Alaska Fisheries Science Center of the National Marine Fisheries Service
2020 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee
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Compiled by Ned Laman, Cara Rodgveller, and Olav Ormseth

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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), the Auke Bay Laboratories (ABL), and the Habitat and Ecological Processes Research program (HEPR). All Divisions work closely together to accomplish the mission of the Alaska Fisheries Science Center.

In 2021, our activities were guided by our Strategic Science Plan with annual priorities specified in the FY21 Annual Guidance and priorities. 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 Publications Center website, where you will also find a link to the searchable AFSC Publications Database.

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

A. RACE DIVISION

The Resource Assessment and Conservation Engineering (RACE) Division conducts quantitative fishery-independent surveys and related research on groundfish and crab in Alaska. Our efforts support implementation of the U.S. Magnuson-Stevens Fishery Conservation and Management Act and other enabling legislation for stewardship of living marine resources. Surveys and research are principally focused on species from the five large marine ecosystems (LMEs) of Alaska (Gulf of Alaska, Aleutian Islands, eastern Bering Sea, northern Bering and Chukchi Seas, Beaufort Sea). The range of surveys conducted by RACE encompass the entire life history of the focal species, from egg to adult. All surveys provide a suite of environmental data supporting an ecosystem approach to fisheries management (EBFM)[1]. In addition, RACE works collaboratively with Industry to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat.

RACE staff are composed of fisheries ecologists and oceanographers, geneticists, technicians, IT Specialists, fishery equipment specialists, administrative support staff, and contract research associates. The status and trend data derived from regular surveys are used by AFSC stock assessment scientists to develop our annual Stock Assessment & Fishery Evaluation (SAFE) reports for 46 unique combinations of species and regions. The research conducted by RACE on our bottom trawl surveys develops our understanding of groundfish population fluctuations and provides environmental data used in stock assessments, Ecosystem Status Reports (ESRs) and Ecosystem Socioeconomic Profiles (ESPs) for selected species. These products and related research communicate explanations for groundfish population trajectories to our stakeholders. The RACE Division science programs include: Fisheries Behavioral Ecology (FBE), Groundfish

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[1] https://www.fisheries.noaa.gov/insight/understanding-ecosystem-based-fisheries-management

Assessment Program (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes Program (RPP), Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations: Seattle, WA; Newport, OR; and Kodiak, AK.

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.

The primary mission of RACE GAP is the continued fishery-independent stock assessment surveys of 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 (even years). The upper continental slope of the eastern Bering Sea was quasi-biennial in even years, but has not be conducted since 2016. RACE GAP and SAP scientists also conduct bottom trawl surveys of Alaskan groundfish and invertebrate resources over the eastern and northern Bering Sea shelf. RACE GAP personnel continue to conduct cooperative Pacific cod satellite tagging studies in the Western Gulf of Alaska and the Bering Sea as well as cooperative surveys of locations untrawlable by the RACE GAP surveys of the Gulf.

The Midwater Assessment and Conservation Engineering (MACE) Program conducts echo integration-trawl (EIT) surveys of midwater pollock and other pelagic fishes in the Gulf of Alaska (winter) and the western and central Gulf of Alaska (summer). MACE and GAP continue to collaboratively design an acoustical-optical survey for fish in grounds that are inaccessible to fisheries research trawls in the Gulf of Alaska and Aleutian Islands. Once implemented, survey results will reduce bias in our survey assessments of fishes found in these untrawlable areas.

The Recruitment Processes Alliance (RPA: RACE RPP and ABL Ecological and Monitoring Assessment (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 and 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 2021, RACE scientists continued research on essential habitats of groundfish, identifying suitable predictor variables for building quantitative habitat models and developing tools to map species distributions and abundances throughout Alaska. For the first time, these scientists have mapped essential fish habitat (EFH) in nearshore nursery areas for early life stages of fishes in Alaska. Independent but related EFH projects have estimated habitat-related survival rates based on individual-based models;, investigated activities with potentially adverse effects on EFH, and determined optimal thermal and nearshore habitat for overwintering juvenile fishes. Juvenile fish growth and condition research characterizing groundfish habitat requirements is ongoing as well.

RACE GAP surveys continue to demonstrate changes to groundfish distribution and abundance related climate-mediated ocean warming and loss of sea ice. In 2021, the cold pool was slightly larger than in 2019, but was still almost entirely restricted to the area north of St. Matthew Island. Shifts in fish distribution due to these phenomena can lead to significant fractions of their populations relocating outside of our historical survey boundaries which violates our assumptions that our indexes of abundance represent a constant proportion 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 (Kupschus et al. 2020). In a related effort, ongoing research by RACE and other Center scientists is examining the efficacy of model-based abundance estimates to supplement our current design-based estimates.

The FBE conducts laboratory, experimental 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, nutritional conditions, 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 Lyle Britt at (206) 526-4501 or Deputy Director Michael Martin at (206) 526-4103.

Literature Cited:

Kupschus, S., S. Kotwicki, and W. Palsson. 2020. ICES Workshop on unavoidable survey effort reduction (WKUSER). ICES Scientific Reports. 2:72. 92pp. http://doi.org/10.17895/ices.pub.7453

B. REFM DIVISION

The research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic

Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. The activities of REFM are organized under several programs that have specific responsibilities but also interact:

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

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 and 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 10 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 eastern Gulf of Alaska 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, 4) whole genome sequencing of multiple groundfish, 5) population structure and distribution of pollock and cod species, 6) tagging juvenile sablefish nearby Sitka, AK, 7) the continuation of the long-term groundfish tagging program, 8) the continuation of a sablefish coast-wide assessment and research group (OR, WA, BC, AK), 9) conducting the AFSC’s annual longline survey throughout Alaska, and 10) the continuation of the northern Bering Sea ecosystem survey.

In 2021 ABL prepared 9 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”, and GOA thornyheads.

For more information on overall programs of the Auke Bay Laboratories, contact the ABL

Laboratory Director Dana Hanselman at (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

2021 Eastern Bering Sea Continental Shelf and Northern Bering Sea Bottom Trawl Surveys – RACE GAP

The thirty-ninth in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed in 2021 aboard the AFSC chartered fishing vessels *Vesteraalen* and *Alaska Knight*, which together bottom trawled at 376 stations over a survey area of 492,898 km^2. Researchers processed and recorded the data from each trawl catch by identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. Supplementary biological and oceanographic data were also collected during the bottom trawl survey to improve the understanding of groundfish and crab life histories and the ecological and physical factors affecting their distribution and abundance.

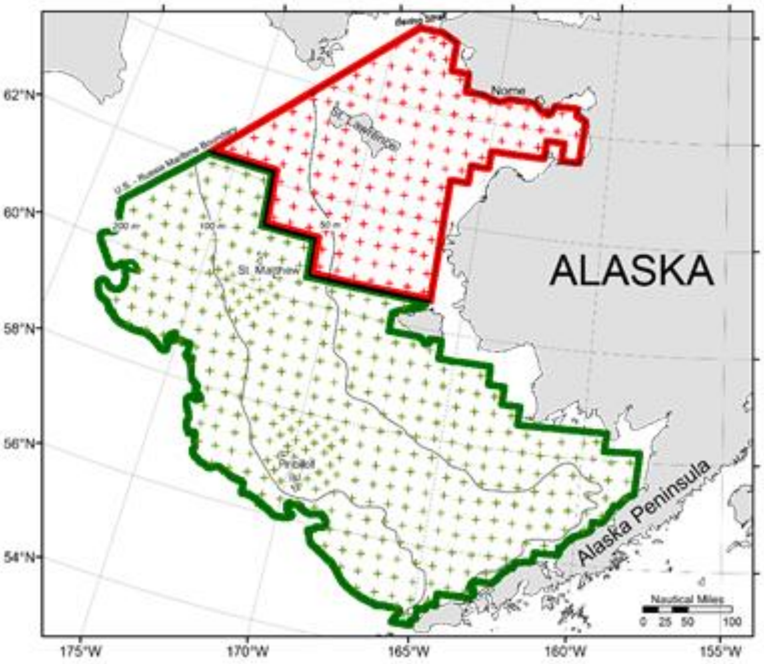

Fig. 1. Map showing survey stations sampled during the 2021 eastern and northern Bering Sea shelf bottom trawl survey.

Survey estimates of total biomass on the eastern Bering Sea shelf for 2021 were 3.0 million metric tons (mt) for walleye pollock, 616.3 thousand mt for Pacific cod, 162.2 thousand mt for yellowfin sole, 1.0 million mt for northern rock sole, 10.7 thousand mt for Greenland turbot, and 131.4 thousand mt for Pacific halibut. Approximately half of the commercially important fish species showed increases in estimated survey biomass compared to 2019 levels. Pacific cod biomass increased 19%, Pacific halibut 15%, Bering flounder 15%, flathead sole 11%, and northern rock sole 6%. Walleye pollock biomass decreased 44%, Greenland turbot 33%, Kamchatka flounder 26%, arrowtooth flounder 21%, yellowfin sole 19%, and Alaska plaice 9%.

The summer 2021 survey period was warmer than the long-term average for the seventh consecutive year. The overall mean bottom temperature was 3.34°C in 2021, which was slightly colder than 2019 (4.34 °C); the mean surface temperature was 7.23°C in 2021, which was almost two degrees colder than 2019 (9.24°C).

After the completion of the EBS shelf survey, which started for both vessels in Dutch Harbor on 29 May 2021, both vessels transitioned into sampling survey stations in the southwest corner of the NBS survey region. After a crew change, the F/V *Alaska Knight* sampled the stations west of Norton Sound moving to the Bering Strait and working south. The F/V *Vesteraalen* conducted sampling in the Norton Sound area traveling east to west. The F/V *Vesteraalen* and the F/V *Alaska Knight* conducted sampling in the NBS from 22 July to 13 August. A total of 520 20 x 20 nautical mile sampling grid stations in the combined EBS and NBS were successfully sampled in 2021.

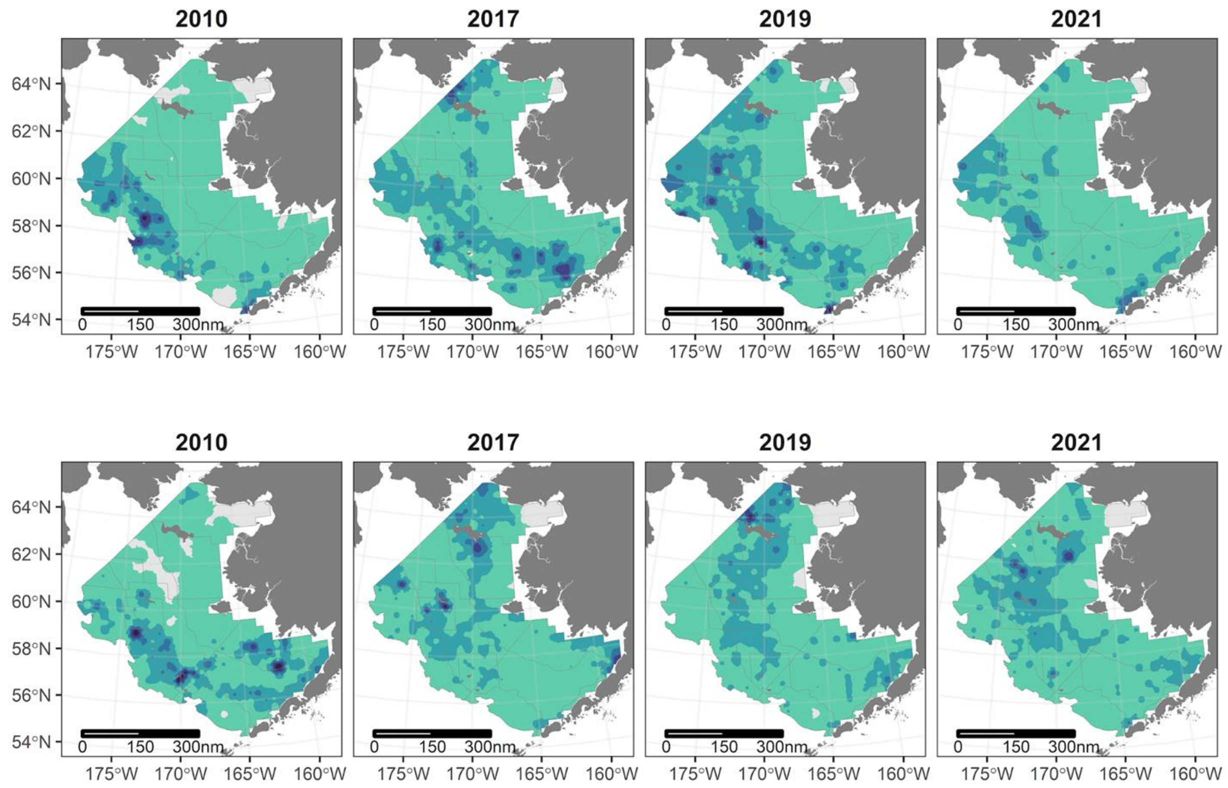

Fig. 2. Spatial distribution of large gadids, in terms of mean CPUE (kg/ha), observed during the 2010, 2017, 2019, and 2021 bottom trawl surveys of the EBS and NBS: Top panel is walleye pollock in (left to right) 2010,2017, 2019, and 2021; bottom panel is Pacific cod in (left to right) 2010, 2017, 2019, and 2021.

The NBS region was fully surveyed using the same standardized protocols and sampling resolution as the EBS survey in 2010, 2017, and 2019. The 2017 distributions of walleye pollock and Pacific cod were completely different than those observed in 2010. In 2010, pollock was mostly concentrated on the outer shelf at depths of 70–200 m north of 56°N (Fig. 2, top left). Pollock biomass was consistently low on the inner and middle shelf, and pollock were almost completely absent from the NBS.

In 2017, pollock biomass in the EBS was concentrated mostly on the middle shelf. In the NBS, there was a high concentration of pollock biomass to the north of St. Lawrence Island (Fig. 2, top middle). The total pollock biomass in 2018 from the EBS was 3.11 million mt. Pollock biomas from the NBS in 2017 was 1.32 million mt. In 2019, pollock distributions were quite different to 2017, 2018 and 2010. In 2018, the EBS pollock were densest in the south east corner of Bristol Bay, in small clusters along the Aleutian chain, and near the shelf break between 59°N and 60°N. During the 2019 EBS, pollock were densest north and west of the Pribilof Islands and the north west survey area In the NBS, pollock were concentrated directly south of St. Lawrence Island and north of the island near the Bering Strait (Figure. 2, top right). The total pollock biomass from EBS was 5.5 million mt, while pollock biomass from the NBS was 1.2 million mt in 2019.

In 2010, Pacific cod biomass in the EBS was concentrated in Bristol Bay and on the middle and outer shelf from the Pribilof Islands north to St. Matthew and cod biomass was low throughout the NBS (Fig. 2, bottom. left). Total cod biomass from the EBS was 8.7 thousand mt, while biomass from the NBS was only 2.9 thousand mt. In contrast, the 2017 Pacific cod densities in the NBS were high both to the north and south of St. Lawrence Island. The 2018 Pacific cod biomass was again concentrated in only a few areas of the EBS. Total estimated cod biomass from the EBS was 5.1 thousand mt during 2018 and biomass from the NBS during 2017 was 2.9 thousand mt. In 2019, Pacific cod biomass was again concentrated in only a few areas of the EBS, but the majority of the biomass was concentrated to the north, east, and south of St. Lawrence Island in the NBS (Fig. 2, bottom. right). Total estimated cod biomass from the EBS was 517 thousand mt, while biomass from the NBS was 365 thousand mt in 2019. In all survey years, Pacific cod were concentrated in areas with bottom temperatures >0°C.

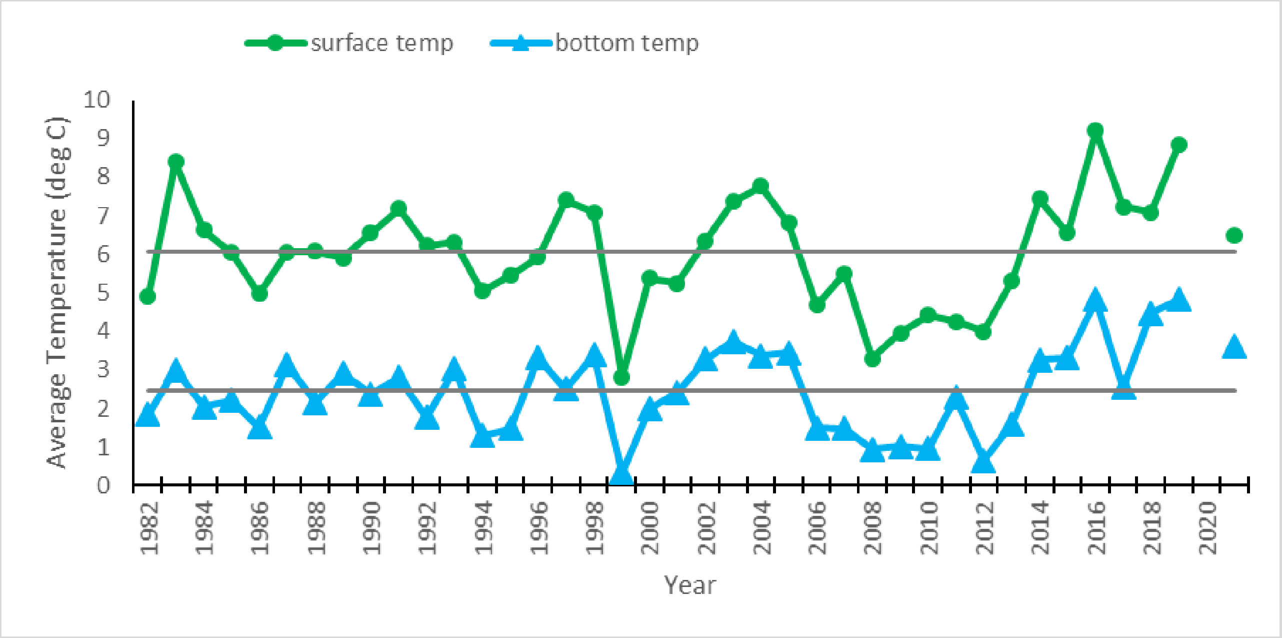

Figure 3: Average annual surface and bottom temperature during the survey period for the eastern Bering Sea shelf survey with the survey mean temperature (1982-2021).

The surface and bottom temperature mean for 2019 eastern Bering Sea shelf increased from 2018 estimates. Both were warmer than the long-term time-series mean (Fig. 3). The 2019 mean surface temperature was 9.2°C, which was 1.6°C higher than 2017 and 2.5°C above the time-series mean (6.7°C). The mean bottom temperature was 4.4°C, which was 0.2°C above the mean bottom temperature in 2018, but 1.6°C above the time-series mean (2.8°C). The 'cold pool', defined as the area where temperatures <2°C, appeared in stations to the west and southwest of St. Lawrence Island (Figure 4). The southern extent in 2019 reached to just south of St. Matthew Island. However, bottom temperatures along the entire length of the inner shelf from Bristol Bay to Chirikov Basin were warm (>6°C) and more developed than in 2017 when the cold pool only reached into a few stations west of St. Lawrence Island.

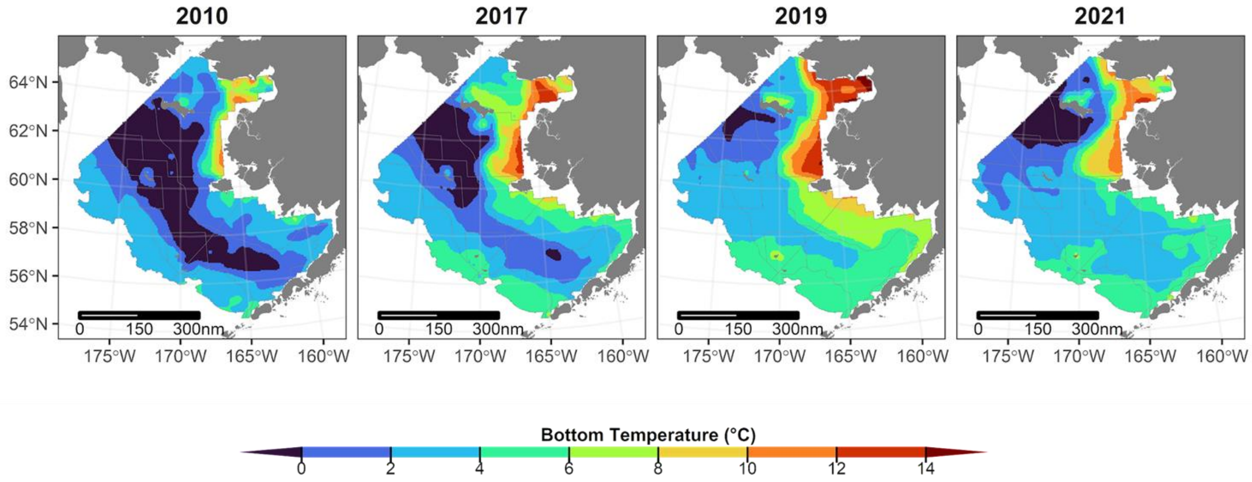

Figure 4: Distribution of survey bottom temperatures for (left to right) 2010, 2017, 2019, and 2021 - the four years that the EBS survey was expanded to comprehensively include the northern Bering Sea shelf.

2021 Gulf of Alaska Biennial Bottom Trawl Survey- RACE GAP

AFSC's RACE Division chartered the fishing vessels *Ocean Explorer* and *Alaska Provider* to conduct the 2021 Gulf of Alaska Biennial Bottom Trawl Survey of groundfish resources. This was the seventeenth survey in this series which began in 1984, was conducted triennially for most years until 1999, and then biennially since. The two vessels were each chartered for 75 days. The cruise originated from Dutch Harbor, Alaska in May and concluded at Ketchikan, Alaska in August. The survey began near the Island of Four Mountains (170° W longitude) and proceeded eastward through the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern management zones trawling in depths between 15 and 700 m.

During these surveys, we measure a variety of physical, oceanographic, and environmental parameters while identifying and enumerating the fishes and invertebrates collected in the trawls. Specific objectives of the 2021 survey included: defining the distribution and estimating the relative abundance of principal groundfishes and important invertebrate species that inhabit the Gulf of Alaska, measuring biological parameters for selected species, and collecting age structures and other samples. The survey design is stratified-random sampling utilizing 54 strata of depths and regions applied to a grid of 5 km^2 cells. Stations that have been identified as untrawlable were excluded from the sampling frame. Stations were allocated amongst the strata using a Neyman optimal sampling scheme weighted by stratum areas, stratum variance, and the ex-vessel values of key species. Stations were trawled with the RACE Division's standard four-seam, high-opening Poly Nor'Eastern survey trawl equipped with rubber bobbin roller gear. This trawl has a 27.2 m headrope and 36.75 m footrope consisting of a 24.9 m center section with adjacent 5.9 m "flying wing" extensions. Accessory gear for the Poly Nor'Eastern trawl includes 54.9 m triple dandylines and 1.8 ´ 2.7 m steel V-doors weighing approximately 850 kg each. The charter vessels conducted 15-minute trawls at pre-assigned stations. Catches were sorted, weighed, and enumerated by species. Biological information (sex, length, age structures, individual weights, stomach contents, etc.) were collected for selected groundfish species. Specimens and data for special studies (e.g., maturity observations, tissue samples, photo vouchers) were collected for various species, as requested by researchers at AFSC and other cooperating agencies and institutions. Specimens of rare fishes or invertebrates, including corals, sponges, and other sessile organisms were collected on an opportunistic basis and accessioned into the AFSC voucher system.

A total of 550 stations were planned across the shelf and upper slope of the Gulf of Alaska to a depth of 700 m (Figure 1). A total of 668 unique taxa were encountered in the 529 trawls completed; 180 of those were fishes and the remainder were invertebrates ranging from decapods to sponges. The total catch of all fish taxa from the survey was around 275 mt and of invertebrates was around 6 mt. A total of 47 taxa were accessioned to the AFSC RACE voucher collection from the 2021 survey, around 180,000 fish lengths were collected, and close to 11,500 otolith pairs were extracted for ageing. A variety of special collections for ecological and environmental studies were also completed A validated data set was finalized on 30 September and estimates of abundance and length composition of managed species and species groups were delivered to the Groundfish Plan Team of the North Pacific Fisheries Management Council (NPFMC); data and estimates have also been made available through the AKFIN system (www.psmfc.org). The Plan Team incorporated these survey results directly into Gulf of Alaska stock assessment and ecosystem forecast models forming the basis for groundfish harvest advice for ABCs and TAC in 2021. Biomass estimates for Pacific ocean perch, Pacific cod, and arrowtooth flounder all remained relatively stable in 2021 compared to 2019 estimates while walleye pollock abundance appeared to increase slightly.

For further information contact Ned Laman (206) 526-4832, Ned.Laman@NOAA.gov

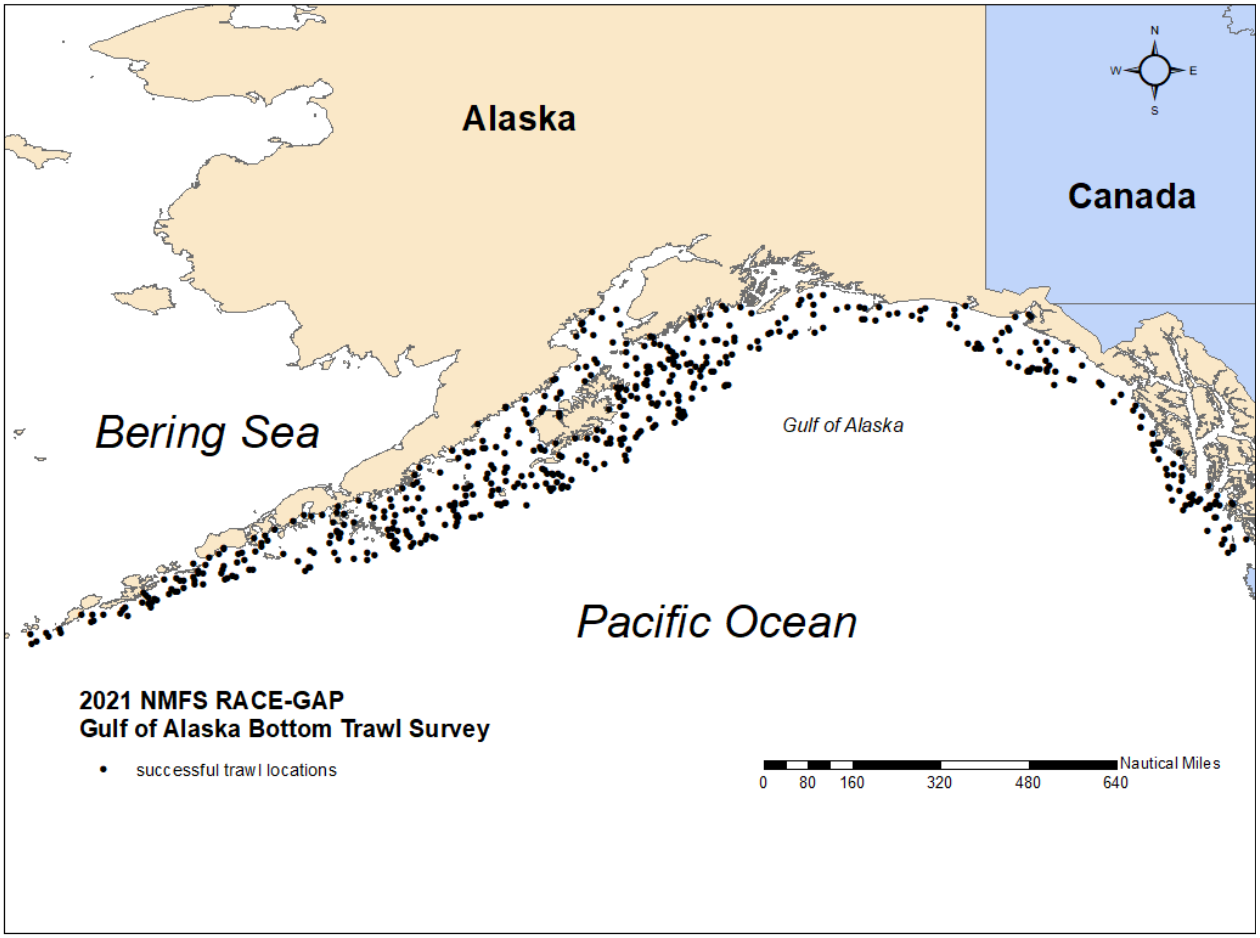

Figure 1. Stations successfully trawled (N = 529) during the 2021 Gulf of Alaska Biennial Bottom Trawl Survey by vessel.

GOA 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.

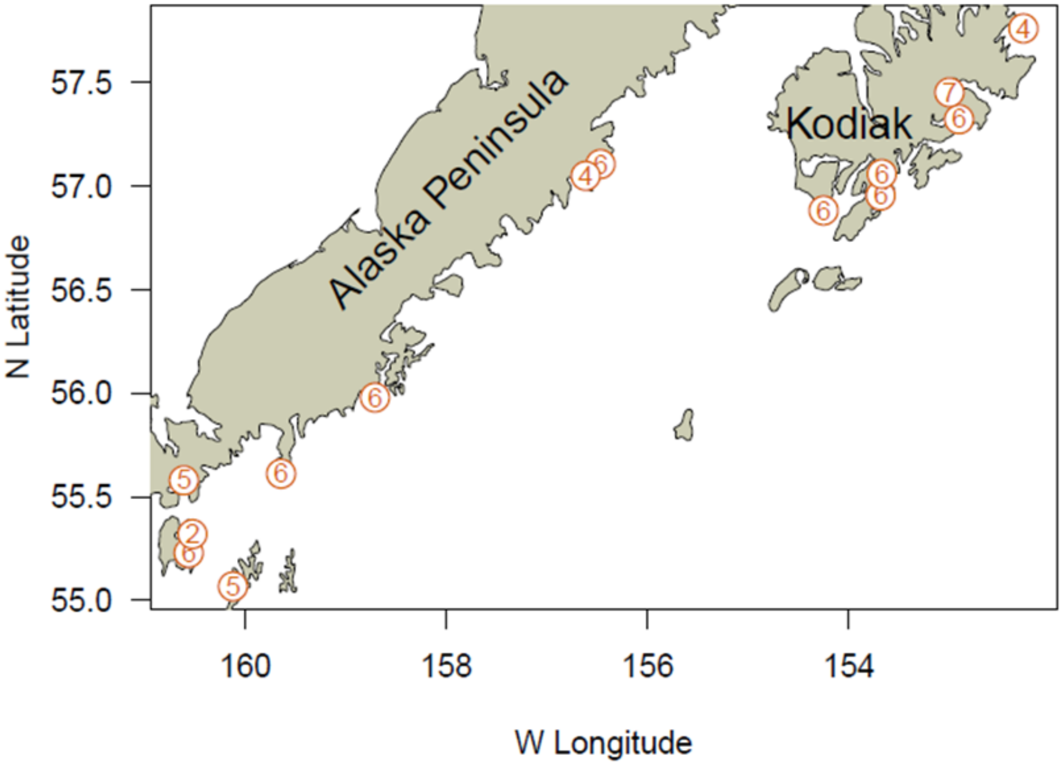

Figure 1: Beach seine sampling locations. Numbers inside circles indicate the total number of seine sets in each bay. A total of 27,992 individuals of 47 species of fish were captured, with age-0 Pacific cod and walleye pollock ranking most common. An additional 40 baited camera sets were also conducted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

Benjamin J. Laurel and Mike Litzow

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Laurel B.J., Ryer, C.H., Knoth, B., Stoner, A.W. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (Gadus macrocephalus). J. Exp. Mar. Biol. Ecol. 377:28-35.

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

Scientists from the Alaska Fisheries Science Center conducted an acoustic-trawl survey in the Shelikof Strait area during late winter 2021 to estimate the distribution and abundance of pre-spawning walleye pollock (*Gadus chalcogrammus*). Winter Gulf pre-spawning pollock surveys have typically included the Shumagin Islands, including Sanak Trough, Morzhovoi Bay, and Pavlof Bay since 2002, and the continental shelf break near Chirikof Island, and Marmot Bay as part of the Shelikof survey. Additionally, the Kenai/Prince William Sound area has been surveyed occasionally and is currently scheduled for odd-year winters. Shelikof and Marmot Bay were the only areas surveyed in winter 2021 due to impacts of the global COVID-19 pandemic. Shelikof Strait and Marmot Bay were surveyed 2-15 March.

The survey was 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. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques.

In Shelikof Strait, acoustic backscatter was measured along 1735.2 km (937 nmi) of transects spaced mainly 13.9 km (7.5 nmi) apart with spacing varying from 11.3 km to 15.6 km (6.1 to 8.4 nmi) in the survey area. Biological data and specimens were collected from 24 LFS1421 hauls targeted on backscatter attributed to pollock. Pollock and eulachon were the most abundant species in the catch by weight (contributing 68.3% and 24.7%, respectively) and also by numbers (contributing 52.1% and 40.9%, respectively). Pollock observed in Shelikof Strait were generally in pre-spawning (females) or spawning (males) maturity stages. The maturity composition of females > 40 cm fork length (FL; n = 219) was 1% immature, 8% developing, 88% pre-spawning, 2% spawning, and 0% spent. Most females were in the pre-spawning stage of maturity, substantially fewer were spawning and none was spent, which suggests that the timing of the 2021 Shelikof Strait survey relative to the spawning period was appropriate.

Pollock were detected throughout the main body of Shelikof Strait from roughly the Semidi Islands to north of Cape Nukshak. Most of the fish were distributed along the west side between Cape Nukshak and Cape Kekurnoi, and in the center of the sea valley south of Cape Kekurnoi, as is typical for previous Shelikof surveys. Most adult pollock were detected in a thick, uniform layer in water column depths between 205 and 275 m. Most juveniles <= 30 cm FL (largely comprising 8-16 cm FL, age-1 pollock) were between depths of 165 and 265 m. Juveniles were often observed in relatively shallow layers in the middle and eastern portion of the Strait, and would typically disperse at night.

A total of 8,364.7 million pollock weighing 526,974 t were estimated to be in the Shelikof Strait at the time of the survey. The 2021 biomass was 14.7% higher than that observed in 2020 (459,399 t) and 27.1% lower than the historic mean of 715,570 t. The relative estimation error of the 2021 biomass estimate based on the 1-D geostatistical analysis was 2.9%.

Pollock biomass at age in Shelikof Strait was marked by three modes at age-9, age-4, and age-1. Walleye pollock between 44 and 65 cm FL were primarily composed of the age-9 (2012) year class (2% of numbers, 27% of the biomass) with additional biomass contributed by the surrounding year classes. Pollock between 24 and 43 cm FL consisted primarily of the age-4 (2017) year class (2% of numbers, 14% of the biomass). The 8 to 16 cm FL age-1 (2020) year-class dominated the Shelikof Strait population numerically (92%) and contributed 13% of the biomass.

Acoustic backscatter was measured along 312.1 km (168.5 nmi) of transects spaced mainly 1.9 km (1 nmi) apart with spacing varying from 1.9 km to 3.7 km (1 to 2 nmi) in the Marmot Bay area. Biological data and specimens were collected in the Marmot Region from 6 LFS1421 hauls targeted on backscatter attributed to pollock. Pollock and eulachon were the most abundant species in the catch by weight, (contributing 98.1% and 1.2%, respectively) and by numbers (contributing 83.9% and 10.8%, respectively). Pollock observed in the Marmot Region were generally in developing (females) or spawning (males) maturity stages. The maturity composition of females > 40 cm FL (n = 19) was 30% immature, 44% developing, 25% pre-spawning, 0% spawning, and 1% spent. As most females were in the developing or pre-spawning stage of maturity and substantially fewer were spawning or spent, the timing of the 2021 Marmot Region survey relative to the spawning period was likely to have been appropriate.

Adult pollock were detected throughout Marmot Region, but were primarily found in Spruce Gully. Most adult pollock (75% of the biomass) were detected between depths of 135 and 265 m. Most juvenile pollock were detected between depths of 85 and165 m.

A total of 180.5 million pollock weighing 7,400.9 t were estimated to be in the Marmot Region at the time of the survey. The 2021 biomass was 17.9% higher than was observed in 2019 (6,275 t), the last time we surveyed that area. The relative estimation error of the 2021 biomass estimate based on the 1-D geostatistical analysis was 5.8%.

Pollock biomass at age in Marmot Bay was marked by three modes at age-9, age-4, and age-1. In contrast to Shelikof Strait, the age-4 (2017) year class made up the highest percentage of pollock biomass (2% of numbers, 28% of biomass) in the Marmot area, whereas the age-9 (2012) year class pollock were relatively less abundant (< 1% of numbers, 11% of the biomass). Age-1 pollock (9-16 cm FL, 2020 year class) accounted for 92% of the numbers and 17% of the pollock biomass.

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

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

Acoustic backscatter data (Simrad ES60, 38 kHz) were collected aboard two fishing vessels chartered for the AFSC summer 2021 bottom trawl surveys (F/V *Alaska Knight*, F/V *Vesteraalen*). These Acoustic Vessels of Opportunity (AVO) data were processed according to Honkalehto et al. (2011) to provide an index of age-1+ midwater pollock abundance for summer 2021 (Stienessen et al. 2022, in review). The 2021 AVO index of midwater pollock abundance on the eastern Bering Sea shelf increased by 37.6 % from the 2019 index value, and is the second highest value on record, only 1.8% less than the value recorded in 2015. The percentage of pollock backscatter east of the Pribilof Islands was 16%. This is on the low end of the range observed during the more recent summers between 2013 and 2019 (ca. 15% to 25%).

References:

Honkalehto, T.H., P.H. Ressler, R.H. Towler, and C.D. Wilson. 2011. Using acoustic data from fishing vessels to estimate walleye pollock abundance in the eastern Bering Sea. Canadian Journal of Fisheries and Aquatic Sciences 68(7): 1231–1242.

Stienessen, S.C., T. Honkalehto, N.E. Lauffenburger, P.H. Ressler, and L. Britt. 2022. Acoustic Vessel-of-Opportunity (AVO) index for midwater Bering Sea walleye pollock, 2021. *In review*.

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

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

The MACE Program completed a summer 2021 acoustic-trawl (AT) survey of walleye pollock (*Gadus chalcogrammus*; hereafter referred to as pollock) across the Gulf of Alaska (GOA) shelf from the Islands of Four Mountains eastward to Yakutat Trough aboard the NOAA ship *Oscar Dyson*. The summer GOA shelf survey also included smaller-scale surveys in the Shumagin Islands, Shelikof Strait, Barnabas Trough, and Chiniak Trough regions. Previous acoustic-trawl surveys of the GOA have also been conducted during the summers of 2003 (partial), 2005 (partial), 2011 (partial), 2013, 2015, 2017, and 2019. In 2021, the Covid-19 pandemic affected survey participation and logistics such that staffing could only support 2 - 20 day legs (40 day survey) instead of 3 (60 day survey). In response, many smaller bays and troughs surveyed since 2013 were not surveyed in 2021; analysis suggested that this will have little impact on the survey estimate as 92% - 98% of the survey biomass from 2013-2019 was within the areas surveyed in 2021.

The primary survey objective was to collect daytime 38 kHz acoustic backscatter and trawl data to estimate the abundance of pollock. Midwater and near-bottom acoustic backscatter was sampled using an LFS1421 trawl. A trawl-mounted stereo camera ("CamTrawl") was used during LFS1421 trawls to aid in determining species identification and size of animals encountered by the trawls at different depths. A poly Nor'eastern (PNE) bottom trawl was used for sampling near-bottom organisms. Midwater macro-zooplankton were sampled using a Methot trawl. Additionally, the survey collected physical oceanographic data. Water temperature profiles were obtained with a temperature-depth probe attached to LFS1421, PNE and Methot trawls, as well as with conductivity-temperature-depth (CTD) collections at calibration sites, at several predetermined stations, and at nightly opportunistic sites. Sea surface temperatures were continuously measured using the ship's flow-thru sea surface temperature system.

Biological data and specimens were collected from 58 LFS1421, 4 Methot, and 5 PNE hauls. Pollock and Pacific ocean perch were the most abundant species by weight in LFS1421 trawls, contributing 51.5% and 36.3% of the catch, respectively. Pollock and eulachon were the most abundant species by number, contributing 44.8% and 18.2% of the catch. In the PNE bottom trawls, Pacific ocean perch and pollock were the most abundant species by weight, contributing 34.8% and 23.8% of the catch. Pacific glass shrimp and pollock were the most abundant species by number, contributing 68.7% and 7.7% of the catch. Euphausiids were the most abundant species by weight (82.9%) and number (99.1%) in Methot trawls.

The estimated abundance of age-1+ pollock for the entire surveyed area was 4,307.6 million fish weighing 431,053 metric tons (t), a decrease of 7.6% by numbers and 27.5% by weight from the 2019 estimated abundance. The majority of the pollock biomass was observed in the GOA Shelf (60%) and Shelikof Strait (28%) regions. In GOA surveys conducted from 2013 to 2019, the historically large 2012 year class was responsible for the bulk of the observed pollock biomass and numbers. Although the pollock from the 2012 year class were still observed by the survey in summer 2021, age-4 pollock dominated by weight, and age-1 pollock dominated numerically: 28% of the total pollock biomass was attributed to age-4 fish from the 2017 year class, and 84% of the total pollock numbers were attributed to age-1 fish from the 2020 year class.

Abundance estimates were also calculated for Pacific ocean perch (*Sebastes alutus*) and Pacific capelin (*Mallotus catervarius*). Pacific ocean perch ranged from 16 cm to 47 cm fork length (FL), with a mode at 39 cm. The estimated amounts of POP for the 2021 GOA survey area were 386.0 million fish weighing 277,941 t, 77% higher by numbers and 93% higher by biomass than the 2019 estimate. Pacific capelin ranged from 7 cm to 15 cm standard length, with a mode at 9 cm. The estimated amounts of Pacific capelin for the 2021 GOA survey area were 1,563.7 million fish weighing 8,593 t, 63% lower by numbers and 41% lower by biomass than the 2019 estimate. Since 2011, an estimate of the distribution and abundance of backscatter attributed to euphausiids (or 'krill,' primarily consisting of *Thysanoessa inermis*, *T. spinifera*, and *Euphausia pacifica*) has also been provided; work to produce this estimate in 2021 is ongoing.

Since 2013, 5 survey areas have been consistently sampled in all summer GOA surveys: the GOA shelf, Shumagin Islands, Shelikof Strait, Barnabas Trough, and Chiniak Trough regions. Within this consistently sampled region and time period, average surface temperatures in previous surveys have ranged from 10.2°C (2013) to 12.0°C (2015). In 2021, the surface temperature was 9.0°C, 1.2°C cooler than in the coolest previous survey (2013). Surface temperatures became progressively warmer from west to east; however, this is confounded with survey timing, as water temperatures increased to seasonal highs during the survey period. Similarly, differences in survey timing confound any inter-annual comparisons of surface temperature, as survey regions were not always sampled at the same time within each survey year and the 2021 survey concluded approximately 20 days earlier than other summer GOA surveys. The mean temperature at 100 m depth in 2021 was 5.4°C, within the range of previous surveys, which have ranged from 5.1°C (2013) to 6.5°C. The mean bottom temperature, as measured during 31 CTD deployments, was 5.0°C, 0.1°C cooler than in the coolest previous survey (mean bottom temperatures in previous surveys have ranged from 5.1°C in 2013 to 6.0°C in 2019).

The GOA Shelf from the Islands of Four Mountains eastward to Yakutat Trough was surveyed between 4 June and 8 July. Acoustic backscatter was measured along 1,415 nmi of trackline on 30 transects spaced 30.0 nmi (west of Kodiak Island) or 40.0 nmi (east of Kodiak Island) apart. Age-1+ pollock ranged in length from 12 to 67 cm FL with modes at 16, 31, and 41 cm FL. Pollock ranged in age from 1 to 12, with age-1 fish comprising the majority by number (74%) and age-4 fish comprising the majority of the biomass (31%). The estimated amounts of age-1+ pollock for the GOA Shelf were 1,653.9 million fish weighing 260.1 thousand tons, 60.3% of the total pollock biomass observed in this survey and 62.4% of the estimate in 2019.

The Shumagin Islands region was surveyed between 9 June and 12 June. Acoustic backscatter was measured along 211 nmi of trackline on 26 transects primarily spaced 3.0 nmi apart. Age-1+ pollock observed on the Shumagin Islands ranged in length from 13 to 62 cm FL with a mode at 15 cm FL. Pollock ranged in age from 1 to 12, with age-1 fish comprising the vast majority by number (98%) and age-1 fish comprising the majority of the biomass (63%). The estimated amounts of age-1+ pollock for the Shumagin Islands were 131.5 million fish weighing 5.5 thousand tons, approximately 1.3% of the total pollock biomass observed in this survey and 28.5% of the estimate in 2019.

The Barnabas Trough region was surveyed between 17 June and 20 June. Acoustic backscatter was measured along 165 nmi of trackline on 12 transects spaced 6.0 nmi apart. Age-1+ walleye pollock observed on the Barnabas Trough ranged in length from 13 to 65 cm FL with modes at 15 and 39 cm FL. Pollock ranged in age from 1 to 12, with age-1 fish comprising the majority by number (54%) and age-3 fish comprising the majority of the biomass (40%). The estimated amounts of age-1+ pollock for the Barnabas Trough were 174.7 million fish weighing 36.0 thousand tons, approximately 8.4% of the total pollock biomass observed in this survey and nearly identical to the estimate in 2019.

The Shelikof Strait region was surveyed between 24 June and 28 June. Acoustic backscatter was measured along 357 nmi of trackline on 12 transects predominantly spaced mainly 20.0 nmi apart. Age-1+ walleye pollock observed on the Shelikof Strait ranged in length from 12 to 62 cm FL with modes at 15 and 39 cm FL. Pollock ranged in age from 1 to 12, with age-1 fish comprising the vast majority by number (93%) and age-1 fish comprising the majority of the biomass (40%). The estimated amounts of age-1+ pollock for the Shelikof Strait were 2,228.4 million fish weighing 119.6 thousand tons, approximately 27.7% of the total pollock biomass observed in this survey and an increase of 12% from the estimate in 2019.

The Chiniak Trough region was surveyed between 29 June and 30 June. Acoustic backscatter was measured along 121 km (65 nmi) of trackline on 7 transects spaced 6.0 nmi apart. Age-1+ walleye pollock observed on the Chiniak Trough ranged in length from 14 to 64 cm FL with modes at 15 and 37 cm FL. Pollock ranged in age from 1 to 12, with age-1 fish comprising the vast majority by number (88%) and age-1 fish comprising the majority of the biomass (29%). The estimated amounts of age-1+ pollock for the Chiniak Trough were 119.1 million fish weighing 9.9 thousand tons, approximately 2.3% of the total pollock biomass observed in this survey and twice the estimate in 2019.

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

Longline Survey – ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2021. 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 2021, the 44th annual longline survey sampled the upper continental slope of the Gulf of Alaska and the eastern Bering Sea. One hundred and fifty-two longline hauls (sets) were completed during May 30 – August 26 by the chartered fishing vessel *Alaskan Leader*. Total groundline set each day was 18 km (9.7 nmi) and consisted of 180 skates and a total of 8,100 hooks.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), rougheye/blackspotted rockfish (*Sebastes aleutianus/S. melanostictus*), shortspine thornyhead (*Sebastolobus alascanus*), and Pacific halibut (*Hippoglossus stenolepis*). A total of 169,613 sablefish, with an estimated total round weight of 392,897 kg (866,189 lb) were caught during the survey. This represents increases of 14,774 fish and 50,296 kg (110,884 lb) of sablefish over the 2020 survey catch. Sablefish (6,156), shortspine thornyhead (312), and Greenland turbot (*Reinhardtius hippoglossoides*, 27) were tagged with external Floy tags and released during the survey. Length-weight data and otoliths were collected from 3,480 sablefish. Killer whales (*Orcinus orca*), depredating on the catch, occurred at 10 stations in the eastern Bering Sea and one station in the western Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 10 stations in 2021 and were observed depredating on the gear at 5 stations in the central Gulf of Alaska, one station in the West Yakutat region, and 2 stations in the East Yakutat/Southeast region.

In 2021, the number of AFSC staff that participated on the survey was reduced for COVID-19 precautions. AFSC permanent staff participated on 4 out of 6 legs of the survey. An experienced contractor participated on all legs and served in the role of Chief Scientist for the two legs not supervised by AFSC staff. With reduced scientific staff onboard, special projects were curtailed but did include the collection of sablefish eyeballs for examining stable isotope ratios in eye lenses for tracking trophic level changes through development.

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).

Northern Bering Sea Surface Trawl and Ecosystem Survey - ABL

The 2021 survey occurred at standard stations in the northern Bering Sea in 2021. Station sampling included phytoplankton, zooplankton, invertebrate nekton, fish, seabird, and marine mammals. The average surface temperature (9.4°C) in 2021 was just above the overall average annual temperature (8.8°C) recorded during the survey from 2003 to 2021. The most abundant benthic fish species captured was yellowfin sole and they were present at nearshore stations throughout the survey. We plan to continue the survey on an annual basis to provide scientific support for salmon, groundfish, and crab resources in the northern Bering Sea.

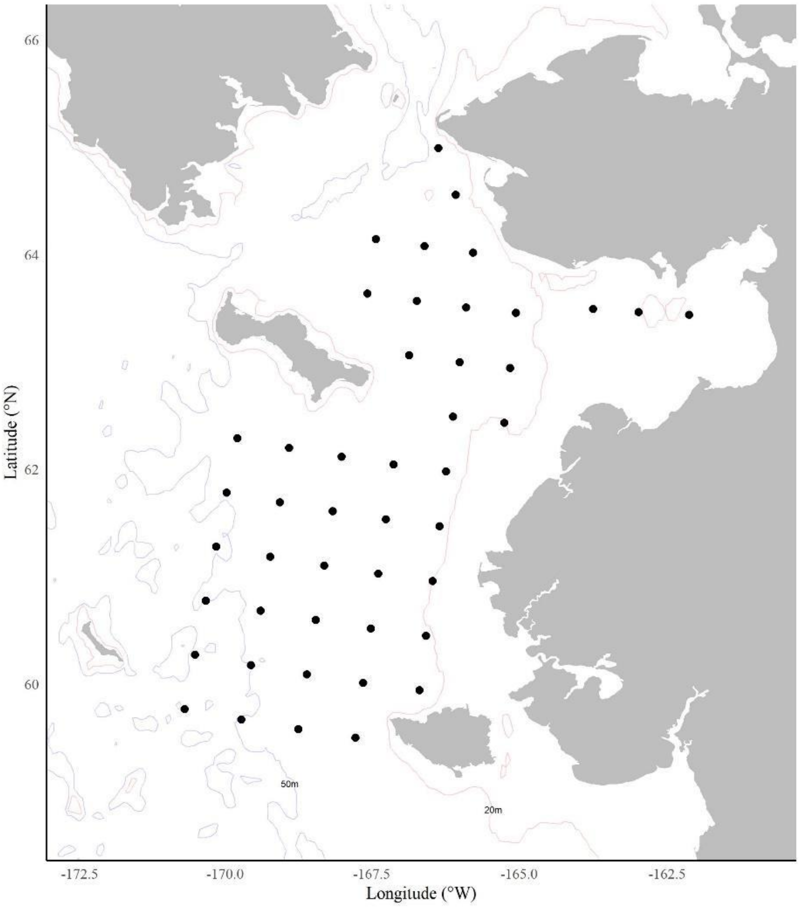


Figure 1. Standard stations sampled during 2021 Northern Bering Sea Surface Trawl and Ecosystem Survey, August 27 to September 20, 2021.

North Pacific Groundfish 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 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. Hagfish

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

B. Dogfish and other sharks

1. Research

Population Genetics of Pacific Sleeper Sharks - ABL

The purpose of this study is to investigate the population structure of Pacific sleeper sharks (*Somniosus pacificus*) 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. Samples of Greenland shark (*S. microcephalus*) and southern sleeper sharks (*S. antarcticus*) were also used in this study. We generated next-generation sequencing data using the reduced representation library method RADseq and conducted phylogenomic and population genomics analyses to provide novel information for use in stock assessments. Our results strongly support the species status of *S. microcephalus* (n = 79), but recover *S. antarcticus* (N = 2) intermixed within the *S. pacificus* (N = 170) clade. Population genomic analyses reveal genetic homogeneity within *S. pacificus* and *S. microcephalus*, and estimates of effective population size suggest populations of hundreds of individuals. Kinship analysis identified two first-degree relative pairs within our dataset (one within each species). Overall, our research provides insight into the evolutionary relationships within the Somniosus Somniosus subgenus. A manuscript is currently in review.

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

Ageing of Pacific Sleeper Sharks – ABL

A pilot study is underway by staff at ABL, REFM, 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 1). 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 1, 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. Proposals are pending which would further fund this study and address the concerns and assumptions highlighted by the pilot study work.

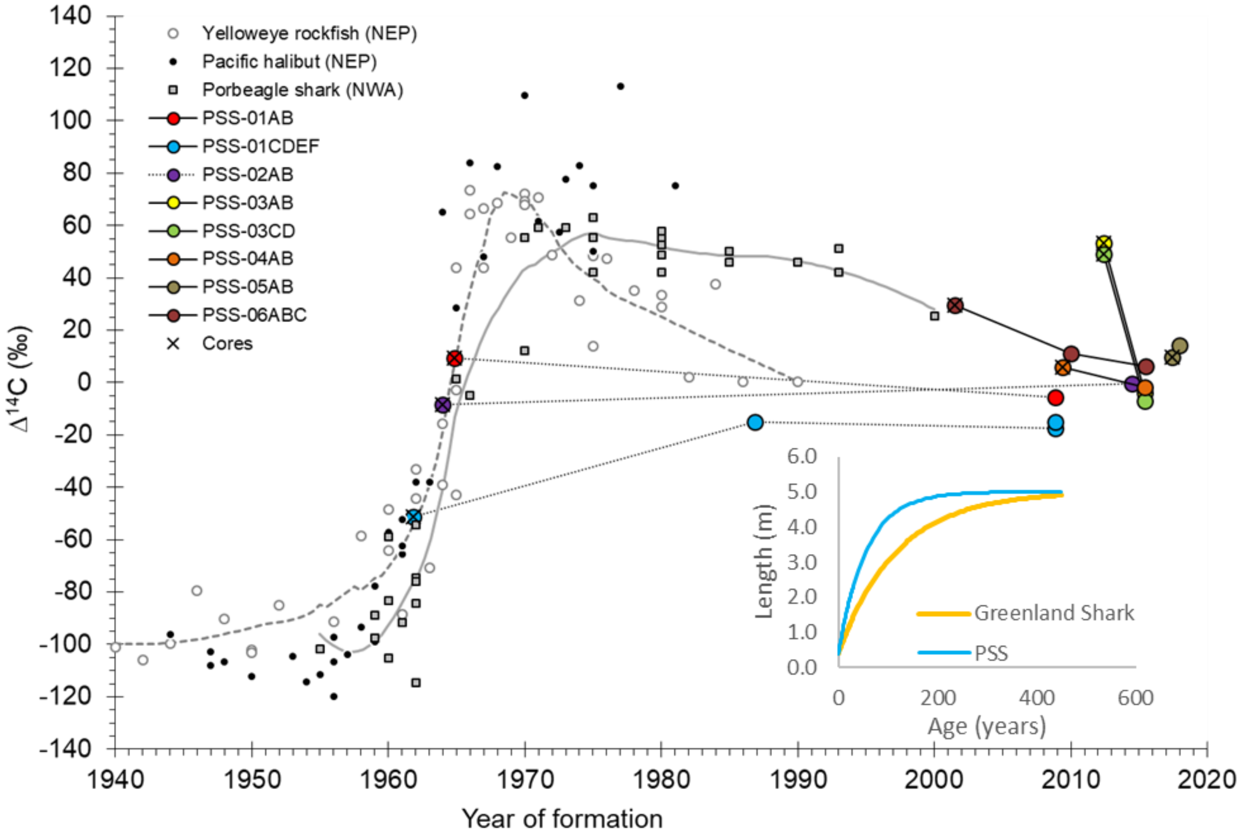


Figure 1. Pacific sleeper shark (PSS) eye lens 14C values from the pilot study plotted as estimated year of formation relative to regional 14C references. Data from six sharks are shown as a series of samples from the core to the outer eye lens. Both eye lenses were sampled in two sharks (PSS-01 and 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.

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

Shark tagging – ABL

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 modeling 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, four 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.

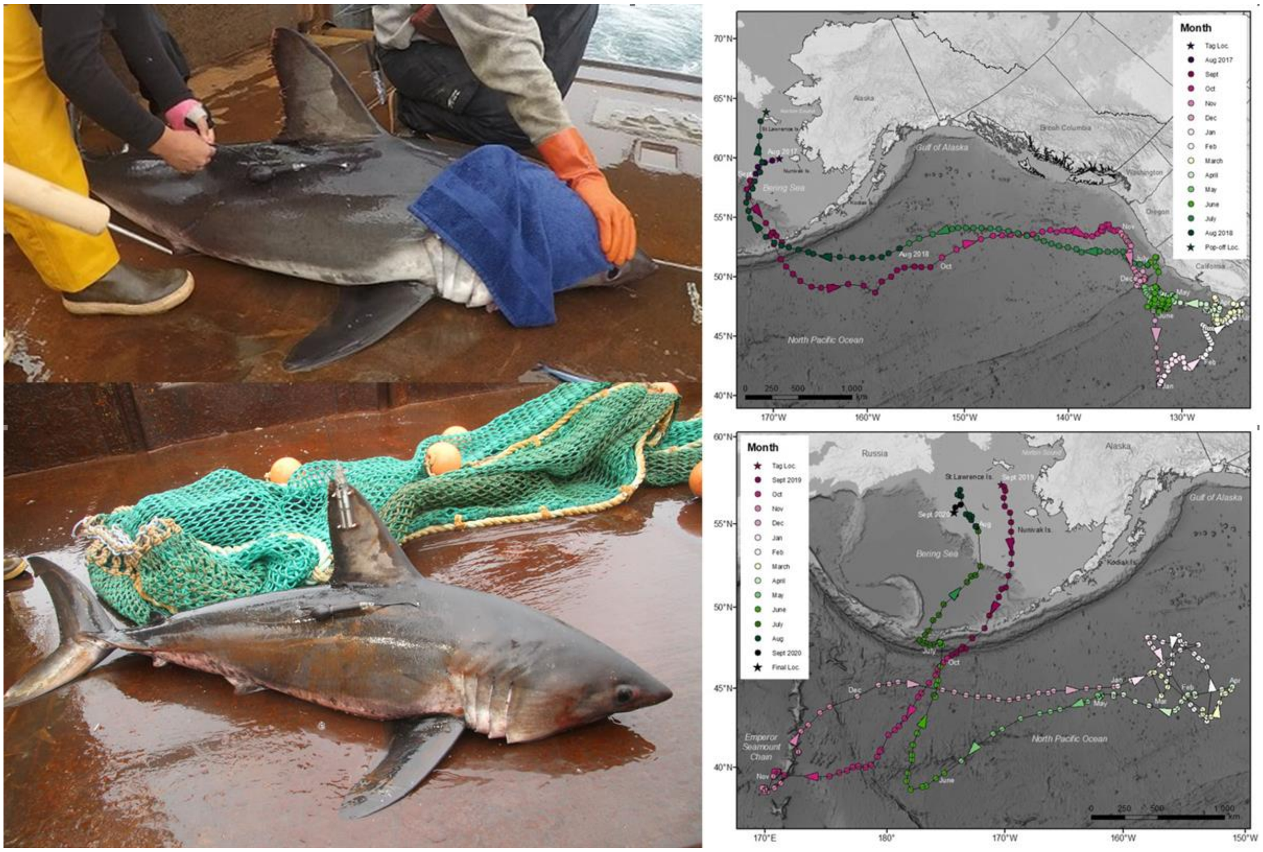


Figure. (Left) Shark A (top) being tagged with a PSAT using two tethers on August 27, 2017. The harness of the second tether attachment is being looped around the body of the tag. Shark B (bottom) with a SPOT-257 tag affixed to the dorsal fin and a PSAT attached with two tethers in the musculature beneath 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.

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

2. Stock Assessment

Sharks - ABL

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) are on biennial cycles in even years. There were no assessments in 2021.

C. Skates

1. Research

2. Assessment

Bering Sea and Aleutian Islands (REFM)
re-insert 2020 text here since it's a rollover - only assessed in even years

Gulf of Alaska (REFM)
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

For more information contact Ron Felthoven or Stephani Zador at Ron.Felthoven@NOAA.gov or Stephani.Zador@NOAA.gov .

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.

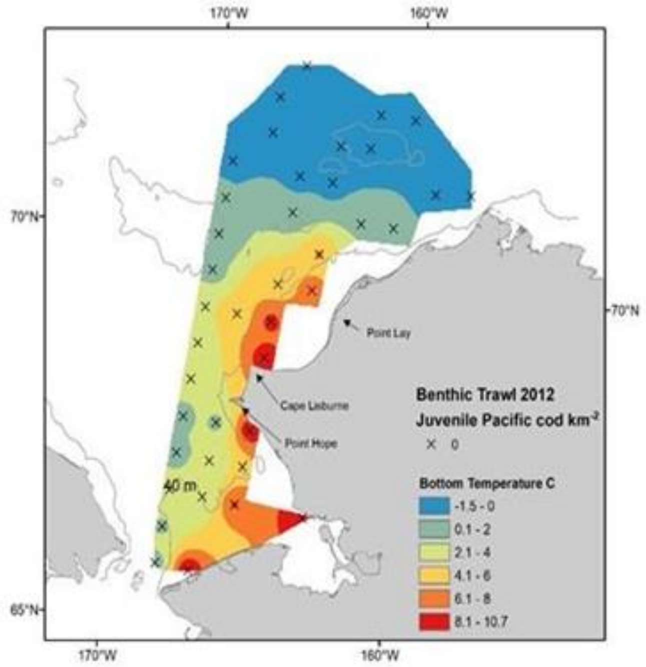
Cod appear unique in their spatial distribution, migration patterns, and sensitivity to temperature. The projects outlined here are designed to test and implement the performance of an ecosystem-based fisheries management approach for Pacific cod in the eastern Bering Sea (EBS), Aleutian Islands (AI), 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 2021 has shown that a large proportion of cod tagged in the western Gulf of Alaska moved as far north as the northern Bering Sea. More work is needed to understand spawning and migration patterns and responses to climate change that can be integrated into model projections.

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

a. 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.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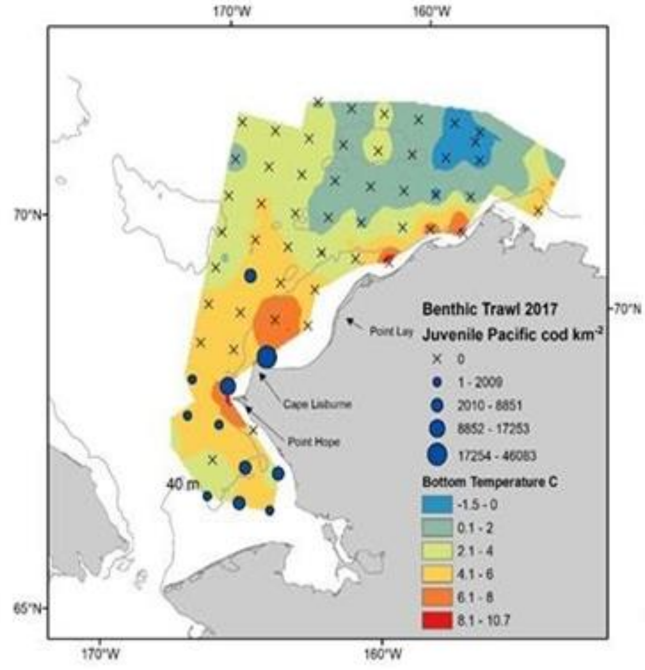
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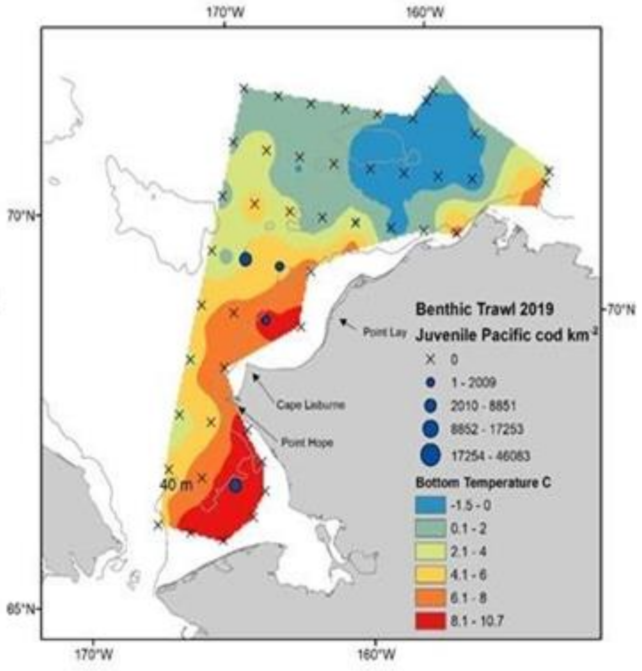
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8.1 - 10.7

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

b. 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.

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

d. 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 climate change, 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.

e. 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.

f. 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.

g. 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.

h. PSAT #2 - Gulf of Alaska (Winter 2021); EBS and Chukchi, Summer 2021: Continuation of Pacific cod Satellite tagging 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. In 2021, scientist from the RACE GAP group released 25 satellite tagged Pacific cod in March in the Gulf of Alaska and 26 satellite tagged Pacific cod in the EBS and NBS during the summer. These tagging studies were cooperative projects with the commercial fisheries and the Aleutian East borough. From the Gulf of Alaska study, 19 satellite tags have successfully popped up and 4 conventional tags were recovered by the fishery. Locations of tags recovered in March, April, and May were largely in the vicinity of the release area but fish with tags recovered in June, July, and August had moved west toward the Aleutian Islands region and north into the EBS, NBS, and Russia. More than half of the tag recoveries (9 of 16) between the beginning of June and the end of August were located in the Bering Sea, indicating substantial seasonal connectivity between the Gulf of Alaska and Bering Sea management regions. One tag recovery in September had moved into the southern Chukchi Sea. We are in the process of modeling the movement path of the tagged fish using a geospatial model developed from previous tag releases. This will make it possible to estimate the percentage of time fish spent in each management area over the course of a year and help inform stock assessment and management.

For more information please contact Steve Barbeaux (steve.barbeaux@noaa.gov) or Ingrid Spies (ingrid.spies@noaa.gov).

i. Tracking age-1 Pacific cod across thermal habitats with acoustic transmitters - RACE-GAP – There is growing evidence that seasonal metabolic stress influences the growth and survival of Pacific cod though little information has been gathered on the use of habitat during the early life stages. To link age-1 Pacific cod with their use of nearshore nursery habitats a study was developed using telemetry, bio-loggers, diet analysis, and bioenergetic modeling. The study was conducted in a semi enclosed bay that is known nursery habitat for Pacific cod, Anton Larson Bay (57° 53’ 05” N; 152° 47’03” W) on Kodiak Island, Alaska.

A passive acoustic array was established to track the movement of P. cod in the bay. The array was comprised of 15 moorings equipped with Vemco VR2W-69 kHz receivers. Three gates were deployed across the mouth of the bay and at natural choke points in/out of the bay. Additionally, a number of non-overlapping receivers were set to monitor movements within bay (**Figure 1**). A network of thermographs recorded water temperature across a range of locations and depths.

Twenty age-1+ P. cod were implanted with Vemco V7-4TP multi-sensor tags (location & temperature). The average size of the tagged fish was 281.0 ± 20.5 mm TL. Movements of tagged fish were monitored from July - October, 2021. Individual fish were detected an average of 46 days out of the 92 day study (min 5 and max 89 days). In general early in the study (July & Aug) fish detections predominantly occurred in the inner bay near their initial point of release. Later in the study fish detections tended to occur at outer bay stations. Analysis of the tagging data is currently underway.

Baited cameras were used to monitor changes in fish abundance over time. Sampling was conducted monthly (July-Oct) at 3 depths (10', 30', and 50', with 10 replicates each). During the initial review of large numbers age-0 and 1+ P. cod were observed in both July and August. Additional analysis of the video data is underway.

To assess temporal variation in diets, stomach contents were collected monthly (n=>20 per/period). While the target number of fish were sampled in both July & August, no fish were caught in either September or October, suggesting that they may have moved out of the bay. In the lab, their stomach contents were analyzed to determine their diet composition. This information along with data on fish movements and their thermal environment will be input into existing Wisconsin bioenergetics models (Holsman & Aydin, 2015). The models attempt to develop bioenergetics estimates for: metabolic demand, relative foraging rate (RFR), prey energy density, and growth potential (G').

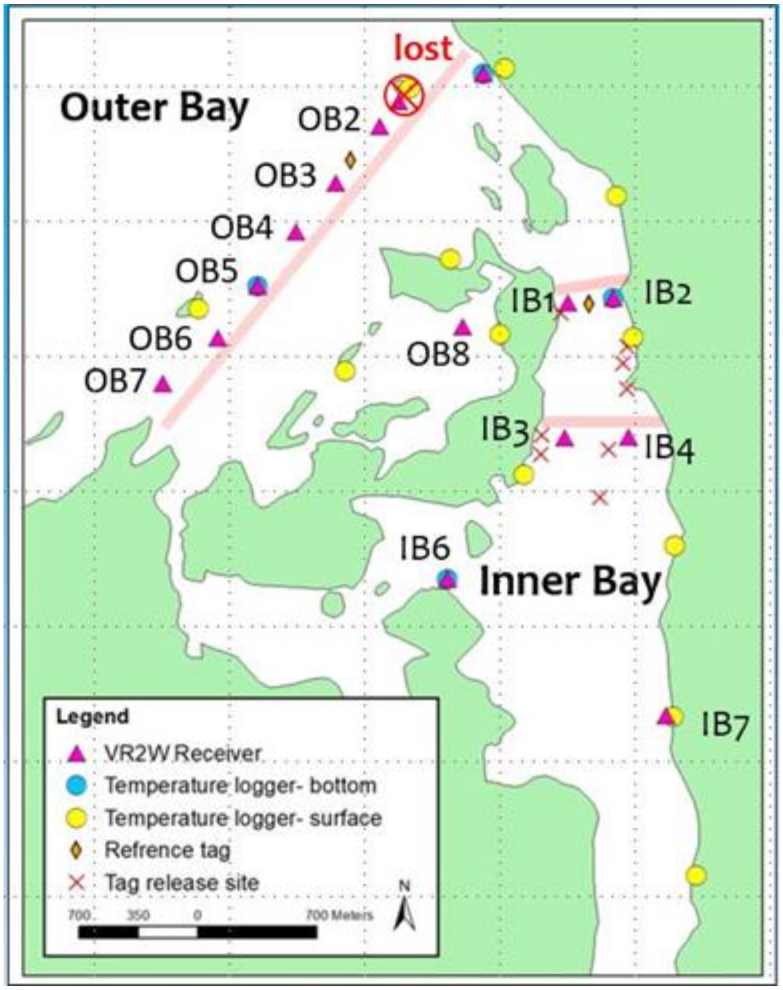

Figure 1: Anton Larson Bay study site showing locations of VR2W acoustic receivers, temperate loggers, and fish release sites. Release sites indicate where fish implanted with Vemco V7-4TP multi-sensor tags were returned to the bay.

For more information contact Sean Rooney (Sean.Rooney@NOAA.GOV)

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 is 155,873 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 AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

F. Walleye Pollock

1. Research

Winter acoustic-trawl surveys of pre-spawning walleye pollock 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.

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

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

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).

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

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

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.

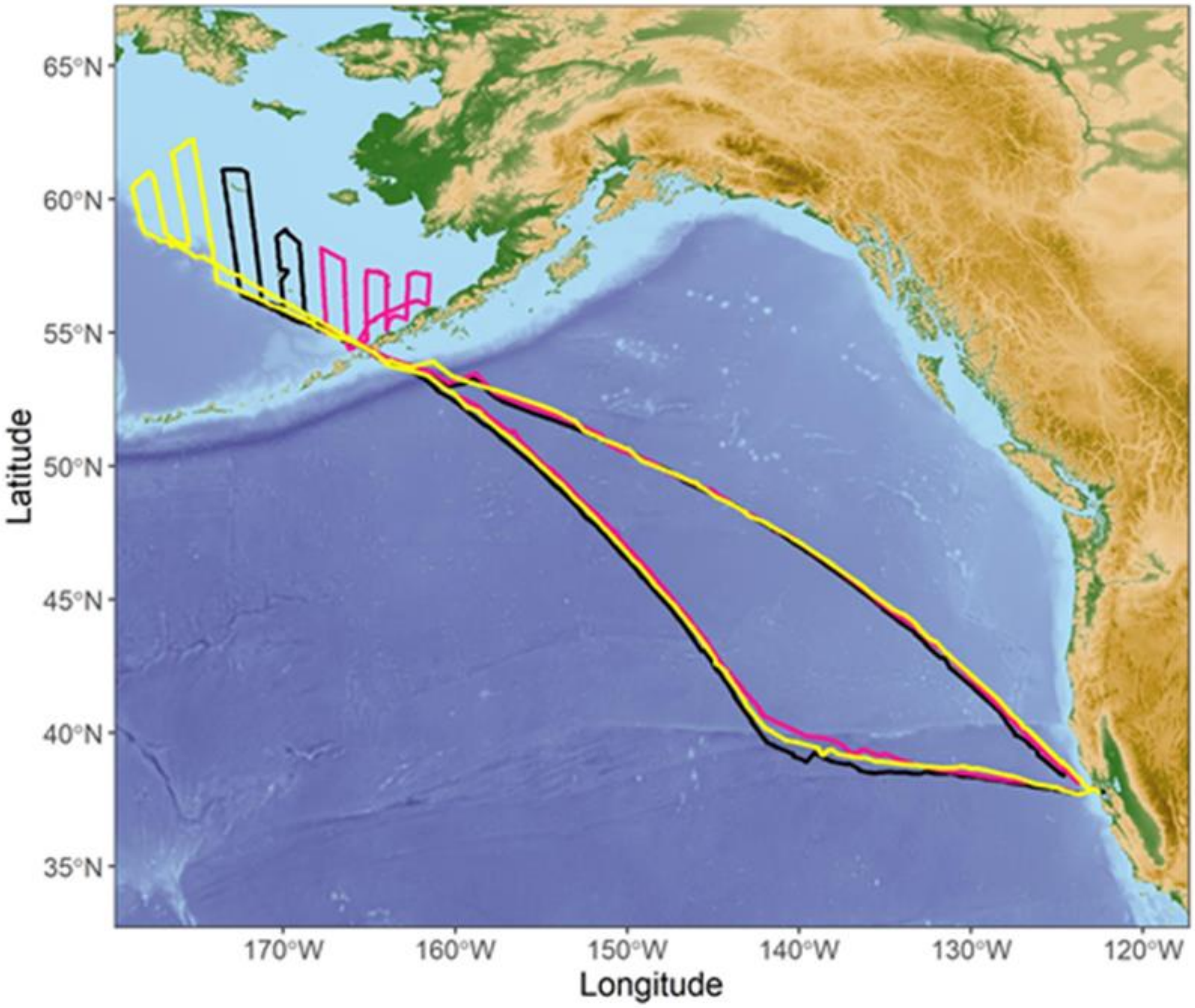

Fig. 1. Path taken by saildrones as they sailed from California across the North Pacific to the survey area in the Bering Sea and returned. Each USV track is depicted in a different color

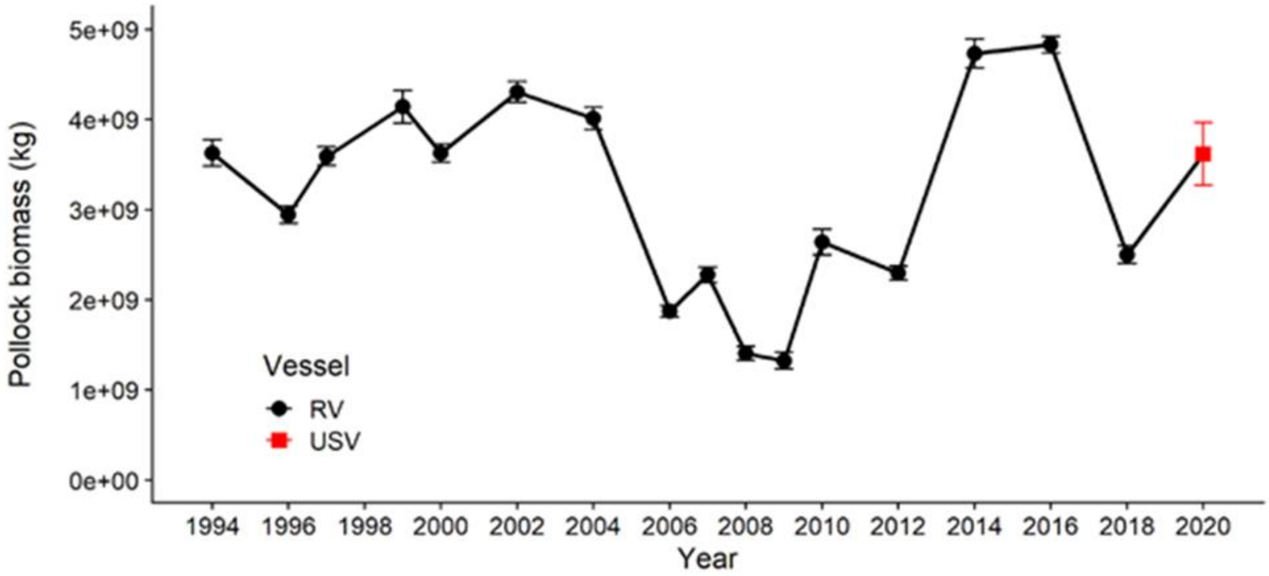

Fig. 2. Time series of EBS pollock acoustic-trawl abundance estimates with error bars showing ± 1 standard deviation of the estimate based on geostatistical 1-D estimates. The 2020 estimate (red square) was conducted with USVs at half the transect spacing of previous surveys. The 2020 uncertainty estimate accounts for the increased uncertainty introduced by the backscatter to biomass conversion.

References

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ICES 2020. ICES Workshop on unavoidable survey effort reduction (WKUSER). ICES Scientific Reports. 2:72. 92pp. http://doi.org/10.17895/ices.pub.745

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

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

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.

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

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

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. 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. 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 temperature change (TC) index is a composite index for the pre- and post-winter thermal conditions experienced by walleye pollock (*Gadus chalcogrammus*) from age-0 to age-1 in the eastern Bering Sea (Martinson et al., 2012). The TC index (year t) is calculated as the difference in the average monthly sea surface temperature in June (t+1) and August (t) (Figure 1) in the southern region of the eastern Bering Sea. Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock. The 2020 year class of pollock experienced above average summer temperatures during the age-0 stage and a warm spring in 2021 during the age-1 stage indicating below average conditions for over wintering survival from age-0 to age-1. The 2020 TC index value of -5.37 was below the long-term average of -4.58, therefore we expect below average recruitment of pollock to age-4 in 2024 from the 2020 year class (Figure 2).

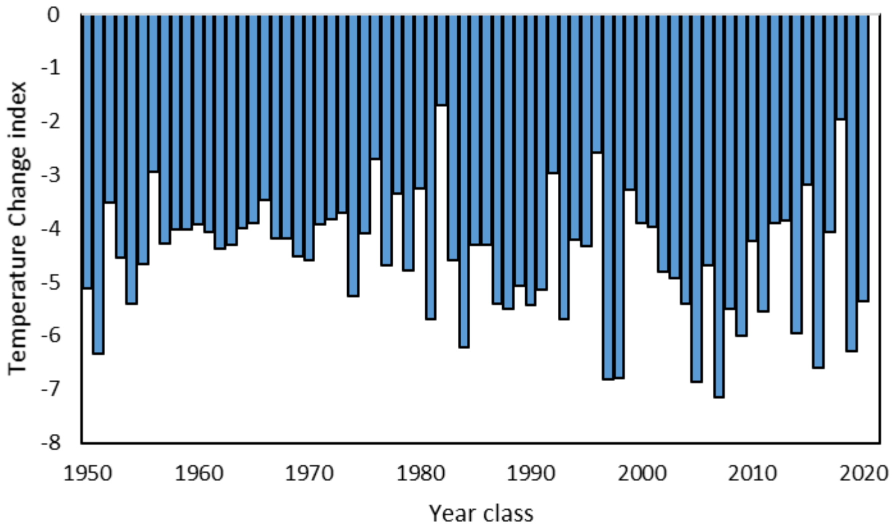

Figure 1: The Temperature Change index values for the 1950 to 2020 year classes of pollock. Values represent the differences in sea temperatures in the south eastern Bering Sea shelf. Less favorable conditions (more negative values) represent a warm summer during the age-0 life stage followed by a relatively cool spring during the age-1 life stage.

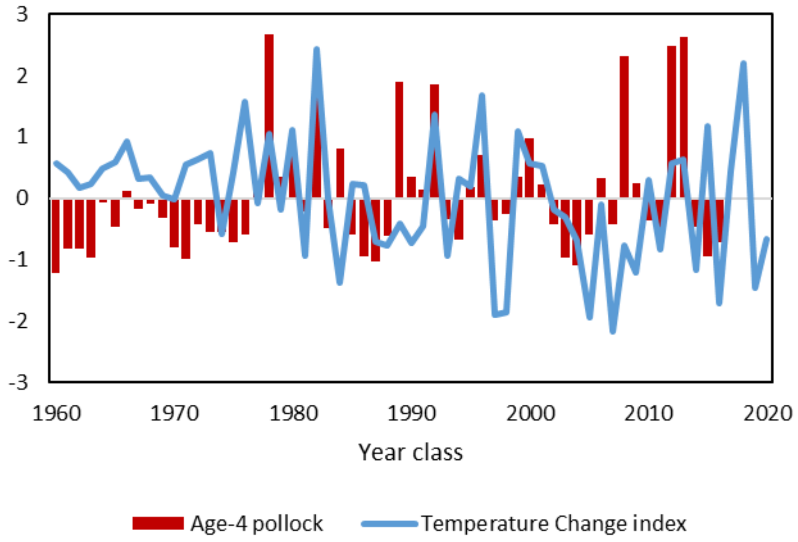

Figure 2: Normalized time series values of the temperature change index indicating conditions experienced by the 1960-2020 year classes of pollock during the summer age-0 and spring age-1 life stages. Normalized values of the estimated abundance of age-4 walleye pollock in the eastern Bering Sea from 1964-2020 for the 1960-2016 year classes. Age-4 walleye pollock estimates are from the Alaska walleye pollock stock assessment (Ianelli et al. 2020).

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

Interannual variations in large copepod abundance during the pollock 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. 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. Data were collected on the Bering Arctic Subarctic Integrated Survey 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). Zooplankton data were not available for 2013. Age-3 pollock abundance was obtained from the stock assessment report for the 2002-2016 year classes. 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.

Positive, significant linear relationships were found between age-3 pollock abundance and the 1) the BASIS sample-based mean abundances and 2) the BASIS VAST-modeled mean abundances of large copepods collected during the age-0 stage for the 2002-2015 year classes (Figure 1). There was a stronger relationship between the VAST model copepod estimates and the age-3 pollock abundance (R^2 = 0.720 vs R^2= 0.43). This appeared to be partially due to the VAST model filling in data for survey areas missed in some years (e.g., 2008). The results show a low availability of large copepod prey for age-0 pollock during the first year of life in 2017 and 2018. The 2020 estimate is larger than the 2021 estimate; however, they are relatively low to other years (Figure 2).

These large zooplankton taxa contain high lipid concentrations (especially in cold, high ice years) which in turn increases the lipid content in their predators such as age-0 pollock and other fish that forage on these taxa. Increases in energy density (lipids) in age-0 pollock allow them to survive their first winter (a time of high mortality) and eventually recruit into the fishery (Heintz et al., 2013). Accordingly, a strong relationship has been shown for energy density in age-0 fish and age-3 pollock abundance (Heintz et al., 2013). This relationship 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 to large crustacean zooplankton and subsequently to the pollock fishery in the southeastern Bering Sea.

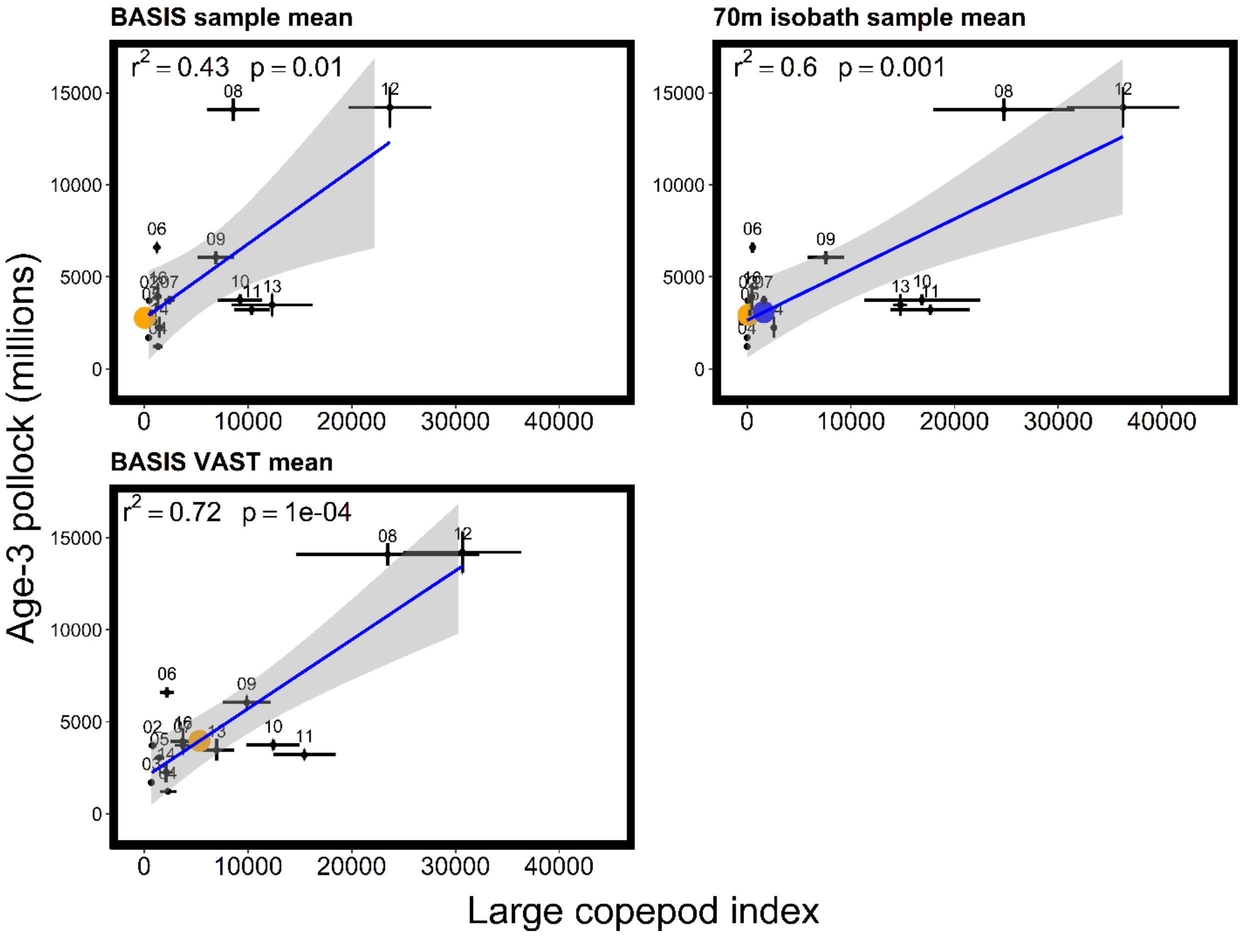

Figure 1. Linear relationships between sample-based (top) from the BASIS and 70 m isobaths surveys and BASIS VAST-model (bottom) estimated mean abundance of large copepods (C+MN, sum of *Calanus marshallae/glacialis, Metridia pacifica* and *Neocalanus* spp.) during the age-0 life stage of pollock, and the estimated abundance (millions) of age-3 pollock from Ianelli et al. (2019) for 2002-2018 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.

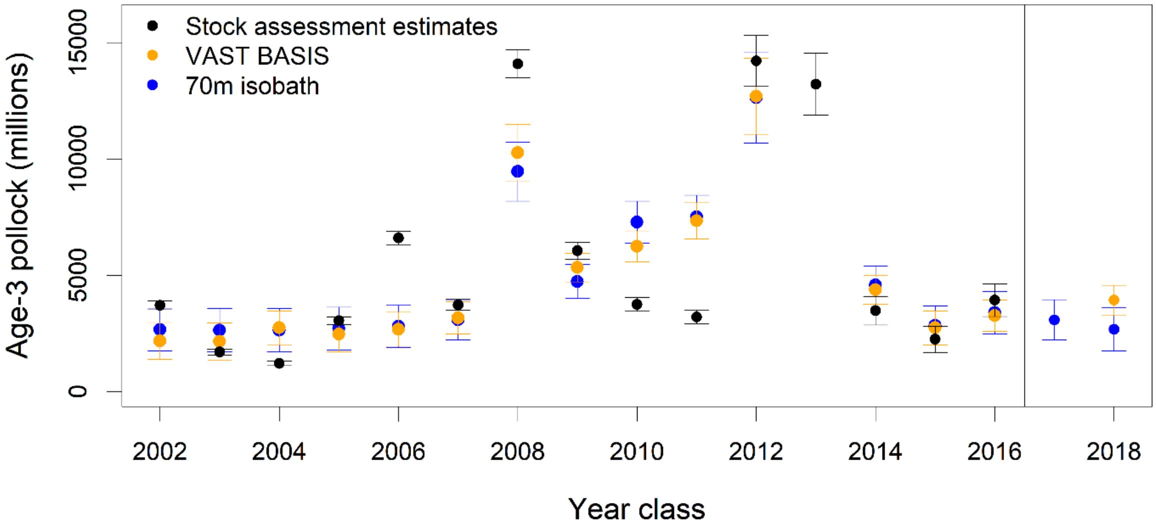

Figure 2. Fitted means and standard errors of the age-3 pollock abundance estimated from the linear regression models using VAST estimates of large copepods (orange), sample mean abundance of large copepods at the 70m isobaths stations (blue), and means from the pollock stock assessment estimates (black) 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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For more information contact Ellen Yasumiishi (ellen.yasumiishi@noaa.gov).

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 findings 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.

For further information see Hurst et al. 2012, or, contact Tom Hurst, 541-867-0222, thomas.hurst@noaa.gov

Literature cited:

Hurst, T.P., L.A Copeman, M. Stowell, J.F. Andrade, C.E. Al-Samarrie, J.L. Sanders, and M.L. Kent. 2021. Expanding evaluation of ocean acidification responses in a marine gadid: elevated CO_2 impacts development, but not size of larval walleye pollock. *Marine Biology* 168:119. doi: 10.1007/s00227-021-03924-w

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.

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

Gulf of Alaska

Changes in spawn timing and availability of walleye pollock to assessment surveys in the Gulf of Alaska

Lauren A Rogers, Martin Dorn, Darin Jones, Kresimir Williams, Cole Monnahan

Changes in phenology, or the seasonal timing of events, are a widely-documented response to changes in climate. Spawn timing, in particular, has been shown to be sensitive to temperature in many species, including walleye pollock. Beyond implications for recruitment and survival of offspring, climate-driven changes in the timing of spawning can affect the availability of fish to surveys designed to monitor their abundance, complicating efforts to assess stock status and sustainably manage fisheries.

In recent years, biomass estimates from four surveys used to monitor Gulf of Alaska (GOA) pollock have diverged, giving conflicting estimates of survey biomass and temporal trends. In particular, from 2017-2019, estimates of pollock biomass were record high in the winter pre-spawner survey in Shelikof Strait, while other GOA summertime surveys estimated near record low biomass. These conflicting trends increased uncertainty in the stock assessment and occurred during a time of rapid environmental change in the GOA. Following recent evidence of shifting spawn timing in GOA pollock, we hypothesized that changes in spawn timing relative to survey timing affected availability of pollock to the winter Shelikof survey. To test this, we reconstructed relative spawn timing from estimated hatch dates of larvae collected during spring larval surveys and from observations of spawning state in mature female pollock collected during the winter Shelikof survey. We then compared estimates of spawn timing/survey timing overlap with residual errors from an age-structured stock assessment model to evaluate whether model lack-of-fit to survey biomass estimates was related to the timing of spawning relative to the timing of the survey. Results suggest that changes in spawn timing relative to survey timing can explain a significant portion of recent and historical discrepancies in survey biomass estimates. Based on this, we developed a time series of covariates for survey catchability for the stock assessment model to account for changing availability of pollock to the winter Shelikof survey. As climate change accelerates, changes in phenology may complicate efforts to monitor and assess stock status. We show that knowledge of underlying processes can guide approaches to account for these changes in assessment frameworks, expanding our toolkit for climate-ready fisheries management.

For more information, contact Lauren Rogers (lauren.rogers@noaa.gov)

Bering Sea

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)
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 Condition and Reproductive Studies - RACE GAP Kodiak

The development of accurate and logistically feasible methods to assess fish condition and reproductive success across the large spatial scales of the marine ecosystems of Alaska would be a valuable tool for assessing the importance of habitat for commercially important species. This research project is a collaborative effort with researchers from the EBS GAP group, the REFM Age and Growth Program (NOAA Strategic Initiative), and the Deep Sea Coral and Sponge Initiative.

Fish condition is generally thought to be a predictor of fish productivity and has been directly linked to reproductive success for some species (Kjesbu et al. 1991, Lambert and Dutil 2000). By measuring both condition indices and reproductive parameters (maturity, skipped spawning, and fecundity), it is possible to quantify the link between fish condition and reproductive status and success. Reproduction is energetically costly, and there is evidence that fish in better condition or that have higher energy reserves are more reproductively successful. The realization of maturity is related to greater body condition in some species (Henderson and Morgan 2002, Feiner et al. 2019). Improved fish condition is also linked to increased fecundity, earlier spawning, and eggs with larger energy reserves (Gagliano and McCormick 2007, Donelson et al. 2008, Feiner et al. 2019). Spawning omission has also been related to fish condition and low energy reserves (Rideout and Rose, 2006, Skjaeraasen et al. 2012, McBride et al. 2015). Several rockfish species in Alaska waters have been shown to exhibit some reproductive failure or skipped spawning (Conrath 2017, 2019), but it is unknown if body condition relates to this reduction in spawning effort.

Spatial differences in condition have been related to both water temperature and depth (Lloret and Ratz 2000, Chouinard and Swain 2002), but differences due to the presence of different substrate types are not as well documented. Rockfish species are frequently associated with coral and sponge habitat in both the Gulf of Alaska and the Aleutian Islands (Rooper et al. 2007, Rooper and Martin 2011, Conrath et al. 2019). It is often assumed structure-forming invertebrates provide a valuable habitat that results in higher productivity of these species. A previous study in the Gulf of Alaska examining rockfish abundance and community structure in different habitats found that rockfish densities were highest in complex habitat, but additional value of habitat containing structure-forming invertebrates was not shown (Conrath et al. 2019). Similarly, Rooper et al. (2019) found that rockfish in the eastern Bering Sea and the Aleutian Islands had an affinity for coral and sponge habitats, but that any structure is important for rockfish and both abiotic and biotic structure was associated with increased rockfish densities. A more comprehensive examination of fish condition and reproductive success across large spatial scales within the Gulf of Alaska and the Aleutian Islands will support the further examination of the value of coral and sponge habitats within these large marine ecosystems.

Northern Rockfishes and Pacific Ocean Perch - RACE

A project focused on developing an appropriate condition index for use during annual bottom trawl surveys, relating condition to reproductive success, and examining the relationship between these parameters and habitat was initiated in 2021. During 2021, the sampling for this project was focused on developing the best method to examine fish condition during standardized annual bottom trawl surveys. Pacific ocean perch (*Sebastes alutus*) and northern rockfish (*S. polyspinis*) were sampled for this project during the Alaska Fisheries Science Center (AFSC) 2021 Gulf of Alaska Bottom Trawl Survey. Fifty rockfish of each species were sampled throughout the survey area. Each sampled rockfish was measured for length, total weight, liver weight, biological impedance, and water content. These data will be used to calculate length weight residuals, hepatosomatic indices, and lipid/water ratios. These condition indices will be validated using proximate composition and bomb calorimetry to calculate energy density. These results will be used to determine how fish condition will be assessed during the 2022 sampling period and in future years throughout the large marine ecosystems of Alaska.

The focus of sampling in 2022 will be on collecting fish condition and reproductive samples for Pacific ocean perch and northern rockfish in or near areas of high concentrations of structure forming invertebrates and areas without structure forming invertebrates. Sampling will occur during the 2022 Aleutian Islands Bottom Trawl Survey. It is anticipated one sampling day will occur in the Samalga Pass region and one additional sampling day will occur near Seguam Island. Sampling stations will be finalized prior to the onset of the survey based on current sampling maps and additional examination of historical survey and camera data. Current sampling locations are based on 1) initial proposed bottom trawl sampling locations for 2022 2) modeled coral density from Rooper et al. 2018, and 3) differences in model predictions and camera observations from Rooper et al. 2018 (Figure 2).

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

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

The genetics group at Auke Bay Laboratories is using whole genome resequencing to understand population structure in a number of groundfish and crab species including several rockfish, sablefish, king crab, and Pacific cod. The focus of this work will be understanding the population structure of these species. Analysis of sablefish showed no structure, reinforcing results from Jasonowicz et al. 2017. Analyses of other species are in process.

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 2021, an assessment was conducted for Gulf of Alaska Pacific ocean perch. New data in the 2021 assessment included updated 2020 catch and estimated 2021 catch, survey biomass for 2021, and fishery age composition for 2020. There were no changes to the model.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 216,635 t in 2022 and to decrease to 210,257 t in 2023. 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 132,767 t, 0.10, and 0.12, respectively. Spawning biomass for 2022 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier “a” of Tier 3. The 2022 and 2023 catches associated with the $F_{40\%}$ level of 0.10 are 38,268 t and 37,104 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2022 and 2023 OFLs are 45,580 t and 44,196 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2022: Western GOA = 2,602 t, Central GOA = 30,806 t, and Eastern GOA = 4,860 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 2022 is 1,409 t and for E. Yakutat/Southeast the ABC in 2022 is 3,451 t. The recommended OFL for 2022 is apportioned between the Western/Central/W. Yakutat area (41,470t) and the E. Yakutat/Southeast area (4,110 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

Dusky Rockfish-- Gulf of Alaska - ABL

In 2021, a partial assessment was conducted for Gulf of Alaska dusky rockfish. The input data were updated to include final catch for 2020 and preliminary catch for 2021. Only the projection model was run, no changes were made to the assessment model.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 38,371 t in 2022 decreasing to 36,853 t in 2023. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying dusky rockfish for management under Tier 3. With $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ estimated at 24,342 t, 0.114, and 0.093, respectively. Spawning biomass in 2022 is projected to exceed $B_{40\%}$, thereby placing northern rockfish in Tier 3a. The 2022 and 2023 catches associated with an $F_{40\%}$ are 7,069 t and 6,686 t, respectively. A “stair step” methodology was requested by the SSC that specifies the ABC be set halfway between the 2020 ABC (3,676 t) and 2022 model estimated maximum ABC. This results in an adjusted ABC of 5,372 t. and 5,181 t for 2022 and 2023, respectively. These catches were put forward as the authors’ and Plan Team’s recommended ABCs. The 2022 and 2023 OFLs are 8,614 t and 8,146 t.

A random effects model was use to establish regional ABCs based on the proportions of model-based estimates for 2022 with 269 t allocated to the Western GOA, 4,534 t to the Central GOA, and 569 t to the Eastern GOA. The recommended OFLs for 2022 and 2023 are not regionally apportioned. Dusky rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

Northern Rockfish – Bering Sea and Aleutian Islands - REFM

The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

Northern Rockfish - Gulf of Alaska - ABL

In 2021, a partial assessment was conducted for Gulf of Alaska northern rockfish. The input data were updated to include final catch for 2020 and preliminary catch for 2021. Only the projection model was run; no changes were made to the assessment model.

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 40,474 t in 2022 decreasing to 37,408 t in 2023. 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 2022 is projected to exceed $B_{40\%}$, thereby placing northern rockfish in Tier 3a. The 2022 and 2023 catches associated with an $F_{40\%}$ are 5,147 t and 4,921 t, respectively. These catches were put forward as the authors' and Plan Team's recommended ABCs. The 2022 and 2023 OFLs are 6,143 t and 5,874 t.

A random effects model was used to establish regional ABCs based on the proportions of model-based estimates for 2022 with 1,944 t allocated to the Western GOA, 3,202 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 2022 and 2023 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, ben.williams@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

The 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 produced in even years. For this on-cycle year, we incorporated the 2020 and 2021 Relative Population Weights (RPWs) from the AFSC longline surveys, the 2021 trawl survey biomass estimate, and updated catch.

Shortraker rockfish has always been classified into "tier 5" in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, we continue to use a random effects (RE) model fit to the AFSC longline survey RPW index (1992 – 2021) and the AFSC bottom trawl survey biomass index (1984 – 2021), to estimate the exploitable biomass that is used to calculate the recommended ABC and OFL values for the 2022 fishery. Estimated shortraker biomass is 31,331 mt, which is < 0.5 % decrease from the 2019 estimate. The NPFMC's "tier 5" ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 705 t for the 2022 fishery. Gulfwide catch of shortraker rockfish was 531 t in 2020 and estimated at 532 t in 2021. Shortraker rockfish in the GOA is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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

Other Rockfish – Bering Sea and Aleutian Islands– 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 comprised 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 67,325 t for “Other Rockfish” in 2022 and 2023. 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 2,982 t, which was combined with the tier 6 ABC of 180 t for a total complex ABC of 3,162 t for 2022 and 2023.

Gulfwide catch of Other Rockfish was 882 t and 1,201 t in 2020 and 2021, 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. While this GOA-wide ABC was a small reduction from the previous assessment, due to shifts in the trawl survey biomass distribution, and the relative proportional abundance of the component species, the resultant apportioned ABCs were far below historical catch in the Western and Central GOA, and likely not representative of the true abundance. As such, the SSC and

Council opted to roll over the previous assessments' harvest recommendations until further analysis could be completed.

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 rougheye and blackspotted rockfish (RE/BS) are caught primarily in trawl and longline fisheries and has been a bycatch only fishery since 1991. The GOA RE/BS complex is fully assessed as a Tier 3 stock in odd years to correspond with the GOA trawl survey. In 2021, we presented a full stock assessment with updated data. There were no changes to the assessment model. The 2021 trawl survey biomass estimate decreased 56% from the 2019 estimate and is the lowest in the time series. The 2021 longline survey abundance estimate decreased 36% since 2019, and 2020 was the lowest in the time series. These declines had significant impacts on the parameters that govern the scale of the population, resulting in a significant downgrade in biomass trajectories, recruitment, and estimates of unfished spawning biomass. Despite declines, the stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished.

We recommended the maximum allowable ABC of 788 t from the updated projection model for 2022. This ABC is 35% lower than the 2022 projected ABC of 1,221 t from the 2020 partial assessment. Female spawning biomass is estimated to be decreasing and is projected to be 8,648 t in 2022 and 8,627 in 2023. These estimates are above the $B_{40\%}$ reference point of 5,911 t, thereby placing RE/BS in sub-tier “a” of Tier 3. Area apportionments based on the two survey random effects method are as follows for 2022: Western GOA = 184 t, Central GOA = 235 t, and Eastern GOA = 369 t.

For more information contact Jane Sullivan, jane.sullivan@noaa.gov.

The 2021 stock assessment is available online at: https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/GOArougheye.pdf

I. Thornyheads

1. Research

2. Stock Assessment

Gulf of Alaska - ABL

The thornyhead rockfish stock complex remain on a biennial stock assessment schedule with a full stock assessment produced in even years and no stock assessment or document produced in odd years. Because this was an "off year," the 2021 values were rolled over for the 2022 fishery. Estimated thornyhead rockfish biomass is 86,802 t. The NPFMC's Tier 5 ABC definitions state that FABC $\leq 0.75M$, where *M* is the natural mortality rate. Using an *M* of 0.03 and applying this definition to the exploitable biomass of thornyhead rockfish results in a recommended ABC of 1,953 t for the 2022 fishery. Gulfwide catch of thornyhead rockfish was 274 t in 2021. This is down from 453 t in 2020.

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

J. Sablefish

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 2021. While sablefish is the primary species tagged, tags from shortspine thornyheads, 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 ~450 sablefish and 5 thornyhead. Twenty two percent of the recovered sablefish tags in 2021 were at liberty for over 10 years. About 32 percent of the total 2021 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 33 percent within 100 – 500 nm, 23 percent within 500 – 1,000 nm, and 13 percent over 1,000 nm from their release location (sum will not add to 100 because of rounding). The tag at liberty the longest was for approximately 42 years (15,423 days), and the greatest distance traveled of a 2021 recovered sablefish tag was 2,357 nautical miles from a fish tagged in the northwest Aleutian Islands on 5/25/1982 and recovered off the Oregon coast on 4/18/2021. Two adult and one juvenile sablefish tagged with archival tags were recovered in 2021. Releases in 2021 on the AFSC groundfish longline survey totaled 6,156 adult sablefish, 312 shortspine thornyhead, and 27 Greenland turbot. An additional 143 juvenile (age-1) sablefish were tagged during one juvenile sablefish tagging cruise in 2021.

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

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.

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 2021 thanks to the efforts of the Alaska Department of Fish and Game-Sitka and the crew of the R/V Kittiwake. When NMFS staff were unable to perform this fieldwork due to COVID restrictions, ADF&G graciously volunteered their time and service to ensure this historical time series was not interrupted. The ADF&G sampled St. John Baptist Bay near Sitka, AK for three days (Sept. 13, 15, and 17), tagging 143 juvenile sablefish. The CPUE in 2021 was down considerably from 2020. The average length of fish was 360 mm.

Thank you again to the Alaska Department of Fish and Game – Sitka, particularly Rhea Ehresmann for heading up this endeavor.

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

Sablefish Point of No Return Studies- RPP

The goal of our research funded by the North Pacific Research Board is to examine factors that may influence recruitment in Sablefish, particularly focusing on prey availability and temperature. During year 1, we focused on starvation resiliency of first feeding Sablefish larvae to low prey conditions at 6°C, an average springtime sea surface temperature in the western Gulf of Alaska. Our rearing work was initially delayed by the lack of spawning individuals at the Manchester Seawater Laboratory (NWFSC) and was, ultimately, unsuccessful due to low egg survivorship for the starvation resiliency experiments. However, we did have some success because our partners in the Fisheries Behavioral and Ecology Program also obtained Sablefish eggs and were able to test tank configurations to determine how best to proceed for year 2 temperature experiments.

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

2. Stock Assessment

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

Moderate changes to the assessment model were implemented for the 2021 sablefish (*Anoplopoma fimbria*) SAFE to address increasing retrospective patterns in recent recruitment estimates over the last few assessments. Model refinements included updated biological inputs, new fishery and survey selectivity and catchability parametrizations, and improved data reweighting approaches, all of which have helped to address retrospective patterns.

New data included in the assessment model were relative abundance and length data from the 2021 longline survey, length data from the fixed gear fishery for 2020, length data from the trawl fisheries for 2020, age data from the longline survey and fixed gear fishery for 2020, updated catch for 2020, and projected 2021 – 2023 catches. Estimates of killer and sperm whale depredation in the fishery were updated and projected for 2021 – 2023. In 2021, there was also a NMFS Gulf of Alaska trawl survey; associated relative abundance indices and length data for the Gulf of Alaska in waters less than 500m were included in the assessment. Due to funding issues and timing constraints, 2020 fixed gear fishery catch-per-unit effort (CPUE) data from logbooks were unavailable. Because logbooks are a major component of the CPUE index, no fishery CPUE data point for 2020 was available. Additionally, revised estimates of growth-, weight-, and maturity-at-age using recently collected data were incorporated in the model.

The longline survey abundance index (relative population numbers, RPNs) increased 9% from 2020 to 2021 following a 32% increase in 2020 from 2019. Similarly, the trawl survey biomass index has increased nearly five-fold since 2013, with a 40% increase from 2019 to 2021. 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 recent year classes in 2014, 2016, 2017, and 2018.

Based on the strength of these recent year classes, biomass estimates have more than doubled from a time series low of 215,000 t in 2015 to 553,000 t in 2021. From the time series low in 2017, SSB has increased by 34% to 108,000 t in 2021, which is 36% of the unfished SSB (i.e., SSB_0). The updated point estimate of $B_{40\%}$, is 118,140 t, while projected female spawning biomass (combined areas) for 2022 is 128,789 t (i.e., equivalent to $B_{44\%}$). The maximum permissible 2022 ABC (combined areas) based on the NPFMC harvest control rule is 34,863 t. After accounting for whale depredation in the fishery, the whale adjusted ABC for 2022 is 34,521 t. The recommended 2022 ABC represents an 18% increase from the 2021 ABC, and a tripling of the quota since 2016 when the lowest ABC on record (11,795 t) was enacted.

Because a single area stock assessment model is utilized, it is necessary to apportion the total ABC to management regions. Based on biological rationale, the NPFMC SSC adopted a five-year average survey apportionment method in 2020, which uses a five-year moving average of the longline survey proportions of biomass in each region to apportion the Alaska-wide ABC to each management region. This method tracks biomass across management regions to the best of our current ability (i.e., by using estimates of regional biomass from the yearly longline survey that targets sablefish in prime adult habitat), while still buffering against variability caused by annual measurement error. The SSC also instituted a four-year stair step approach to move from the fixed apportionment used prior to 2020 towards the five-year average survey apportionment. In 2021, a 50% stair step from the 2020 fixed apportionment values towards the 2021 five-year average survey apportionment values was implemented.

Although modeling updates appear to have addressed the retrospective issues associated with previous sablefish assessments, the exact cause of those retrospective patterns is not certain and it is unclear if these patterns may persist when new data is incorporated in coming years. Additionally, a number of concerns related to the sablefish resource remain, which merit careful monitoring as recent recruitment year classes continue to age and help the resource to rebuild. For instance, sablefish age structure is severely truncated and the SSB relies heavily on recent cohorts (i.e., year classes since 2014 constitute >50% of the SSB) with little contribution from early 2000s year classes. Alternate metrics of spawning potential, which better emphasize fully mature age classes (e.g., the biomass of ages > 10), could help maintain a strong spawning portfolio and avoid future contraction of the age structure, thereby improving resilience of the sablefish resource. From a fishery perspective, there has been a rapid shift in the composition of the fixed gear fleet where pot gear now constitutes more than 50% of sablefish removals, which is not fully accounted for in the assessment. In addition, the rapid decline in overall market conditions, particularly due to the influx of small sablefish, may be contributing to differences in targeting and selectivity in all fisheries. Moreover, the projected maximum ABC would represent the largest catch since the late 1980s, which, due to high catches and extended periods of poor recruitment, was followed by subsequent declines in biomass and SSB. Given that sablefish are such a long-lived species and considering the cyclic nature of sablefish dynamics, exploration of a capped (i.e., implementing a maximum cap on the ABC) management procedure (or an ‘inventory management’ strategy) for sablefish may be worthwhile. Compared to using a maximum yearly catch strategy, capped HCRs could aid in stabilizing long-term sablefish dynamics (i.e., help to prevent long-term cyclical declines as the resource transitions between high and low recruitment regimes).

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

Coastwide research discussions for sablefish – ABL

The Pacific Sablefish Transboundary Assessment Team (PSTAT), which was established in 2017, is a research collaboration between the Alaska Fisheries Science Center, the Northwest Fisheries Science Center, the Alaska Department of Fish and Game, and the Department of Fisheries and Oceans Canada. The purpose of the PSTAT is to aid collaboration among scientists and managers across jurisdictions to enable wider understanding of Pacific-wide sablefish population dynamics. In the last year, the group has continued work on a tagging model to estimate movement and mortality within and among management regions, which is expected to be completed next year. Similarly, research continued towards developing a spatially explicit coastwide operating model that incorporates movement rates from the tagging model along with spatially-varying demographics (i.e., as identified through earlier PSTAT research) to emulate sablefish dynamics, and is likely to be completed in the next 1-2 years. The operating model will form the basis of a management strategy evaluation, which aims to inform on the potential risks of current independent, regional assessment-management approaches and also identify whether regionwide management strategies might be more robust. In April 2021, the PSTAT held a stakeholder engagement workshop aimed to solicit feedback on the development, assumptions, and desired performance measures of the MSE tool. Workshop outcomes included:

- Participants increased knowledge of sablefish science and management among regions.
- Participants increased knowledge of the development of the sablefish MSE tool.
- Participants provided feedback on inputs for the Sablefish MSE, including objectives, performance metrics, and management procedures.

For more information contact Dan Goethel (daniel.goethel@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 AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

Gulf of Alaska (REFM)

The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

M. Flatfish

1. Research

Northern rock sole and yellowfin sole growth potential

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

Northern rock sole and yellowfin sole feeding in SEBS nursery areas - FBE RACE

Field collections of juvenile northern rock sole and yellowfin sole in nursery areas along the Alaska

Peninsula were used to examine feeding patterns and diet overlap in these co-occurring species. As observed in other parts of their ranges, the diets of both species included polychaetes and amphipods. The primary difference in the diets of these species was that prey of yellowfin sole were almost exclusively endobenthic and epibenthic invertebrates; northern rock sole had more diverse diets and consumed substantial amounts of hyperbenthic mysids and pelagic euphausiids). Overall dietary overlap was low, in part due to differences in microhabitat use. These observations indicate that direct competition for prey resources between juveniles of these co-occurring species is reduced by a combination of differential habitat associations and prey selection. However, this differentiation indicates that climate change in the SEBS may differentially affect the forage base and productivity of these species (Ferm et al. 2021).

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

Ferm, N.C., J.T. Duffy-Anderson, T.P. Hurst. 2021. Foraging habits and dietary overlap of juvenile yellowfin sole and northern rock sole in a Bering Sea coastal nursery. *Fishery Bulletin* 120:1-12. doi: 10.7755/FB.120.1.1

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.

The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here: https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:

https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 recent stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 high levels of female spawning biomass. The Alaska plaice spawning stock biomass is projected to decline through 2023 while remaining above B35%.

Rex sole - Gulf of Alaska - REFM
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

"Other flatfish" complex - Bering Sea and Aleutian Islands - REFM
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation

(SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

Shallow-water flatfish complex - Gulf of Alaska - REFM
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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

Deep-water flatfish complex - Gulf of Alaska - REFM
The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the assessment sections in this report were not updated. For stock assessment results please see the assessments in the 2021 Stock Assessment and Fishery Evaluation (SAFE) reports here:
https://www.fisheries.noaa.gov/alaska/population-assessments/2021-north-pacific-groundfish-stock-assessments.

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 used 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. This published study is in the Journal of Applied Ecology (https://doi.org/10.1111/1365-2664.13914).

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. In the final year of comprehensive survey data (2017), 49%, 65%, 47% of biomass was in the western and northern Bering Sea for pollock, cod, and plaice, respectively, suggesting that availability of groundfish to the more regular eastern Bering Sea survey is declining. 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. This work was accepted into ICES Journal of Marine Science and will be available online soon.

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

Gulf of Alaska

Establishing groundfish densities estimates in GOA untrawlable habitat with paired lowered stereo-camera system and bottom trawl data – RACE GAP, RACE MACE, REFM, MESA

This newly funded project will collect data from untrawlable (UT) habitats using a lowered stereo-camera system (LSC) and integrate those data with existing bottom-trawl data and bathymetry maps to develop a model-based index of abundance for groundfish that includes UT habitat-specific information. Many groundfish stock assessments in the Gulf of Alaska depend on fishery-independent surveys conducted by the Groundfish Assessment Program (GAP) to provide reliable indices of abundance over time. This work will help to provide more accurate and precise indices to GOA stock assessments for select rockfish species, particularly for those species that rely on rocky habitat, tend to be longer-lived with low fecundity, and thus are particularly vulnerable to overfishing and unfavorable environmental conditions.

For further information, contact Cecilia O'Leary (cecilia.oleary@noaa.gov) or Kresimir Williams (kresimir.williams@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:

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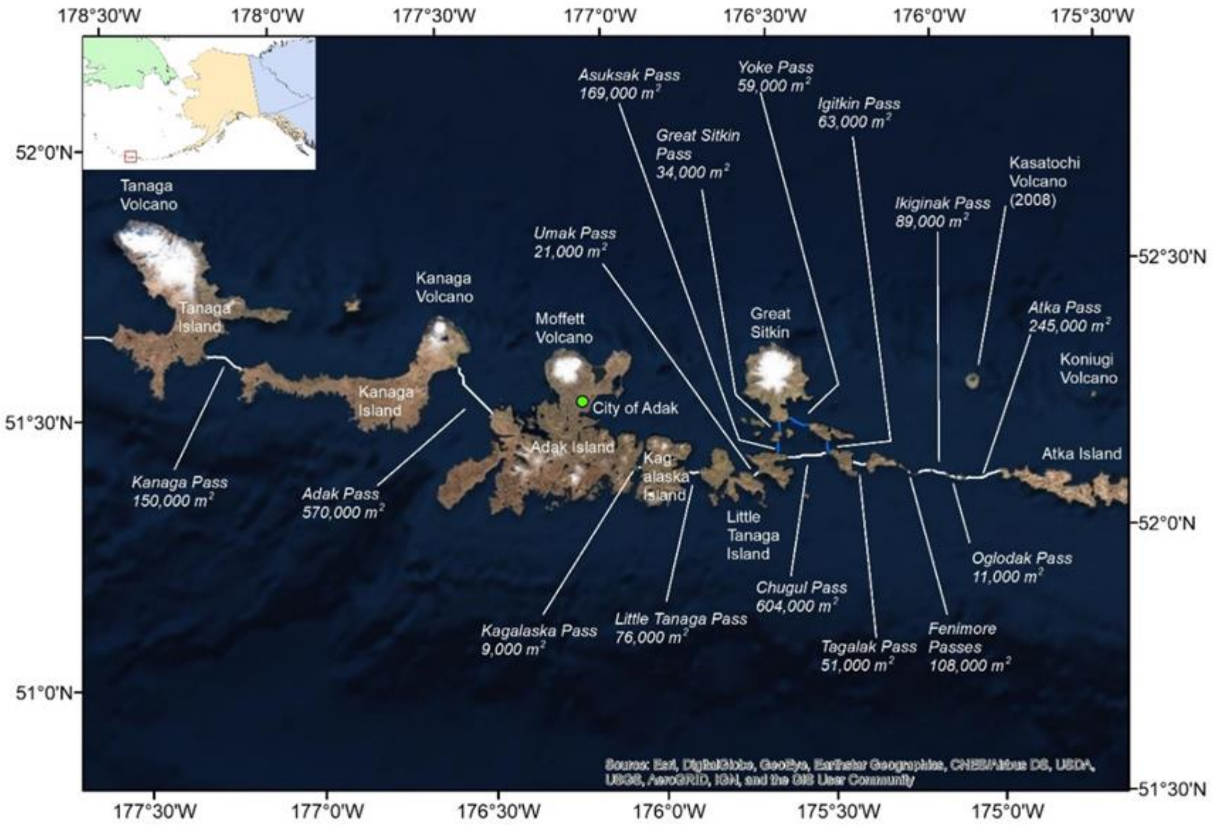
Breddermann, K., M. Stone, and N. Yochum. 2019. Flow analysis of a funnel-style salmon excluder. In Contributions on the theory of fishing gear and related marine systems. Proceedings of the 14th International Workshop on Methods for the Development and Evaluation of Maritime Technologies (DEMaT), 5-7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

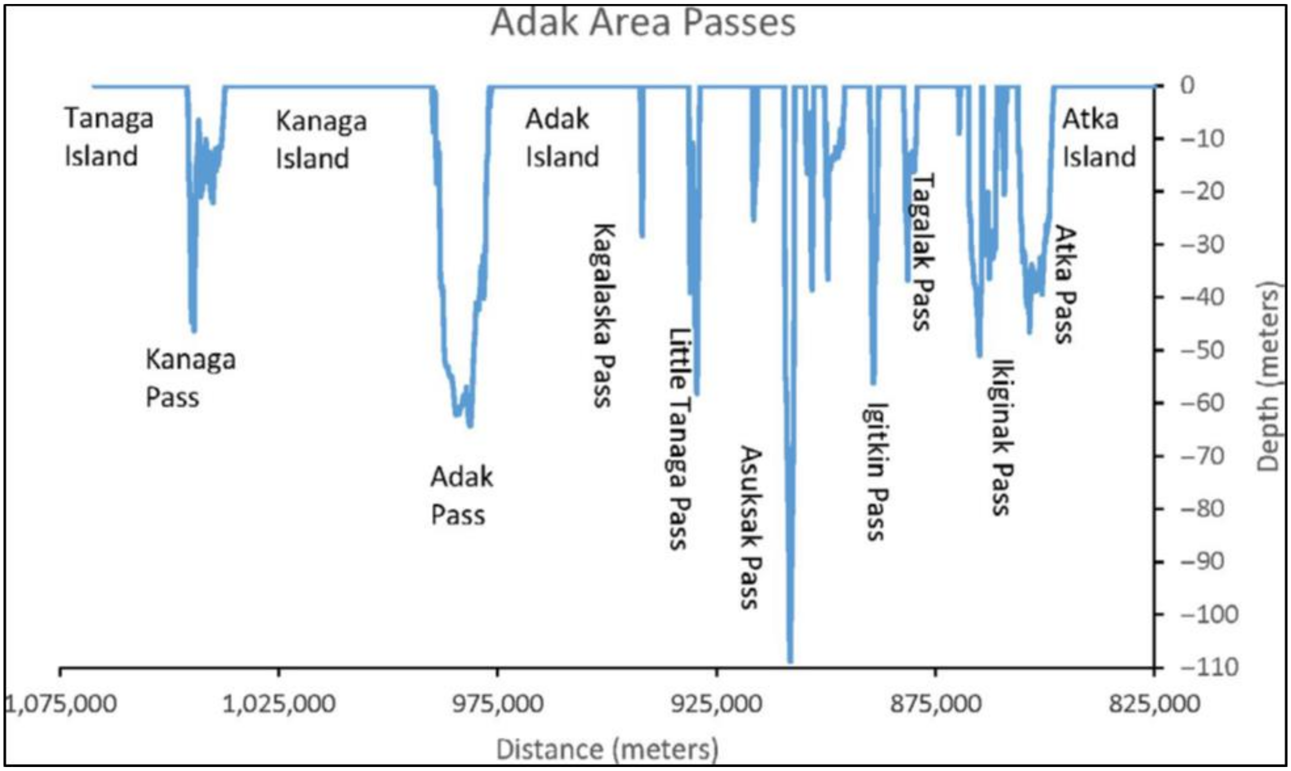
Passes of the Aleutian Islands: First detailed description - RACE GAP

We derived the first detailed and accurate estimates of the location, cross-sectional area, length, and depth of the Aleutian Island passes, which are important bottlenecks for water exchange between the North Pacific Ocean and the Bering Sea. Our pass descriptions utilized original bathymetric data from hydrographic smooth sheets, which are of higher resolution than the navigational chart data used for earlier pass size estimates. All of the westernmost Aleutian passes, from Kavalga to Semichi, are larger (18%–71%) than previously reported, including Amchitka Pass (+23%), the largest in the Aleutians. Flow through Chugul Pass, previously reported as the largest pass in the Adak Island area, is blocked on the north side by Great Sitkin and several other islands. Collectively, these smaller passes (Asuksak, Great Sitkin, Yoke, and Igitkin) are only about half the size of Chugul Pass. The important oceanographic and ecological boundary of Samalga Pass occurs in a location where the cumulative openings of the eastern Aleutian passes equal the minimal opening of Shelikof Strait, carrier of the warmer, fresher water of the Alaska Coastal Current that eventually flows northward, through Samalga and the other eastern passes, into the Bering Sea and Arctic Ocean.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Example figures: FIGURE 6. (a) Pass locations and sizes in the Adak area. Pass location as defined by the Cost Distance tool denoted as white line.



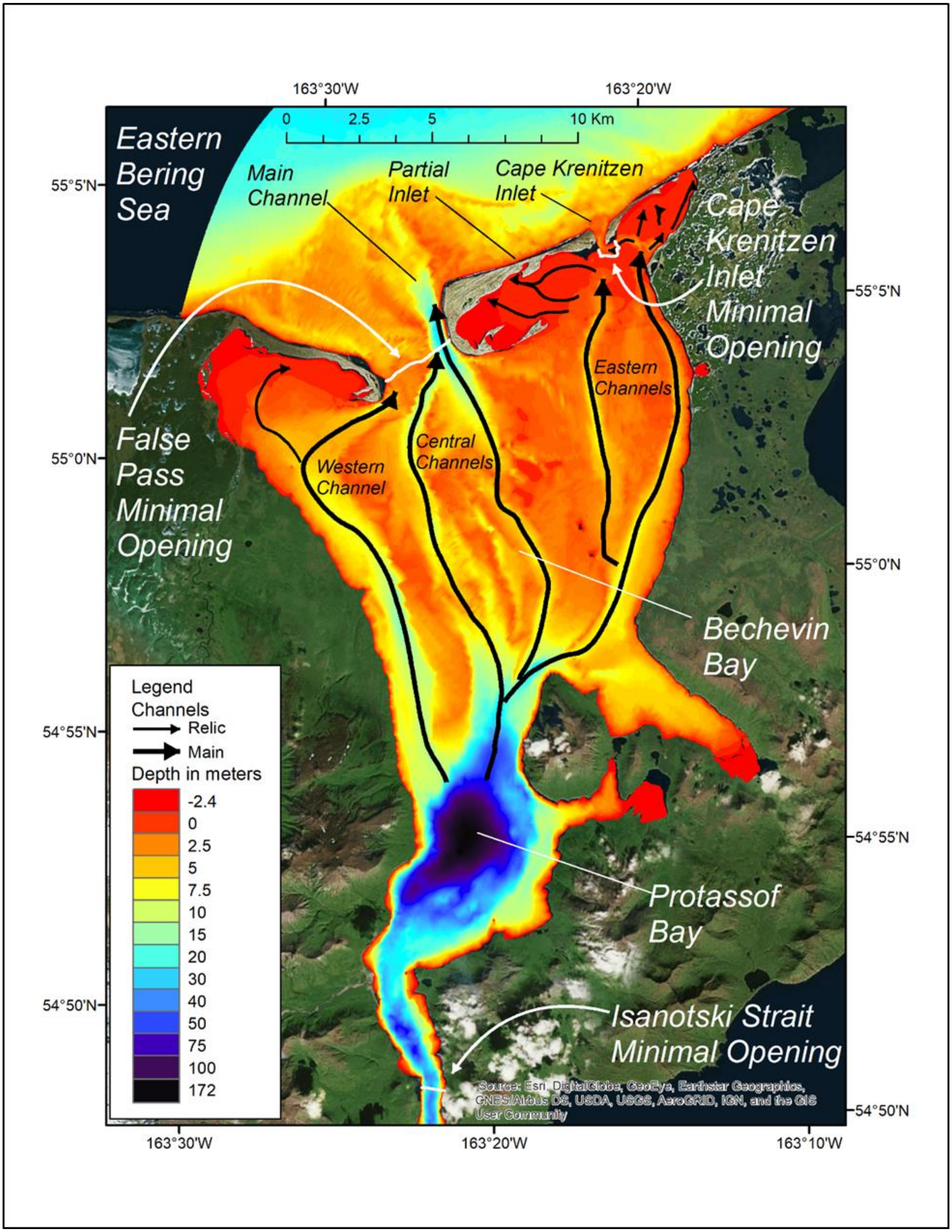
Example figures: FIGURE 6. (b) Graph showing horizontal arrangement of islands and passes, with pass depth shown in meters

Zimmermann, M., Prescott, M.M. 2021. Passes of the Aleutian Islands: First detailed description. Fisheries Oceanography, 30(3), pp.280-299. http://dx.doi.org/10.1111/fog.12519

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

False Pass, Alaska: Significant changes in depth and shoreline in the historic time period- RACE GAP

Global ocean circulation is limited partly by the small passes of Alaska's Aleutian Islands, which restrict North Pacific Ocean water from flowing north into the Bering Sea and eventually to the Arctic, but the size and shape of these Aleutian passes are poorly described. While quantitatively redefining all of the Aleutian passes, we determined that the easternmost pass, with the cryptic name of False Pass, and with an unusual configuration of having both northern and southern inlets, had two or more inlets to the Bering Sea in the recent past, but that it has only a single northern inlet now (15,822 m2), roughly equivalent in size to the southern inlet, Isanotski Strait (15,969 m2). Navigational charts depict the opposite: two inlets to the Bering Sea now, but just one in older charts (1926-43). This discrepancy inspired a thorough review of the hydrographic history from which we concluded that the second northern inlet did exist and hypothesize that it was a remnant of multiple former openings, or a single large opening, potentially allowing greater northward flow of warmer, fresher Alaska Coastal Current water. While the shoreline changes that we document here are often regarded as minor, ephemeral events, we document similar, nearby, permanent shoreline shifts which changed Ikatan Island into a peninsula and which shifted the Swanson Lagoon outlet over 3 km to the east.



Example figure: FIGURE 4. False Pass bathymetry with main channels indicated with thick black arrows and relic mud flat channels indicated with thin black arrows, using the "before" bathymetry

(1924–57). The “after” bathymetry of 2014 was incomplete, without soundings in much of the shallows and without a shoreline.

Zimmermann, M., Prescott, M.M. 2021. False Pass, Alaska: Significant changes in depth and shoreline in the historic time period. Fisheries Oceanography, 30(3), pp.264-279. http://dx.doi.org/10.1111/fog.12517

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

Accounting for trophic relationships in Essential Fish Habitat designations

This funded proposal will seek to characterize the relationship between satellite chlorophyll a (chl-*a*), zooplankton, and forage fish density. We will accomplish this objective by answering 1) Do dynamic environmental conditions, such as temperature, phytoplankton concentrations, and zooplankton abundances influence the abundance and distribution of forage fish? 2) Is there spatial overlap between chl-a hotspots and forage fish hotspots? The proposed project directly addresses the Alaska Essential Fish Habitat (EFH) Research Plan’s Core EFH Research Priority 1: to characterize habitat utilization and productivity, increase the level of information available to describe and identify EFH; and Research Priority 2: apply information from EFH studies at regional scales. The outcomes from this study are intended to advance EFH for forage fish and invertebrate prey species including capelin [*Mallotus villosus*], herring [*Clupea pallasii*], age-0 walleye pollock [*Gadus chalcogrammus*], and large copepods. If possible based on model performance, more spatially and temporally explicit zooplankton biomass estimates from ROMS-NPZ may be incorporated into EFH models. Our proposed work will develop methodology for describing prey habitat and incorporating dynamic environmental covariates in species distribution models. This project involves co-PIs from CICOES, ABL, and EMA and collaborators from EcoFOCI and AKRO.

For more about this project, contact Margaret Siple (margaret.siple@noaa.gov ; RACE) or Jens Nielsen (jens.nielsen@noaa.gov ; CICOES).

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

Councils and NMFS are required to review the essential fish habitat (EFH) components of Fishery Management Plans (FMPs) and revise or amend these components based on available information at least every five years (50 CFR 600.815(a)(10)) in an EFH 5-year Review. This study demonstrates advances in EFH component 1 descriptions and identification (maps) based on refinements to the habitat-based species distribution modeling (SDM) approach to mapping EFH that was established in the 2017 EFH 5-year Review. All of the SDM ensembles constructed for FMP species in three regions in Alaska (GOA, AI, and the Bering Sea) in this present work describe and map EFH Level 2 (habitat related abundance), meeting a key objective of the EFH Research Plan for Alaska. For early juvenile life stages in the GOA, SDMs describe and map EFH Level 1 (distribution) for the first time. Another objective of the Research Plan was met by introducing maps for a subset of species with EFH Level 3 information (habitat related vital rates) for the first time. In this study, 229 new or revised EFH descriptions and maps were generated for 211 species' life stages and 10 stock complexes available across all regions. For the majority of stocks and life stages, 2022 ensemble performance demonstrated clear improvements over the 2017 SDMs. The maps and descriptions here present the best available science to form a basis for assessing anthropogenic impacts to habitats in Alaska and are extensible to other fishery and ecosystem management information needs. This process revealed some recommendations for the next EFH review cycle, including a goal to develop methods for combining disparate data sources to expand spatial and seasonal coverage; and the goal of increasing the scope of EFH research to address rapidly changing environmental conditions in the region. These tech memos contain methodological advancements in species distribution modeling, leading to better species coverage and more robust habitat maps in the 2022 Five Year-Review. In order to make these transparent and available to other scientists and to ensure continuity in the methodology used for EFH, members of the analytical team produced a publicly available R package.

For more about this project, contact Ned Laman (ned.laman@noaa.gov), Margaret Siple (margaret.siple@noaa.gov) or Jodi Pirtle (Jodi.pirtle@noaa.gov).

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 monitoring 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 2021: (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 Status 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/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands#2018.

Groundfish Stomach Sample Collection and Analysis - REFM-REEM

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.

The AFSC, REFM program representative to the TSC left AFSC in Spring 2022. Because of this recent change, some of the sections in this report were not updated.

Contact Kerim Aydin with any questions regarding the REEM program within REFM.

Online sources for REEM data on food habits and fish ecology (*note that the AFSC website hosting these sites has been updated but the links below were not updated before the REFM representative to the TSC retired in Spring 2022*).

- 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, 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 2021 Economic SAFE largely focuses on the results of the fisheries in 2020. The economic SAFE is part of the larger document and available at: https://www.npfmc.org/safe-stock-assessment-and-fishery-evaluation-reports/.

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

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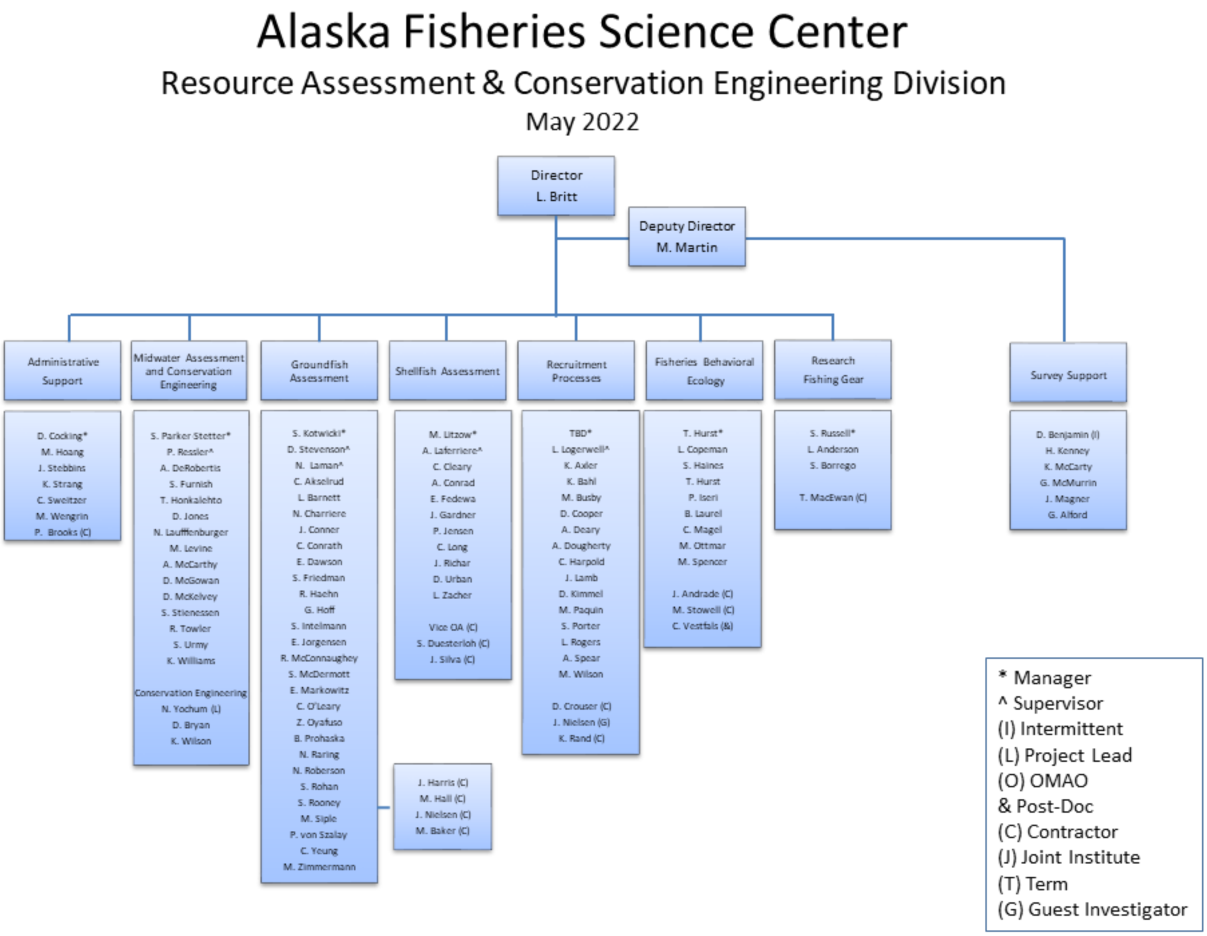
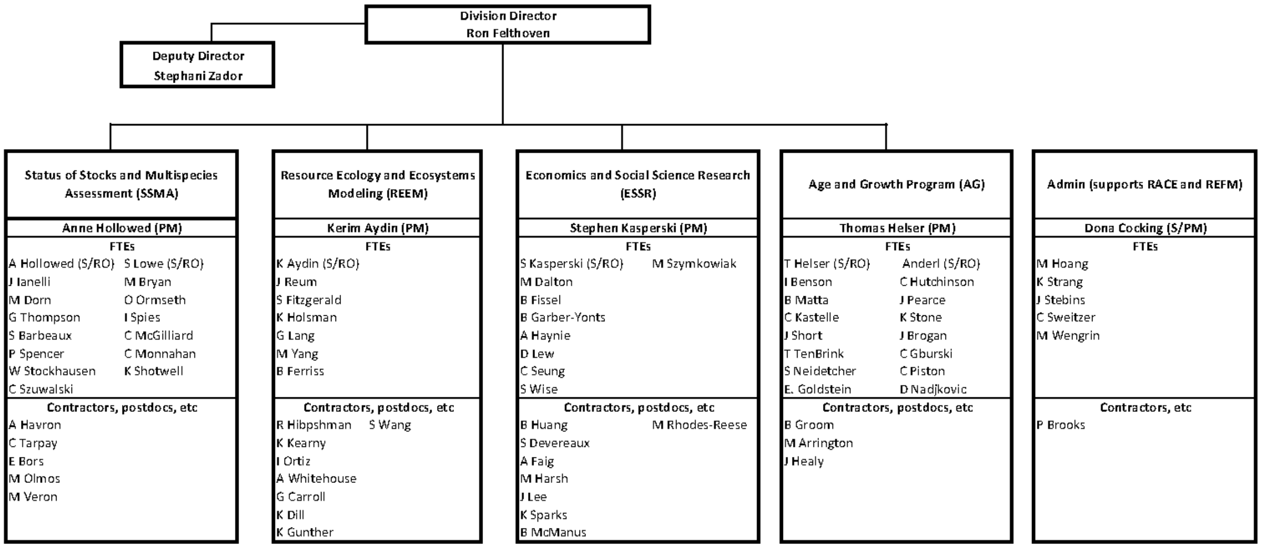
APPENDIX I. RACE ORGANIZATION CHART

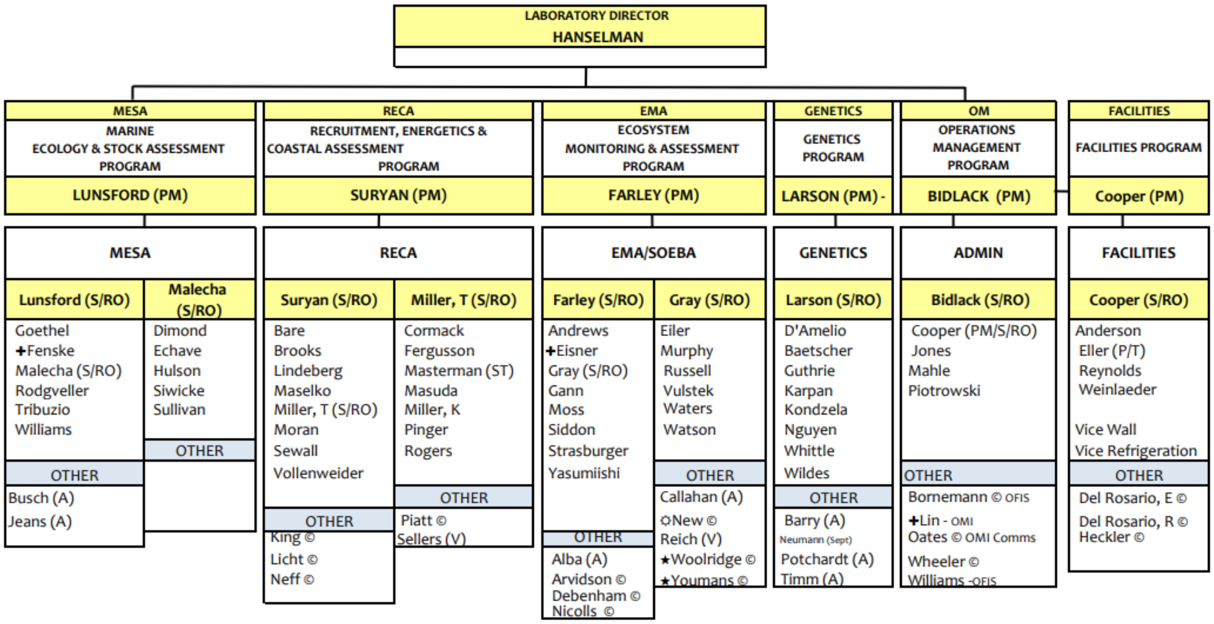


APPENDIX II. REFM ORGANIZATION CHART



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



LABORATORY DIRECTOR
HANSELMAN

MESA
MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM
LUNSFORD (PM)

MESA

Lunsford (S/RO)
- Goethel
- ✚Fenske
- Malecha (S/RO)
- Rodgveller
- Tribuzio
- Williams

OTHER
- Busch (A)
- Jeans (A)

Malecha (S/RO)
- Dimond
- Echave
- Hulson
- Siwicke
- Sullivan

OTHER

RECA
RECRUITMENT, ENERGETICS & COASTAL ASSESSMENT PROGRAM
SURYAN (PM)

RECA

Suryan (S/RO)
- Bare
- Brooks
- Lindeberg
- Maselko
- Miller, T (S/RO)
- Moran
- Sewall
- Vollenweider

OTHER
- King ©
- Licht ©
- Neff ©

Miller, T (S/RO)
- Cormack
- Fergusson
- Masterman (ST)
- Masuda
- Miller, K
- Pinger
- Rogers

OTHER
- Piatt ©
- Sellers (V)

EMA
ECOSYSTEM MONITORING & ASSESSMENT PROGRAM
FARLEY (PM)

EMA/SOEBA

Farley (S/RO)
- Andrews
- ✚Eisner
- Gray (S/RO)
- Gann
- Moss
- Siddon
- Strasburger
- Yasumiishi

OTHER
- Alba (A)
- Arvidson ©
- Debenham ©
- Nicolls ©

Gray (S/RO)
- Eiler
- Murphy
- Russell
- Vulstek
- Waters
- Watson

OTHER
- Callahan (A)
- ☼New ©
- Reich (V)
- ★Woolridge ©
- ★Youmans ©

GENETICS
GENETICS PROGRAM
LARSON (PM) -

GENETICS

Larson (S/RO)
- D'Amelio
- Baetscher
- Guthrie
- Karpan
- Kondzela
- Nguyen
- Whittle
- Wildes

OTHER
- Barry (A)
- Neumann (Sept)
- Potchardt (A)
- Timm (A)

OM
OPERATIONS MANAGEMENT PROGRAM
BIDLACK (PM)

ADMIN

Bidlack (S/RO)
- Cooper (PM/S/RO)
- Jones
- Mahle
- Piotrowski

OTHER
- Bornemann © OFIS
- ✚Lin - OMI
- Oates © OMI Comms
- Wheeler ©
- Williams -OFIS

FACILITIES
FACILITIES PROGRAM
Cooper (PM)

FACILITIES

Cooper (S/RO)
- Anderson
- Eller (P/T)
- Reynolds
- Weinlaeder
- Vice Wall
- Vice Refrigeration

OTHER
- Del Rosario, E ©
- Del Rosario, R ©
- Heckler ©

ABBREVIATIONS
PM = Program Manager
A = Associate
© = Contractor
I = Intermittent
RO = Rating Official
S = Supervisor
Seas = Seasonal
St = Student Appointment
T = Term Appointment
V = Volunteer
WL = Non -Supervisory Wage Leader

ABL Organization Totals	
FTE	62
Contractors ©	14
Volunteer (V)	2
Associate (A)	8
TOTAL Active	**88**
VICE	2

FACILITIES
TSMRI
★Little Port Walter Marine Station
☼ Auke Creek Research Station
✚ Bldg 4, Sand Point, Seattle
● Juneau Subport

CODES
F/AKC4 = ABL Routing Code
★ Organization Code
■Operating Unit Number

F/AKC4* AUKE BAY LABORATORIES ■ FS7400
ORGANIZATIONAL CHART
July 15, 2021

APPENDIX IV. FMA ORGANIZATIONAL CHART