, masks, frequent hand sanitizing, and social distancing were required in all public areas. Beginning in March 2020, primary age reading staff took microscopes home and scheduled time to be the sole person in the lab for cutting and baking otoliths. Unexpectedly, age reading efficiency actually improved when staff were working from home, likely because time was dedicated solely to age reading without office distractions and also because port sampling had been curtailed until safer conditions were present. Port sampling and travel to other ports resumed in mid- to late summer, with staff driving in separate vehicles and undergoing frequent COVID-19 testing. Some staff returned to working in the office in the fall, including Andrew Pollak who trained a new age reader on Walleye Pollock; the teaching scope was used while wearing masks and only after negative COVID-19 test results were confirmed by both trainer and trainee. Some staff including Elisa Russ continue to primarily telework as ADF&G agreements remain in effect through 2021. Adaptation is quite impressive – ADF&G managed to implement multiple measures to keep staff safe and were successful in continuing to achieve project goals.

C. Sclerochronology Lab (SCL) – (Stephen Wischniowski)
Pacific Biological Station (PBS), Fisheries and Oceans Canada (CDFO), Nanaimo BC

PBS shut down due to COVID-19 in mid-March 2020. Since SCL staff do not have individual computers it was difficult for staff to work at home as they had no connectivity, and were communicating via personal emails and texting. Staff had health and safety concerns about burning alcohol within family homes, especially with children present. Thus a decision was made to focus on Return to Work (RTW) instead of how to set up ageing stations within individual homes.

The IT department provided SCL staff with temporary laptops in May 2020. During this time SCL leads developed RTW protocols and specific standard working procedures for every aspect of age estimation for all SCL spaces. Once all protocols, procedures, and safety precautions were established and personal protective equipment was obtained, the SCL team was given Essential Status and returned to work in mid-July 2020. Currently PBS is still in lockdown with only 20% occupation for critical and essential services.

SCL staff dynamics

- Ten staff
- Two new hires
- Three senior staff to retire 2022 and 2023

Species of focus upon SCL RTW March 2020 to March 2021

- *Atheresthes stomias* - Arrowtooth Flounder
- *Clupea pallasii* – Pacific Herring
- *Sebastes maliger* – Quillback Rockfish
- *Sebastes flavidus* – Yellowtail Rockfish
- *Sebastes pinniger* – Canary Rockfish
- *Oncorhynchus tschawytscha* – Chinook Salmon
- *Oncorhynchus keta* – Chum Salmon
- *Oncorhynchus nerka* – Sockeye Salmon
- *Oncorhynchus kisutch* – Coho Salmon

The SCL is down in numbers of fish aged compared to pre-COVID numbers

- Groundfish down 4,000
- Salmon down 6,000
- Herring down 6,000

The SCL Structure Library was completed to house 1.6 million otoliths, 3 million salmon scales, and assorted fin-ray collections. This space is an assortment of static and mobile shelving units with an otolith washing and scale press station. This space is approximately 1400 sq. ft. and should provide 15 years of future capacity.

The SCL Direct Data Entry application for groundfish is ready for beta testing. Direct Data Entry (DDE) has been a historic priority for the SCL that dates back to the previous program manager, Shayne MacLellan. Efforts over the last ~20 years have been unsuccessful, mainly because of the historical lack of technology and recent lack of funding. The vision of DDE has changed since its original conception; the main objectives were to:

- increase work throughput and efficiencies

- eliminate paper usage
- eliminate/reduce transcriptional errors
- eliminate client key punching
- add real time statistical analysis for increased QA/QC
- provide immediate access to historical data

These attributes are foundational in the implementation of DDE and will play a key role. However the hidden advantage of computerized workstations is the increased capacity to record data that historically were too cumbersome and time consuming to collect. Computerized age workstations will provide the ability to record otolith weights and take images, supplemental data that will facilitate real-time quality control measures within the daily routine of producing age estimates.

- Otolith weight. There is a direct and linear relationship between otolith weight and age. Measuring otolith weight facilitates the real-time identification and examination of outliers that do not fit this relationship before data is released to the client.
- Otolith images. The utility of Otolith Shape Analysis (OSA) has in recent years become a powerful tool for the identification of species based on morphometric measures of the otolith. A recent SCL/GF pilot study has had great success in identifying species within the *S. aleutianus/melanostictus* complex based on OSA, otolith weight, fish length, and age. More recently its utility has been implemented in the identification of populations within species that reveal no genetic disparity.

Climate change is certain to increase the difficulty of estimating fish age. The SCL has observed in several species an increasingly "noisier" pattern; based on the timing of these occurrences this change can potentially be attributed to the onset of a changing climate. To reduce ageing error and provide more certainty in the data produced will require the SCL to move away from a single subjective determiner of age. Otolith weight and shape can be considered analogues to age and when used synergistically will deliver a more robust, higher quality set of data.

D. International Pacific Halibut Commission (IPHC) – (Joan Forsberg)

The IPHC currently has four age readers on site. We age an average of 25,000 to 30,000 otoliths per year.

<u>Pandemic issues:</u>

Most IPHC staff, including the age lab staff, have been working from home since late March 2020. Anyone needing to come to the office must request permission in advance. Depending on the phase Washington State was in at the time, number of staff at the office have been limited to 5 or 10 at a time and masks are worn while in the office.

The age lab supervisor would be notified when samples were ready to pick up and would request permission to come into the office, pick up the samples and deliver them to the other readers. As readers finished reading a batch of otoliths, they would arrange to drop the samples off with the age lab supervisor or have them picked up. Age sheets were picked up along with the aged otoliths and delivered to the office for data-entry staff to pick up. Otoliths were distributed for second reads in a similar manner.

Fewer otoliths were collected on the setline survey in 2020 because of late start and reduced number of stations fished.

Projects:
IPHC genetics staff looked into obtaining DNA from blood and tissue adhering to otoliths. Good results were obtained from otoliths stored dry with visible blood on the surface (n=7); no DNA was obtained from cleaned otoliths stored in glycerin solution (n=10).

The IPHC photographed and measured ~1900 baked otolith sections for an increment study.

E. Washington Department of Fish and Wildlife (WDFW) – (Andrew Claiborne)

WDFW's Fish Ageing Lab

- Christina Jump—Age Reader (freshwater), salmon data entry
- Austin Anderson—Age Reader (salmon and trout), research projects
- Sandra Rosenfield—Age Reader (groundfish lead)
- Jenny Topping—Age Reader (groundfish), groundfish data entry
- Andrew Claiborne—Age Lab Team Lead and Age Reader (salmon and trout)

COVID-19 and Ageing Activities
WDFW currently has two age readers that focus on groundfish. Prior to 2020, our groundfish age readers partially worked remotely coupled with days in the lab together each week. As such, remote working has been relatively easy except for looking at samples together at our teaching double-microscope, which would violate social distancing mandates. We have used images of otoliths and fin rays and frequent discussions to mitigate our inability to double-scope. We are purchasing cameras for all our scopes that do not already have them to facilitate more streamlined collaboration.

In the spring of 2020, we were able to return to the lab on a regular basis. That marked an improvement in our production of salmon and freshwater species and preparation of lingcod fin rays. Those of us with small children welcomed this return to our usual lab space.

Species and Numbers Aged Since 2019 CARE

Species Name	n
Black Rockfish	1,088
Copper Rockfish	729
Lingcod	2,613
Northern Anchovy	148
Pacific Sardine	12
Petrale Sole	281
Quillback Rockfish	1,527
Vermilion Rockfish	628
Widow Rockfish	1,480
Yelloweye Rockfish	731

Yellowtail Rockfish	3,508
Total	12,745
Salmon, Trout, Freshwater	~75,000

F. Alaska Fisheries Science Center (AFSC) – (Delsa Anderl)

AFSC staff includes 16 full-time employees, of which half are age readers and half are responsible for research studies and database management and support. Three more staff members are contract employees.

AFSC went into mandatory telework on March 23, 2020. Access to campus was highly restricted in those early days, so otolith boxes for estimated work through the following June were removed from campus and stored in all eight age reader's homes along with microscopes, low-speed saws, toaster ovens and anything else that age readers needed to continue work in their temporary home work stations. Makeshift work stations were set up on dining room tables, available counters, and in home offices.

The biggest challenge faced was how to maintain the process of quality control that includes exchanging samples so a second reader (tester) is able to age 20% of an ageing sample and resolving discrepancies. A best-practice protocol of exchanging otolith boxes between homes was designed and is maintained to this day. Initially, the team lead was the sole runner for transporting boxes between homes. Now, all age readers run between their homes and their tester's homes. Then, there was the challenge of resolving reader-tester discrepancies, which under normal circumstances is most frequently undertaken by viewing structures together at a double-headed teaching microscope. Eventually the lab was able to purchase microscope cameras for all age readers to allow discrepancies to be resolved through photo images to inform discussions towards resolved ages via online sharing platforms.

For the AFSC, mandatory telework is still currently in effect. While working through the pandemic, AFSC age readers were able to release a total of nearly 34,000 ages prior to the assessment cycle that ended on Sept 30. This number of ages is comparable to a normal year. The breakdown of species includes:

Common_Name	Number Aged
Alaska Plaice	258
Arrowtooth Flounder	708
Atka Mackerel	1,702
Blackspotted Rockfish	300
Dover Sole	332
Dusky Rockfish	1,079
Flathead Sole	2,786
Greenland Turbot	110
Kamchatka Flounder	448
Northern Rock Sole	2,187

Northern Rockfish	1,606
Pacific Cod	4,072
Pacific Ocean Perch	3,666
Sablefish	2,333
Southern Rock Sole	673
Walleye Pollock	9,975
Yellowfin Sole	1,421

The summer surveys for 2020 were canceled, so in place of ageing summer survey samples, AFSC age readers aged archived Pacific Cod samples that had been lower on the priority list. Also, time was available to train 3-4 age readers to learn to age Sablefish, Greenland Turbot, Pacific Ocean Perch, Rougheye Rockfish, Blackspotted Rockfish, Atka Mackerel and Pacific Cod.

As part of a NOAA funded 5-year strategic initiative (SI), scientists at the AFSC are investigating the use of Fourier transform near infrared (FT-NIR) spectroscopy. The strategic initiative entitled, "A revolutionary approach for improving age determination efficiency in fish using Fourier transform near infrared (FT-NIR) spectroscopy" led by Dr. Thomas Helser is a nation-wide effort that involves seven biological labs focused on operationalizing this technology within the NOAA Fisheries age estimation enterprise. The FT-NIR spectrometer measures the absorption of near infrared energy by material when it directs near infrared light onto a sample and records how light is modified according to the composition of the sample. The spectral information most meaningful for otoliths are in the regions related to the functional groups in proteins such as carbon-hydrogen (C-H), oxygen-hydrogen (O-H) and nitrogen-hydrogen (N-H) groups. As such, the chemical properties of the otoliths, such as the quantity of the absorbed energy within those specific regions, are a proxy for fish age.

Among the case studies to be illustrated, FT-NIR spectra of eastern Bering Sea Walleye Pollock otoliths explained 90% - 95% of the variation in traditional age estimates, predicted fish age within ± 1.0 year 90% of the time, and achieved better precision and less bias. In addition to Walleye Pollock, we are collecting spectra for a variety of other groundfish species. Moreover, pilot data suggests FT-NIR spectroscopy holds promise for rapid assessment of other life history properties such as reproductive status from ovaries and energy density (condition) from muscle/liver scans. Some of the FT-NIR projects in development right now are:

- age prediction of long-lived species such as Northern Rockfish and Pacific Ocean Perch
- using known-age data to improve model predictions using tagged Sablefish
- exploring the use of NIR spectral and biological data fusion using deep learning neural network models to improve prediction
- development of a simulation framework to evaluate: 1) impacts of ageing uncertainty in reference data on model predictions, 2) stock assessment model outcomes from FT-NIR vs. traditional age data products
- species discrimination using otolith FT-NIR spectra
- rapid estimation of reproductive status from ovaries and energy density from muscle or liver
- using Raman spectroscopy as complementary to FT-NIR data analysis

- ground-truth spectral data with target life history properties such age fish age, reproductive status, and condition using lab-based and captive rearing studies

Published FT-NIR research:

A transformative approach to ageing fish otoliths using Fourier transform near infrared spectroscopy: a case study of eastern Bering Sea walleye pollock (*Gadus chalcogrammus*). Helser, T. E., I. Benson, J. Erickson, J. Healy, C. Kastelle, and J.A. Short. 2018. Can. J. Fish. Aquat. Sci. https://doi.org/10.1139/cjfas-2018-0112

Proceedings of the research workshop on the rapid estimation of fish age using Fourier Transform Near Infrared Spectroscopy (FT-NIRS). Helser, T. E., I. M. Benson, and B. K. Barnett (editors). 2019. AFSC Processed Rep. 2019-06, 195 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Classification of fish species from different ecosystems using the near infrared diffuse reflectance spectra of otoliths. Benson, I. M., B. K. Barnett and T. E. Helser. 2020. J. Near Infrared Spec. https://doi.org/10.1177/0967033520935999

Age estimation of red snapper *(Lutjanus campechanus*) using FT-NIR spectroscopy: feasibility of application to production ageing for management. Passerotti, M. S., T. E. Helser, I. M. Benson, B. K. Barnett, J. C. Ballenger, W. J. Bubley, M. J. M. Reichert and J. M. Quattro. 2020. ICES J. Mar. Sci. 77:2144-2156. https://doi.org/10.1093/icesjms/fsaa131

Recently accepted papers:

Aging Fish at the Molecular Level using Fourier Transformed Near-Infrared Spectroscopy (FT-NIRs): A Case Study on Pacific Cod (*Gadus macrocephalus*) Stocks in the Eastern Bering Sea. J. Healy, T. Helser, I. Benson, L. Tornabene

Recently submitted papers:

Rapid age estimation of longnose skate (*Raja rhina*) vertebrae using near infrared spectroscopy. M. Arrington, T. Helser, I. Benson, T. Essington, M. Matta, A. Punt

Rapid and reliable assessment of fish physiological condition for fisheries research and management using Fourier transform near-infrared spectroscopy. E. Goldstein, T. Helser, J. Vollenweider, A. Sreenivasan, F. Sewall

G. Oregon Department of Fish & Wildlife (ODFW) – (Mark Terwilliger)

Production Aging: In 2020, emphasis was placed on species up for assessment in 2021. Initially, it was believed that there might be a full assessment on Oregon Copper Rockfish, so I produced break-and-burn age estimates for 363 Copper Rockfish from the commercial fishery (73 tested; captured from 2002-2019) and 2,298 from the recreational fishery (459 tested, captured from 2005-2019). These ages were used to inform an externally estimated growth curve for a data-moderate assessment.

Due to some uncertainty over the next species to focus on for 2021 assessments, I moved to aging Black Rockfish in preparation for a 2023 assessment. Break-and-burn age estimates were generated for 648 Black Rockfish (0 tested) captured in the 2017 commercial fishery.

In September 2020, I began generating ages for a full 2021 Vermilion Rockfish assessment. To that end, I produced break-and-burn estimates for 896 Vermilion Rockfish from the commercial fishery (180 tested; captured from 2004-2020) and 621 from the recreational fishery (0 tested; captured from 2009-2019). Aging of samples from the recreational fishery would continue into 2021.

Aging activities affected by COVID-19 in 2020 included the preparation of Lingcod fin ray sections. Typically, agers from Pacific States Marine Fisheries Commission (PSMFC) cut and mount fin ray sections from our recreational catch. Standard practice requires the use of a fume hood for mounting the sections to slides with Cytoseal. Due to COVID-19, PSMFC agers were not able to access their lab, so sections were cut by ODFW personnel and affixed to slides using Crystalbond (a non-toxic thermoplastic resin), and nail polish was used to elucidate annual marks. This method produced clear sections that were able to be read and served as a good alternative to the standard mounting method described in the CARE aging manual.

Age Validation: The 2015 stock assessment for California, Oregon, and Washington stocks of Black Rockfish identified the need for validation and verification of annuli as a recommended avenue for research in order to improve future assessments. In May 2020 we began a collaborative study with the Canadian Centre for Isotopic Analysis at the University of Alberta to validate annuli on otoliths of Black Rockfish (a semi-pelagic rockfish), Cabezon (a difficult-to-age sculpin), and Copper Rockfish (a demersal rockfish) using secondary ion mass spectroscopy to measure oxygen isotope ratios ($\delta^{18}O$) in otoliths over the lifespan of the fish. Because an otolith is acellular, metabolically inert, and grows throughout the life of the fish, any elements or compounds accreted onto its surface are permanently retained. Otoliths therefore contain a complete record of the temperature and chemical composition of the ambient water a fish experienced over its lifespan. A known inverse relationship exists between water temperature and $\delta^{18}O$, so our goal is to relate peaks in the $\delta^{18}O$ signal (corresponding to cold water temperatures) to annual marks on the otolith.

H. Northwest Fisheries Science Center Newport (NWFSC) – (Patrick McDonald)

<u>Status</u>

We started working from home in March of 2020. We were able to meet and exchange otoliths at our off-site storage unit during the mandatory telework. We purchased some microscope eye-piece attachments to take images with our smart phone cameras. This was one way we could continue to resolve double-read specimens. We also allowed lead agers to resolve double-read specimens on their own. We are still working from home, but in late January we received approval for Return-To-Work to begin processing lingcod fin rays for the upcoming assessment.

<u>Assessments supported –</u>

2021

- Copper Rockfish
- Squarespot Rockfish
- Vermilion Rockfish
- Quillback Rockfish
- Dover Sole

Sablefish
Hake
Lingcod

2019

Big Skate
Sablefish
Widow Rockfish
Hake
Petrale Sole

Numbers of aged otoliths for 2019 and 2020

2019: Total numbers are 30,481
2020: Total numbers are 33,651
Those numbers are production and double reads combined.

Exchanges Participated - 2019 and 2020

Vermilion – ODFW, WDFW, SWFSC
Sablefish known-age – ADFG, AFSC, DFO
Dover Sole – AFSC
Widow Rockfish – WDFW

Personnel/Staffing

We currently have 4 full-time agers and one team lead. Our staffing has been stable, but we might be hiring a part-time age reader later this year to assist on a Hake project.

I. Southwest Fisheries Science Center (SWFSC) – (Melissa Monk)

The Southwest Fisheries Science Center Santa Cruz rejoined CARE in 2019. After the retirement of our only federal production ager, we are working to rebuild ageing capacity as staff time allows. Melissa Monk is now the contact for otolith requests and manages the otolith library at the SWFSC. In preparation for the 2021 Vermilion Rockfish stock assessment, the SWFSC initiated a round-robin otolith exchange for Vermilion Rockfish among the SWFSC, ODFW, WDFC, and the NWFSC. Each lab provided 50-60 otoliths. The exchange is now complete and analyses are forthcoming. This is the first time that vermilion rockfish have been aged in large quantities for an assessment.

The SWFSC is also participating in the FT-NIRS strategic initiative led by Tom Helser at the AFSC. We received a Bruker Tango (a NIR spectrometer) in 2020, but due to COVID-19, we have not been able to install the spectrometer.

B. Age Structure Exchanges

Age structure exchanges occur periodically to assess calibration among CARE age-reading agencies. Depending on results, specimens of interest (e.g., demonstrated biases) are then reviewed and discussed. Exchanges are tracked by the CARE Vice-Chair. Data from exchanges are available on the CARE website.

There were 10 age structure exchanges initiated in 2020 and none in 2021. Seven of the 2020 exchanges have been finalized and will be added to the CARE websites 'Structure Exchange table'.

Table 1. CARE age structure exchanges

CARE Age Structure Exchanges initiated in 2020				
Exchange ID No.	Species	Originating Agency	Coordinator	Participating Agency (Cooperators)
20-001	Dover Sole	NWFSC	Nikki Paige	AFSC
20-002	Dover Sole	AFSC	Julie Pearce	NWFSC
20-003	Sablefish	AFSC	John Brogan	NWFSC, ADFG-Juneau, CDFO
20-004	Rougheye Rockfish	ADF&G-Juneau	Cathy Mattson	AFSC
20-005	Rougheye Rockfish	AFSC	Chris Gburski	ADFG-Juneau
20-006	Yelloweye Rockfish	ADFG-Homer	Elisa Russ	ADFG-Juneau
20-007	Vermilion Rockfish	WDFW	Jenny Topping	NWFSC, ODFW, SWFSC
20-008	Vermilion Rockfish	SWFSC	Melissa Monk	WDFW, ODFW, NWFSC
20-009	Vermilion Rockfish	NWFSC-PSMFC	Patrick McDonald	WDFW, ODFW, SWFSC
20-010	Vermilion Rockfish	ODFW	Mark Terwilliger	NWFSC, WDFW, SWFSC

C. Attendees for the April 6, 2021 Virtual Check-in

Table 1. List of attendees

First name	Last name	Agency	Location	Country
Marian	Ford	ADFG	Homer	USA
Andrew	Pollak	ADFG	Homer	USA
Elisa	Russ	ADFG	Homer	USA
Chris	Hinds	ADFG	Juneau	USA
Catherine	Mattson	ADFG	Juneau	USA
Kevin	McNeel	ADFG	Juneau	USA
Sonya	Elmejjati	ADFG	Kodiak	USA
Delsa	Anderl	AFSC	Seattle	USA
Morgan	Arrington	AFSC	Seattle	USA
Irina	Benson	AFSC	Seattle	USA
John	Brogan	AFSC	Seattle	USA
Chris	Gburski	AFSC	Seattle	USA
Esther	Goldstein	AFSC	Seattle	USA
Brenna	Groom	AFSC	Seattle	USA
Jordan	Healy	AFSC	Seattle	USA
Charles	Hutchinson	AFSC	Seattle	USA
Craig	Kastelle	AFSC	Seattle	USA
Beth	Matta	AFSC	Seattle	USA
Sandi	Neidetcher	AFSC	Seattle	USA
Julie	Pearce	AFSC	Seattle	USA
Kali	Stone	AFSC	Seattle	USA
Barbara	Campbell	CDFO	Nanaimo	Canada
Chelsea	Cooke	CDFO	Nanaimo	Canada
Joanne	Groot	CDFO	Nanaimo	Canada
Mary-Jane	Hudson	CDFO	Nanaimo	Canada
Judy	McArthur	CDFO	Nanaimo	Canada
Chelsea	Rothkop	CDFO	Nanaimo	Canada
Audrey	Ty	CDFO	Nanaimo	Canada
Stephen	Wischniowski	CDFO	Nanaimo	Canada
Joan	Forsberg	IPHC	Seattle	USA
Chris	Johnston	IPHC	Seattle	USA
Dana	Rudy	IPHC	Seattle	USA
Kimberly	Sawyer	IPHC	Seattle	USA
Robert	Tobin	IPHC	Seattle	USA
James	Hale	NWFSC	Newport	USA
Betty	Kamikawa	NWFSC	Newport	USA
Patrick	McDonald	NWFSC	Newport	USA

Nikki	Paige	NWFSC	Newport	USA
Leif	Rasmuson	ODFW	Newport	USA
Mark	Terwilliger	ODFW	Newport	USA
Melissa	Monk	SWFSC	Santa Cruz	USA
Diana	Watters	SWFSC	Santa Cruz	USA
Austin	Anderson	WDFW	Olympia	USA
Andrew	Claiborne	WDFW	Olympia	USA
Christina	Jump	WDFW	Olympia	USA
Sandy	Rosenfield	WDFW	Olympia	USA
Jennifer	Topping	WDFW	Olympia	USA

Figure 1: Photo of virtual check-in attendees