Alaska Fisheries Science Center of the National Marine Fisheries Service
2023 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee
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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2023

I. Agency Overview

Groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the following Divisions: Resource Assessment and Conservation Engineering (RACE), Resource Ecology and Fisheries Management (REFM), Fisheries Monitoring and Analysis (FMA), and the Auke Bay Laboratories (ABL). All Divisions work closely together to accomplish the mission of the Alaska Fisheries Science Center.

In 2023, our activities were guided by our ***Alaska Strategic Science Plan 2023-27*** with annual priorities specified in the ***AFSC Annual Guidance Memorandum for 2023***. 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 of 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 of the Alaska Fisheries Science Center (AFSC) conducts quantitative fishery-independent surveys and related research on groundfishes and crabs 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

[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. The GAP, MACE, and RPP programs are based in Seattle, WA; the FBE Program is sited in Newport, OR; and the SAP Labs are in 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. These surveys provide direct measures of juvenile abundance and have documented significant changes in spawn timing and early growth of Pacific cod with warming in the 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 Alaska 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). RACE GAP surveys in the Bering Sea continue to monitor changes to groundfish distribution and abundance related to climate-mediated ocean warming and loss of sea ice. In 2023, the size and location of the Bering Sea cold pool was very similar to 2022, extending farther south on the Bering Sea shelf than in recent years. Overall mean surface and bottom temperatures across the Bering Sea shelf measured during the surveys were near, but slightly below, the 40-year mean. The changing temperature regime in the Bering Sea has implications for the groundfish populations within our survey areas. Shifts in fish distribution due to variations in the extent of seasonal sea ice, and the resultant extent of the summer cold pool, can lead to variation in the fractions of populations located outside of our historical survey boundaries. This variation may violate our assumptions that our indices of abundance represent a constant proportion of the population from one year to the next. The upper continental slope survey of the eastern Bering Sea was quasi-biennial in even years, but has not been conducted since 2016. In 2023, RACE GAP personnel also continued to conduct cooperative Pacific cod satellite tagging studies in the Gulf of Alaska (GOA) along with drop camera-trawl catch comparisons from the survey platform and we augmented those studies with environmental DNA (eDNA) collections. On the 2023 GOA summer trawl survey, bottom temperatures remained about the same as in 2021, which was slightly lower than the bottom temperatures in 2019, and surface temperatures continued a cooling trend begun in 2015. Biomass estimates for groundfish species reviewed from the GOA 2023 survey results were mixed with the majority showing stable or increasing abundance with some abundance declines for other species.

The Midwater Assessment and Conservation Engineering (MACE) Program conducts acoustic-trawl surveys of pollock and other pelagic fishes in the Gulf of Alaska and eastern Bering Sea (winter) and the western and central Gulf of Alaska and eastern Bering Sea (summer). MACE and GAP continue to work collaboratively toward 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 from this proposed survey 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) conduct surveys on the early life history stages of groundfish species in the spring and summer, as well as observing the environmental conditions necessary to explain growth and mortality of fishes. Spring surveys focus on the distribution, abundance, and survival of larvae of groundfish species such as walleye pollock, Pacific cod, arrowtooth flounder, and northern and southern rock sole. The objective of the summer survey is to describe the abundance and distribution of the age-0 and age-1 juvenile stages of groundfish species, as well as forage fishes including capelin, eulachon, and Pacific herring. Additionally, environmental variables that can potentially affect the ecology of those fishes are measured. This survey also estimates whether age-0 fish have sufficient energy reserves to survive their first winter.

In 2023, RACE scientists continued research into environmental effects on and essential habitats of groundfishes in Alaska. Research into impacts of ocean acidification on early life history growth and survival continue at our Newport, Oregon, and Kodiak facilities. Work on Essential Fish Habitat (EFH) in 2023 included focus on forage fishes and prey availability as another valuable aspect of the habitat of groundfish predators. Independent but related EFH projects have estimated habitat-related survival rates from individual-based models, investigated activities with potentially adverse effects on EFH, and determined optimal thermal and nearshore habitat for overwintering juvenile fishes. Juvenile fish and crab growth and condition research characterizing groundfish habitat requirements continues as well.

For more information on all RACE Division programs, contact Division Director Lyle Britt at (206) 526-4501 or Acting Deputy Director Bianca Prohaska at (206) 526-4145.

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 (NMFS) 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, for sharks, sablefish, and grenadiers for all of Alaska, and conducts management strategy evaluations (MSEs). MESA also conducts biological research, such as movement, growth, stock structure, and ageing. ABL's Ecosystem Monitoring and Assessment Program (EMA) captures groundfishes in their surveys of the Bering Sea and the eastern Gulf of Alaska and conducts research on impacts of the environment on groundfish, growth, survival, and recruitment. The Recruitment Energetics and Coastal Assessment Program (RECA) studies the trophic level and energetics of juvenile groundfish in various environments and developmental stages, and the Genetics Program conducts research on Pacific cod, Alaska pollock, sablefish, rockfish, shark, and forage fish stock structure and distribution.

In 2023, ABL prepared 12 stock assessment and fishery evaluation reports for Alaska groundfish: Alaska sablefish, Gulf of Alaska (GOA) Pacific ocean perch, GOA Pacific cod, GOA northern rockfish, GOA dusky rockfish, GOA rougheye/blackspotted rockfish, GOA shortraker rockfish, Bering Sea/Aleutian Islands (BSAI) "Other Rockfish", GOA "Other Rockfish", GOA thornyheads, and BSAI and GOA sharks. Stock assessments can be accessed at https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments

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 (disbanded)

The Habitat and Ecological Processes Research Program (HEPR) focused on integrated studies that combine scientific capabilities and create comprehensive research on habitat and ecological processes. HEPR has been disbanded and responsibilities for HEPR's core research areas have been moved to other divisions: Loss of Sea Ice remains a multi-division effort, Essential Fish Habitat is located in RACE in collaboration with AKRO, and Ocean Acidification is also located in RACE).

II. Surveys

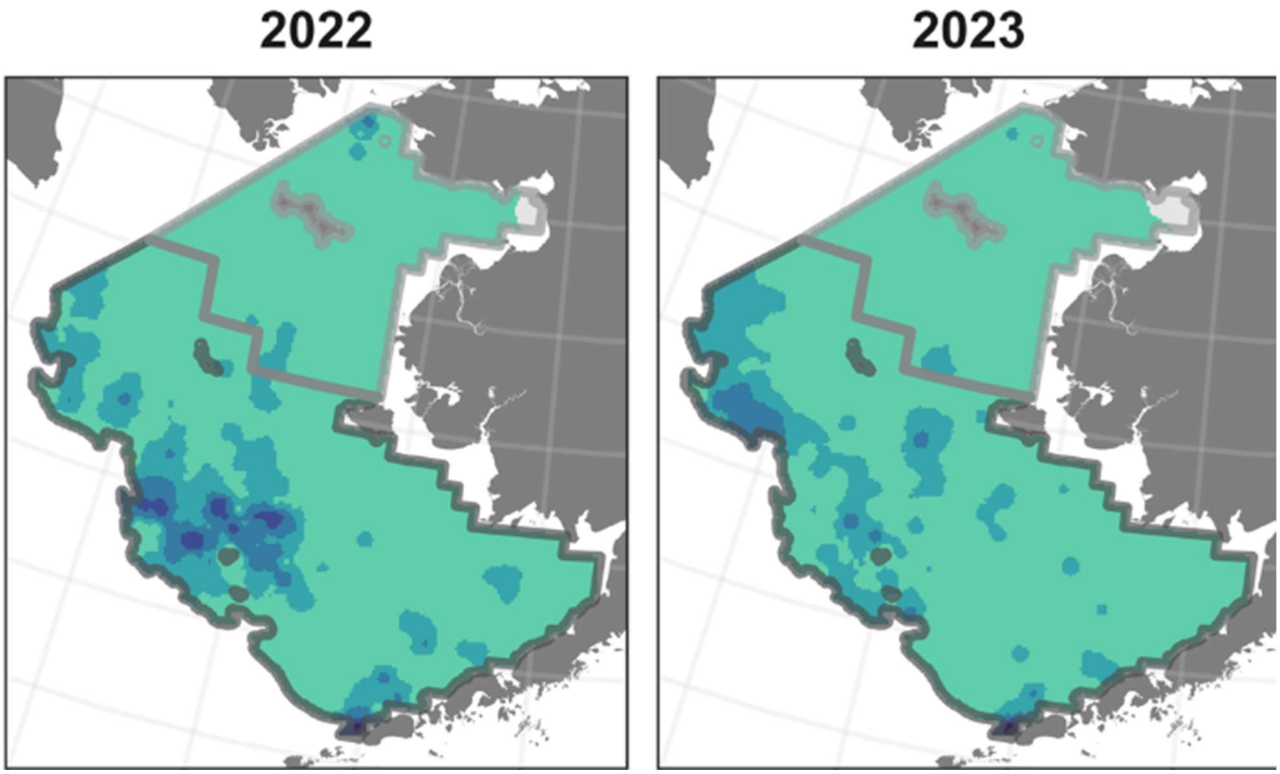
2023 Eastern Bering Sea Continental Shelf and Northern Bering Sea Bottom Trawl Surveys – RACE GAP

The 41st in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed in 2023 aboard the AFSC chartered fishing vessels *Northwest Explorer* and *Alaska Knight*, which together bottom trawled at 376 stations over a survey area of 492,990 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 2023 eastern and northern Bering Sea shelf bottom trawl survey.

Survey estimates of total biomass on the eastern Bering Sea shelf in 2023 were 3.1 million metric tons (mt) for walleye pollock, 663 thousand mt for Pacific cod, 1.4 million mt for yellowfin sole, 1.4 million mt for northern rock sole, 5.9 thousand mt for Greenland turbot, and 170.2 thousand mt for Pacific halibut. Most of the commercially important fish species showed declines in estimated survey biomass compared to 2022. Walleye pollock biomass decreased 24%, yellowfin sole 32%, Greenland turbot 26%, flathead sole 15%, Kanchatka flounder 16%, and Alaska plaice 7%. Pacific halibut biomass increased 14%, northern rock sole 7%, Pacific cod 2%, and Bering flounder 9%.

After the completion of the EBS shelf survey, which started for both vessels in Dutch Harbor on 28 May 2023, the F/V *Alaska Knight* transitioned into sampling survey stations in the southwest corner of the NBS survey region, while the F/V *Northwest Explorer* conducted sampling in the Norton Sound area traveling east to west. The F/V *Northwest Explorer* and the F/V *Alaska Knight* conducted sampling in the NBS from 29 July to 20 August. In the NBS survey area, only 116 of 144 planned stations were sampled. Thus, a total of 492 20 x 20 nautical mile sampling grid stations in the combined EBS and NBS were successfully sampled in 2023.



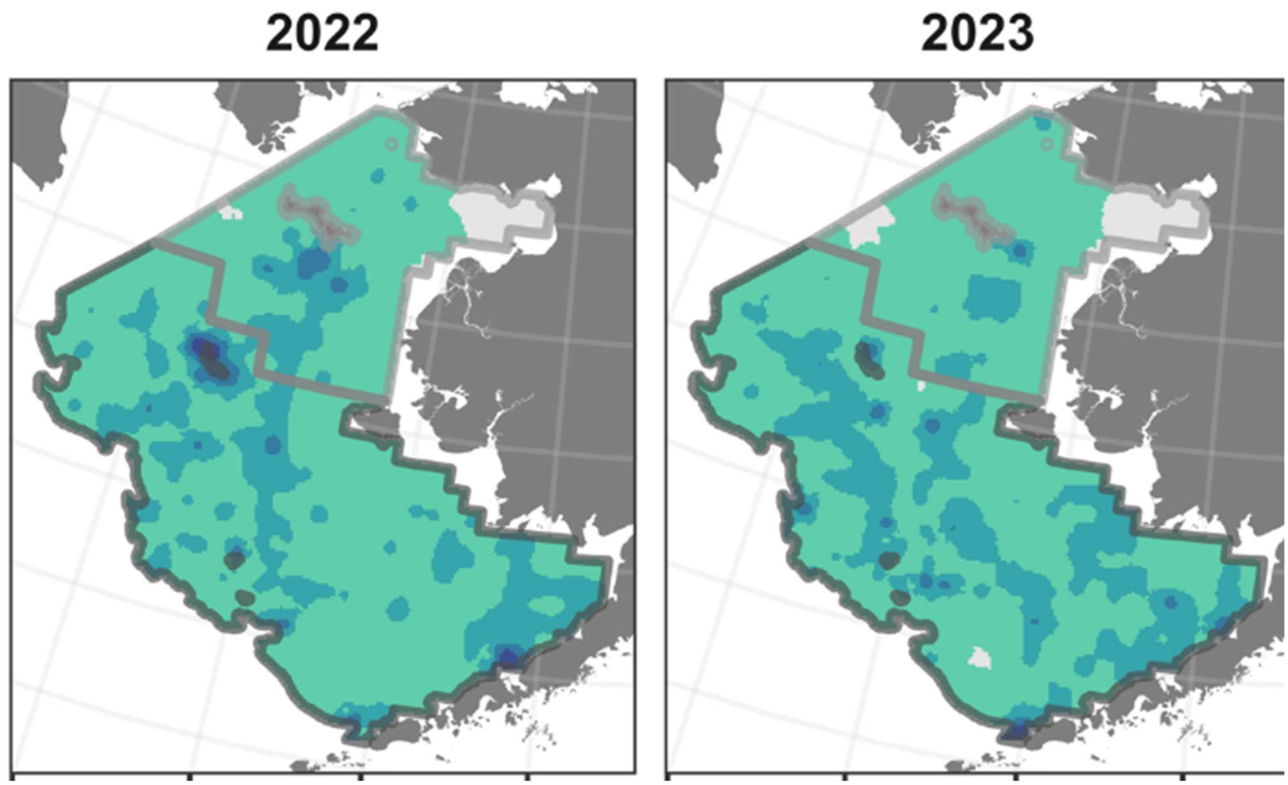


Fig. 2. Spatial distribution of large gadids, in terms of mean CPUE (kg/ha), observed during the 2022 and 2023 bottom trawl surveys of the EBS and NBS: Top panel is walleye pollock; bottom panel is Pacific cod.

The NBS region was fully surveyed using the same standardized protocols and sampling resolution as the EBS survey in 2010, 2017, 2019, 2021, 2022, and 2023. In recent years, distributions of walleye pollock and Pacific cod have been completely different than those observed in 2010. In 2010, pollock were mostly concentrated on the outer shelf at depths of 70–200 m north of 56°N. Pollock biomass was consistently low on the inner and middle shelf, and pollock were almost completely absent from the NBS. In 2017-2019, pollock biomass in the EBS was concentrated mostly on the middle shelf, and there were large concentrations of pollock in the NBS. In 2021-2023, pollock distribution has been more similar to historical (2010) distribution patterns, with aggregations in the EBS in the middle and outer domains, particularly along the northern shelf edge, and to the north and west of the Pribilof Islands (Fig. 2). For the past three survey years, walleye pollock have been relatively rare throughout the NBS survey area, with a small area of higher density in the Chirikov Basin just south of the Bering Strait and another small concentration near the border with the EBS survey area.

In 2010, Pacific cod biomass in the EBS was concentrated in Bristol Bay, on the middle and outer shelf from the Pribilof Islands north to St. Matthew, and cod biomass was low throughout the NBS. In contrast, the 2017-2019 surveys revealed high densities of Pacific cod in the NBS both to the north and south of St. Lawrence Island, and Pacific cod were concentrated in only a few areas of the EBS. In the three most recent survey years (2021-2023), Pacific cod distribution has moved south again, with the largest concentrations located near St. Matthew Island and to the south of St. Lawrence Island, although moderate densities have also been recorded throughout the EBS shelf (Fig. 2). In all survey years, Pacific cod were concentrated in areas with bottom temperatures >0°C.

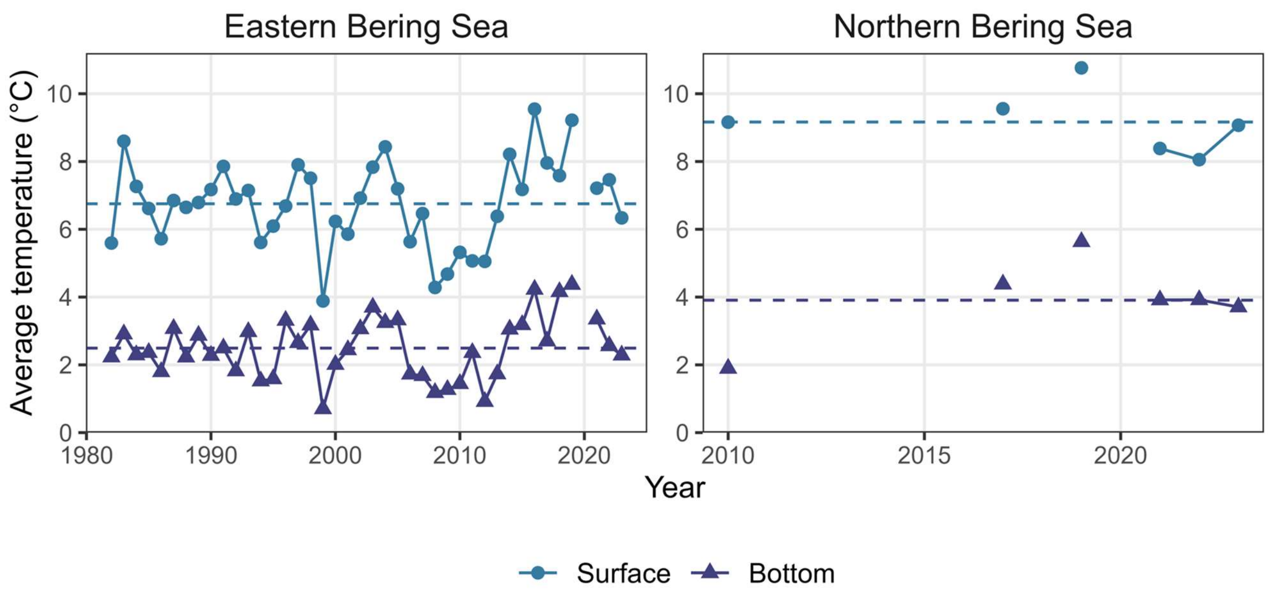


Figure 3: Average annual surface and bottom temperature during the survey period for the eastern and northern Bering Sea shelf survey with the survey mean temperature (1982-2023).

The surface and bottom temperature means for the 2023 eastern Bering Sea shelf were similar to 2022 estimates. Both were slightly colder than the long-term time-series mean (Fig. 3). The 2023 mean surface temperature was 6.3°C, which was colder than 2022 (7.5°C), and colder than the time-series mean (6.8°C). The mean bottom temperature was 2.3°C in 2023 which was colder than 2022 (2.6°C), and slightly below the time-series mean (2.5°C). In the NBS, mean surface temperature for 2023 (9.1°C) was warmer than in 2022 (8.1°C), and mean bottom temperature (3.7°C) was very similar for both years. The 'cold pool', defined as the area with bottom temperatures <2°C, covered a nearly identical area in 2022 and 2023, which is more extensive than in other recent years (Fig. 4), extending south from the NBS through the middle domain of the EBS and almost into Bristol Bay. Among recent survey years, only 2017 had a similarly extensive cold pool. During the 40-year time series, the cold pool area has ranged from 1.2% to 78.2% of the total EBS shelf area (Fig. 5). In 2023, the cold pool occupied 36.4% of the EBS shelf area, which was almost identical to 2022 (36.2 %).

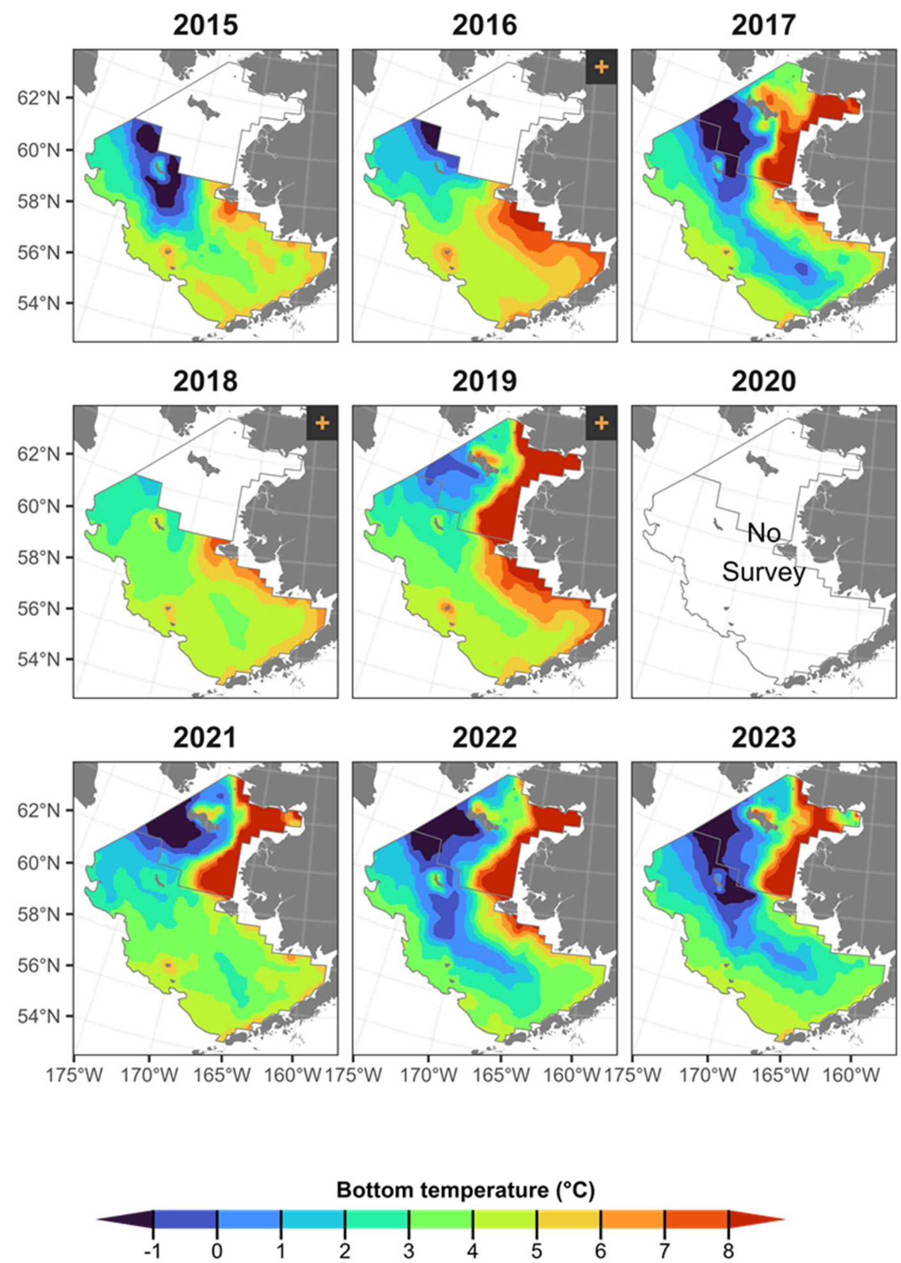


Figure 4: Distribution of survey bottom temperatures for recent survey years (2015-2023).

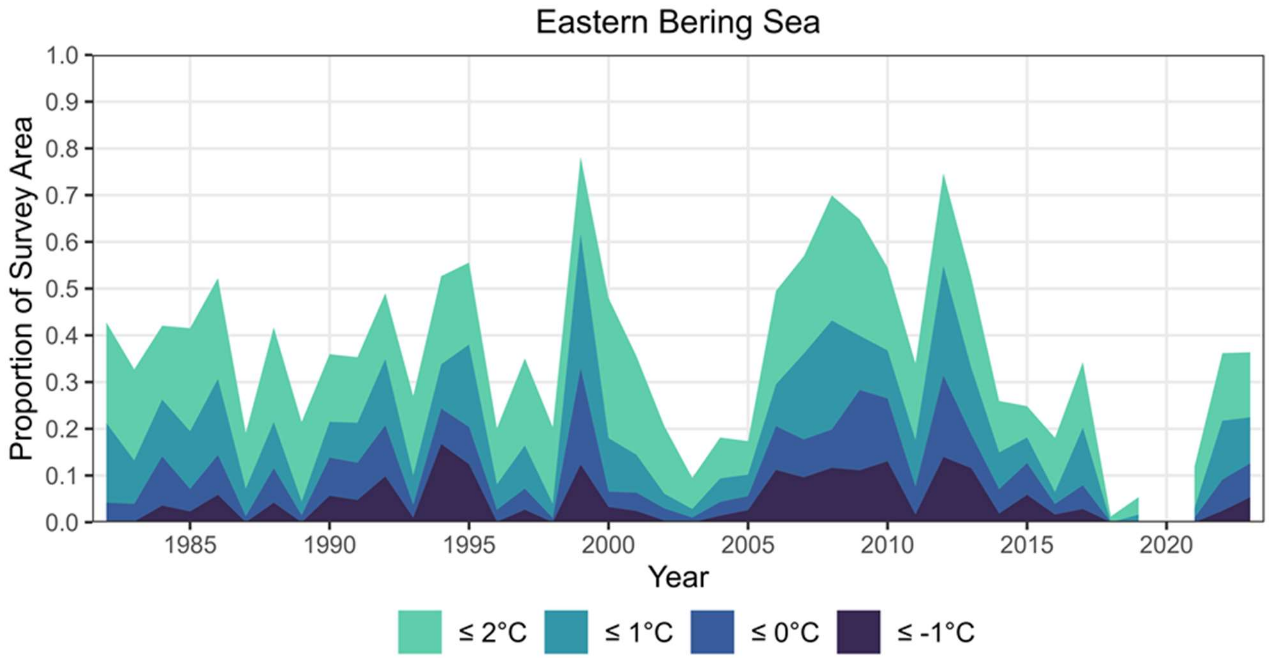


Figure 5: Areal extent of the summer cold pool on the eastern Bering Sea shelf, based on observations from the eastern Bering Sea bottom trawl surveys (1982-2023), shown as a percentage of the total EBS survey area.

<u>2023 Gulf of Alaska Biennial Bottom Trawl Survey- RACE GAP</u>

The Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering Division's (RACE) Groundfish Assessment Program (GAP) chartered the fishing vessels *Ocean Explorer* (75-day charter) and *Alaska Provider* (81-day charter) to conduct the 2023 Gulf of Alaska (GOA) Biennial Bottom Trawl Survey of groundfish resources in the region. This was the eighteenth standardized bottom trawl survey of the GOA since 1990. The survey began in Dutch Harbor, Alaska in May and concluded in Ketchikan in August. Trawl catch samples were collected from nearshore waters to a depth of 700 m on the continental shelf and upper continental slope between the Island of Four Mountains in the eastern Aleutian archipelago and Dixon Entrance in the eastern GOA at the border with Canada.

Oceanographic and environmental parameters are collected along with identified and enumerated collections of fishes and invertebrates from the trawl catches. Among the objectives of the 2023 GOA bottom trawl survey were defining the distribution and estimating the relative abundance of principal groundfishes and important invertebrate species that inhabit the region, measuring biological parameters for selected species, and collecting age structures and other samples. The survey design is random and stratified across depth, statistical management zone, and regional boundary strata overlaid with 25 km^2 grid cells. Stations identified as untrawlable are excluded from the sampling frame and trawlable or unknown stations are allocated to strata using a Neyman optimization weighted by stratum area, stratum variance, and the ex-vessel values of key species. The survey deploys a standard four-seam, high-opening Poly Nor'Eastern survey trawl equipped with rubber bobbin roller gear to collect samples. 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, 1.8 × 2.7 m steel V-doors weighing approximately 850 kg each, and a small under bag (*a.k.a.* "the benthic bag") attached to the footrope of the trawl. Charter vessels conduct 15-minute trawls at pre-assigned stations and catches of all live animals are identified to the lowest possible taxon. Biological samples (e.g., length, age structures, individual weights, stomach contents, etc.) are collected for selected groundfish species. Specimens and data for special studies (e.g., maturity observations, tissue samples, photo vouchers, eDNA) are also collected as requested by AFSC researchers and other cooperating agencies and institutions. Specimens of uncommon fishes or invertebrates are collected on an opportunistic basis and accessioned into the AFSC voucher system.

Surface and bottom temperatures were collected at each trawl station and summarized over the region (Figure 1). Historically, these temperatures have been collected using a variety of methods that may not be directly comparable (see von Szalay and Raring 2018 for methods). The temperatures presented here have not been inter-calibrated across collection methods nor have they been adjusted for tidal cycles. Surface temperatures in 2023 were generally cooler than those in 2021 and ranged from 4.6 to 15.5°C. Bottom temperatures were similar to those encountered in 2021, ranging from 3.8 to 8.1°C.

There were 520 stations planned for the shelf and upper continental slope of the Gulf of Alaska to a depth of 700 m (Figure 2). In 2023, we continued efforts begun in 2022 to reduce ergonomic injuries and physical fatigue reported in recent survey years by reducing the overall station allocation by around 5% from what had typically been a 550 station survey for two vessels while also reducing the number of sexed lengths and otoliths collected, and generally slowing the pace of the survey to try and reduce injury rates. However, we provided opportunities for field teams to pick up additional stations as time allowed and, as a result, out of 555 stations attempted, 526 stations were successfully trawled in 2023. From the successfully trawled stations sampled during the GOA 2023 survey, a total of around 250 metric tons (mt) comprised of 163 unique fish taxa were collected as were about 5.4 mt of 406 unique invertebrate taxa. There were 25 fish and invertebrate taxa vouchered over the course of the survey, more than 150,000 fish and squid lengths were collected, and more than 9,000 pairs of otoliths from 18 fish species were collected for age and growth studies. In 2021, we collected around 350 lengths/haul while in 2023 we collected closer to 290/haul, representing a real reduction in repetitive motion activities. The 9,000 otolith specimens collected also represented a decrease in total collection effort compared to 12,000 otoliths collected in 2021. Special collections for fisheries acoustics, environmental monitoring, population genetics, feeding habits, and International Pacific Halibut Commission monitoring were all prosecuted during this summer survey. Validated data were finalized prior to the September Joint Groundfish Plan Team Meetings and presented there. Data from the survey were made available at that time on the Pacific States Marine Fisheries Commission's Alaska Fisheries Information Network (AKFIN)[2] as well is in NMFS' Fisheries One-Stop Shop (FOSS)[3].

Species composition of the more abundant fishes in 2023 was similar to previous years (Figure 3). Pacific ocean perch (POP) and Arrowtooth flounder had the highest survey biomass estimates, followed by walleye pollock and Pacific halibut. Cod and pollock biomass was fairly consistent throughout the 2000s in survey

[2] PSMFC Alaska Fisheries Information Network: https://akfin.psmfc.org/

[3] NMFS Fisheries One-Stop Shop: https://www.fisheries.noaa.gov/foss/f?p=215:28

estimates with the possible exception of the lower biomass estimated in 2012. Among fishes caught in 2023, arrowtooth flounder, POP, and Pacific cod were among the most common, occurring in ~65% or more of all successful trawl hauls. Rougheye and shortraker rockfish were among the least common in our catches, occurring in <7% of successful trawl catches.

Total estimated biomass was higher in 2023 than the previous few surveys (Figure 3). The relative contributions of most fish taxa to the species composition of the Gulf has remained fairly stable over the last 3 to 4 surveys (6-8 calendar years). The contributions of pollock to the overall biomass over that same time frame appear to be increasing. Pacific cod biomass contribution has increased slightly since its low during the 2017 survey, but remains at lower contribution levels than in survey years prior to 2017.

For further information contact Gulf-Aleutian Bottom Trawl Team Leader, Ned Laman (206) 526-4832 [Google Voice], Ned.Laman@NOAA.gov

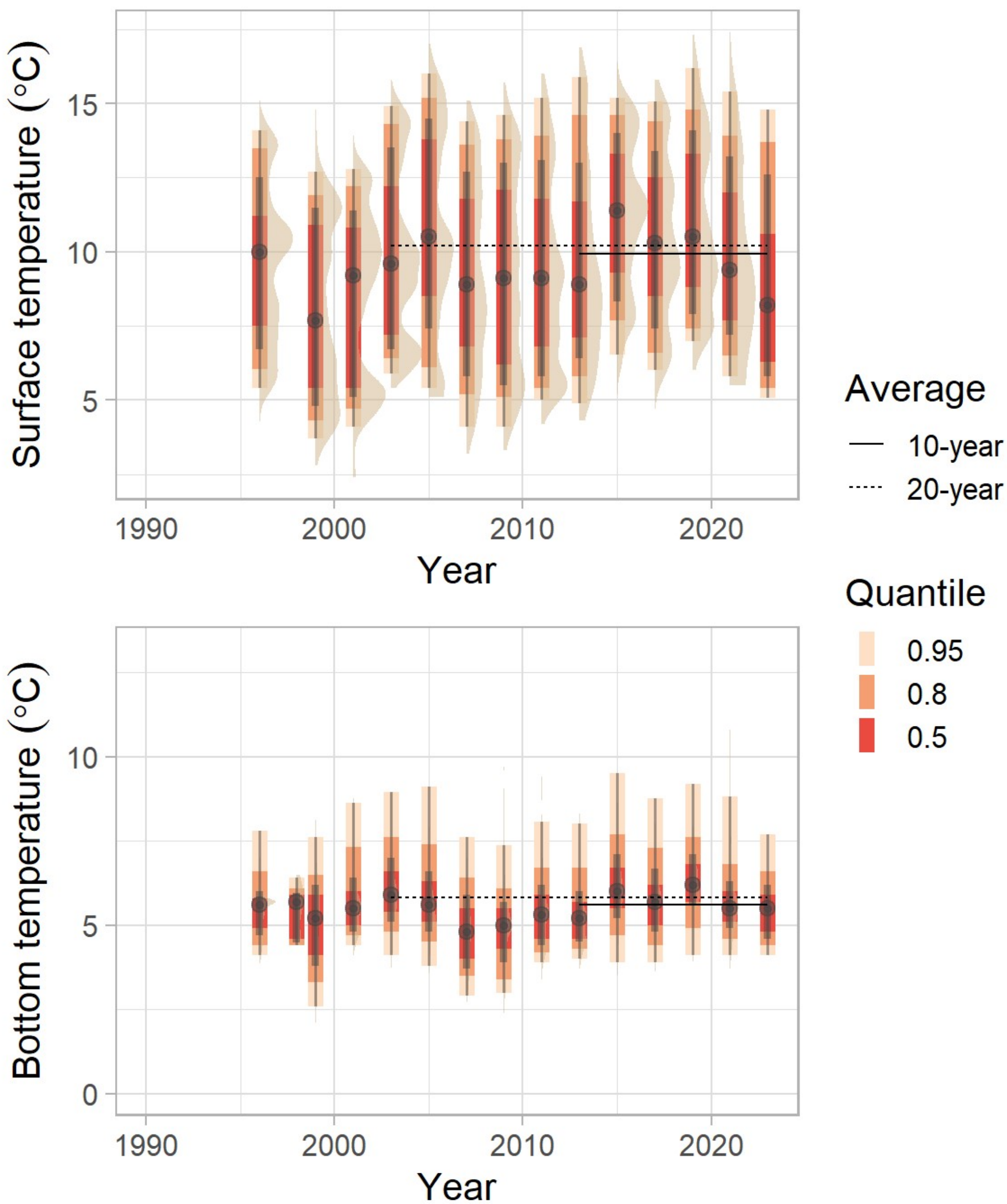
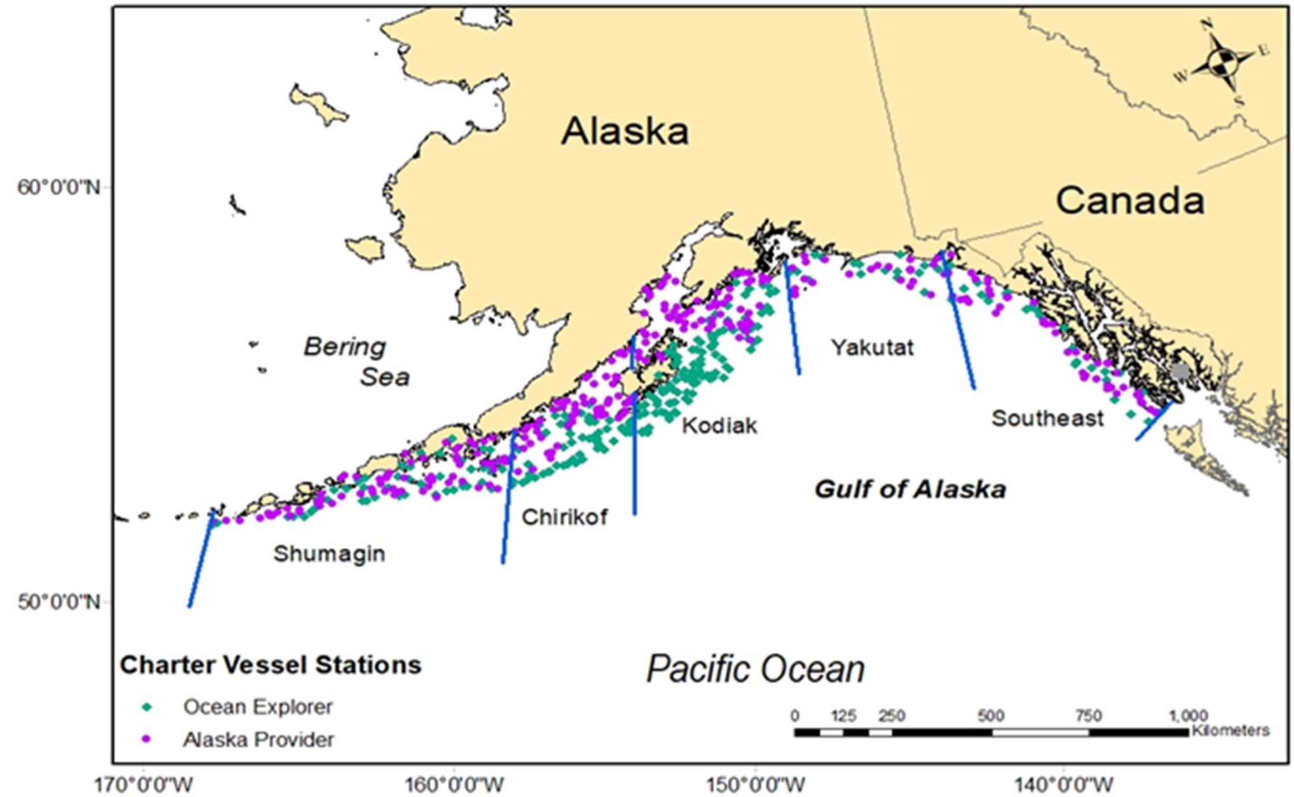


Figure 1. Mean and raw surface and bottom temperatures collected during the last 14 years on Gulf of Alaska biennial Summer Bottom Trawl Surveys aboard chartered commercial fishing vessels.



Alaska
Canada
60°0'0"N
50°0'0"N
Bering Sea
Yakutat
Kodiak
Southeast
Chirikof
Shumagin
Gulf of Alaska
Pacific Ocean
Charter Vessel Stations
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0 125 250 500 750 1,000
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170°0'0"W
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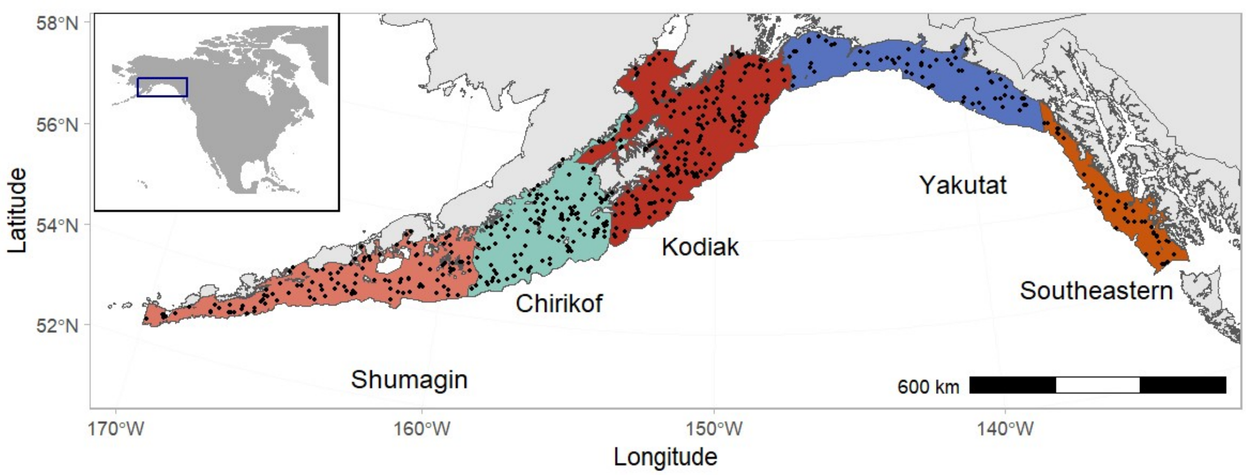


Figure 2. Station allocation (N = 520) for the 2023 Gulf of Alaska biennial Summer Bottom Trawl Survey.

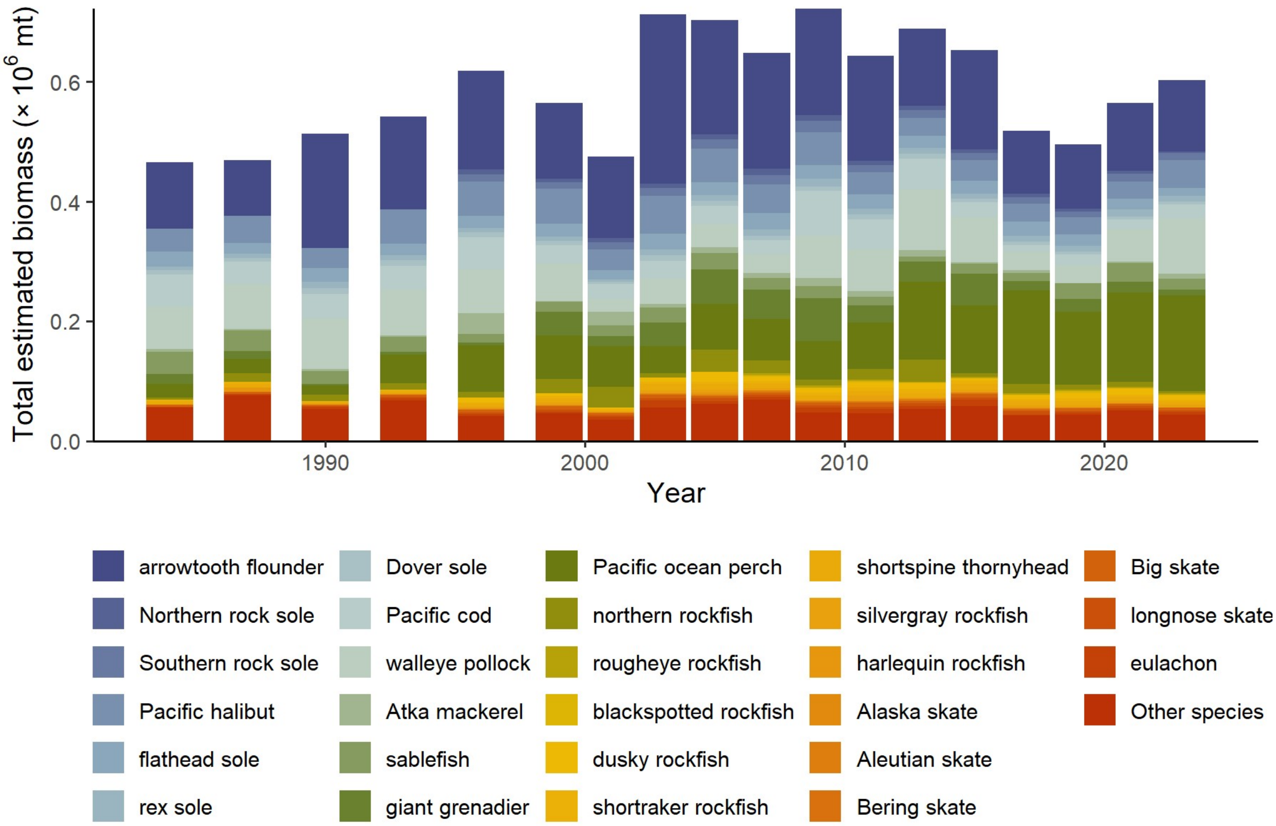


Figure 3. Catch composition of the most abundant fishes from the 2023 Gulf of Alaska biennial Summer Bottom Trawl Survey.

<u>Winter acoustic-trawl survey of pre-spawning walleye pollock in the Gulf of Alaska MACE</u>

Two cruises were conducted to survey several GOA walleye pollock (*Gadus chalcogrammus*; hereafter pollock) spawning areas in the winter of 2023. The first cruise (DY2023-03) surveyed the Shumagin Islands area (i.e., Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait, 14-16, 19-20 February; Pavlof Bay, 16 February; and Morzhovoi Bay, 18-19 February). The second cruise (DY2023-04) covered Shelikof Strait (4-11 March), Chirikof shelf break (11-13 March), and Marmot Bay (15-16 March).

All surveys were conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. Midwater and near-bottom acoustic backscatter at 38 kHz sampled using an LFS1421 trawl was used to estimate the abundance of walleye pollock. Backscatter data were also collected at 4 other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques. The trawl hauls conducted in the GOA winter surveys included a CamTrawl stereo camera attached to the net forward of the codend. The

CamTrawl was used to capture stereo images for species identification, fish length measurements, and depth as fishes passed through the net toward the codend.

In the Shumagin Islands area, acoustic backscatter was measured along 861.5 km (465.2 nmi) of transects. The survey transects were spaced mainly 9.3 km (5 nmi) apart with spacing varying from 2.8 km to 9.3 km (1.5 to 5 nmi) in the survey area. Pollock lengths from 8 trawl samples ranged between 10-55 cm fork length (FL), with numerical modes at 12-13 cm and 32-34 cm FL. The smaller, juvenile pollock (likely age-1) were present mainly in Shumagin Trough whereas the larger, adult pollock were detected throughout the area but to a lesser extent in the Shumagin Trough. Adult pollock were aggregated in Unga Strait and off Renshaw Point, and they were most abundant in dense layers between Popof and Unga Islands. Most juvenile pollock were distributed between 95-175 m depths, and within 55 m of the sea floor, whereas most adult pollock were detected shallower, in 75-155 m depths and within 50 m of the sea floor. The abundance weighted maturity composition for males > 40 cm FL (n = 17) in the Shumagin Islands was 0% immature, 0% developing, 100% pre-spawning, 0% spawning, and 0% spent, and for females > 40 cm FL (n = 13) the abundance weighted maturity composition was 39% immature, 6% developing, 56% pre-spawning, 0% spawning, and 0% spent. The estimated abundance of pollock for the Shumagin Islands were 550 million pollock weighing 48,868 t (with a relative estimation error of 8.7%). This biomass estimate was the largest estimate in the Shumagin survey time series since 2015.

In Pavlof Bay, acoustic backscatter was measured along 72.2 km (39 nmi) of transects spaced mainly 3.7 km (2 nmi) apart, with spacing varying from 3.7 km to 6.1 km (2-3.3 nmi). Pollock were observed throughout Pavlof Bay and were most abundant at the mouth of the Bay. Based on one trawl sample, pollock lengths ranged between 10-62 cm FL; most of the fish measured were adults > 30 cm FL, with a mode centered at about 32-34 cm FL. The maturity composition in the Pavlof Bay of males > 40 cm FL (n = 10) was 0% immature, 0% developing, 80% pre-spawning, 20% spawning, and 0% spent. The abundance weighted maturity composition of females > 40 cm FL (n = 4) was 50% immature, 0% developing, 25% pre-spawning, 25% spawning, and 0% spent. Adults and juvenile pollock (≤ 30 cm FL) were detected intermixed in the water column. Most of the pollock biomass was observed within 50 m of the seafloor. A total of 18.1 million pollock weighing 5,536.95 t (with a relative estimation error of 13.6%) were estimated to be in Pavlof Bay at the time of the survey. The 2023 survey biomass estimate is the largest in the Pavlof Bay survey time series.

In Morzhovoi Bay, acoustic backscatter was measured along 70.7 km (38.2 nmi) of transects spaced 3.7 km (2 nmi) apart with spacing varying from

3 km to 5 km (1.6 to 2.7 nmi) in the survey area. Pollock were observed throughout the surveyed area and were most abundant to the southeast, in the mouth of the bay. Adult and juvenile pollock (≤ 30 cm FL) were detected intermixed and not separated horizontally or vertically; most of the pollock were observed within 50 m of the seafloor. Based on one trawl sample, pollock lengths ranged between 9-64 cm FL, with modes at 12-13, 44, and 52-53 cm FL. Pollock observed in Morzhovoi Bay were generally in prespawning (females) or spawning (males) maturity stages. The abundance weighted maturity composition in the Morzhovoi Bay of males > 40 cm FL (n = 46) was 0% immature, 4% developing, 20% pre-spawning, 76% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 9) was 0% immature, 11% developing, 44% pre-spawning, 44% spawning, and 0% spent. A total of 5.6 million pollock weighing 4,021.22 t (with a relative estimation error of 5.4%) were estimated to be in Morzhovoi Bay at the time of the survey. The 2023 biomass was 106.6% of that observed in 2018 (3,772 t) and 75.6% of the historic mean of 5.3 thousand tons.

In the Shelikof Strait sea valley, acoustic backscatter was measured along 1,663.9 km (898.5 nmi) of transects spaced mainly 13.9 km (7.5 nmi) apart. Pollock were observed throughout the surveyed area and were most abundant in the central part of the surveyed area, along the Alaska Peninsula side of the Strait between Cape Kuliak and just southwest of Cape Kekurnoi, where large numbers of pre-spawning fish have been observed during most Shelikof surveys. Most of the pollock were detected between 195-285 m depth. Although pollock in Shelikof Strait ranged between 11 and 64 cm FL, 30 the population were primarily adults with the length mode centered around 48 cm FL by weight. The abundance weighted maturity composition of females > 40 cm FL (n = 373) was 1% immature, 1% developing, 94% pre-spawning, 5% spawning, and 0% spent, while the maturity composition of males > 40 cm FL (n = 325) was 0% immature, 1% developing, 18% pre-spawning, 78% spawning, and 3% spent, based on data from specimens collected from 16 LFS1421 hauls. A total of 287.4 million pollock weighing 258,109.5 t (with a relative estimation error of 4.8%) were estimated to be in Shelikof Strait at the time of the survey. Very few age-1 walleye Pollock, between 10-14 cm FL, were observed. The 2023 biomass decreased 29.4% from that observed in 2022 (365,409 t) and was 36.9% of the historical mean of 699.8 thousand tons. The 2023 survey biomass estimate is the lowest since 2009.

During the Chirikof shelfbreak survey, acoustic backscatter was measured along 329.3 km (177.8 nmi) of transects spaced mainly 11.1 km (6 nmi) apart. Biological data were collected from 6 LFS1421 hauls in this area. Pollock lengths ranged from 30-62 cm FL. Adult pollock (defined as > 30 cm FL) were detected across the Chirikof shelfbreak area, with the largest aggregations concentrated in areas south of the Trinity Islands, adjacent to Snakehead Bank, and at the mouth of

Barnabas Trough. As in previous years adult pollock were often caught intermixed with Pacific ocean perch and in similar schooling aggregations. The abundance weighted maturity composition of females > 40 cm FL (n = 109) was 2% immature, 19% developing, 70% pre-spawning, 10% spawning, and 0% spent, while the maturity composition of males > 40 cm FL (n = 84) was 3% immature, 4% developing, 8% pre-spawning, 80% spawning, and 5% spent. A total of 69.6 million pollock weighing 39,874.7 t (with a relative estimation error of 11.5%) were estimated to be at the Chirikof shelfbreak at the time of the survey. Most of the pollock were detected between depths of 205-365 m. Pollock measuring ~ 44 cm FL were the most abundant by number and weight. The 2023 survey biomass estimate is the highest since 2013.

In Marmot Bay, acoustic backscatter was measured along 341.1 km (184.2 nmi) of parallel transects spaced mainly 3.7 km (2 nmi) apart. Pollock were detected throughout Marmot Bay, with the largest aggregations concentrated in the northeast portion of the inner bay and in the Spruce Gully area. Pollock were observed in inner Marmot Bay as low-density, near-bottom backscatter layers of mixed sizes, periodically topped with very dense midwater juvenile schools at ~ 50 m depths. Near bottom, mixed size, backscatter layers were somewhat denser in Spruce Gully, with diffuse near-surface juvenile pollock backscatter. Juvenile pollock were also observed in outer Marmot Bay. Most adult pollock (comprising 78.6% of total biomass) were detected between depths of 55–225 m. Most juvenile pollock (comprising 57.2% of total abundance) were between depths of 45–125 m. Biological samples were collected from 5 LFS1421 hauls. Pollock ranged from 10-62 cm FL with clear modes at 12 and 25 cm FL by number. The abundance weighted maturity composition of females > 40 cm FL (n = 44) was 8% immature, 26% developing, 58% pre-spawning, 0% spawning, and 8% spent, while the maturity composition of males > 40 cm FL (n = 27) was 47% immature, 0% developing, 0% pre-spawning, 47% spawning, and 7% spent. A total of 62.6 million pollock weighing 9,284.4 t (with a relative estimation error of 8.3%) were estimated to be in Marmot Bay at the time of the survey. The 2023 survey biomass estimate is the highest since 2018.

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

The MACE Program conducted a summer 2023 acoustic-trawl survey of the Gulf of Alaska (GOA) shelf aboard the NOAA ship *Oscar Dyson* to estimate the distribution and abundance of age-1 and older walleye pollock (*Gadus chalcogrammus*; hereafter pollock) between 14 June and 17 August 2023. Previous surveys of the GOA have also been conducted by the MACE program during the summers of 2003, 2005, and every other year since 2011. The 2023 survey covered the shelf from the Islands of Four Mountains to Yakutat Trough as well as the Shumagin Islands, Shelikof Strait, Chiniak Trough, and Barnabas Trough regions. These regions have been consistently surveyed since 2013. A total of 20 sea days were lost from legs 1 and 3 due to vessel staffing issues, but we were able to survey the entire GOA shelf survey area that has been covered in previous years by utilizing wider transect spacing between the shelf transects (increased from 25 nmi to 30–40 nmi spacing) and by not surveying most of the smaller bays and troughs sampled in previous years. Coverage is similar to that of the most recent prior survey in summer 2021, which was curtailed by impacts of the COVID-19 pandemic.

Acoustic backscatter was measured along 4,396 km (2,374 nmi) of trackline along 94 transects spaced from 3.4 km (1.9 nmi) to 74.1 km (40.0 nmi) apart using a Simrad EK80 echosounder. Midwater and near-bottom acoustic backscatter at 38 kHz was sampled to estimate the abundance of pollock using an LFS1421 trawl (n = 63 trawls) with a trawl-mounted stereo camera (CamTrawl), and a poly Nor'eastern (PNE) bottom trawl (n = 2). Backscatter data were also collected at four other frequencies (18-, 70-, 120-, and 200-kHz) to support multifrequency species classification techniques. A Methot trawl was used to target midwater macro-zooplankton (n = 3). Conductivity-temperature-depth (CTD) casts (n = 35) were conducted to characterize the physical oceanographic environment across the surveyed area.

Pollock and Pacific ocean perch (*Sebastes alutus*; POP) were the most abundant species by weight in LFS1421 trawls used in the analysis, contributing 68.1% and 15.7% of the catch by weight. Pacific capelin (*Mallotus catervarius*; hereafter capelin) and pollock were the most abundant species by number in the LFS1421 trawls, contributing 37.8% and 19.5% of the catch by number. Pollock and POP were the most abundant species by weight in PNE trawls, contributing 88.8% and 4.1% of the catch by weight. Pollock and POP were the most abundant species by number in the PNE trawls, contributing 89.6% and 4.2% of the catch by number.

Abundance estimates of age-1+ pollock were based on an analysis where backscatter was attributed to all trawl-captured species and size classes using the biological length-frequency data from the nearest trawl locations. Abundance estimates also included a correction for escapement of fishes and other catch from the survey trawl (i.e., net selectivity). The estimated abundance of age-1+ pollock for the entire surveyed area was 1,774.2 million fish weighing 732,863 metric tons (t), a decrease of 58.8% (by numbers) and an increase of 70.0% (by weight) from the 2021 estimated abundance. The relative estimation error on biomass was 7%. The majority of the pollock biomass was observed in the GOA Shelf (84%) and Shelikof Strait (9%) regions, with pollock biomass concentrated on the GOA shelf southwest of Kodiak Island and the GOA shelf northeast of Kodiak Island. Age-3 pollock (2020 year class) dominated numerically (33% of total pollock numbers) and by weight (36% of total pollock biomass), which is the first time a year class has accounted for both the highest numbers and biomass since 2017. Age-5 and -6 pollock (2018 and 2017 year classes) also contributed 26 and 14% of total pollock biomass, respectively.

Additionally, abundance estimates were calculated for POP (190.7 million fish weighing 137,892 t) and Pacific capelin (21,057.3 million fish weighing 71,712 t). The relative estimation error on POP biomass was 15% and on capelin biomass was 19%. POP were most often found intermixed with pollock in the midwater and were located predominately along the shelf break across all NMFS management areas, with high concentrations in the southern portion of Shelikof Strait. POP were also observed more broadly distributed over the GOA shelf east of Kodiak, but not concentrated in high densities as in the 2021 survey. Capelin were predominately concentrated in shallow waters (< 100 m bottom depth) over Portlock and Albatross Banks over the Kodiak shelf and along the edges of Barnabas and Chiniak Troughs, as well as in the southwestern portion of Shelikof Strait. The summer 2023 biomass estimate is the highest abundance for capelin since 2013, indicating a possible recovery of the population following its collapse during the 2014–2016 marine heatwave.

During the summer 2023 GOA survey, the average sea surface temperature recorded from the hull mounted flow-thru seawater system was 10.0°C, within the range of 2013–2021 surveys (9.0–12.0°C). A similar pattern was seen with near-surface temperatures recorded at fishing locations in the regions that have been sampled consistently since 2013. The mean temperature at 100 m depth in the consistently sampled areas in 2023 was 5.5°C, within the range of previous surveys (5.1–6.5°C). The mean bottom temperature, as measured during 35 CTD deployments during 2023, was 5.3°C, within the range of previous surveys (5.0–6.0°C).

The DriX uncrewed surface vehicle was tested during leg 2 of the survey (28 June – 22 July) as part of a NOAA Office of Marine and Aviation Operations (OMAO)-funded project. This 8 m motorized vehicle is equipped with EK80 echosounders similar to those used on the *Oscar Dyson*. The DriX project goals were to test operation and evaluate its potential to make separate complimentary observations during acoustic-trawl surveys. The *Oscar Dyson* was modified to facilitate launch, recovery, and operation of DriX by adapting the boat davit, adding a fueling station, and installing a large deployable painter boom. Initial testing of the DriX was conducted on Lake Washington in December 2022 and aboard the *Oscar Dyson* in January 2023 during gear trials off Seattle. For the summer field test, work first included refining DriX deployment and recovery in calm conditions, conducting simulated emergency rescue operations of a non-functional vehicle, and developing a calibration procedure for the EK80 echosounder while the vehicle is suspended from the davit. At-sea trials involved gradually increasing operations away from the ship, beginning with “side-by-side” survey operations with DriX within sight at moderate sea states, and then allowing DriX to survey increasingly farther away from the ship with maximum separation of ~25 km. The DriX was successfully operated and monitored in several ways: over a radio link from the ship, by satellite link from the ship, through an OMAO facility, and via remote operations center in France. Underwater radiated noise from DriX and *Oscar Dyson* was measured using an AFSC-designed buoy. Overall, this was a logistically demanding project requiring careful coordination from a variety of parties including the ship, OMAO, the science party and Exail, the DriX vendor. The project received excellent support from all involved.

<u>Longline Survey – ABL</u>

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2023. The survey is a joint effort involving the AFSC’s Auke Bay Laboratory and Resource Assessment and Conservation Engineering (RACE) Divisions. 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 2023, the 46th annual longline survey sampled the upper continental slope of the Gulf of Alaska and the eastern Bering Sea. One hundred fifty longline sets were made from 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 with 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*), shortspine thornyhead

(*Sebastolobus alascanus*), rougheye/blackspotted rockfish (*Sebastes aleutianus/S. melanostictus*), and Pacific halibut (*Hippoglossus stenolepis*). A total of 178,374 sablefish, with an estimated total round weight of 405,086 kg (893,062 lb) were caught during the survey. This represents decreases of 1,335 fish and 16,137 kg (35,576 lb) of sablefish from the 2022 survey catch. The number of sablefish caught in 2023 is the second highest number recorded in the time series. Sablefish (5,985), shortspine thornyhead (189), and Greenland turbot (*Reinhardtius hippoglossoides*, 4) were tagged with external Floy tags and released during the survey. Length-weight data and otoliths were collected from 3,568 sablefish. Killer whales (*Orcinus orca*), depredating on the catch, occurred at 12 stations in the eastern Bering Sea, 3 stations in the western Gulf of Alaska, and 3 stations in the central Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were present during survey operations at 19 stations and were observed depredating on the gear at 7 stations in the central Gulf of Alaska, 3 stations in the West Yakutat region, and 9 stations in the East Yakutat/Southeast region.

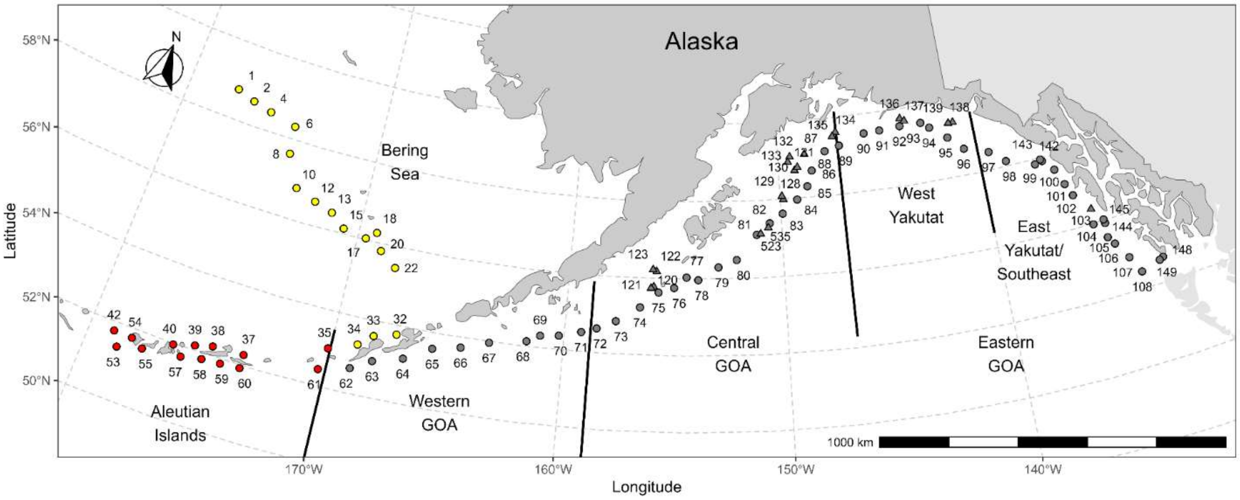
In 2023, COVID-19 precautions continued to be employed, including 3-day shelter-in-place isolation periods at each port of departure. AFSC staff participated on each of the six survey legs. Several special projects continued, including 3 days of comparisons between hook and line and slinky pots to investigate gear selectivity and catch efficiency. A third year of sablefish eyeball collections from across the survey region was completed to examine isotopic growth layers of the eye lens of adult sablefish to obtain individual chronologies (young-of-year to time of collection) of their dietary and migratory behavior. Additionally, samples were collected to conduct eye-lens-based age validation of sablefish, shortraker and yelloweye rockfish, which involves application of the radiocarbon chronometer, as well as a novel approach based on amino acid racemization. Furthermore, DNA from these fish will be used to construct draft epigenetic clocks with validated age estimates from eye lens core C14 analysis. Rockfish tissue samples were collected from shortspine thornyhead, shortraker, blackspotted and rougheye rockfish to improve our understanding of stock structure and investigate the genetic basis of sex determination for these species. Temperature profiles were collected that continue a time series starting in 2005 and show a continuation of above-average sub-surface temperature in the Bering Sea and western Gulf of Alaska and a decline to mean temperatures in the central and eastern Gulf of Alaska.

Longline survey cruise reports and 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).



Map of AFSC longline survey station locations. Bering Sea stations (yellow) are sampled in odd years, Aleutian Islands stations (red) are sampled in even years, and Gulf of Alaska (GOA) stations (grey) are sampled every year. Circles indicate stations included in abundance index calculations while triangles indicate stations that are not.

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. Multispecies assessment

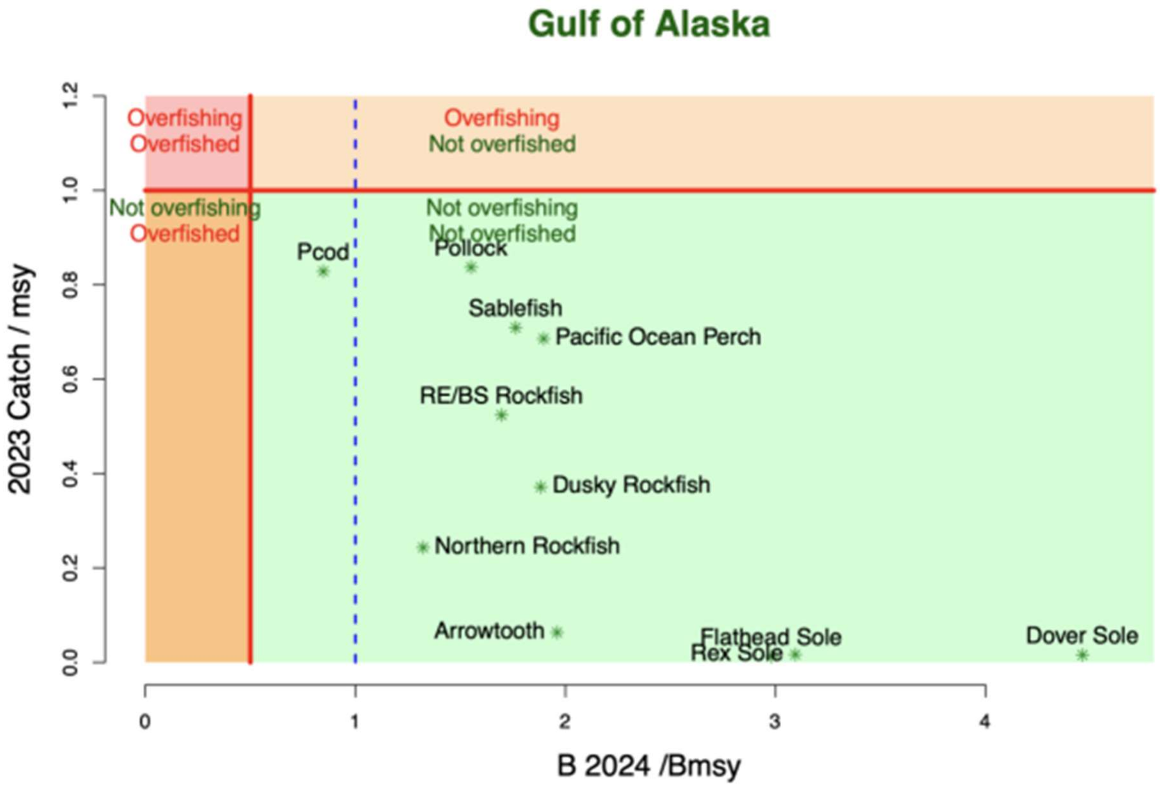
a. Gulf of Alaska

Overfished or approaching an overfished condition is determined for all age-structured stock assessments by comparing the stock level to its MSY level according to the following two harvest scenarios (Note for Tier 3 stocks, the MSY level is defined as B35%):

- Overfished condition (listed in each assessment as projection scenario 6) is defined as: In all future years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its MSY level in the current year or 2) above ½ of its MSY level in current year and above its MSY level 10 years in the future under this scenario, then the stock is not overfished.)

- Approaching an overfished condition (listed in each assessment as scenario 7): In 2024 and 202, F is set equal to max FABC, and in all subsequent years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its MSY level in 2024 or 2) above 1/2 of its MSY level in 2024 and expected to be above its MSY level in 2034 under this scenario, then the stock is not approaching an overfished condition.)

Annual groundfish stock assessments can be downloaded at https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments



Summary of Gulf of Alaska stock status next year (spawning biomass relative to BMSY; horizontal axis) and current year catch relative to fishing at FMSY (vertical axis). Note that sablefish is for Alaska-wide values including the BSAI catches.

Revised Stock Assessment Schedule

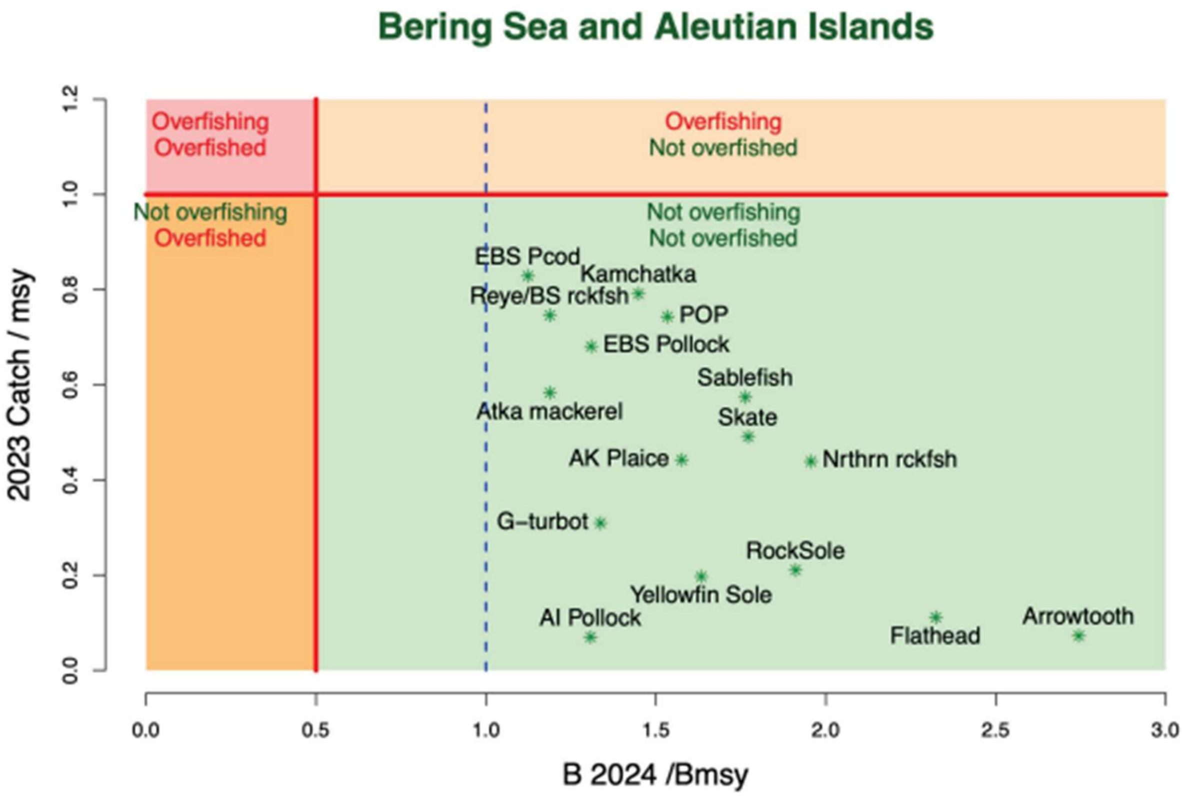
Based on consideration of stock prioritization including assessment methods and data availability, some stocks are assessed on an annual basis while others are assessed less frequently. The following table provides an overview of the level of assessment presented in this year's SAFE reports, the Tier level and schedule, as well as the year of the next full assessment by stock.]

Stock Assessment schedule for the Gulf of Alaska				
Stock	**2022 Assessment status**	**Tier**	**Schedule (years)**	**Year of next Full Assessment**
Pollock	Full	3	1	2023
Pacific cod	Full	3	1	2023
Sablefish	Full	3	1	2023
Northern and southern rock sole	Partial	3	4	2025
Shallow water flatfish (excluding northern and southern rock sole)	Partial	5	4	2025
Deepwater flatfish (Dover)	Partial	3/6	4	2023
Rex sole	Partial	3	4	2025
Arrowtooth flounder	Partial	3	2	2023
Flathead sole	Full	3	4	2025[1]
Pacific ocean perch	Partial	3	2	2023
Northern rockfish	Full	3	2	2024
Shortraker rockfish	None	5	2	2023
Other rockfish	None	4/5/6	2	2023
Rougheye & blackspotted rockfish	Partial	3	2	2023
Dusky rockfish	Full	3	2	2024
Demersal shelf rockfish	Full	4/6	2	2024
Thornyheads	Full	5	2	2024
Atka mackerel	None	6	2	2023
Octopus	None	6	2	2023
Skates	None	5	2	2023
Sharks	Full	6	2	2024
Sculpins	None	eco	4	2023
Forage species (including Squid)	Report	eco	2	2024
Grenadiers (BSAI/GOA)	None	eco	4	2024

For more information contact the Gulf of Alaska Plan Team Co-chair, Chris Lunsford, Chris.Lunsford@noaa.gov . Report: https://meetings.npfmc.org/CommentReview/DownloadFile?p=b0e846bf-0674-4707-97ed-32f55af846aa.pdf&fileName=C5%20GOA%20Groundfish%20SAFE%20Intro.pdf

b. Bering Sea and Aleutian Islands

Annual stock assessments can be downloaded from https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments



Summary of Bering Sea and Aleutian Islands stock status next year (spawning biomass relative to BMSY; horizontal axis) and current year catch relative to fishing at FMSY (vertical axis). Note that sablefish is for Alaska-wide values including the GOA catches.

Stock assessment schedule

Based on the stock prioritization schedule, not all stocks are assessed on an annual basis. The table below summarizes the stock assessment schedule for 2023-2026. OP indicates an operational, HP indicates harvest projections, CR indicates a catch report, and NA indicates no assessment.

Stock	Tier	Freq.	Last Full	2023	2024	2025	2026
EBS Pollock	1	1	2022	OP	OP	OP	OP
AI Pollock	3	2	2022	HP	OP	HP	OP
Bogoslof Pollock	5	2	2022	CR	OP	CR	OP
EBS Cod	3	1	2022	OP	OP	OP	OP
AI Pacific Code	3	1	2022	OP	OP	OP	OP
Sablefish	3	1	2022	OP	OP	OP	OP
Yellowfin Sole	1	1	2022	OP	OP	OP	OP
Greenland Turbot	3	2	2022	HP	OP	HP	OP
Arrowtooth Flounder	3	4	2022	HP	HP	HP	OP
Kamchatka Flounder	3	2	2022	HP	OP	HP	OP
Northern Rock Sole	1	2	2022	HP	OP	HP	OP
Flathead Sole	3	4	2020	HP	OP	HP	HP
Alaska Plaice	3	4	2021	HP	OP	HP	HP
Other Flatfish	5	4	2020	CR	OP	CR	CR
Pacific Ocean Perch	3	2	2022	HP	OP	HP	OP
Northern Rockfish	3	2	2021	OP	HP	OP	HP
Blackspotted & Rougheye Rockfish	3	2	2022	HP	OP	HP	OP
Shortraker Rockfish	5	2	2022	CR	OP	CR	OP
Other Rockfish	5	2	2022	CR	OP	CR	OP
Atka Mackerel	3	2	2022	HP	OP	HP	OP
Skates	3, 5	2	2020	OP	HP	OP	HP
Sharks	6	4	2022	CR	CR	CR	OP
Octopus	6	4	2020	OP	CR	CR	CR
Grenadiers	ESR Report	4	2020	NA	OP	NA	NA
Sculpins	ESR Report	4	2020	OP	NA	NA	NA
Forage Fish	ESR Report	2	2021	OP	NA	OP	NA

B. 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.

C. Dogfish and other sharks

1. Research

Ageing of Pacific Sleeper Sharks – ABL

The NPRB has funded a study to investigate ageing methods for Pacific sleeper shark. This project is a collaboration between staff at ABL, REFM, the Lawrence Livermore National Laboratory and the American River. 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. Eyes from six Pacific sleeper shark were used for a pilot study. Pilot study results demonstrate that ^{14}C is measurable in the eye lens cores and outer layers, and two of the PSS had values that could be correlated with the ^{14}C rise period (late 1950s to mid-1960s; Figure). Specifically, results from the largest shark sampled (310 cm TL) indicate the age was not older than 50 years. This observation is in contrast to the Nielsen et al. (2016) study, which estimated an age of 105 years for a Greenland shark of the same length.

Further, our results suggest that the growth rate of PSS could be twice as high as that of the Greenland shark (Figure, inset). The current study will expand on the work of the pilot study to refine the reference curve and establish plausible age ranges for samples. Sample processing will begin in 2024.

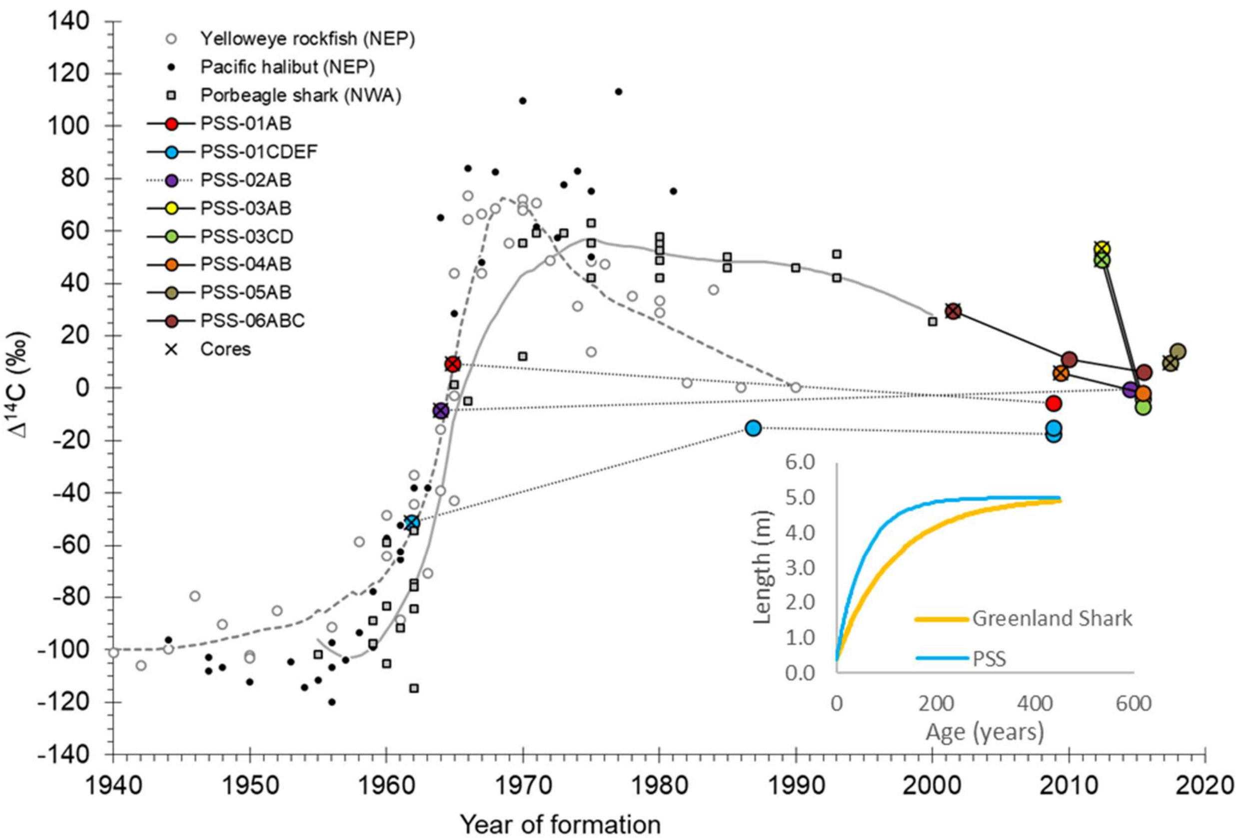


Figure. Pacific sleeper shark (PSS) eye lens 14C values from the pilot study plotted as estimated year of formation relative to regional 14C references. Data from six sharks are shown as a series of samples from the core to the outer eye lens. Both eye lenses were sampled in two sharks (PSS-01 and PSS-03). 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, collaborating with UAF, the Alaska Sea Life Center, Kingfisher Marine Research and Wildlife Technology Frontiers on a collaborative tagging project on Pacific sleeper shark. This

NPRB funded project will apply modern modelling techniques to historical PSAT data, as well as deploy and analyze data from recent and future tags.

Staff at ABL are collaborating with ADF&G, UAF and Kingfisher Marine Research to deploy tags on salmon shark in the GOA and Bering Sea. To date, five male and one female salmon shark have been tagged in the Northern Bering Sea, Of these six sharks, one was tagged with a PSAT, three were double-tagged with both a SPOT (i.e., GPS) and PSAT tag, and two were tagged with a SPOT tag (Figure). One male and one female salmon shark were tagged in the North Pacific Ocean/Gulf of Alaska (Figure), and both of these sharks were double-tagged with a SPOT 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). Regular updates are posted to the ADF&G – The Undersea World of Salmon and Sharks Facebook page. Further tags are planned for 2023 and onwards as tags and opportunities are available.

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

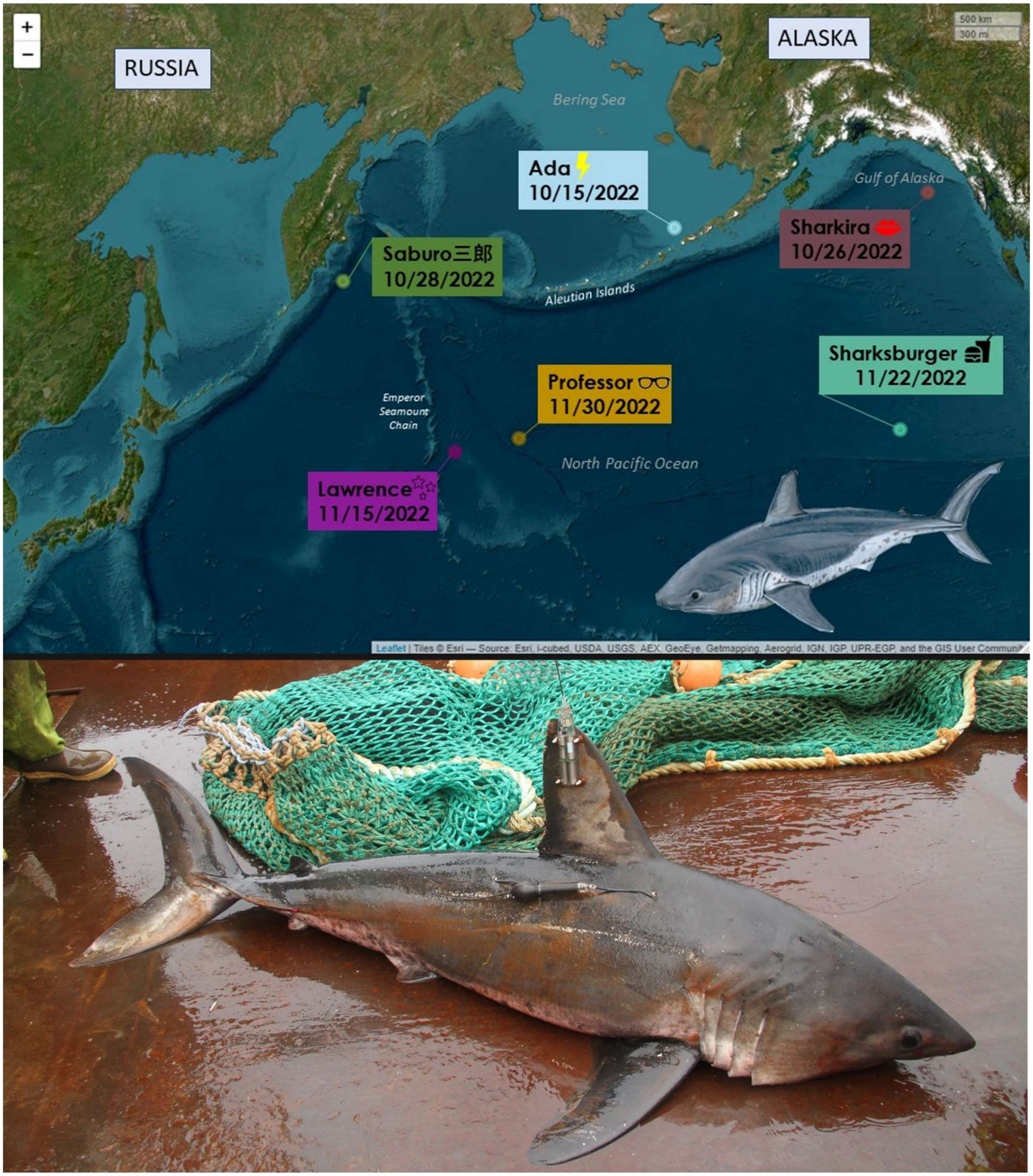


Figure. (top) Recent locations from SPOT tags of the six salmon shark currently transmitting; (bottom) double tagged salmon shark prior to release, the SPOT tag is attached to the dorsal fin and the PSAT is attached to the dorsal musculature (S. Garcia, ADFG&G).

Electronic Monitoring: large shark size estimation– ABL

Staff at ABL are collaborating with AFSC FMA division, AKRO, PSMFC, Alaska Pacific University, and the University of Washington to develop artificial intelligence tools for expanding data collections from vessels using electronic monitoring (EM) equipment in lieu of at-sea observers. This specific project is funded through the NOAA Catch Shares program, but is also in parallel with the Electronic Monitoring Initiative project underway with FMA and PSMFC. This project aims to develop tools which will automate the review of EM videos from longline vessels by detecting and speciating catch. Large sharks are a special case, they are generally not brought onboard, and therefore not available to observers to collect any size information. Thus, a global average weight is applied to all large shark catches from longline vessels, which has been shown to underestimate the size of the animals caught, and thus underestimating total catch estimates. The second AI tool from this project will size grade large sharks caught by vessels using EM, and analysts will be able to provide an informed range of sizes to adjust total catch estimates to be more reflective of true catch. These tools are being designed to be portable and applicable beyond Alaska fisheries. The shark detection and classification algorithm was completed in 2023 and is being integrated into AKFIN for end user applications.

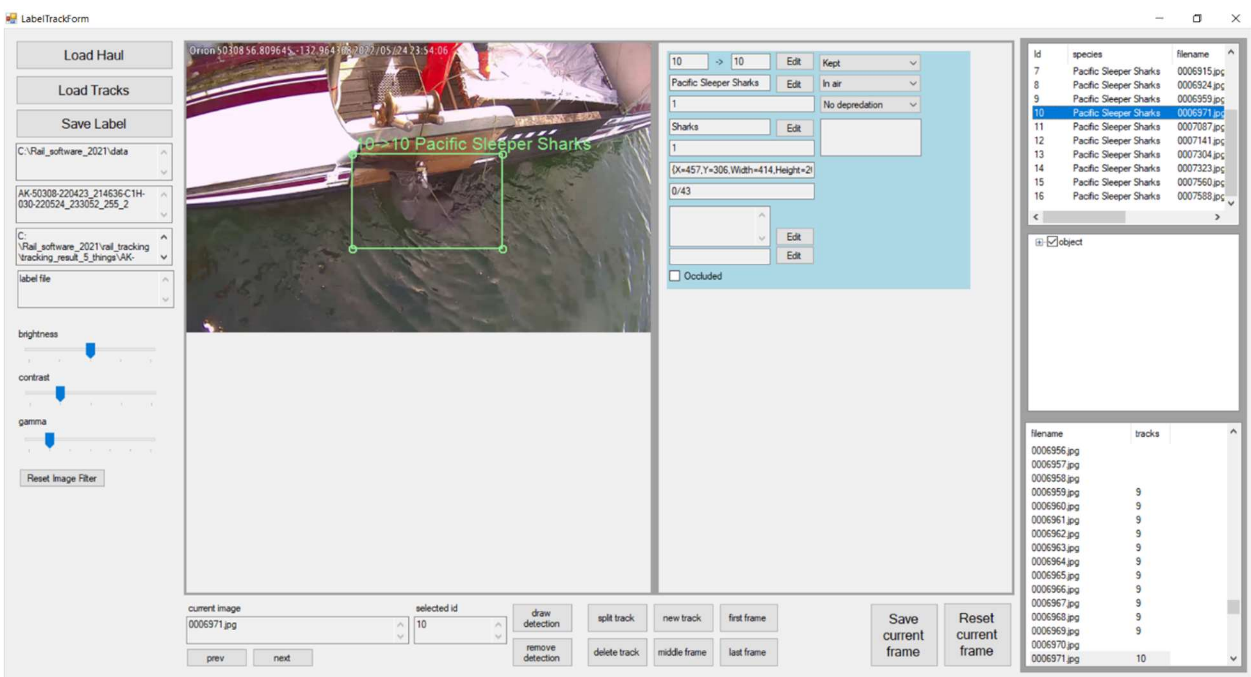


Figure. Screenshot of species classifier successfully identifying a Pacific sleeper shark.

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

2. Stock Assessment

https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments

D. Skates

1. Research

2. Assessment

Bering Sea and Aleutian Islands (REFM)
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIskate.pdf
For more information, contact Cindy Tribuzio (cindy.tribuzio@noaa.gov).

Gulf of Alaska (REFM)

https://www.npfmc.org/wp-content/PDFdocuments/SAFE/2023/GOAskate.pdf
For more information, contact Lee Cronin-Fine (lee.cronin-fine@noaa.gov)

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

Satellite and conventional tagging of Pacific cod in the Bering sea and the Gulf of Alaska RACE

Tagging work conducted in 2021-2023 has shown that a large proportion of cod tagged in the western Gulf of Alaska moved as far north as the northern Bering Sea. Fish distributed in the Northern Bering sea during the summer have shown to move into the Southeastern Bering sea, Russian water, and the Gulf of Alaska in the winter. This work will continue into 2024, where a large tag release effort in the Western and Central Gulf of Alaska will be conducted. This continuing work will give insights into the spawning and migration patterns of Pacific cod under different climate scenarios. The results from this work can be integrated into model projections.

For more information contact Susanne McDermott, susanne.mcdermott@noaa.gov

Ocean warming and acidification effects on Gadid early life stages (RACE-FBEP):

Laboratory experiments were conducted to assess how combined ocean warming and ocean acidification may impact the early life stages of Arctic cod as previous studies demonstrated sensitivity to both temperature and CO_2 level. Arctic cod larvae were reared across three temperatures (2, 5, 7°C) and two CO_2 levels (ambient: ~360µtm; high: ~1500µatm) to 5-weeks post-hatch. Survival, size, growth, and condition were examined. Temperature had a pervasive influence on all measured traits. The optimal temperature for Arctic cod development was 5°C, which led to high condition, low mortality, and rapid growth. At 7°C, Arctic cod mortality was highest, suggesting this temperature was at the edge of their thermal tolerance. Compared to temperature, the effect of elevated CO_2 was not consistent across measured traits. Responses to elevated CO_2 were temperature dependent and included a potential for lipid dysregulation and enhanced immune function. Similar to previous findings for Pacific cod, these findings suggest ocean warming will likely be more detrimental to Arctic cod than ongoing ocean acidification and provide additional insight into changing habitat suitability in the Bering Sea. Samples from these experiments are being analyzed for metabolic enzyme activities and gene expression to examine the physiological processes responsible for observed patterns of vulnerability and resilience to climate conditions identified in this study.

For further information contact Tom Hurst thomas.hurst@noaa.gov or Emily Slesinger emily.slesinger@noaa.gov

2. Stock Assessment

Eastern Bering Sea, Aleutian Islands, Gulf of Alaska (REFM, ABL)

https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments

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 (Spies, 2012). 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 (Spies et al., 2020). 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. The model uses the Stock Synthesis 3 framework. A major issue in recent years has been an apparent shift in the distribution of EBS Pacific cod into the northern Bering Sea (NBS), an area which historically has not been surveyed. Surveys in the NBS were conducted in 2010, 2017-2019, and 2021. 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.

Authorship of EBS Pacific cod transitioned from Dr. Grant Thompson, who led the assessment from 1988-2021, to Dr. Steve Barbeaux. The ensemble of models presented and accepted for use in 2021 were rerun with new data as parameterized in last year's assessment.

Recruitment is estimated to have been below average for the 2014-2017- and 2019-year classes, above average for 2018, and near average for 2020. Estimated spawning biomass from the ensemble increased from 2010 through 2019 to 332,967 t and has been on a downward trajectory since that time. Spawning biomass is projected to be 245,594 in 2023.

The 2023 maxABC in this tier as calculated using the weighted average of the models in the ensemble is 144,834 t and the projected 2024 maxABC is 140,159 t. The 2023 OFL from the weighted ensemble is 172,495 t. The 2024 projected OFL is 166,814 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 since it was first assessed separately. The authors presented two alternative age-structured models this year. However, these models were not accepted for management by the BSAI Groundfish Plan Team. Therefore, no changes were made to the methodology used for recommending harvest specifications. Catch data from 1991-2021 were updated and preliminary catch data for 2022 were included in the assessment, but these have no impact on recommended harvest specifications under Tier 5. The 2022 Aleutian Islands bottom trawl survey biomass index was added to the Tier 5 random effects model.

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 approximately 4% from the 2016 estimate (84,409 t). There was no Aleutian Island survey in 2020 and the most recent Aleutian Island survey for Pacific cod conducted in 2022 was 51,539 t, 37% below the 2018 estimate.

The Plan Team's recommended ABC is 13,812 t, and OFL is 18,416 t. The estimate of the natural mortality rate is 0.34, which is unchanged from the previous assessment.

F. <u>Walleye Pollock</u>

1. Research

<u>Summer acoustic vessel of opportunity (AVO) index for midwater Bering Sea walleye pollock MACE</u>

Acoustic backscatter data (Simrad ES60, 38 kHz) were collected aboard two fishing vessels chartered for the AFSC summer 2023 EBS bottom trawl surveys (F/V *Alaska Knight,* F/V *NW Explorer*). Traditional methods to estimate the AVO index were based on backscatter from a representative portion of the acoustic-trawl (AT) survey footprint (55%) and used a combination of manual and automatic backscatter classification methods to separate pollock from non-pollock

(Honkalehto et al., 2011). A new suite of methods has been implemented to increase the spatial coverage of the AVO index area (100% of the AT survey footprint). This new methodology uses systematic subsampling (Levine and De Robertis, 2019) and only manual classification of the backscatter, which omits assumptions inherent in the automatic classification. AVO data have been re-processed back to 2009 (2009-2010, 2012, 2014-2019, 2021-2022) with these new methods to create new AVO index estimates.

Based on the new AVO time series, the 2023 index decreased 14.5% from 2022 and was slightly higher than 2021 by 2.9%. The 2023 AVO index estimate was similar to the overall mean (4.0% higher). The percentage of pollock backscatter east of the Pribilof Islands was 25%, which was close to the time series average of 26%. The correlation between the AVO index and the AT survey biomass is very strong (new AVO index, $r^2 = 0.9$, n = 7 surveys; old AVO index, $r^2 = 0.6$, n=7 surveys for the same years).

Literature Cited:

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

Levine, M. and A. De Robertis. 2019. Don't work too hard: Subsampling leads to efficient analysis of large acoustic datasets. 10.1016/j.fishres.2019.105323.

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)

2. Stock Assessment

Eastern Bering Sea (REFM)

The assessment can be found here: https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/EBSPollock.pdf

For more information contact Jim Ianelli (jim.ianelli@noaa.gov)

Aleutian Islands (REFM)

The assessment can be found here: https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/AIpollock.pdf

For more information contact Jim Ianelli (jim.ianelli@noaa.gov)

Bogoslof Pollock (REFM)

The assessment can be found here: https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BOGpollock.pdf

For more information contact Steve Barbeaux (steve.barbeaux@noaa.gov)

Gulf of Alaska (REFM)

The assessment can be found here: https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOApollock.pdf

For more information contact Cole Monnahan (cole.monnahan@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.

Sampling in 2022 was focused 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. During the 2022 Aleutian Islands Bottom Trawl Survey, 163 northern rockfish and 390 Pacific ocean perch were sampled. As part of this sampling fish length, weight, liver weight were measured and indirect fish condition measurements were taken using a Yamato Fish Analyzer and a Distell Fish Fat Meter. In addition, ovarian condition was noted and the ovary was preserved for later analyses. Data analyses for this project will be initiated in 2024 after the completion of bioenergetic analyses of the 2021 samples are completed. For further information, please contact Christina Conrath (907) 481-1732

Whole genome resequencing of rockfish - ABL

The genetics group at AFSC is using whole genome resequencing to understand population structure in a number of groundfish and crab species including various 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. Analysis of red king crab showed similar structure as previous microsatellite studies. Analysis of Pacific Ocean perch revealed potential cryptic species which is being further investigated. A new high throughput GTseq panel has been developed for Pacific cod and has been used to understand stock-specific distributions.

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

2. Assessment

Pacific Ocean Perch (POP) – Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIpop.pdf.
For more information contact Paul Spencer (paul.spencer@noaa.gov)

Northern Rockfish – Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAInork.pdf.
For further information, contact Paul Spencer (paul.spencer@noaa.gov)

Other Rockfish – Gulf of Alaska – ABL

A full stock assessment was conducted in 2023 for Gulf of Alaska (GOA) Other Rockfish stock complex, which included 27 *Sebastes* species managed under 3 data-levels (i.e., tiers). Each tier is assessed separately and summed to obtain a total stock complex level harvest specifications. The input data were updated to include the most recent fisheries catch data and the 2023 NMFS bottom trawl survey. A number of changes were made to the assessment methodology and species assignments to the tier levels. More specifically, the REMA model using the *rema* R package, which is a successor of the previously used random effects (RE) model, was applied to estimate the biomass for Tier 4 and Tier 5 species. See the 2023 TSC report for REMA details. Additionally, an alternative average weighted natural mortality (weighted *M*) was implemented, which used the average weighted *M* from the past 6 years, as a proxy for F_{OFL} for Tier 5 rockfish species in the Other Rockfish complex. The previous weighted *M* method was based on the survey biomass estimates from a single year, which was susceptive to high variability and uncertainty; thus, an average weighted M across a 6-year time frame (i.e., covering 3 surveys) was proposed and accepted to mitigate the yearly variability that caused sudden changes in biomass estimates for the Tier 5 species. Under the North Pacific Fisheries Management Council regulations, Tier 6 species are managed based on the maximum catch from a stable, reliable catch history in the fishery. In 2023, the maximum catch time series was expanded from 2013-2016 (4-year time series) to 2013-2022 (10-year time series). Lastly, twelve Other Rockfish species moved from Tier 5 to Tier 6, such that a total of 4 species are assigned to Tier 5 and 21 species in Tier 6. Previous research demonstrated that the twelve rockfish species had unreliable survey biomass based on several metrics (i.e., the trawl survey was unable to effectively sample their population), thus should not be managed under Tier 5, which utilizes the trawl survey to estimate their biomass. As a result, the new Tier 6 species are managed under the same regulations as the other assigned Tier 6 species using maximum catch in a reliable time series.

The recommended ABC for the 2024 fishery is 3,773 t and the OFL is 4,977 t, which is a 7% decrease from 2023. However, there is no evidence to suggest overfishing is occurring for the Other Rockfish complex in the GOA because the OFL has not been exceeded. The total fisheries catch constitutes about 25% of the OFL. However, the catch has surpassed the area apportionment (often referred to as subarea ABCs) in the combined Western and Central GOA subarea for the past several years. Based on the limited biological data on Other Rockfish species, the stock appears not to be overfished (catches are relatively unchanged) and species belonging to the complex are not targeted by the fisheries. Additionally, many of the Other Rockfish species inhabit both trawlable (i.e., survey and fishery assessible) and untrawlable (fishery assessible) habitat, leading to underestimated and biased trawl survey results. As a response to the area apportionment overages in the Western/ Central GOA, the assessment authors brought forward a discussion on balancing the minimal biological concerns of the stock complex with fishery considerations. As a result, the Plan Team proposed combining West Yakutat apportioned subarea ABC in the Eastern GOA with the currently combined Western/ Central GOA apportioned subarea ABC, while continuing to monitor the fisheries catches in each area for the 2025 fisheries. The SSC and Council both supported the subarea combination of West Yakutat with the Western/ Central GOA and decided to implement the new area apportionment for the 2024 fisheries. Further discussion on area-specific apportionment can be found in the recent 2023 Other Rockfish stock assessment.

For more information contact Kristen Omori (ABL, kristen.omori@noaa.gov).

Blackspotted/rougheye Rockfish Complex – Bering Sea and Aleutian Islands - REFM
The assessment can be found here: https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIrougheye.pdf.

For further information, contact Paul Spencer (paul.spencer@noaa.gov)

I. Thornyheads

1. Research

2. Stock Assessment
https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments
For more information, 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 2023. While sablefish is the primary species tagged, tags from shortspine thornyheads (SST), 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 ~425 sablefish and 6 SST. Of these recovered tags, approximately 14 percent were recovered by trawl gear, 51% by pot gear, 25% by hook and line, and 10% on the AFSC longline survey. Sixteen percent of the recovered sablefish tags in 2023 were at liberty for over 10 years. About 42% of the total 2023 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 31% within 100 – 500 nm, 15% within 500 – 1,000 nm, and 12% over 1,000 nm from their release location. The tag at liberty the longest was for approximately 48 years, and the greatest distance traveled of a 2023 recovered sablefish tag was 1,730 nautical miles from a fish tagged in the Aleutian Islands and recovered off of Vancouver Island approximately 4 years later. Two adult sablefish and one SST tagged with archival tags were recovered in 2023. Releases in 2023 on the AFSC groundfish longline survey totaled 5,987 adult sablefish, 188 shortspine thornyhead, and 4 Greenland turbot. An additional 214 juvenile (age-1) sablefish were tagged during one juvenile sablefish tagging cruise near Sitka, AK in 2023.

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

Juvenile Sablefish Studies – ABL

Juvenile (age-1) sablefish tagging studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2023. Two hundred and fourteen juvenile sablefish were tagged in St. John Baptist Bay near Sitka, AK during three days (August 25, 26, and 27) of sampling. The average length of fish was 360 mm.

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

Young of the Year Sablefish Feeding Ecology and Growth - ABL

Juvenile growth may be a strong indicator of sablefish recruitment potential. Previous projects have reconstructed juvenile sablefish life history using otoliths; therefore, otolith analyses may be useful in predicting recruitment success. To evaluate this utility, comparisons of otolith and otolith increment measurements across structures and with fish size and growth were made. Specifically, daily age estimates from paired lapillar and sagittal otolith samples were compared to determine agreement between structures, otolith dimensions were compared to body length to support the correlation between daily increment width and somatic growth, and paired otolith samples recovered from a previous temperature and feeding ration study were used to investigate otolith increment width with known growth rates. The evidence reported herein suggests both lapillar and sagittal otoliths produce reliable age estimates, and growth planes between structures are highly correlated with somatic growth. Daily otolith increment width mirrored the results of the somatic growth study in both structures. Generally, the lapillus had fewer complications resulting in a better fit to growth and treatment data, primarily due to the lack of accessory growth centers.

Contact wes.strasburger@noaa.gov with questions.

Transboundary Management Strategy Evaluation

A management strategy evaluation was developed with stakeholders and scientists from three regions to investigate whether spatially-structured management paradigms might result in better conservation and economic outcomes. The publication can be found here: https://cdnsciencepub.com/doi/10.1139/cjfas-2024-0008

Contact Maia Kapur (maia.kapur@noaa.gov) with questions.

2. Stock Assessment
https://www.fisheries.noaa.gov/alaska/population-assessments/2023-north-pacific-groundfish-stock-assessments

For further 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

https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIatka.pdf
For further information, contact Jane Sullivan (Jane.sullivan@noaa.gov)

M. Flatfish

1. Research

2. Assessment

Yellowfin sole - Bering Sea and Aleutian Islands -REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIyfin.pdf.
For more information, contact Ingrid Spies (ingrid.spies@noaa.gov)

Greenland turbot - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIturbot.pdf.
For further information, contact Meaghan Bryan (meaghan.bryan@noaa.gov)

Arrowtooth flounder - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIatf.pdf.
For more information, contact Kalei Shotwell (kalei.shotwell@noaa.gov).

Arrowtooth flounder - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOAatf.pdf.
For more information, contact Kalei Shotwell (kalei.shotwell@noaa.gov).

Kamchatka flounder - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIkamchatka.pdf
For more information contact Meaghan Bryan (meaghan.bryan@noaa.gov)

Northern rock sole - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIrocksole.pdf.
For more information, contact Cary McGilliard (carey.mcgilliard@noaa.gov).

Northern and southern rock sole - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOAnsrocksole.pdf
For more information contact Meaghan Bryan (meaghan.bryan@noaa.gov)

Flathead sole - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIflathead.pdf.
For more information, contact Maia S. Kapur (maia.kapur@noaa.gov)

Flathead sole - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOAflathead.pdf
For more information, contact Maia S. Kapur (maia.kapur@noaa.gov)

Alaska plaice - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIplaice.pdf.
For more information, contact Lee Cronin-Fine (lee.cronin-fine@noaa.gov)

Rex sole - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOArex.pdf
For more information, contact Cary McGilliard (carey.mcgilliard@noaa.gov).

"Other flatfish" complex - Bering Sea and Aleutian Islands - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/BSAIoflat.pdf.
For more information, contact Cole Monnahan (cole.monnahan@noaa.gov)

Shallow-water flatfish complex - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOAshallowflat.pdf
For more information, contact Meaghan Bryan (meaghan.bryan@noaa.gov)

Deep-water flatfish complex - Gulf of Alaska - REFM
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2023/GOAdeepflat.pdf
For more information, contact Carey McGilliard (carey.mcgilliard@noaa.gov)

N. Pacific halibut

1. Research

O. Other Research

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.

Gulf of Alaska

Establishing groundfish density 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 collected data from untrawlable (UT) habitats using a lowered stereo-camera system (LSC). We successfully carried out a beta-test of integrating this drop camera protocol into the FY24 RACE Groundfish Assessment Program (GAP) GOA Bottom Trawl Survey and completed 38 camera tows. We are now analyzing imagery and will 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 RACE 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

Commercial fishing vessels engaged in directed hook-and-line fishing for halibut *(Hippoglossus stenolepis*), sablefish (*Anoplopoma fimbria*), and Greenland turbot (*Reinhardtius hippoglossoide*s) in the Gulf of Alaska, Bering Sea, and Aleutian Islands face increasing depredation of their catch by orcas (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*). Several presentations and conversations during a 2022 International Pacific Halibut Commission (IHPC) International Workshop on Protecting Fishery Catches from Whale Depredation (https://iphc.int/uploads/pdf/ws/ws001/iphc-2022-ws001-r.pdf) led IPHC scientists to focus on two possible techniques to protect longline catch from whales: (1) an underwater shuttle that removes catch near the ocean floor and securely transports the catch to the surface, and (2) an underwater shroud that slides over a cluster of captured fish to cover them as they are brought to the surface.

In May of 2023, AFSC scientists participated in a five-day IHPC-led pilot study (described in more detail elsewhere in the 2024 TSC report) aboard a 56' longline vessel based out of Newport, Oregon to test these techniques. AFSC MACE program scientists provided custom-built underwater camera systems to monitor the performance of gear and behavior of fish during the study. Ten sets of each gear configuration were made. Video collected during these sets helped researchers understand gear performance, allowed modifications to be made in real time, and will support future designs.

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

Essential Fish Habitat

Alaska comprises 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.

The major research needs for habitat research 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.

In 2023, the final technical memorandum for the 2023 EFH Five-Year Review was published, which contains EFH descriptions for the Gulf of Alaska:

Pirtle, J.L., Laman, E.A., Harris, J., Siple, M.C., Rooper, C.N., Hurst, T. P., Conrath, C.L., Gibson, G. A., 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska (No. 468), NOAA technical memorandum NMFS-AFSC. [object Object], Seattle, WA.

Reproducible code for fitting the species distribution models used in the 2023 EFH Five-Year Review is stored publicly at https://github.com/alaska-groundfish-efh/EFHSDM.

The most recently published Essential Fish Habitat Research Plan in Alaska is Sigler et al. (2017). A draft of the updated Research Plan is available for comment. Contact Dr. Jodi Pirtle (jodi.pirtle@noaa.gov) for more information.

Sigler, M. F., M. P. Eagleton, T. E. Helser, J. V. Olson, J. L. Pirtle, C. N. Rooper, S. C. Simpson, and R. P. Stone. 2017. Alaska Essential Fish Habitat Research Plan: A Research Plan for the National Marine Fisheries Service's Alaska Fisheries Science Center and Alaska Regional Office. AFSC Processed Rep. 2015-05, 22 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Pathways to the modern fisheries-independent surveys of the future - RACE-GAP

Fisheries-independent surveys (hereafter surveys) are foundational to modern fisheries management, and fisheries and ecosystem research. They are conducted worldwide to study the status of marine populations and ecosystems. The primary role of surveys is to provide consistent time series data for use in stock and ecosystem assessments. To assure this consistency surveys often concentrate on enhancing standardization. However, standardization is becoming more difficult because of the changes undergoing in survey technologies; regulations, and in the environment. For example: new sampling tools are becoming available (e.g. cameras, acoustics, and eDNA); some areas become closed to surveys (e.g. MPAs, trawl exclusion zones, wind farms); fish stocks change their distribution. These developments underscore the need for developing pathways to modernize and adapt surveys to the new circumstances while assuring consistency of survey data products. This is a considerable challenge that can only be addressed with a broad range of actions. These actions should include: 1. education of future survey practitioners, stakeholders and public; 2. developing new survey designs that are flexible and less sensitive to changing circumstances; 3. developing methods for incorporation of new technologies to surveys. 4. evaluating new designs and new survey methods; 5. combining multiple surveys, platforms, or technologies; 6. establishing standards for propagation of uncertainty for survey data products; 7. prioritization of objectives in multi-objective surveys; 8. improvement of survey-data products using models, covariates, and other auxiliary information. 9. transitions from destructive or lethal survey methods.

Vision of the future survey should be free of exaggerations and consider both new and traditional survey methods and practices. We envision that future surveys will incorporate multiple platforms and methods, such as: advanced sampling technologies, use of the models is survey design, effort allocation, and data products derivation, and use of artificial intelligence. Surveys will collect more data types and a larger volume of data. Surveys will be more responsive to the stakeholders and assessment needs However, traditional survey methods (trawling, dredging, pots, etc), although reduced, will continue to be essential for collecting samples for different purposes. Sampling designs and subsampling will still require understanding of state of the art statistical methods. Surveys will continue to cope with difficulties associated with working out at sea, bad weather, equipment breakdowns, etc. and scientists and sailors will continue going out to sea and coming back home.

For further information, contact Stan Kotwicki (stan.kotwicki@noaa.gov)

Modernizing fisheries-independent groundfish surveys in Alaska

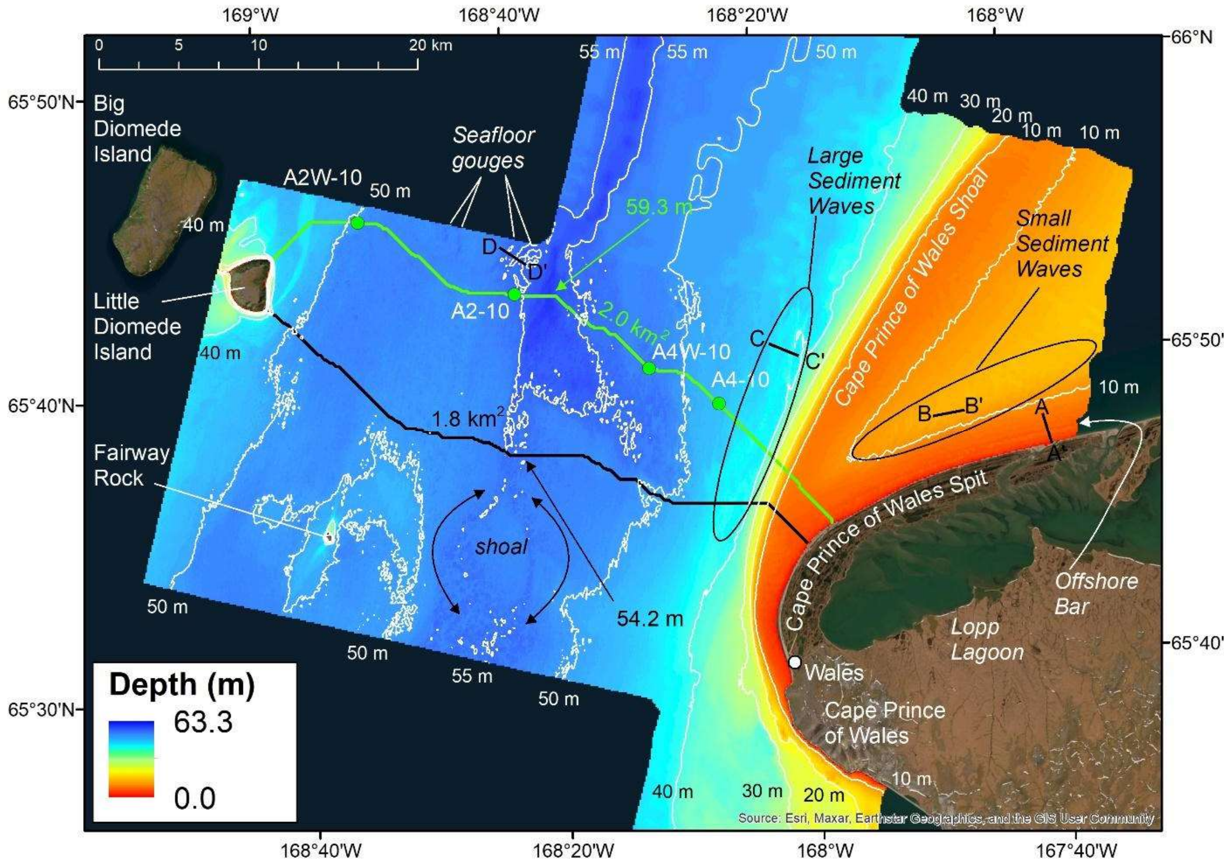
(Stan Kotwicki, Lyle Britt, Mike Litzow, Duane Stevenson, Lewis Barnett, Zack Oyafuso, Rebecca Haehn, Sean Rohan, Shawn Russell, Nicole Charriere, Paul Spencer, Meaghan Bryan)

Fisheries-independent groundfish surveys (hereafter surveys) support management of more than 50 fish stock in Alaska. The primary role of surveys is to provide consistent time series data for use in stock and ecosystem assessments. To assure this consistency surveys to date concentrated on enhancing standardization of survey methodology. However, standardization is becoming more difficult because of the changes undergoing in fishing and monitoring technologies; regulations, and in environment. For example: old trawls are becoming obsolete, new sampling tools are becoming available (e.g. new fishing gear, cameras, acoustics, and eDNA), and fish stocks change their distribution. This creates a need to modernize and adapt surveys to the new circumstances while assuring consistency of survey data products. This is a considerable challenge that can only be addressed with broad range of actions. The planned actions for Alaska surveys include: revising sampling designs, designing and testing new survey trawls, modernizing survey protocols, survey calibrations, and planning for transition from old to new survey methods. To date, we've redesigned the Gulf of Alaska survey to make it more efficient and more flexible to shifting survey effort while maintaining continuity in survey time-series. In the Bering Sea we are currently working on new sampling design that would increase sampling efficiency and merge 3 historically conducted surveys into one. We are also working with stakeholders to modernize survey trawls and fishing methods and are preparing for future survey calibrations. The end goal of these efforts is to create more efficient and flexible that can adapt to changing environment, technology, and data needs.

For further information, contact Stan Kotwicki (stan.kotwicki@noaa.gov)

Gateway to the arctic: Defining the eastern channel of the Bering Strait - RACE GAP

The Bering Strait is the sole gateway and an oceanographic bottleneck for the seasonally warm and comparatively fresh and nutrient-rich Pacific waters to flow into the Arctic, melting ice, lowering salinity, and feeding bird, mammal, and fish populations. The Diomede Islands split this small strait into two main channels, both with northward flow (in the annual mean). The eastern channel, in U.S. waters, also seasonally carries the warmer, fresher Alaskan Coastal Current. Year-round in situ mooring observations (in place since 1990 with annual servicing) show a significant flow increase in the (northward) throughflow, along with seasonal and annual fluctuations. To help with measuring and modeling water flow estimates, we created the first detailed shore-to-shore bathymetric surface of the Bering Strait's eastern channel, located its narrowest cross-section (1.8 km2) as occurring 5–10 km south of the moorings, and quantified the cross-section across the moorings (2.0 km2), both slightly larger than previously estimated (1.6 km2). Overlaps between older (~1950) and newer (~2010) bathymetry data sets identified clear areas of erosion and deposition, with much of the eastern channel having eroded by > 1 m. Since the depth is uniformly ~ 50 m across much of the eastern channel, the 1 m of erosion that we quantified would only slightly (2 %) increase the sizes of the cross-sections. Much of the seafloor is hard substrate and probably composed of cobbles, but we hypothesize that friction from strong (~1 + knot) seafloor currents is the most likely explanation for the erosion that we observed. In softer and siltier areas, the bathymetry showed additional evidence of potential current impacts in the form of small seafloor waves (~0.5 to ~ 1.0 m tall) and a shore-parallel bar offshore of Cape Prince of Wales Spit. There are large (~2 m tall) seafloor waves seaward of Cape Prince of Wales Shoal. A previously undescribed (~1 to 2 km wide, ~4 m deep) seafloor channel of unknown origin occurred along a linear north/south axis for the full 75 km extent of the bathymetric surface. The southern end of this seafloor channel was near the end of three larger seafloor channels extending westerly out of nearby Norton Sound, suggesting a common origin. These Norton Sound channels may be paleodrainages, as their eastern ends point toward Seward Peninsula inlets with large drainages where paleoglaciers were reported to have existed, but the morphology of these channels is also consistent with tidal channels.



Example figure:

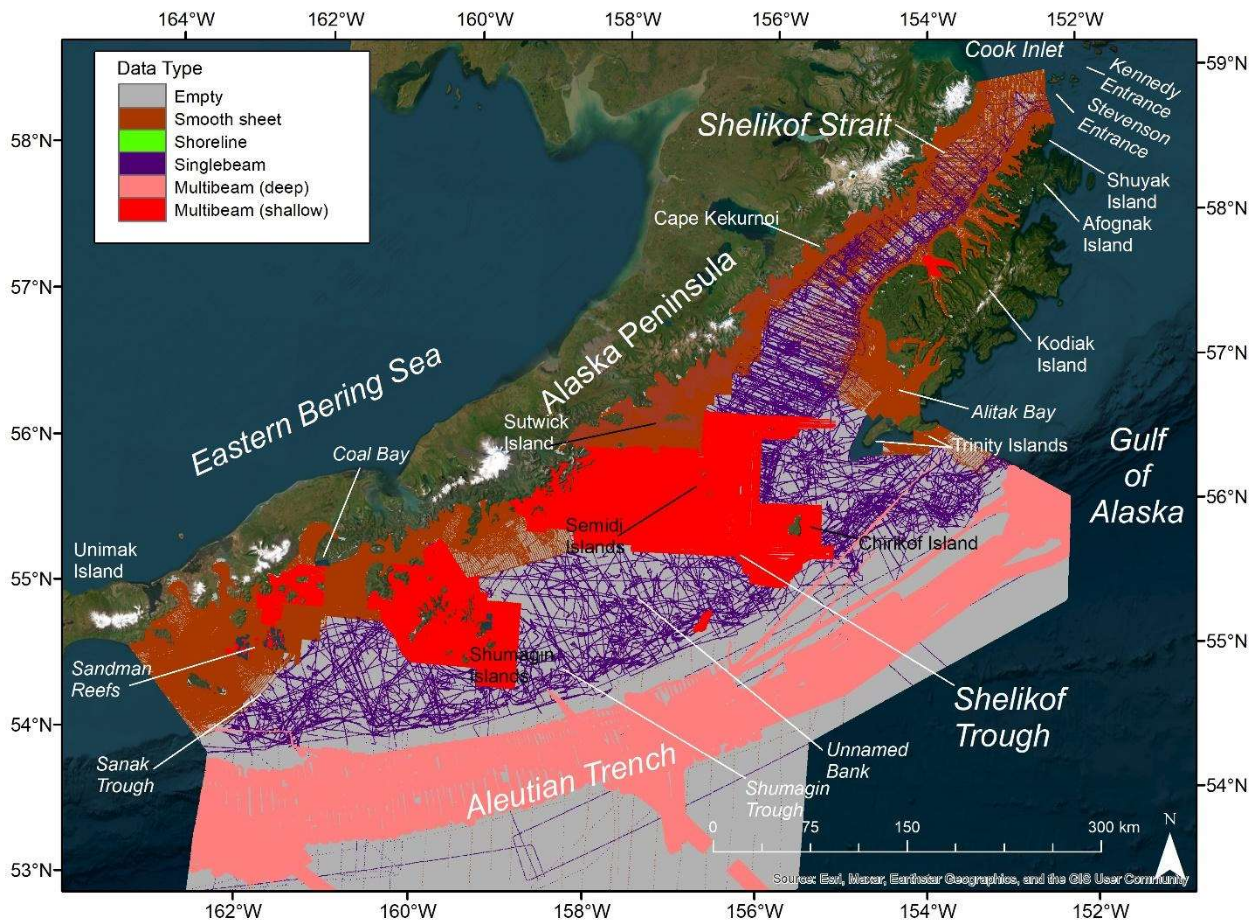
Fig. 3. Shore-to-shore bathymetry raster across the eastern channel of Bering Strait created from a combination of original (~1950) and recent (~2010) hydrographic surveys. The four UW APL historical mooring locations (A2W-10, A2-10, A4W-10, A4-10) are shown as solid green points bounded by black outlines and labeled with names. The minimal cross-sectional opening across the eastern channel (1.8 km2, deepest point = 54.2 m) is indicated with a continuous black line, and the minimal opening across the moorings (2.0 km2, deepest point = 59.3 m) is indicated with a continuous green line. Cross-sectional profiles, two km in length, were drawn across some small but noteworthy seafloor features (see Fig. 6). An offshore bar (cross-sectional profile A to A') occurs along the NW coast of Prince Cape of Wales Spit. Small sediment waves (B to B'), crests perpendicular to the shore occur seaward of the 10 m depth contour near Cape Prince of Wales Spit, and larger sediment waves (C to C'), crests parallel to a north-south axis, occur seaward of Cape Prince of Wales Shoal and the 40 m depth contour. Two pairs of parallel seafloor gouges occur north of mooring A2-10 and profile D to D' was drawn across the eastern pair.

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

Zimmermann, M., Woodgate, R.A. and Prescott, M.M., 2023. Gateway to the arctic: Defining the eastern channel of the Bering Strait. Progress in Oceanography, 215, p.103052. https://doi.org/10.1016/j.pocean.2023.103052

Towards mapping the gaps in Alaska - RACE GAP

In 2018, the General Bathymetric Chart of the Oceans (GEBCO) announced the Nippon Foundation-GEBCO Seabed 2030 Project to improve further the GEBCO map of the world's oceans. The United States (U.S.) has responded with different initiatives to complete a map of its Exclusive Economic Zone (EEZ). With Alaska accounting for the greatest fraction of the U.S. EEZ, here we provide an analysis showing which portions of the National Oceanic and Atmospheric Administration's, National Marine Fisheries Service, Alaska Fisheries Science Center (AFSC) bathymetry maps are supported by actual observations. Data support of raster cells ranged from 2.4 % to 43.4 % within six previously published AFSC bathymetry compilations, with high variability by depth and supporting hydrographic data type. This will guide new Alaska mapping efforts towards the gaps and away from remapping areas, increasing progress in fulfilling the goals of Seabed 2030 Project.



Example figure:

Fig. 6 The Type Identifier Grid (TID) for the 100 m Eastern Bering Sea Slope (EBSS) bathymetry compilation.

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

Zimmermann, M., Prescott, M.M. 2023. Towards mapping the gaps in Alaska. The International Hydrographic Review 29(2):28-45. DOI: 10.58440/ihr-29-2-a22 , https://ihr.iho.int/wp-content/uploads/2023/11/IHR-29-2-A22.pdf

V. Ecosystem Studies

Ecosystem and Socioeconomic Profiles (ESP) – REFM
Ecosystem-based science is a primary component of effective marine conservation and resource management. Our national standard guidelines require the consideration of ecosystem processes with regard to specifying optimum yield through our stock assessment and fishery evaluation (SAFE) reports. Progress has been made toward implementing ecosystem management with the comprehensive ecosystem and economic status reports; however, the gap remains between conducting ecosystem research and integrating within the fishery management process. Primary obstacles are a lack of a consistent approach to deciding when to incorporate ecosystem and socioeconomic information into stock assessment and fisheries management and how to test the reliability of this information for identifying future change. Over the past several years a new standardized methodology and reporting framework termed the Ecosystem and Socioeconomic Profile (ESP) has been developed to overcome these obstacles (Shotwell et al., 2023). The ESP uses a four-step process that culminates in a focused, succinct, and meaningful communication of potential drivers on a given stock. The resulting ESP product facilitates the integration of ecosystem and socioeconomic factors into fishery management decisions by informing uncertainty with additional context and informing stock assessment model assumptions, choices, and potential covariates. The ESPs serve as a corollary stock-specific process to the large-scale ecosystem or economic status reports, effectively creating a two-pronged system for tracking and communicating ecosystem based fisheries management (EBFM) activities.

The first ESP was produced at the Alaska Fisheries Science Center (AFSC) for the Alaska sablefish stock in 2017 (Hanselman et al., 2017). Following this initial ESP, the North Pacific Fishery Management Council (NPFMC) recommended ESPs be developed for priority stocks in the Alaska groundfish and crab fishery management plans (e.g., Dorn et al., 2019, Palof et al., 2019). To date, seven of the seventeen recommended ESPs have been produced for sablefish, pollock, Pacific cod, blue king crab, red king crab, and snow crab stocks and are updated within the stock assessment schedule. In 2021, the Northeast Fisheries Science Center (NEFSC) began operationalizing ESPs within their research and management track assessments. An ESP for bluefish was completed in 2022 to evaluate term of reference 1 and a similar process has started for black seabass, Atlantic cod, goldline tilefish, and herring. Examples of ESPs and ESP-like reports are also being developed in multiple other science centers and for many different types of stocks (e.g., Ayers et al., 2022). ESPs are an efficient testing ground for developing ecosystem linked stock assessments and improving the uptake of ecosystem and socioeconomic information into the fishery management process. The ESPs also provide a set of reporting tools that can be tailored to a large variety of audiences in order to effectively merge the ecosystem, socioeconomic, and stock assessment disciplines.

ESPs respond to the priorities of the NMFS Next Generation Stock Assessment Improvement Plan (NGSAIP, Lynch et al., 2018), the EBFM Policy and Road Map, and the Climate Science Strategy. The implementation of ESPs requires coordination between a diverse set of programs within any given science center, regional office, university and other agencies to provide expertise and collect data to conduct the ESPs. Multiple workshops have been conducted at different science centers and nationally to begin development of ESPs (AFSC 2019-2021, NEFSC 2021, National 2022-2023). The lessons learned from the AFSC, NEFSC, and National ESP development workshops are currently being used to create a national ESP initiative that will help begin, streamline, and coordinate the ESP process at all six U.S. science centers and communicate the process and progress broadly to the international community. The national ESP initiative will allow for a unified framework to integrate the portfolio of ecosystem and socioeconomic research activities within our stock assessment enterprise and produce an accounting mechanism to show progress toward EBFM. This effort will benefit the science centers that have already operationalized their ESPs by continuing to refine and improve the ESP process and provide a forum to learn from each other as all the centers implement their ESPs. The standardized reporting framework of the ESPs will improve communication of ongoing ecosystem and socioeconomic research and resulting management advice to stock assessment scientists, the regional offices, the fishery management councils, stakeholders, and the public.

Next year we plan to continue the workshops of the national ESP initiative through virtual share out and hybrid co-creating activities that we hope will continue to build the community of ESP practitioners across the U.S. Several technical memorandums of the previous regional workshops and potentially two lessons learned manuscripts are also planned to create a resources library for those who would like to create ESPs in their region both nationally and internationally. There has also been increasing interest in the data management system initiated by the AFSC for creating their ESPs. In response to this, we are hoping to work more with the Alaska Fisheries Information Network (AKFIN) to expand this management system to other regions and support development and coordination of ESP data across the U.S.

For more information, contact Kalei Shotwell (kalei.shotwell@noaa.gov).

Gulf of Alaska Climate Integrated Modeling Project phase 2 - 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 include:

- Process and summarize MOM6 output for hindcast, historical, and future climate scenarios for the GOA for use in ecosystem models. ROMS projections for the several CMIP6 earth system models were developed during the first phase of GOA-CLIM and are available as backup and comparison to MOM6 output.
- Extend and refine coupled climate-biological-socio economic models, including 1) an Atlantis end-to-end ecosystem model, 2) a multispecies size-spectrum model, 3) ECOPATH models for the Western, Central, Northern and Eastern Gulf of Alaska, 4) a CEATTLE multi-species model, 5) climate-enhanced single-species models, 6) a fleet dynamics model embedded in Atlantis, and 7) a computable general equilibrium (CGE) regional economic model.
- Specific improvement to the Atlantis ecosystem model will include:
    - Refine the modeling of commercial fleets and their spatial footprint and utilize the dynamic fishing effort modeling capacity of Atlantis.
    - Include more realistic representation of salmon species in the model.
    - Improve the modeling of state-managed species and fisheries.
    - Expand the model to capture commercial and subsistence fisheries.
- Conduct management strategy evaluations of alternative NPFMC harvest control rules under climate change using an ensemble of ecosystem models to represent multiple biological and economic processes in the GOA. Harvest control rules tested will be consistent with those being evaluated as part of ACLIM phase 2 to provide comparable results to the NPFMC.
- Conduct cross-ecosystem research on the effects of climate change on carrying capacity for the Eastern Bering Sea, GOA, and the California Current system using MOM6 output as the shared oceanographic forcing.
- Refine the modeling of top predators in GOA ecosystem models, with a focus on Atlantis. Evaluate model skill in predicting predator population dynamics under normal and warm environmental conditions, and investigate sensitivity of Atlantis to predator parameters that are influenced by climate change.

Greater detail can be found at: https://www.fisheries.noaa.gov/alaska/ecosystems/gulf-alaska-climate-integrated-modeling-project. For more information please contact Meaghan Bryan (meaghan.bryan@noaa.gov), Carey McGilliard (carey.mcgillard@noaa.gov), and Marysia Szymkowiak (marysia.szymkowiak@noaa.gov).

Resource Ecology and Ecosystem Modeling Program (REFM/REEM)

The REEM Program creates various types of statistical models that incorporate ecosystem information such as predator-prey relationships, food web relationships, diet analysis and socio-economic data that is used to inform fishery management decisions for Alaska groundfish species.

Ecosystem Status Reports 2023: the Status of Alaska's Marine Ecosystems completed and posted online

The status of Alaska's marine ecosystems is presented annually to the North Pacific Fishery Management Council as part of the Groundfish Stock Assessment and Fishery Evaluation (SAFE) report. There are separate reports for each of four ecosystems: the eastern Bering Sea, Aleutian Islands, Gulf of Alaska, and the Arctic. In 2023, new information became available to update the reports for the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska. The goal of these Ecosystem Status Reports (ESRs) 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. In addition to the ESRs, ecosystem information was summarized for outreach publications ('In Briefs') and was used to inform the ecosystem considerations parts of stock-specific risk tables, found in each full stock assessment. The ESRs and In Briefs are now available online at the Ecosystem Considerations website at: https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Groundfish Stomach Sample Collection and Analysis

The Resource Ecology and Ecosystem Modeling (REEM) Program continued regular collection of food habits information on key fish predators in Alaska's marine environment. During 2023, AFSC personnel analyzed the stomach contents of 11 species sampled from the eastern Bering Sea, Gulf of Alaska and Aleutian Islands regions. The contents of 8,925 stomach samples were analyzed in the laboratory in addition to 2,460 stomach samples analyzed at sea during the Gulf of Alaska groundfish survey.

Predator-Prey Interactions and Fish Ecology

The predator fish species for which we have available stomach contents data can be found at https://apps-afsc.fisheries.noaa.gov/refm/reem/webdietdata/dietdataintro.php. Diet composition tables have been compiled for many predators and can be accessed, along with sampling location maps at https://apps-afsc.fisheries.noaa.gov/refm/reem/webdietdata/diettableintro.php. REEM also compiles life history information for many species of fish in Alaskan waters, and this information can be located at https://apps-afsc.fisheries.noaa.gov/refm/reem/lhweb/index.php.

These data are annually updated and time series of diets are produced for use in groundfish stock assessments presented to the North Pacific Fishery Management Council, as part of either the Ecological and Socioeconomic Profile for that stock, or as a contribution to the annual Ecosystem Status Reports.

Development of Multispecies Models

The REEM program maintains and regularly updates a set of multispecies and ecosystem models for use in strategic analyses of Alaskan fisheries. These include food web models (Ecopath/Ecosim), size-structured models (Mizer) and multispecies statistical models (Ceattle). Past work has established this set of models as operational for the Bering Sea; model development is currently focused on the Gulf of Alaska, with newly-developed Ecopath models exploring the dynamics of the eastern and western GOA separately, and a spatially structured ecosystem model (Atlantis) currently undergoing calibration. The GOA models are all integral to the GOACLIM project. Modeling scenarios are focused on testing management strategies for resilience in the face of climate change, as projected using a set of oceanographic models from the Coupled Model Intercomparison Project phase 6 (CMIP6). These scenarios are being brought into the fisheries management process in part through the NPFMC's Bering Sea Climate Change Taskforce (https://www.npfmc.org/about-the-council/plan-teams/bering-sea-fishery-ecosystem-plan-team/#climate-change)

Economics and Social Sciences Research (REFM/ESSR)

The Economic SAFE report contains detailed information about economic aspects of the groundfish fisheries through 2022, including figures and tables, economic performance indices, year-to-date information on volume and value, an Amendment 80 fishery economic data report (EDR) summary, market profiles for the most commercially valuable species, and product price and ex-vessel price nowcast projections for 2023. Data tables are organized into four sections: (1) All Alaska, (2) BSAI, (3) GOA, and (4) Pacific halibut. The figures and tables in the report provide estimates of total groundfish catch, groundfish discards and discard rates, prohibited species catch (PSC) and PSC rates, the ex-vessel value of the groundfish catch, the ex-vessel value of the catch in other Alaska fisheries, the gross product value of the resulting groundfish seafood products, the number and sizes of vessels that participated in the groundfish fisheries off Alaska, vessel activity, and employment on at-sea processors. Generally, the data presented in this report cover 2018-2022, but limited catch and ex-vessel value data are reported for earlier years to illustrate the rapid development of the domestic groundfish fishery since the 1980s and to provide a more complete historical perspective on catch. The data behind the tables from this and past Economic SAFE reports will be available online at:
https://reports.psmfc.org/akfin.

The commercial FMP groundfish fisheries off Alaska had a total catch of 1.87 million metric tons (mt) in 2022 (including catch in federal and state waters), a decrease of 7% from 2021. Groundfish accounted for 83 % of Alaska's 2022 total catch. Total catches of Alaska's FMP groundfish fisheries increased in 2022 for sablefish, Pacific cod, and the flatfish and rockfish species complexes, and decreased for pollock and Atka mackerel.

The aggregate ex-vessel value of the FMP groundfish fisheries off Alaska was $944.71 million, which was 46% of the ex-vessel value of all commercial fisheries off Alaska in 2022.[4] After adjusting for inflation, the real ex-vessel value of FMP groundfish increased $138.42 million in 2022 and the aggregate real ex-vessel price increased 27% to $0.24 per pound. Nominal pollock ex-vessel prices increased 25% to $0.17 per pound in the Bering Sea and Aleutian Islands (BSAI), and 36% to $0.17 per pound in the Gulf of Alaska (GOA). Pacific cod nominal ex-vessel prices

[4] The data required to estimate net benefits to either the participants in fisheries or the Nation, such as cost or quota value (where applicable) data, are not available. Unless otherwise noted 'value' should be interpreted as gross revenue.

increased 22% to $0.42 per pound in the BSAI, and increased 25% to $0.49 per pound in the GOA. Among the other species that are the focus of the shoreside ex-vessel fisheries: GOA flatfish ex-vessel price increased 47%, GOA rockfish prices increased 18%, and GOA sablefish prices increased 14% (in nominal terms). For BSAI FMP groundfish in aggregate, the change in price was larger than the change in catch, while in the GOA, prices and catch were both increasing with the change in catch the more dominant of the two. For other fisheries in Alaska, halibut and herring, ex-vessel revenues increased, and salmon and shellfish, ex-vessel revenues decreased.

The gross value of the 2022 groundfish catch after primary processing (first-wholesale) was $2.6 billion, an increase of 13% in real terms from 2022. This change was the combined effect of a 14% increase in the real aggregate 2022 first-wholesale price to $1.56 per pound which was offset by aggregate production volumes decreasing 1% to 755.5 thousand mt. In the BSAI, aggregate first-wholesale value increased 15% and value was increasing for nearly all species including, pollock, Pacific cod, sablefish, rockfish, and flatfish. The average first-wholesale price for all products was increasing for most species. In the GOA, aggregate first-wholesale value increased (54%) with increases in value for all species except for flatfish. Prices were increasing for most species with the exception of some flatfish species.

The first-wholesale value of Alaska's FMP groundfish fisheries accounted for 50.4% of Alaska's total first-wholesale value from commercial fisheries. First-wholesale value of Alaska's fisheries products other than FMP groundfish fisheries totaled $2.59 billion, most of which ($2.03 billion) came from Pacific salmon. Pacific salmon value decreased 1% due to a decline in production, though year-over-year prices increased. Pacific halibut fisheries, which are concentrated in the Gulf of Alaska, saw a modest increase of 0.8% in value in 2022 to $165.5 million as a result of an increase in price, which offset a decline in volume.

The groundfish fisheries off Alaska are an important segment of the U.S. fishing industry. In 2021, it accounted for 52% of the weight of total U.S. domestic landings and 17% of the ex-vessel value of total U.S. domestic landings (Fisheries of the United States, 2021). Alaska fisheries as a whole (including salmon, halibut, herring, and shellfish) accounted for 63% of the weight of total U.S. domestic landings and 46% of the ex-vessel value of total U.S. domestic landings.

With the exception of the annual economic census Economic Data Report program in BSAI Crab and Amendment 80 catch share programs, NOAA Fisheries collects only limited data on employment in the fisheries off Alaska. The most direct measure available is the number of 'crew weeks' on at-sea processing vessels and catcher vessels of FMP groundfish. These data indicate that in 2022, crew weeks for both sectors decreased by 2%, compared to 2021, totaling 105,161.5 with the majority of them (89,138) occurring in the BSAI groundfish fishery. In the BSAI, the months with the highest employment correspond with the peak of the pollock seasons in February-March and July-September. In the Gulf of Alaska, crew weeks peak June-August with the catcher vessel hook and line fisheries targeting sablefish and Pacific cod.

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

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APPENDIX I. RACE ORGANIZATION CHART

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Michael Martin

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- Connor Cleary
- Jennifer Gardner
- Jon Richar
- Megan Burns, contractor

Mike Litzow, Supervisor
- Chris Long
- Emily Ryznar
- Leah Zacher
- Shannon Hennessey
- Shelby Bacus, contractor

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Recruitment Process (FOCI)

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- David Kimmel
- Kelia Axler
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- Dan Cooper
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- Steve Porter
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APPENDIX II. REFM ORGANIZATION CHART

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APPENDIX III. AUKE BAY LABORATORY ORGANIZATIONAL CHART

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