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

TABLE OF CONTENTS

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

I. Agency Overview

Groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the following Divisions: Resource Assessment and Conservation Engineering (RACE) Resource Ecology and Fisheries Management (REFM), Fisheries Monitoring and Analysis (FMA), and the Auke Bay Laboratories (ABL). All Divisions work closely together to accomplish the mission of the Alaska Fisheries Science Center. In 2020 our activities were guided by our Strategic Science Plan (www.afsc.noaa.gov/GeneralInfo/FY17StrategicSciencePlan.pdf) with annual priorities specified in the FY19 Annual Guidance Memo (https://www.afsc.noaa.gov/program_reviews/2017/2017_Core_Documents/FY18%20AFSC%20AGM.pdf). A review of pertinent work by these groups during the past year is presented below. A list of publications relevant to groundfish and groundfish issues is included in Appendix I. Lists of publications, posters and reports produced by AFSC scientists are also available on the AFSC website at http://www.afsc.noaa.gov/Publications/yearlylists.htm, where you will also find a link to the searchable AFSC Publications Database. **Note that NOAA-Fisheries Science Center web materials can be found on the national NOAA-Fisheries web site after April 30, 2019 (https://www.fisheries.noaa.gov); they may no longer be available on the afsc.noaa.gov web site. Users should be able to find the same materials on the new national site.**

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

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

A. RACE DIVISION

The core function of the Resource Assessment and Conservation Engineering (RACE) Division is to conduct quantitative fishery-independent surveys and related research on groundfish and crab in Alaska. Our efforts are directed at supporting implementation of the U.S. Magnuson-Stevens Fishery Conservation and Management Act and other enabling legislation for the wise stewardship of living marine resources. Surveys and research are principally focused on species from the five large marine ecosystems of Alaska (Gulf of Alaska, Aleutian Islands, eastern Bering Sea, northern Bering and Chukchi Seas, Beaufort Sea). Our surveys often cover the entire life history of the focal species, from egg to adult. All surveys provide a rich suite of environmental data that are key to practicing an ecosystem approach to fisheries management (EBFM: https://www.fisheries.noaa.gov/insight/understanding-ecosystem-based-fisheries-management) . In addition, the Division works collaboratively with Industry to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat.

RACE staff is composed of fishery and oceanography research scientists, geneticists, technicians, IT Specialists, fishery equipment specialists, administrative support staff, and contract research associates. The status and trend information derived from regular surveys are used by Center stock assessment scientists to develop our annual Stock Assessment & Fishery Evaluation (SAFE) reports for 46 unique combinations of species and regions. Research by the Division increases our understanding of what causes population fluctuations. This knowledge and the environmental data we collect are used in the stock assessments, and in annual ecosystem status and species-specific ecosystem and socioeconomic reports. The understanding and data enable us to provide to our stakeholders with strong mechanistic explanations for the population trajectories of particular species. RACE Division science programs include: Fisheries Behavioral Ecology (FBE), Groundfish Assessment (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes (RPP), Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations: Seattle, WA, Newport, OR, and Kodiak, AK.

One of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish and crab species of the northeast Pacific Ocean and Bering Sea. Regularly scheduled bottom trawl surveys in Alaskan waters include an annual survey of the crab and groundfish resources of the eastern Bering Sea shelf and biennial surveys of the Gulf of Alaska (odd years) and the Aleutian Islands and the upper continental slope of the eastern Bering Sea (even years). In summer 2019, RACE Groundfish Assessment Program (GAP) and Shellfish Assessment Program (SAP) scientists conducted a bottom trawl survey of Alaskan groundfish and invertebrate resources over the eastern and northern Bering Sea shelf
The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock and other pelagic fish abundance in the Gulf of Alaska (winter) and the western and central Gulf of Alaska (summer). A collaborative cruise to test the efficacy of a new type of trawl excluder to minimize salmon bycatch was accomplished, as well. MACE and GAP continue to collaboratively design an acoustical-optical survey for fish in grounds that are inaccessible to fisheries research trawls (e.g Gulf of Alaska or Aleutian Islands). Once implemented, the survey will reduce bias in our survey assessments of particular taxa such as rockfish.

The Recruitment Processes Alliance (RPA: RACE RP and ABL EMA Programs) conducted Gulf of Alaska surveys on the early life history stages of groundfish species in the spring and summer, as well as the environmental conditions necessary to explain growth and mortality of fish. Spring surveys focus on winter and early spring spawners such as Walleye Pollock, Pacific cod, Arrowtooth Flounder, and Northern & Southern Rock Sole. Summer surveys concentrate on the age-0 and age-1 juvenile stages of the winter/spring spawners as well as summer spawners (e.g. forage fishes including Capelin, Eulachon, and Pacific Herring). This survey also estimates whether or not age-0 fish have sufficient energy reserves to survive their first winter.

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

In 2019 RACE scientists continued research on essential habitats of groundfish including: identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, including the nearshore areas and early life history stages of fishes in Alaska's subarctic and arctic large marine ecosystems; estimating habitat-related survival rates based on individual-based models; investigating activities with potentially adverse effects on EFH, such as bottom trawling; determining optimal thermal and nearshore habitat for overwintering juvenile fishes; benthic community ecology, and juvenile fish growth and condition research to characterize groundfish habitat requirements.

Groundfish surveys by the RACE Division have been increasingly challenged by climate-mediated ocean warming and loss of sea ice. These phenomena are likely directly related to changes in fish distribution, particularly the northern summer expansion of pollock and cod stocks. During the 2019 summer survey we observed one of the smallest cold pool extents in the history of our time series. Movement of fish outside of our historical survey boundaries challenges the assumption that our surveys capture an invariant fraction of the population from one year to the next. These distributional changes are occurring at exactly the same time as our survey and science resources are declining. The RACE Division is collaborating with an international team of scientists to examine the impacts of reduced survey effort on the accuracy and precision of survey biomass estimates and stock assessments. AFSC hosted an ICES workshop on the impacts of unavoidable survey effort reduction (ICES WKUSER) in the winter 2019/2020. Work on the topic began in late 2018 and substantial progress was made before the 2020 meeting. A workshop report will soon be available on the ICES web page (https://www.ices.dk/community/groups/Pages/WKUSER.aspx). Similarly, current research by RACE and other Center scientists will examine the efficacy of model-based survey estimates to supplement our current design-based surveys.

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

For more information on overall RACE Division programs, contact Division Director Jeffrey Napp at (206) 526-4148 or Deputy Director Michael Martin at (206) 526-4103.

B. REFM DIVISION

The research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. The activities of REFM are organized under several programs that have specific responsibilities but also interact:

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

extensive annual report on the status of Alaska marine ecosystems.

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

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

C. AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL's Marine Ecology and Stock Assessment Program (MESA) publishes groundfish stock assessments for rockfish in the Gulf of Alaska, and sharks, sablefish, and grenadiers for all of Alaska. They also conduct management strategy evaluations (MSEs). MESA also conducts biological research, such as movement, growth, stock structure, ageing, and maturity. Presently, the program is staffed by 11 full time scientists and 1 term employee. ABL's Ecosystem Monitoring and Assessment Program (EMA) capture groundfish in their surveys in the Bering Sea and the Arctic Ocean and conduct research on impacts of the environment on groundfish. The Recruitment Energetics and Coastal Assessment Program (RECA) studies the energetics and diet of juvenile groundfish and the Genetics Program conducts research on cod, pollock, sablefish, shark, and forage fish stock structure and distribution.

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

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

For more information on overall programs of the Auke Bay Laboratories, contact the ABL Laboratory Director Dana Hanselman at (907) 789-6626, Dana.Hanselman@noaa.gov). For more information on the ABL reports contact Cara Rodgveller (cara.rodgveller@noaa.gov).

D. FMA DIVISION

The Fisheries Monitoring and Analysis Division (FMA) monitors groundfish fishing activities in the U.S. Exclusive Economic Zone (EEZ) off Alaska and conducts research associated with sampling commercial fishery catches, estimation of catch and bycatch mortality, and analysis of fishery-dependent data. The Division is responsible for training, briefing, debriefing and oversight of observers who collect catch data onboard fishing vessels and at onshore processing plants and for quality control/quality assurance of the data provided by these observers. Division staff process data and make it available to the Sustainable Fisheries Division of the Alaska Regional Office for quota monitoring and to scientists in other AFSC divisions for stock assessment, ecosystem investigations, and an array of research investigations. For further information please contact Jennifer Ferdinand, (206) 526-4194.

E. HEPR

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

Loss of Sea Ice

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

Essential Fish Habitat

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

Habitat Research in Alaska

Major research needs are

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

Essential Fish Habitat Research Plan in Alaska

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

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

II. Surveys

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

References

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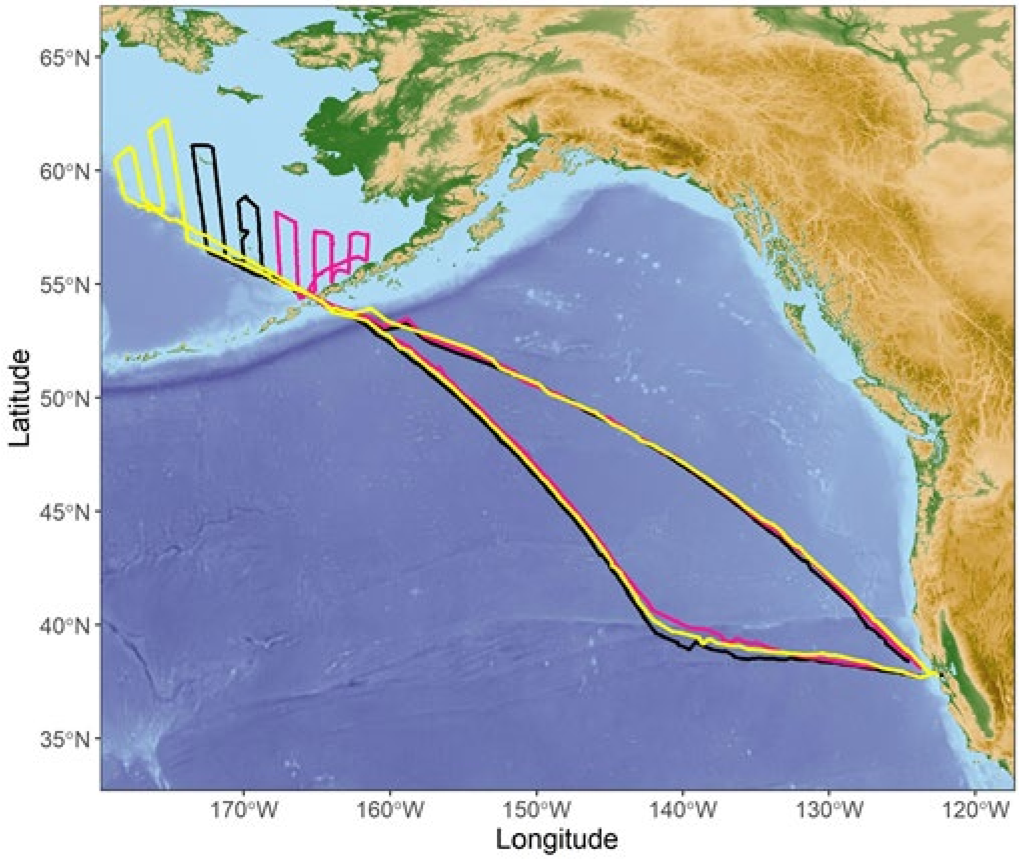

Fig. 1. Path taken by saildrones as they sailed from California across the North Pacific to the survey area in the Bering Sea and returned. Each USV track is depicted in a different color

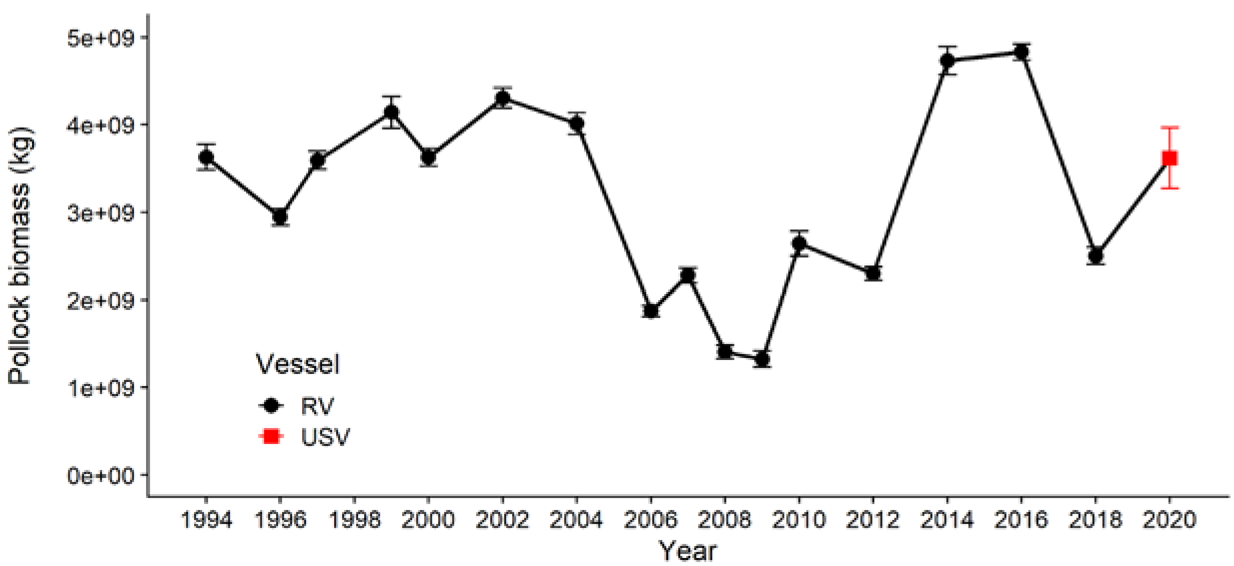

Fig. 2. Time series of EBS pollock acoustic-trawl abundance estimates with error bars showing ± 1 standard deviation of the estimate based on geostatistical 1-D estimates. The 2020 estimate (red

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

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

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

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

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

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

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

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

2020.

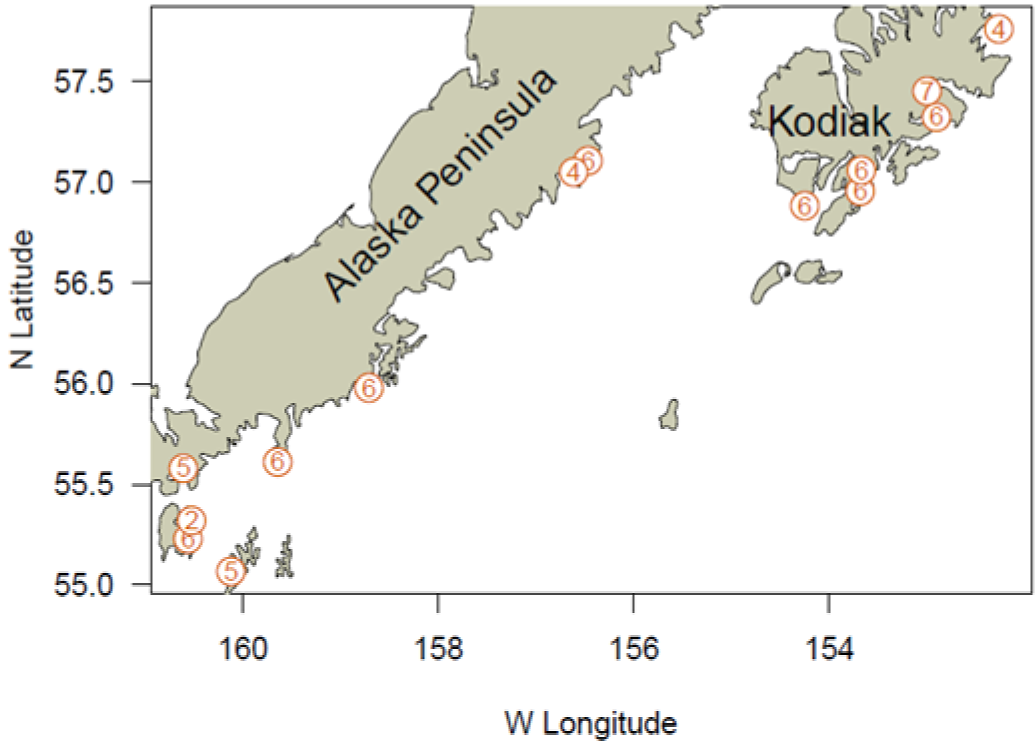

Figure 1: Beach seine sampling locations. Numbers inside circles indicate the total number of seine sets in each bay. A total of 27,992 individuals of 47 species of fish were captured, with age-0 Pacific cod and walleye pollock ranking most common. An additional 40 baited camera sets were also conducted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

For more information contact Benjamin J. Laurel (ben.laurel@noaa.gov) or Mike Litzow (mike.litzow@noaa.gov)

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

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

Longline Survey – ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2020. The survey is a joint effort involving the AFSC's Auke Bay Laboratories and Resource Assessment and Conservation Engineering (RACE) Division. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978 to 1994 and samples gullies not previously sampled during the cooperative longline survey. In 2020, the 43rd annual longline survey sampled the upper continental slope of the Gulf of Alaska and the eastern Aleutian Islands. One hundred and fifty-two longline hauls (sets) were completed during June 3 – August 29 by the chartered fishing vessel *Alaskan Leader*. Total groundline set each day was 18 km (9.7 nmi) and contained 180 skates with 8,100 hooks.

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

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

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

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

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

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

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

III. Reserves

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

Note: Management of federal groundfish fisheries in Alaska is performed by the North Pacific Fishery Management Council (NPFMC) with scientific guidance (research and stock assessments) from the AFSC and other institutions. Assessments are conducted annually for major commercial groundfish stocks, with biennial or quadrennial assessments for most of the other stocks. Groundfish populations are typically divided into two geographic stocks: Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA). Some BSAI stocks are further divided into Eastern Bering Sea (EBS) and Aleutian Islands (AI). In the GOA, assessment and management for many stocks is structured around large-scale spatial divisions (western, central, and eastern GOA) although the application of these divisions varies by stock. Current and past stock assessment reports can be accessed on the AFSC website (https://www.fisheries.noaa.gov/alaska/ population-assessments/north-pacific-groundfish-stock-assessments-and-fishery-evaluation).

A. Hagfish

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

B. Dogfish and other sharks

1. Research

Population Genetics of Pacific Sleeper Sharks - ABL

The purpose of this study is to investigate the population structure of Pacific sleeper sharks in the eastern North Pacific Ocean. Tissue samples have been opportunistically collected from ~400 sharks from the West Coast, British Columbia, the Gulf of Alaska, and the Bering Sea. Sequences from three regions of the mitochondrial DNA, cytochrome oxidase c- subunit 1 (CO1), control region (CR), and cytochrome b (cytb), were evaluated as part of a pilot study. A minimum spanning haplotype network separated the Pacific sleeper sharks into two divergent groups, at all three mtDNA regions. Percent divergence between the two North Pacific sleeper shark groups at CO1, cytb, and CR respectively were all approximately 0.5%. We obtained samples from Greenland sharks, S microcephalus, which are found in the Arctic and North Atlantic, to compare to the two observed groups in the North Pacific samples, as well as Antarctic sleeper shark from the Southern Ocean. The Greenland shark samples were found to diverge from the other two groups by 0.6% and 0.8% at CO1, and 1.5% and 1.8% at cytb. No Greenland shark data was available for CR. Results suggest that Greenland shark do not comprise one of the groups observed in the North Pacific sleeper shark samples. The Antarctic samples have not been run yet. The consistent divergence from multiple sites within the mtDNA between the two groups of Pacific sleeper sharks indicate a historical physical separation. There appears to be no modern phylogeographic pattern, as both types were found throughout the North Pacific and Bering Sea. All samples have been consolidated and are being prepared for next generation genome sequencing.

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

Ageing of Pacific Sleeper Sharks – ABL

A pilot study is underway by staff at ABL, REFM, the Lawrence Livermore National Laboratory and the American River College to investigate potential ageing methods for Pacific sleeper sharks. A recent study suggested extreme longevity in a closely related species by examining the levels of bomb-derived radiocarbon (14C) in the eye lens. The eye lens is believed to be a metabolically inert structure and therefore the levels of 14C could reflect the environment during gestation, which may be used to compare to existing known age 14C reference curves to estimate either a rough age, or a "at least this old" age estimate. For the pilot study, eyes from six animals were removed whole and stored frozen until lab processing. One lens from each shark was excised and lens layers were removed and cleaned by sonication and dried. For larger sharks, both the lens core (earliest deposited material) and outer layer (most recently deposited material) were saved for analysis. Dry samples were sent to an accelerator mass spectrometry (AMS) facility for carbon isotope analyses (^{14}C, ^{13}C), measurement error, and conventional radiocarbon age, when applicable (pre-bomb (<1950); Gagnon et al. 2000) — it was expected that all outer layer samples would be modern and that some cores could have pre-bomb or early bomb ^{14}C rise levels based on rough estimates of age.

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

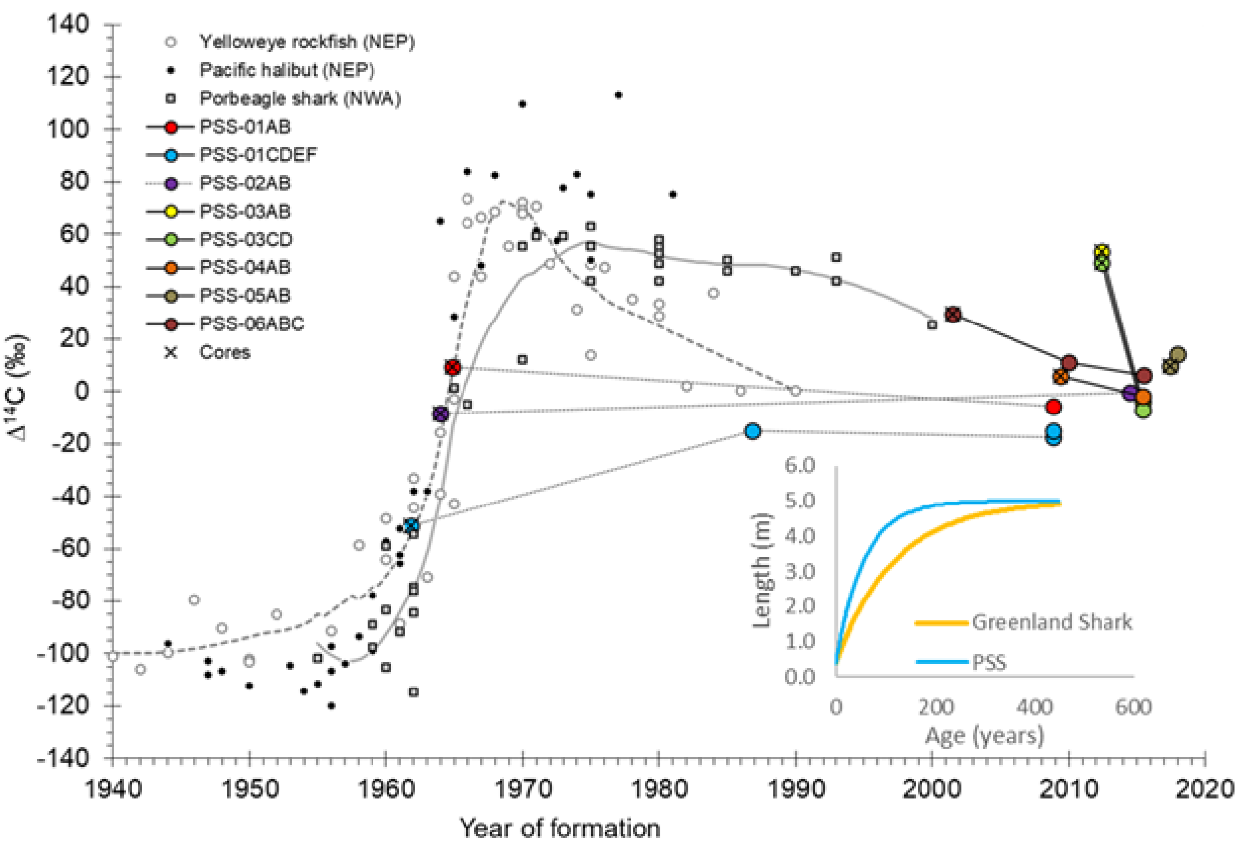

Figure. Pacific sleeper shark (PSS) eye lens 14C values from the pilot study plotted as estimated year of formation relative to regional 14C references. Data from six sharks (PSS-01 to PSS-06, Table 1) are shown as a series of samples from the core to the outer eye lens. Both eye lenses were sampled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

Greenland shark.

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

Shark tagging – ABL

A tagging program for spiny dogfish began in 2009, with 186 pop-off satellite archival tags (PSATs) deployed between 2009 - 2018. Data were recovered from 157 of those tags (nine tags are still at liberty), with eight tags physically recovered. The PSATs record depth, temperature, light levels and sunrise/sunset for geolocation. A subset of the data is transmitted to ARGOS satellites and any if any tags are physically recovered, the high resolution data can be downloaded. Preliminary results suggest that spiny dogfish can undertake large scale migrations rapidly and that they do not always stay near the coast (e.g. a tagged fish swam from nearby Dutch Harbor to Southern California in nine months, in a mostly straight line, not following the coast). Also, the spiny dogfish that do spend time far offshore have a different diving behavior than those staying nearshore, with the nearshore animals spending much of the winter at depth and those offshore having a significant diel diving pattern from the surface to depths up to 450 m. Staff at ABL, along with Julie Nielsen (Kingfisher Marine Research) have developed a Hidden Markov Movement (HMM) model based on these tag data which incorporates environmental variables (e.g. temperature/depth profiles and sea-surface temperature). The HMM model provides daily locations in the form of probability surfaces as well as total residence probabilities for the duration of deployment for each tag. The results will be used to define habitat utilization distributions, and eventually inform Essential Fish Habitat. A manuscript detailing the model development is in review. Further manuscripts are in preparation.

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

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

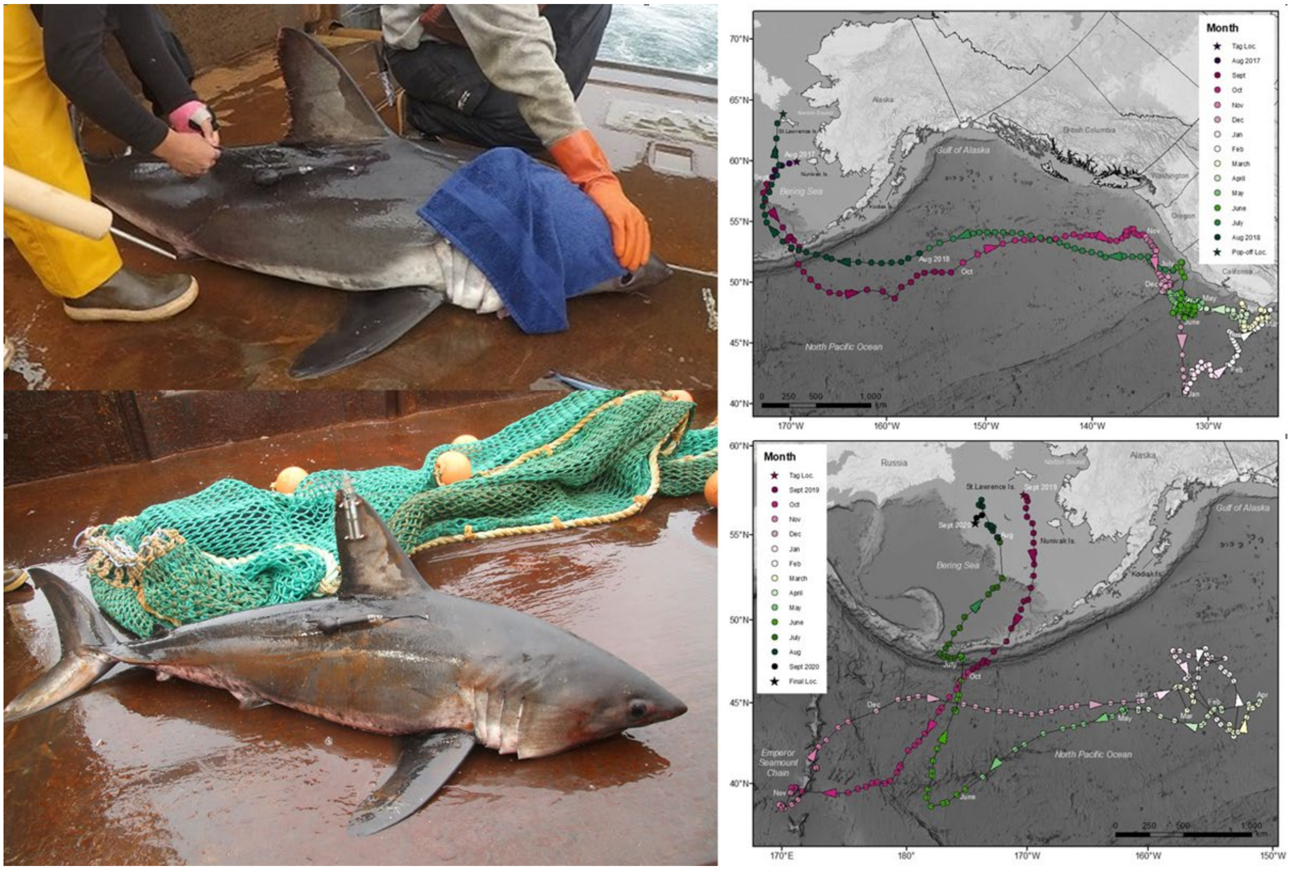

Figure. (Left) Shark A (top) being tagged with a PSAT using two tethers on August 27, 2017. The harness of the second tether attachment is being looped around the body of the tag. Shark B (bottom) with a SPOT-257 tag affixed to the dorsal fin and a PSAT attached with two tethers in the musculature beneath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

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

2. Stock Assessment

Sharks - ABL

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) are on biennial cycles in even years. There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI or GOA, and most incidentally captured sharks are not retained.

In the 2020 assessments, catch estimates from 2003-2020 were updated from the NMFS Alaska Regional Office's Catch Accounting System. In the GOA, total shark catch in 2020 was 1,625 t, which was down from the 2019 catch of 1,997 t. The GOA assessment also reports catch of sharks occurring in federally managed fisheries in NMFS areas 649 (Prince William Sound) and 659 (Southeast Alaska inside waters), 194 t in 2019 and 306 t in 2020, however these do not accrue against the TAC. The assessment authors have been tasked with working with Council staff to explore options for incorporating these catches into the assessment.

The most recent GOA trawl survey was in 2019, with the next planned for 2021. The trawl survey biomass estimates are used for ABC and OFL calculations for spiny dogfish and are not used for other shark species. The 2019 survey biomass estimate for spiny dogfish (22,014 t, CV = 15%) was the lowest biomass since the 1990 survey and substantially lower than the last four surveys (2017 biomass was 59,979, CV = 19%). Such variability in annual estimates is expected due to the patchy distribution of this species. The random effects model for survey averaging was used to estimate the 2017 (and thus 2018 because there was no survey that year) GOA biomass for spiny dogfish (54,301 t), which was used for Tier 5 calculations of spiny dogfish ABC and OFL.

The GOA shark assessment is a complex of both Tier 5 and 6 species. Spiny dogfish are Tier 5, where the random effects biomass estimates are adjusted by a catchability parameter and multiplied by $F_{OFL} = F_{max}$ from a demographic analysis to estimate the OFL. The Tier 6 species in the complex remained consistent, using the historical mean catch to calculate ABC and OFLs. The recommended GOA-wide ABC and OFL for the entire complex is based on the sum of the ABC/OFLs for the individual species, which resulted in an author recommended ABC = 3,775 t and OFL = 5,006 t for 2021 and 2022.

The shark stock complex in the BSAI are all considered Tier 6 because the survey biomass estimates are highly uncertain and not informative. The Tier 6 calculations in the BSAI are based on the maximum catch of all sharks from the years 2003-2015. The resultant recommended values for 2021 and 2022 were ABC = 517 t and OFL = 689 t. In the BSAI, estimates of total shark catch from the Catch Accounting System from 2020 were 180 t, which is not close to the ABC or OFL. Pacific sleeper shark are usually the primary species caught, however catches of salmon shark have been greater for the last two years (92 t and 106 t salmon shark in 2019 and 2020, respectively and 53 t and 68 t of Pacific sleeper sharks).

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

C. Skates

1. Research

2. Assessment

Bering Sea and Aleutian Islands (REFM)
The Bering Sea and Aleutian Islands (BSAI) skate complex includes at least 13 skate species, which are highly diverse in their spatial distribution. The complex is managed in aggregate, with a single set of harvest specifications applied to the entire complex. However, to generate the harvest recommendations the stock is divided into two units. Harvest recommendations for Alaska skate

Bathyraja parmifera, the most abundant skate species in the BSAI, are made using the results of an age structured model (Stock Synthesis). The remaining species ("other skates") are managed under Tier 5 (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). The individual recommendations are combined to generate recommendations for the complex as a whole.

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

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

Following are the main developments in the 2019 skate assessment:

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

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

D. <u>Pacific Cod</u>

1. Research

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Pacific cod juveniles in the Chukchi Sea-RPP

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

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

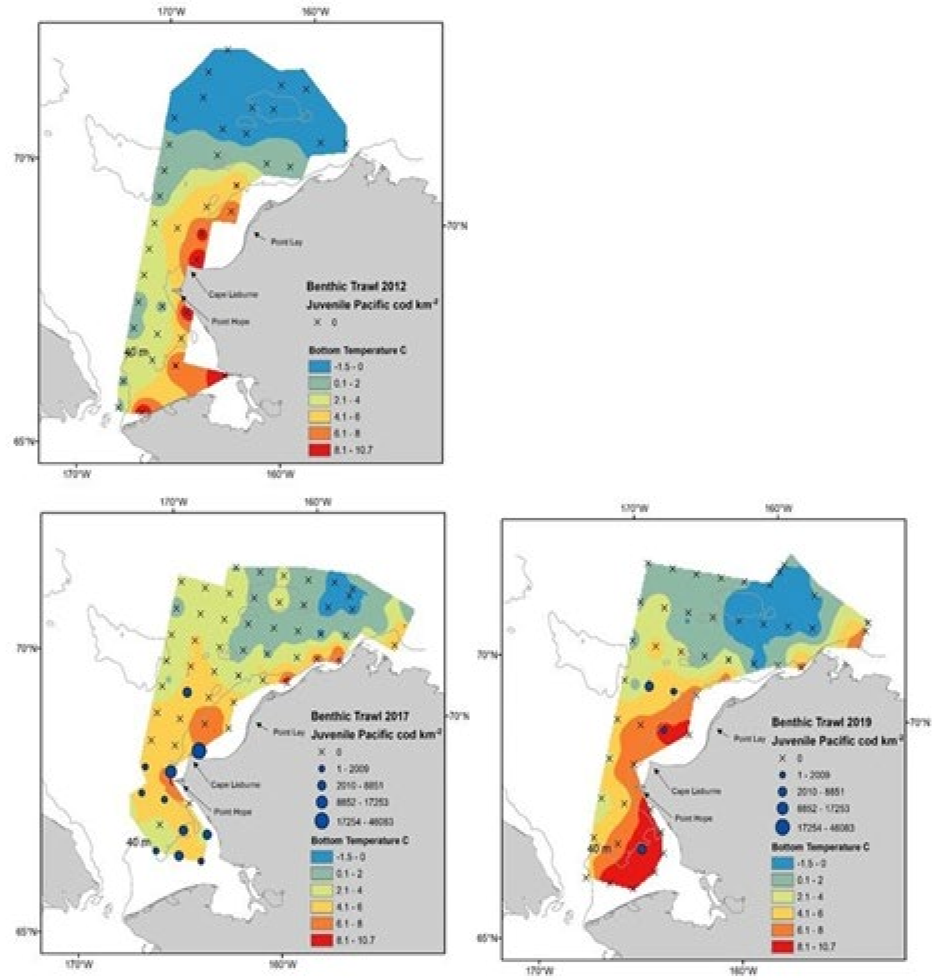

Figure 1. Age-0 Pacific cod catch per unit effort and bottom temperature interpolations from 2012, 2017, and 2019.

Cod species and population structure in the Arctic - ABL

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

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

2. Stock Assessment

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

The EBS Pacific cod model has undergone numerous model changes and refinements over the last decade. Preliminary models are reviewed in the spring of each year. The model uses the Stock Synthesis 3 framework. A major issue in recent years has been an apparent shift in the distribution of EBS Pacific cod into the northern Bering Sea (NBS), an area which historically has not been surveyed. Surveys in the NBS were conducted in 2010 and during 2017-2019, and regular NBS surveys are likely to be conducted into the future as EBS groundfish stocks experience changes in distribution. The lack of survey data in the NBS has caused assessment difficulties for Pacific cod and other stocks.

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

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

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

After declining by more than 50% between 1991 and 2002, survey biomass has since stayed in the range of 50-90 kilotons. The 2018 Aleutians survey biomass estimate (81,272 t) was down about 4% from the 2016 estimate (84,409 t). The estimate of the natural mortality rate is 0.34, which was taken from the 2018 EBS Pacific cod assessment model. For 2020 and 2021, the recommended ABC is 20,600 t, and OFL is 27,400 t.

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

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

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

F. Walleye Pollock

1. Research

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

Description of indicators: The temperature change (TC) index is a composite index for the preand post-winter thermal conditions experienced by walleye pollock (*Gadus chalcogrammus*) from age-0 to age-1 in the eastern Bering Sea (Martinson et al., 2012). The TC index (year t) is calculated as the difference in the average monthly sea surface temperature in June (t+1) and August (t) (Figure 1) in an area of the southern region of the eastern Bering Sea (56.2°N to 58.1°N latitude by 166.9°W to 161.2°W (193.1, 198.8 longitude). Time series of average monthly sea surface temperatures were obtained from the NOAA Earth System Research Laboratory Physical Sciences Division website. Sea surface temperatures were based on NCEP/NCAR gridded reanalysis data (Kalnay et al., 1996, data obtained from http://www.esrl.noaa.gov/psd/cgi-bin/data/timeseries/timeseries1.pl). Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock.

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

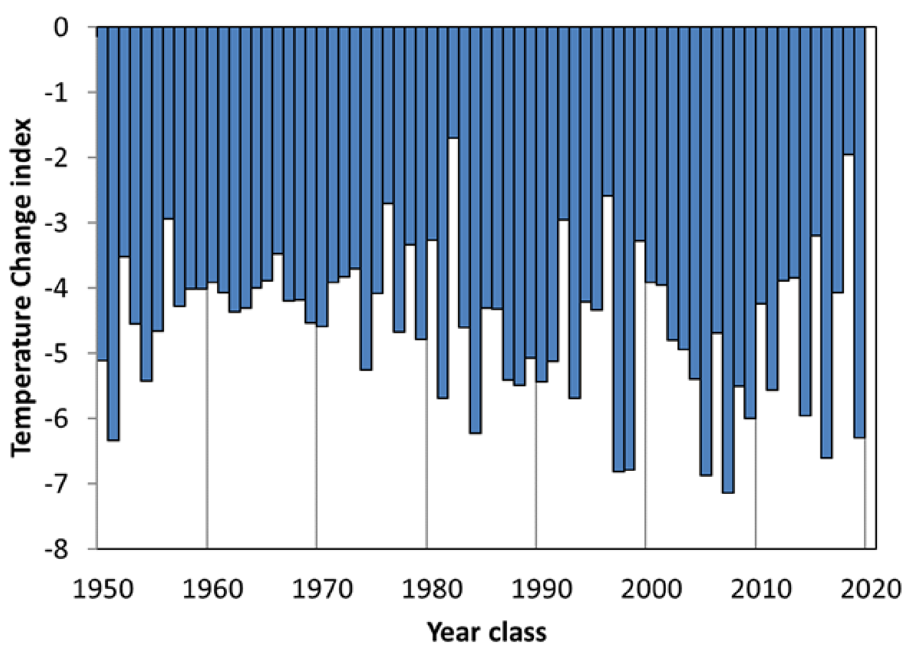

Figure 1: The Temperature Change index values for the 1950 to 2019 year classes of pollock. Values represent the differences in sea temperatures on the south eastern Bering Sea shelf experienced by the 1950-2019 year classes of pollock. Less favorable conditions (more negative values) represent a warm summer during the age-0 life stage followed by a relatively cool spring during the age-1 life stage. More favorable conditions (less negative values) represent a cool summer during the age-0 life stage followed by a relatively warm spring during the age-1 life stage.

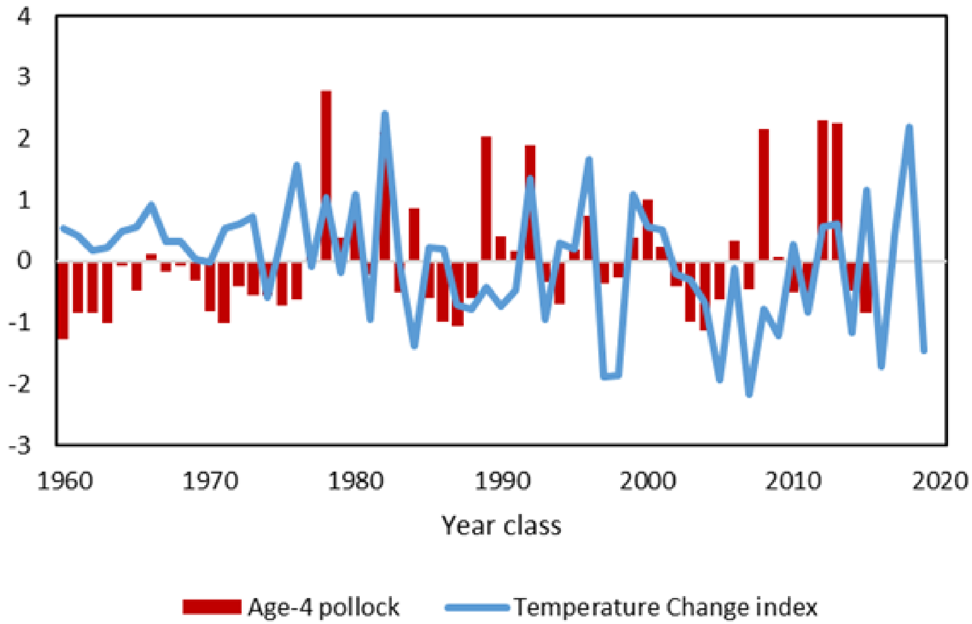

Figure 2: Normalized time series values of the temperature change index indicating conditions experienced by the 1960-2019 year classes of pollock during the summer age-0 and spring age-1 life stages. Normalized values of the estimated abundance of age-4 walleye pollock in the eastern Bering Sea from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

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

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

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

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

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

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

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

Description of indicator: Interannual variations in large copepod abundance during the age-0 life stage were compared to age-3 walleye pollock (*Gadus chalcogrammus*) abundance (billions of fish) for the 2002-2018 year classes on the southeastern Bering Sea shelf, south of 60°N, < 200 m bathymetry (Eisner et al. 2020). The large copepod index sums the abundances of *Calanus marshallae/glacialis* (copepodite stage 3 (C3)-adult), *Neocalanus* spp. (C3-adult), and *Metridia* *pacifica* (C4-adult), taxa typically important in age 0 pollock diets (Coyle et al. 2011). Zooplankton samples were collected with oblique bongo tows over the water column using 60 cm, 505 µm mesh nets for 2002-2011, and 20 cm, 153 µm mesh or 60 cm, 505 µm nets, depending on taxa and stage for 2012-2018. Data were collected on the Bering Arctic Subarctic Integrated Survey (BASIS) fishery oceanography surveys and along the 70 misobath during mid-August to late September, for four warm years (2002-2005) followed by one average (2006), six cold (2007-2012), four warm (2014-2016, 2018) and an average year (2017, 70 m isobath only) using methods in Eisner et al. (2014). Zooplankton data were not available for 2013. Age-3 pollock abundance was obtained from the stock assessment report for the 2002-2016 year classes (Ianelli et al., 2019). Two estimates of large copepod abundances were calculated, the first using means among stations (sample-based), and the second using the means estimated from the geostatistical model, Vector Autoregressive Spatial Temporal (VAST) package version 9.4.0 (Thorson et al., 2016a, b; Thorson and Barnett, 2017). We specified 30 knots, a log normal distribution, and the delta link function between probability or encounter and positive catch rate in VAST.

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

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

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

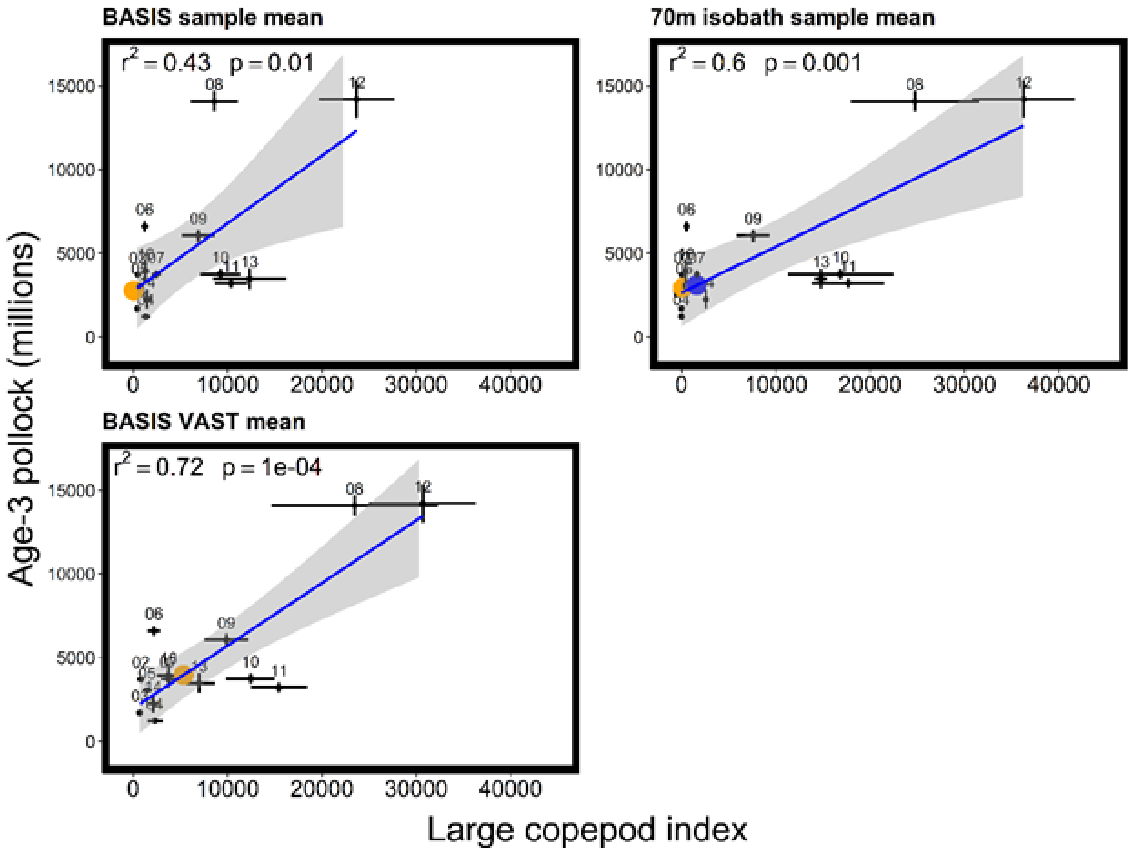

Figure 1. Linear relationships between sample-based (top) from the BASIS and 70 m isobaths surveys and BASIS VAST-model (bottom) estimated mean abundance of large copepods (C+MN, sum of *Calanus marshallae/glacialis, Metridia pacifica* and *Neocalanus* spp.) during the age-0 life stage of pollock, and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

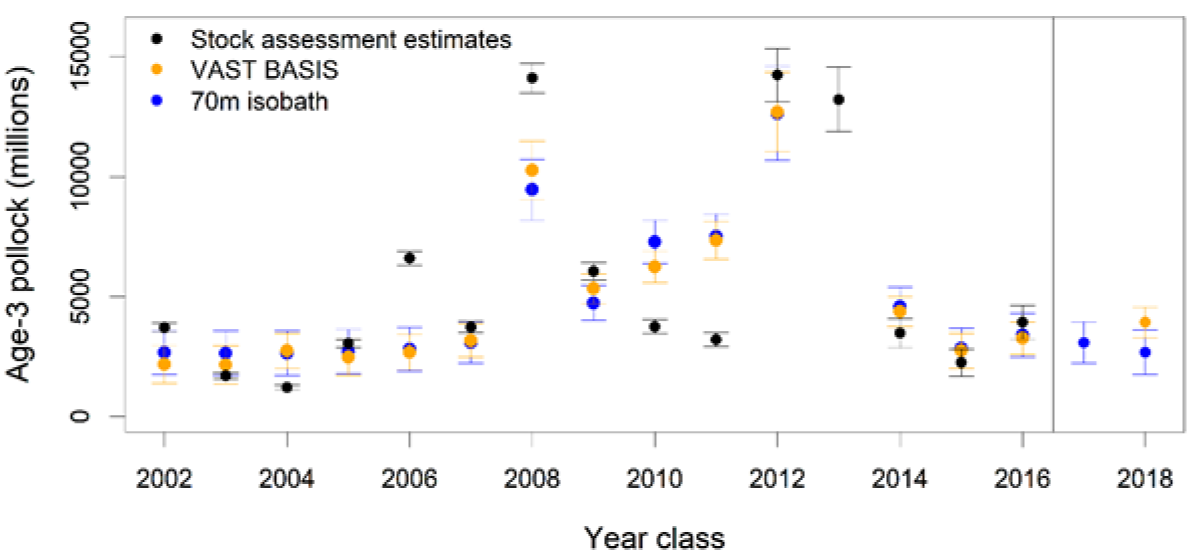

Figure 2. Fitted means and standard errors of the age-3 pollock abundance estimated from the linear regression models using VAST estimates of large copepods (orange), sample mean abundance of large copepods at the 70m isobaths stations (blue), and means from the pollock stock assessment estimates (black)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

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For more information contact Lisa Eisner at (206) 526-4060, lisa.eisner@noaa.gov or Ellen Yasumiishi at (907) 789-6604, ellen.yasumiishi@noaa.gov

Ocean acidification effects in larval walleye pollock-FBE RACE

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

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

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 Janet Duffy-Anderson at: Janet.Duffy-Anderson@noaa.gov

Gulf of Alaska

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

Matthew T. Wilson

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

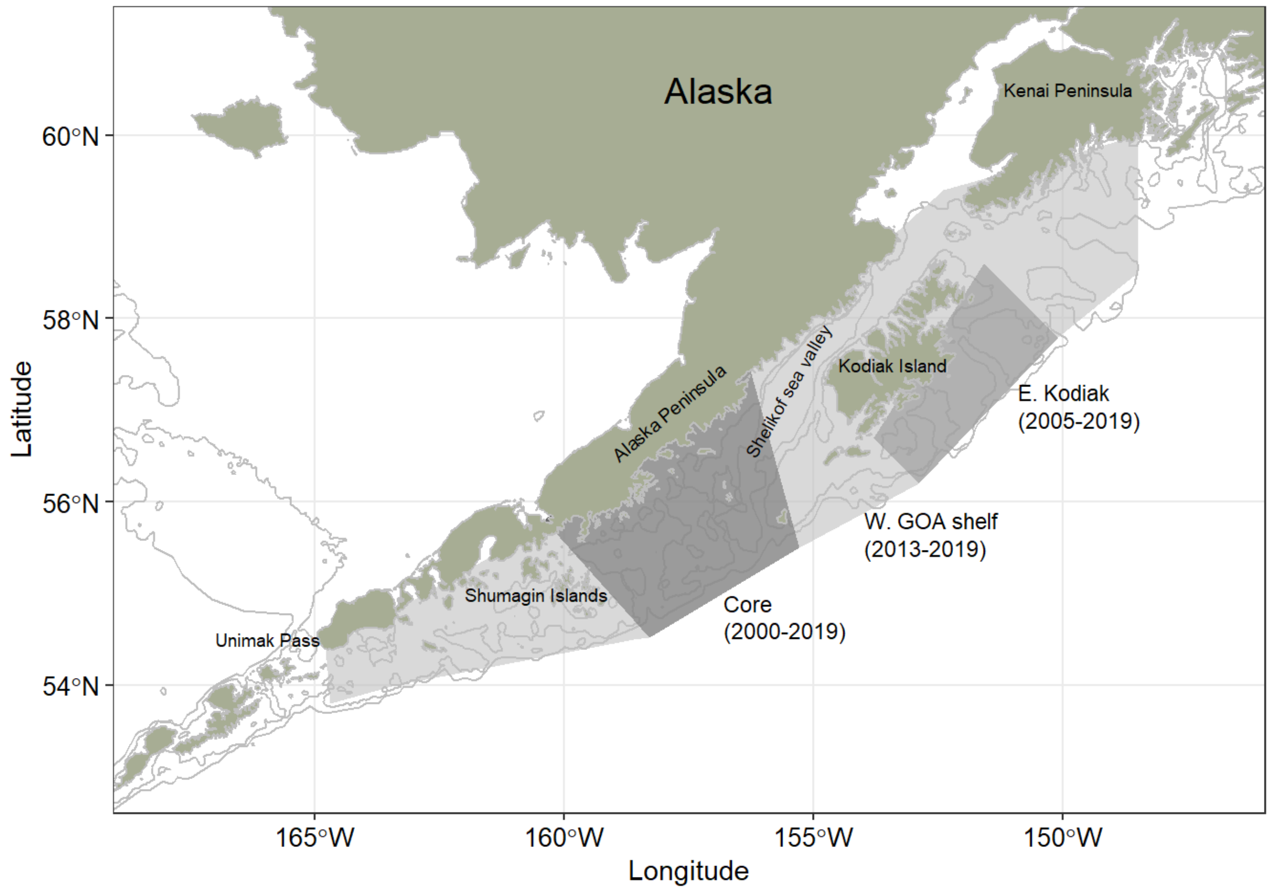

Figure 1. Geographic areas covered by the late-summer surveys of juvenile walleye pollock in the western GOA during 2000 and 2001-2019 odd years only. Polygons approximate the area(s) surveyed each year: 1) Core Area, 2000 - 2019 (dark gray); 2) E Kodiak Area, 2005 - 2019 (medium gray); and 3) W GOA, 2013 - 2019 (light gray).

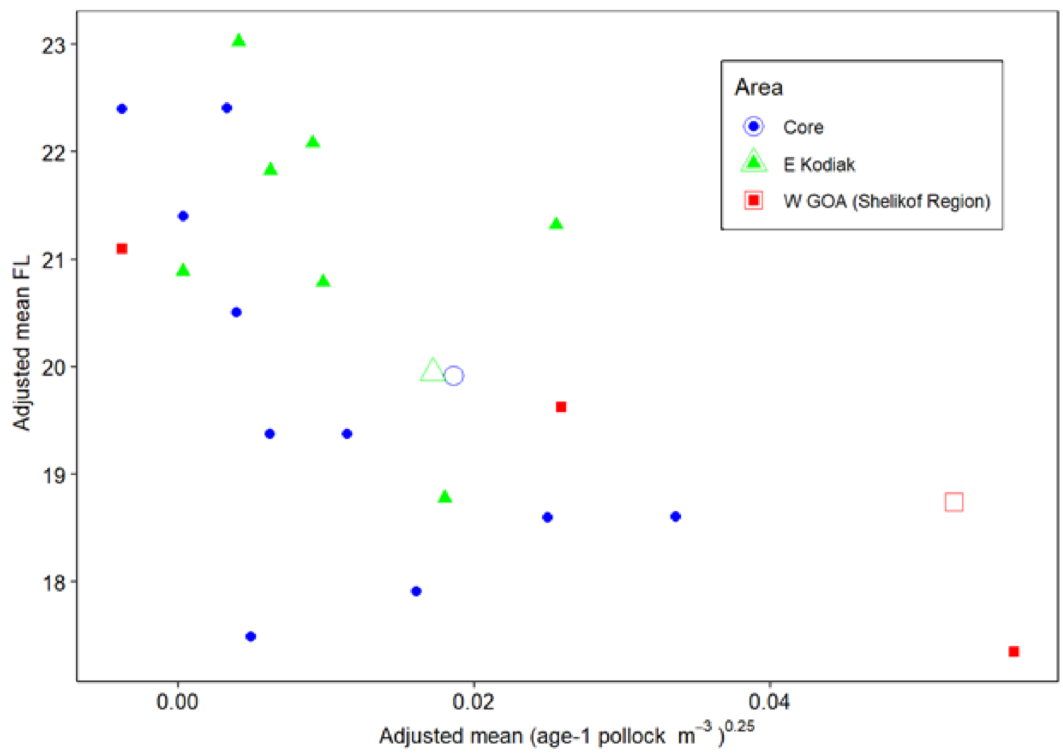

Figure 2. Adjusted means of population density (fish $m^{-3})^{0.25}$ and FL (cm) of age-1 walleye pollock collected during late summer, 2000-2019, by survey area and year. Large, unfilled symbols distinguish the 2019 survey year.

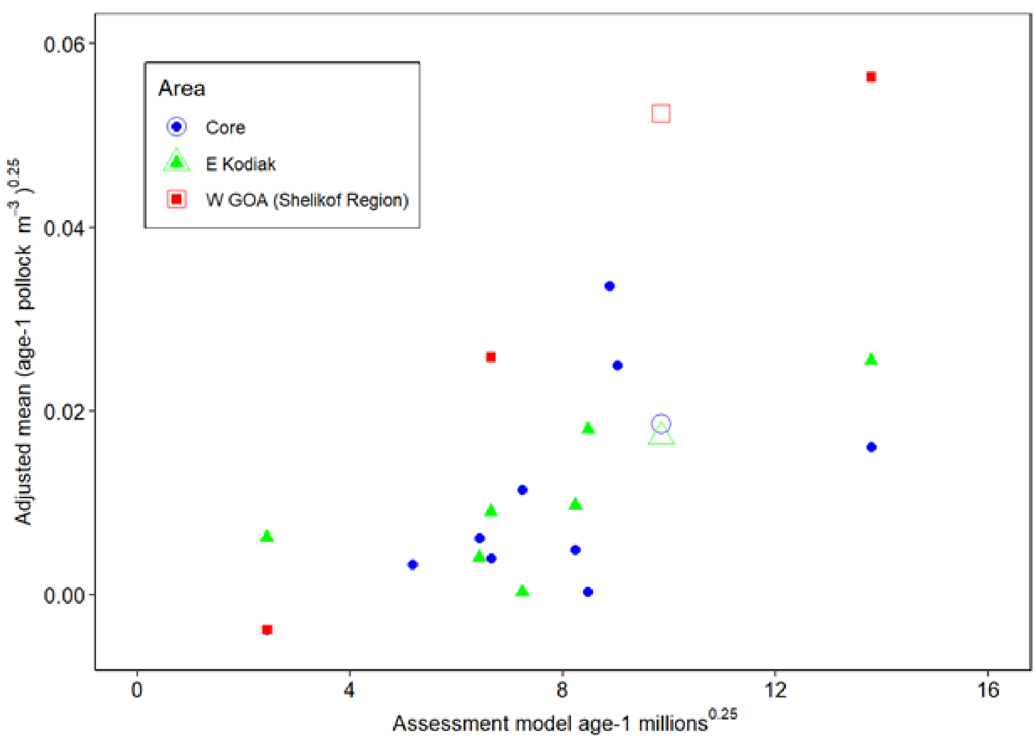

Figure 3. Age-1 pollock abundance indicators during late summer in relation to Gulf-wide

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

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For More Information Contact Matt Wilson at: Matt.Wilson@noaa.gov

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

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

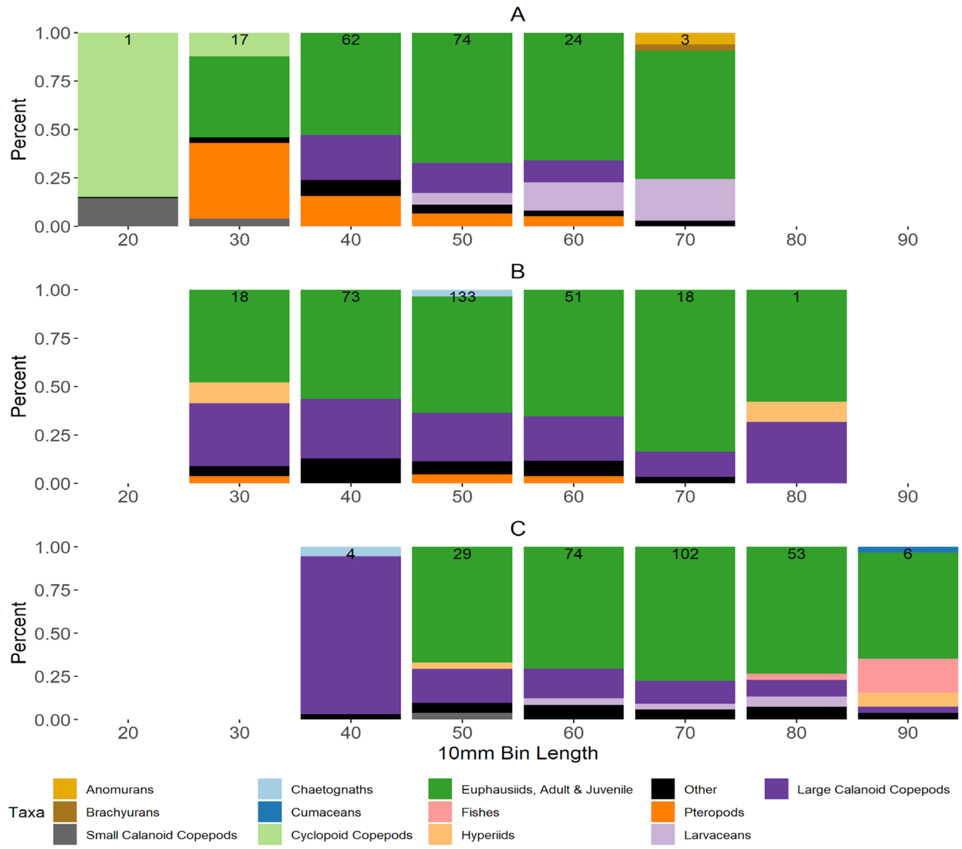

Figure 1. Age-0 pollock diet composition (percent weight) by 10mm length bins. The “Other” prey category was the sum total of prey categories that comprised less than 3% of the total prey weight in both regions.

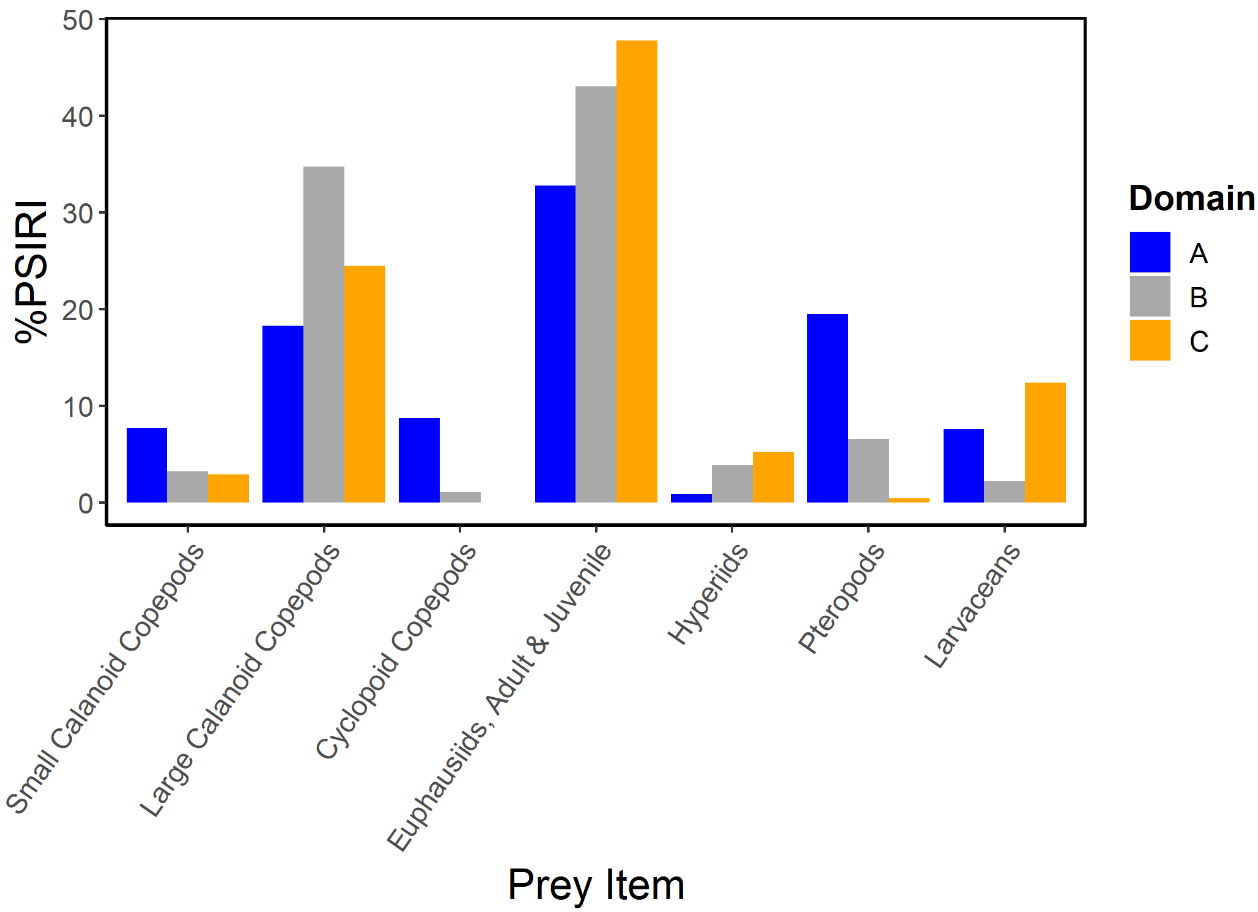

Figure 2. The top five selected prey taxa as determined by the PSIRI for stations southwest of Shumagin Is. (Domain A), between the Shumagin Is. and Kodiak Is. (Domain B) and stations surrounding and to the northeast of Kodiak Isl. (Domain C).

For more information please contact Jesse Lamb at: Jesse.F.Lamb@noaa.gov or David G. Kimmel

Bering Sea

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

As part of the Bering Arctic Subarctic Integrated Survey (BASIS), we analyzed acoustic –trawl (AT) survey data collected on the Oscar Dyson during routine research surveys over the SEBS shelf. A cold year (2012), an intermediate year (2011), and 2 warm years (2014-2016) were included in the analysis to compare the vertical distribution of age-0 Walleye Pollock (*Gadus chalcogrammus*) during different temperature regimes. Surface, midwater, and oblique tows were conducted using the Cantrawl, Marinovich, and Nets-156 trawls. Age-0 pollock AT data collected during intermediate and cold years showed a deeper vertical distribution, while age-0 pollock AT data collected during warm years showed a shallower, more surface oriented distribution (Figure 1). Juvenile pollock that were caught in deeper depths were more energy dense, than fish caught in the surface, in both warm and cold years (Figure 2). Shifts to deeper, colder water during warm years could provide a metabolic refuge from warm surface waters (see Duffy-Anderson et al., 2017), as well as an improved prey base as age-0 pollock follow the diel vertical migration patterns of major prey species (copepods, euphausiids) to promote continued vertical overlap with prey.

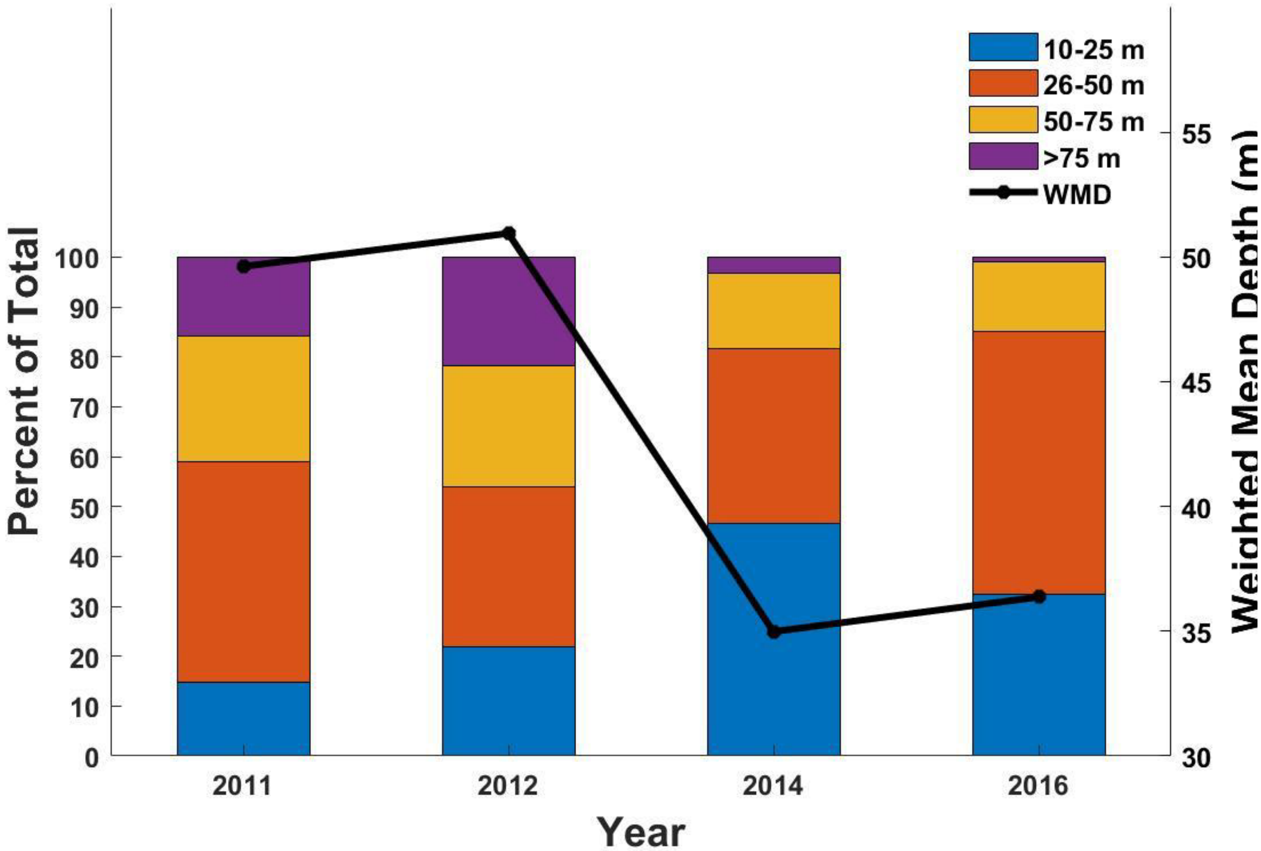

Figure 1. Depth distribution as percent of total abundance (fish nmi^{-2}) and weighted mean depth of age-0 pollock estimated by acoustic-trawl methods in 2011,2012, 2014,2016.

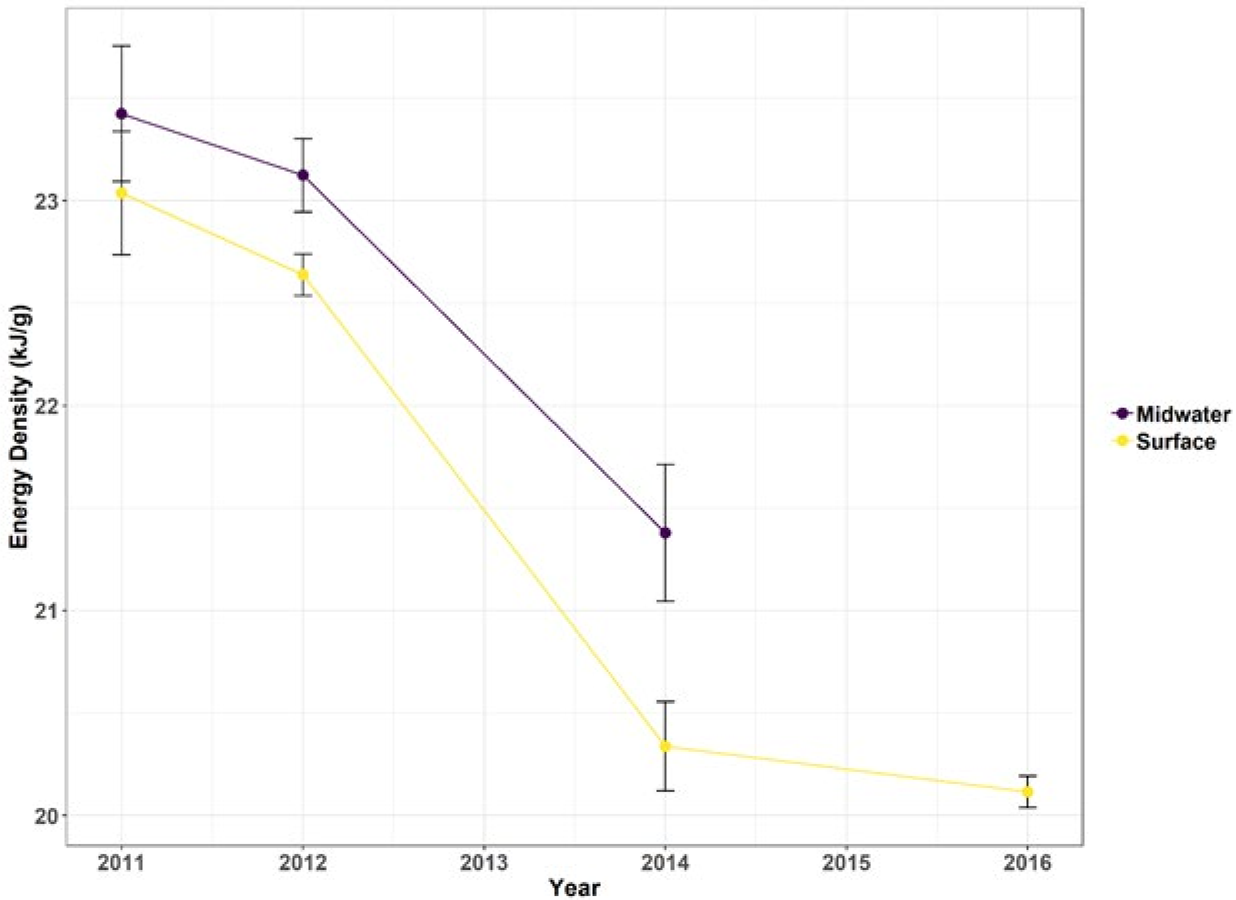

Figure 2. Energy density (± S.E.) for age-0 pollock caught in surface and midwater trawls.

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

For more information please contact Adam Spear at: Adam.Spear@noaa.gov or Alex Andrews.

Management strategies for the eastern Bering Sea pollock fishery with climate change -- ESSR
Recent studies indicate that rising sea surface temperature (SST) may have negative impacts on eastern Bering Sea walleye pollock stock productivity. A previous study (*Ianelli et al 2011 ICES J Mar Sci 68: 1297–1304*) developed projections of the pollock stock and alternative harvest policies for the species, and examined how the alternative policies perform for the pollock stock with a changing environment. The study, however, failed to evaluate quantitative economic impacts. The present study showcases how quantitative evaluations of the regional economic impacts can be applied with results evaluating harvest policy trade-offs; an important component of management strategy evaluations. In this case, we couple alternative harvest policy simulations (with and without climate change) with a regional dynamic computable general equilibrium (CGE) model for Alaska. In this example we found (i) that the status quo policy performed less well than the alternatives (from the perspective of economic benefit), (ii) more conservative policies had smaller regional output and economic welfare impacts (with and without considering climate change), and (iii) a policy allowing harvests to be less constrained performed worse in terms of impacts on total

regional output, economic welfare, and real gross regional product (RGRP), and in terms of variability of the pollock industry output. The results of this project are summarized in Seung and Ianelli (2017), which is currently under review / revision at a peer-reviewed journal. For further information, contact Chang.Seung@noaa.gov

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

2. Stock Assessment

Eastern Bering Sea (REFM)
Walleye pollock (Gadus chalcogrammus; hereafter referred to as pollock) are broadly distributed throughout the North Pacific with the largest concentrations found in the Eastern Bering Sea. Also known as Alaska pollock, this species continues to play important roles ecologically and economically. This is a mature assessment done annually with new catch, survey, and composition information.For the 2019 assessment this included data from the 2019 NMFS bottom-trawl (BTS) and acoustic-trawl (ATS) surveys as well as total catch through 2019. In addition, opportunistic acoustic data from vessels (AVO) conducting the 2019 BTS was used as an added index of pollock biomass in mid- water. Observer data for catch-at-age and average weight-at-age from the 2018 fishery were finalized and included.

Spawning biomass in 2008 was at the lowest level since 1981 but had increased by a factor of 2.52 by 2017, and has now started trending downward again. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent increases were fueled by recruitment from the very strong 2008, 2012, and 2013 year classes along with spawning exploitation rates below 20% since 2008. Spawning biomass is projected to be well above BMSY in 2020. The 2020 OFL is 4,273,000 t and the maximum ABC is 3,578,000 t.

In addition to the ecosystem considerations listed in the SAFE chapter, an appendix to the SAFE chapter describes a multi-species model ("CEATTLE") involving walleye pollock, Pacific cod, and arrowtooth flounder. The authors view this as a "strategic" model rather than a model that would be used for setting annual harvest specifications.

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

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

Bogoslof Island (REFM)
Assessments for Bogoslof-area pollock are performed in even years and the harvest recommendations are not revised in off years. Harvest recommendations for Bogoslof-area pollock are made by multiplying the biomass estimate from the NMFS acoustic-trawl survey by an estimate of natural mortality. The biomass estimate is made using a random effects model used widely in AFSC assessments. Natural mortality was re-evaluated using the age-structured model presented in previous assessments (unchanged except for new survey, fishery, and age composition data from the survey).

Between 1997 and 2016, biomass estimates varied between 508,051 t and 67,063 t. The most recent acoustic-trawl survey of the Bogoslof spawning stock was conducted in March of 2018 and estimated a biomass estimate of 663,070 t, resulting in a random-effects survey average of 610,267 t. Assuming FOFL = M = 0.3 and FABC = 0.75 x M = 0.225, OFL for 2020 is 183,080 t and the maximum permissible ABC for 2020 is 137,310 t.

Gulf of Alaska (REFM)

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

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

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

G. Pacific Whiting (hake)

There are no hake fisheries in Alaska waters.

H. Rockfish

1. Research

Rockfish Reproductive Studies - RACE GAP Kodiak

RACE groundfish scientists initiated a multi-species rockfish reproductive study in the Gulf of Alaska with the objective of providing more accurate life history parameters to be utilized in stock assessment models. Another goal of this project is to examine the variability of rockfish reproductive parameters over varying temporal and spatial scales. The analysis of maturity for three deep water rockfish species, blackspotted rockfish, *Sebastes melanostictus,* rougheye rockfish, *S. aleutianus,* and shortraker rockfish, *S. borealis,* has been complicated by the presence of a significant number of mature females that skip spawning. Additional data are needed to determine if skip spawning rates and other maturity parameters vary with time. Recent studies suggest variation in size and age at maturity may occur for the three most commercially important rockfish species, Pacific ocean perch, *S. alutus,* northern rockfish, *S. polyspinis,* and dusky rockfish *S. variabilis.* Researchers at the AFSC Kodiak Laboratory will be examining annual and spatial differences in reproductive parameter estimates of Pacific ocean perch and northern rockfish in the upcoming years. Sampling for this study was initiated in 2009 and opportunistically continues with the anticipation that sampling will be sustained at least through the 2021 reproductive season.

Northern and Dusky Rockfishes - RACE

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

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

Rougheye and blackspotted rockfish - RACE

The recent discovery that rougheye rockfish are two species, now distinguished as ‘true’ rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further highlights the need for updated reproductive parameter estimates for the members of this species complex. Current estimates for age and length at maturity for this complex in the GOA are derived from a study with small sample sizes, few samples from the GOA, and an unknown mixture of the two species in the complex. A critical step in improving the management of this complex is to understand the reproductive biology of the individual species that comprise it. This study re-examined the reproductive biology of rougheye rockfish and blackspotted rockfish within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Maturity analyses for these species and other deepwater rockfish species within this region are complicated by the presence of mature females that are skipped spawners. Results from this study indicate age and length at 50% maturity for rougheye rockfish are 19.6 years and 45.0 cm FL with 36.3% of mature females not developing or skip spawning. Samples of blackspotted rockfish were also collected and analyzed during this time period. This study found age and length at 50% maturity for blackspotted rockfish are 27.4 years and 45.3 cm FL with 94% of mature females collected for this study skip spawning. The analyses of these data is complicated by the presence of both skip spawning individuals within the sample as well as a large number of large and/or old immature individuals. More samples are needed to clarify the reproductive parameters of this species. These updated values for age and length at maturity have important implications for stock assessment in the GOA.

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

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

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

Shortraker rockfish - RACE

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

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

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

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

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

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

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

2. Assessment

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

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

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

Pacific Ocean Perch - Gulf of Alaska - ABL

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

Spawning biomass was above the $B_{40\%}$ reference point and projected to be 207,096 t in 2021 and to decrease to 198,179 t in 2022. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 126,814 t, 0.10, and 0.12, respectively. Spawning biomass for 2021 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier "a" of Tier 3. The 2021 and 2022 catches associated with the $F_{40\%}$ level of 0.10 are 36,177 t and 34,602 t, respectively, and were the authors' and Plan Team's recommended ABCs. The 2021 and 2022 OFLs are 42,977 t and 41,110 t.

A random effects model was used to set regional ABCs based on the proportions of model-based estimates for 2021: Western GOA = 1,643 t, Central GOA = 27,429 t, and Eastern GOA = 7,105 t. The Eastern GOA is further subdivided into west (called the West Yakutat subarea) and east (called the East Yakutat/Southeast subarea, where trawling is prohibited) of 140° W longitude using a weighting method of the upper 95% confidence of the ratio in biomass between these two areas. For W. Yakutat the ABC in 2021 is 1,705 t and for E. Yakutat/Southeast the ABC in 2021 is 5,400 t. The recommended OFL for 2021 is apportioned between the Western/Central/W. Yakutat area (45,003 t) and the E. Yakutat/Southeast area (6,414 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

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

Dusky Rockfish-- Gulf of Alaska - ABL

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

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

Northern Rockfish – Bering Sea and Aleutian Islands - REFM

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

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

Northern Rockfish - Gulf of Alaska - ABL

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

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

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

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

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

Shortraker Rockfish - - Bering Sea and Aleutian Islands - REFM

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

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

Shortraker Rockfish – Gulf of Alaska – ABL

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

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

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

Other Rockfish – BSAI – ABL

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

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

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

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

Other Rockfish – Gulf of Alaska – ABL

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

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

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

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

Blackspotted/rougheye Rockfish Complex – Bering Sea and Aleutian Islands - REFM
Fish previously referred to as rougheye rockfish are now recognized as consisting of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*). The current information on these two species is not sufficient to support separate assessments, so they are combined as a complex in one assessment.In 2005, BSAI rockfish were moved to a biennial assessment schedule with full assessments in even years to coincide with the occurrence of trawl surveys in the Aleutian Islands (AI) and the eastern Bering Sea (EBS) slope. In odd years, partial assessments include revised harvest recommendations. The 2020 maximum ABC is 817 t and the 2020 OFL is 675 t.

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

Blackspotted/rougheye Rockfish Complex – Gulf of Alaska - ABL

Rougheye (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) have been assessed as a stock complex since the formal verification of the two species in 2008. The GOA rougheye and blackspotted rockfish (RE/BS) complex is fully assessed as a Tier 3 stock in odd years to correspond with the GOA trawl survey. As an off-cycle assessment in 2020, only the projection model was run and no changes were made to the assessment model. New data in the 2020 assessment included updated 2019 catch and estimated 2020 and 2021 catches.

The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished. Female spawning biomass is estimated to be increasing and is projected to be 12,540 t in 2021 and 12,563 in 2022. These estimates are well above the $B_{40\%}$ reference point of 8,263 t, thereby placing RE/BS in sub-tier "a" of Tier 3. The 2021 and 2022

ABCs associated with the target $F_{40\%}$ of 0.040 are 1,212 t and 1,221 t, respectively. The recommended 2021 and 2022 OFLs are 1,456 t and 1,467 t.

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

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

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

I. Thornyheads

1. Research

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

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

2. Stock Assessment

Gulf of Alaska - ABL

The Gulf of Alaska (GOA) thornyhead complex are assessed on a biennial stock assessment schedule with a full stock assessment produced in even years and no stock assessment produced in odd years. For this on cycle year, we incorporated the 2019 and 2020 Relative Population Weights (RPWs) from the AFSC longline survey, the 2019 trawl survey biomass estimate, and updated catch. Gulf of Alaska thornyheads (Sebastolobus) are assessed as a stock complex under Tier 5 criteria in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, we continue to use a random effects (RE) model fit to the AFSC longline survey RPW index (1992 – 2020) and the AFSC bottom trawl survey biomass index (1984 – 2019), to estimate the exploitable biomass that is used to calculate the recommended ABC and OFL values for the 2021 fishery. Estimated thornyhead biomass is 86,802 t, which is a decrease of 3% from the 2018 estimate. The NPFMC's Tier 5 ABC definitions state that $F_{ABC} \leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 the recommended ABC is 1,953 t for the 2021 fishery. Gulfwide catch of thornyhead rockfish was 777 t in 2019 and 462 t in 2020. Thornyhead rockfish in the GOA are not being subjected to overfishing. It is not possible to determine whether this complex is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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

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

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

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

Juvenile Sablefish Studies – ABL

Juvenile (age-1) sablefish tagging studies have been conducted by the Auke Bay Laboratories in

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

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

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

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

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

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

Sablefish Point of No Return - RPP

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

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

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

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

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

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

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

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

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

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

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

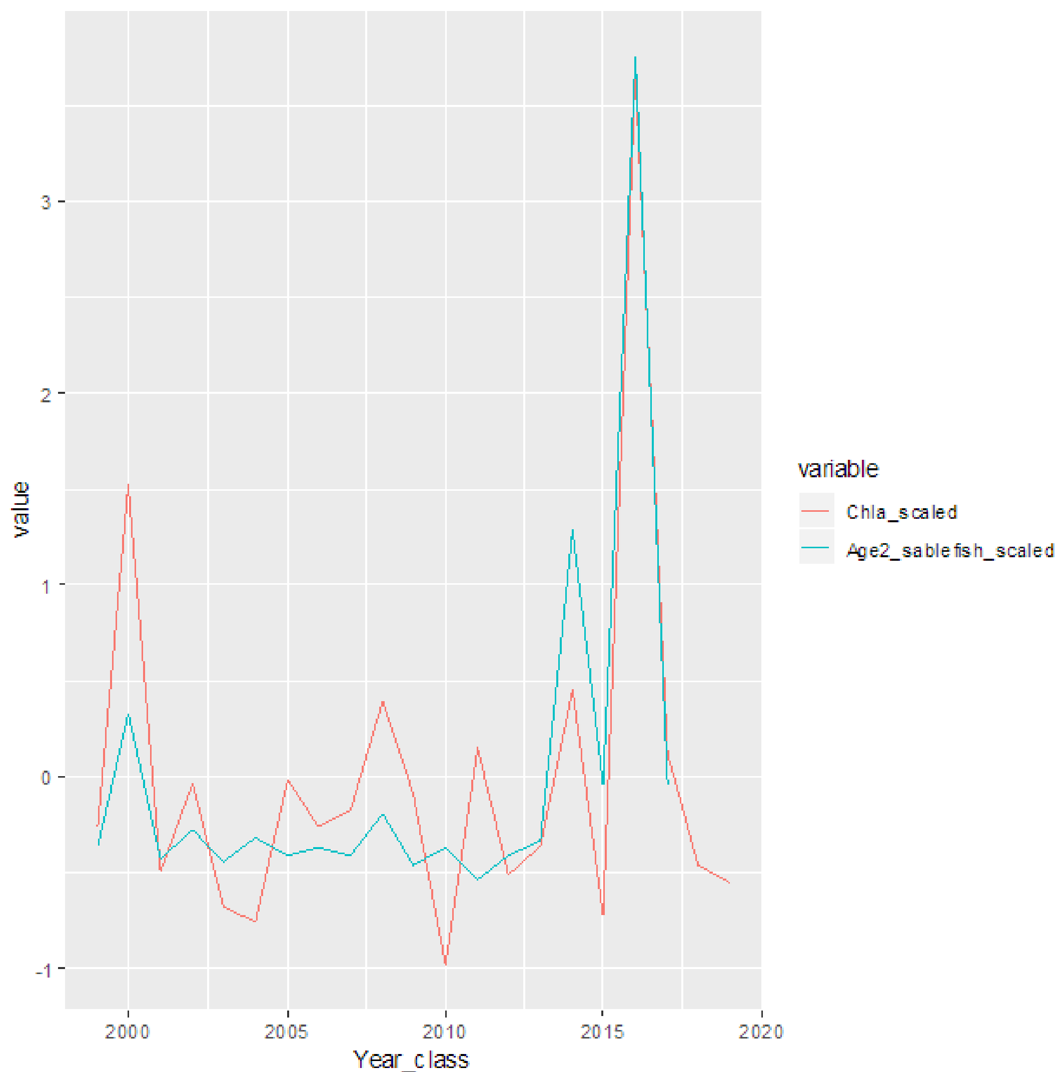

Figure 1. Scaled time series of age-2 sablefish lagged to year class 1999 to 2017 (Age2_sablefish_scaled) and scaled data for chlorophyll a sampled in Icy Straits during the Southeast Coastal Monitoring survey from 1999-2019 (Chla_scaled) during the age-0 life stage of sablefish.

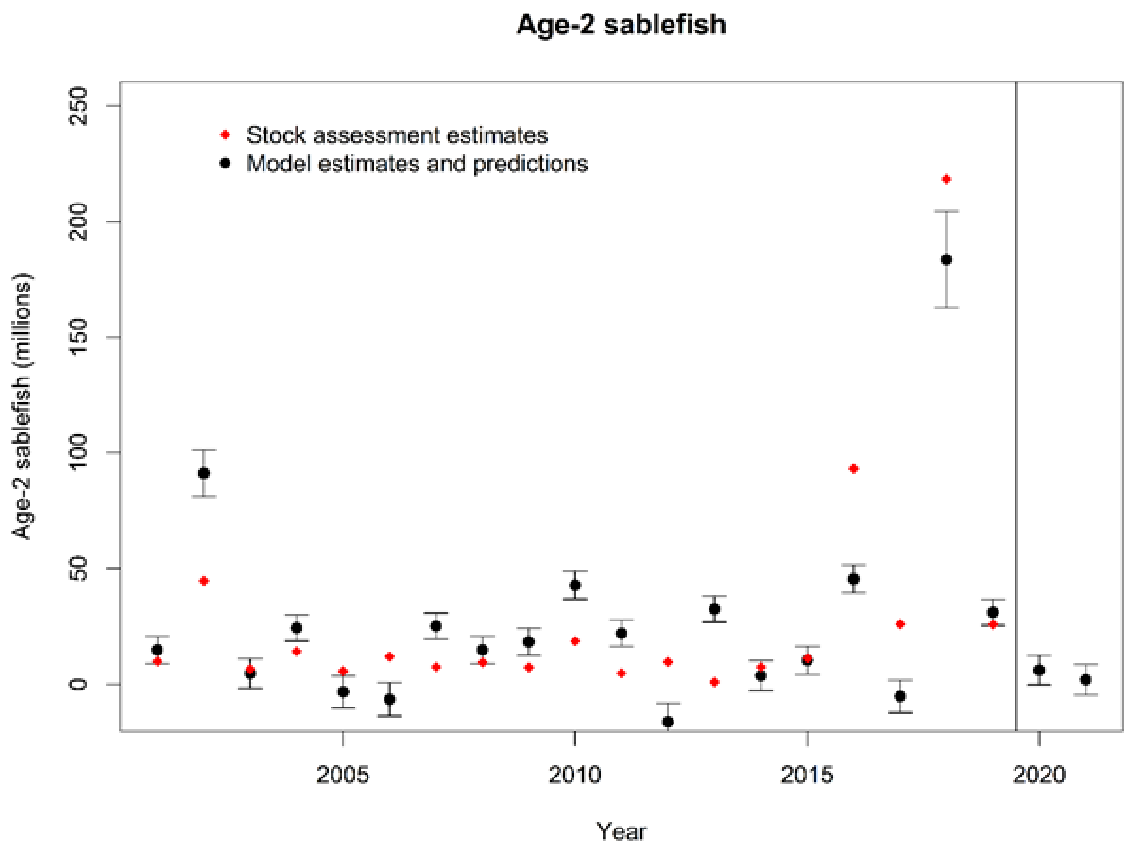

Figure 2. Stock assessment estatimes (2001-2019), model estimates (2001-2019), and the 2020 and 2021 predictions for age-2 Alaska sablefish. Stock assessment estimates of age-2 sablefish were modeled as a function of late August chlorophyll *a* levels in the waters of Icy Strait in northern southeast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

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Authors: Ellen Yasumiishi, Emily Fergusson, Kalei Shotwell, Dana Hanselman
For more information, contact Ellen Yasumiishi at ellen.yasumiishi@noaa.gov.

2. Stock Assessment

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

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

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

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

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

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

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

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

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

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

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

Coastwide research discussions for sablefish – ABL

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

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

IFQ Sablefish Release Allowance - NPFMC Initial Review - ABL

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

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

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

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

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

K. Lingcod

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

L. Atka Mackerel

1. Research

2. Stock Assessment

Bering Sea and Aleutian Islands - REFM
The BSAI Atka mackerel assessment uses the Assessment Model for Alaska (AMAK), a statistical catch-at-age-model. No changes to the base model were made this year. New data for 2019 included catch through 2019 (2019 projected) and 2018 fishery age compositions.

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

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

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

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

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

M. Flatfish

1. Research

Yellowfin sole and northern rock sole habitat - GAP

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

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

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

Northern rock sole and yellowfin sole growth potential-FBE RACE

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

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

2. Assessment

Yellowfin sole - Bering Sea and Aleutian Islands -REFM
The yellowfin sole fishery in the EBS is the largest flatfish fishery in the world. This stock is assessed using an age-structured population dynamics model implemented in the software program AD Model Builder. Survey catchability (*q*) has been shown to be linked to bottom water temperatures, so in the model *q* is estimated as a function of an included bottom temperature index. In 2019 a new model was introduced based on the 2018 model that retains female natural mortality fixed at 0.12 while allowing the model to estimate male natural mortality.

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

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

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

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

Greenland turbot - Bering Sea and Aleutian Islands - REFM

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

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

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

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

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

Arrowtooth flounder - Gulf of Alaska - REFM
The Gulf of Alaska (GOA) arrowtooth flounder stock is classified as a Tier 3 stock for setting the acceptable biological catch (ABC) and overfishing level (OFL). In accordance with the new assessment schedule frequency, we conducted a partial assessment for arrowtooth flounder in 2020. We use a statistical age-structured model as the primary assessment tool for arrowtooth flounder. For this off-cycle (even) year, we present a partial assessment consisting of an executive summary with recent fishery catch and survey trends as well as recommend harvest levels for the next two years. There were no changes made to the assessment model inputs since this was an off-cycle year. However, new data added to the projection model included an updated 2019 catch estimate and new catch estimates for 2020-2022. In on-cycle (odd) years, we will present a full stock assessment

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

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

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

Kamchatka flounder - Bering Sea and Aleutian Islands - REFM

Before 2011, Kamchatka flounder and arrowtooth flounder were managed in aggregate as a single stock. Due to the emergence of a directed Kamchatka flounder fishery and concerns about overharvesting, the stocks were separated in 2011. The BSAI Kamchatka flounder assessment is conducted in even years, with a partial update in odd years that includes revised harvest recommendations. For 2020, the OFL is 11,495 t and the maximum ABC is 9,708 t.

Northern rock sole - Bering Sea and Aleutian Islands - REFM

The vast majority of rock sole in the BSAI region is northern rock sole, and it is managed as a single stock. The stock is assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. No assessment was performed in 2019, s the 2020 ABC and OFL values are 143,700 t and 147,500 t, respectively. Recommended ABCs correspond to the maximum permissible levels. This is a stable fishery that lightly exploits the stock because it is constrained by PSC limits and the BSAI optimum yield cap. Usually the average catch/biomass ratio is about 3-4 percent.

Northern and southern rock sole - Gulf of Alaska - REFM

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

Flathead sole - Bering Sea and Aleutian Islands - REFM

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

Flathead sole - Gulf of Alaska - REFM

This assessment is conducted using Stock Synthesis on a four-year schedule. 2019 was an off-year thus a partial assessment was presented. The projection model was run using updated catches. The 2019 spawning biomass estimate was above B40% and projected to increase through 2020. Biomass (age 3+) for 2019 was estimated to be 283,285 t and projected to slightly decrease in 2020. For 2019, the authors' recommendation was to use the maximum permissible ABC of 38,196 t from the updated projection. The FOFL is set at F35% (0.36) which corresponds to an OFL of 46,572 t.

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

Alaska plaice - Bering Sea and Aleutian Islands - REFM
Alaska plaice are assessed biennially using an age-structured population dynamics model implemented in the software program AD Model Builder. The 2019 assessment indicated that above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002 have contributed to recent highs level of female spawning biomass. The Alaska plaice spawning stock biomass is projected to decline through 2023 while remaining above B35%. The recommended ABC for 2020 is 31,600 t based on an F40% = 0.125 harvest level, a 9% decrease from 2018. The 2020 overfishing level of 37,600 t is based on a F35% (0.15) harvest level.

Rex sole - Gulf of Alaska - REFM
This stock is on a four-year assessment cycle and a full assessment is due in 2021. In 2019 a partial assessment was conducted, with the projection model run using updated catches. The model estimates of female spawning biomass and total biomass (3+) for the eastern area is stable and the western area appears to be increasing slightly. The recommendations for 2019 are an ABC of 14,878 t and an OFL of 18,127 t.

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

"Other flatfish" complex - Bering Sea and Aleutian Islands - REFM
The BSAI "Other flatfish" complex includes all flatfishes not managed individually, but the primary species by abundance are starry flounder, rex sole, longhead dab, Dover sole, and butter sole. This complex is on a 4-year assessment cycle and a full assessment is due in 2020. Harvest recommendations are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL) and are not revised during off years. The ABC and OFL are calculated separately for rex sole, Dover sole, and a single group of all remaining species; these are then aggregated to produce a single set of recommendations for the complex. Survey data through 2018 indicate that the other flatfish species group is at a high level relative to the time series average and is lightly exploited. The resultant 2020 OFL and ABC are 21,824 t and 16,368 t respectively.

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

Shallow-water flatfish complex - Gulf of Alaska - REFM
The GOA shallow-water flatfish complex includes northern and southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole, and Alaska plaice. Northern and southern rock soles are assessed using an age-structured model; for the remaining species harvest recommendations are made using Tier 5 methods (OFL = F * biomass, where F=M; ABC = 0.75 * OFL). The ABCs and OFLs for all groups are aggregated to produce recommendations for the complex. The complex has been moved to a 4-year assessment cycle. A full assessment was conducted in 2017 and will be repeated in 2021. For 2019 a partial assessment was done, and the projection model for northern and southern rock sole was re-run to generate new harvest recommendations. The resultant 2020 OFL and ABC are 68,010 t and 55,463 t respectively. Area ABCs are apportioned based on random-effects model estimates of survey biomass.

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

Deep-water flatfish complex - Gulf of Alaska - REFM
The GOA deep-water flatfish complex includes Dover sole, Greenland turbot, and deepsea sole; Dover sole is the dominant species. Dover sole is assessed using Stock Synthesis, while Greenland turbot and deepsea sole recommendations are based on historical catch. The OFLs and ABCs for the individual species in the deepwater flatfish complex are determined and then summed for calculating a complex-level OFL and ABC. In 2019 a full assessment was conducted. Since Dover sole comprises approximately 98% of the deepwater flatfish complex they are considered the main component for determining the status of this stock complex. Catch levels for this complex remain well below the TAC and below levels where overfishing would be a concern. The 2020 OFL is 7,163 and 2020 ABC is 6,030 t, substantially lower than the previous full assessment.

N. <u>Pacific halibut</u>

1. Research

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

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

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

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

O. Other Groundfish Species

Other groundfish stocks assessed by the AFSC - REFM

In addition to the assessments described above, the AFSC assesses and provides harvest recommendations for an octopus complex in both the BSAI and GOA. These are non-target species and exploitation rates are low. In addition, the AFSC produces status reports for several species groups included in the FMPs as "Ecosystem Components". These are stocks for which there are not active conservation concerns, but which have ecosystem roles that warrant some level of monitoring. These groups currently include grenadiers, squids, and a diverse forage fish group (the osmerids capelin and eulachon, as well as Pacific sand lance, are the main species of interest). Sculpins are also included in the FMP as Ecosystem Components but receive no reports.

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

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

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

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

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

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

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

Participants were encouraged to contribute to the following topics:

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

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

Stan Kotwicki Challenges and priorities for WKUSER and beyond.

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

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

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

CONSERVATION ENGINEERING (CE)

The Conservation Engineering (CE) group of the NMFS Alaska Fisheries Science Center (AFSC) (Dr. Noëlle Yochum, lead) conducts cooperative research with Alaska fishing groups and other scientists to better understand and mitigate bycatch, bycatch mortality, and fishing gear impacts to fish habitat. This is done through the evaluation of fish biology and behaviour, and gear design and use. In 2020, CE research focused on evaluating a bycatch reduction device (BRD) designed to reduce Pacific salmon bycatch (primarily chum, Oncorhynchus keta, and Chinook, O. tshawytscha) in the eastern Bering Sea walleye pollock ("pollock", Gadus chalcogrammus) pelagic trawl fishery.

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

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

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

References:

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

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

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

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

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

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

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

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

seabed2030.gebco.net/).

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

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

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

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

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

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

Research on surveying untrawlable habitats-RACE MACE & GAP

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

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

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

- Acoustic-optics studies
- Experiments with stationary triggered cameras
- Mapping and habitat classification efforts

- Remotely operated vehicle surveys
- Studies of fish response to camera equipment and movement
- A study of fish visual spectrum sensitivity
- Research into computer automated image analyses

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

For more information contact: Kresimir Williams (Kresimir.williams@noaa.gov)

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

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

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

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

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

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

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

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

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

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

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

This study will address the Alaska Essential Fish Habitat (EFH) Research Plan's (referred to hereafter as the Research Plan) Research Priority #1 – *Characterize habitat utilization and productivity* (Sigler et al., 2017) by using the best available science to accomplish Objective #1 – *Develop EFH Level 1 information (distribution) for life stages and areas where missing* and

Objective #2 – *Raise EFH level from 1 or 2 (habitat-related densities) to Level 3 (habitat-related growth, reproduction, or survival rates)*. We will characterize habitat utilization and productivity by generating spatial predictions of EFH from habitat-based species distribution models (SDMs) of North Pacific Fishery Management Plan (FMP) species' life stages where additional data sources (e.g., presence, presence-absence, and abundance data, updated life history schedules, and updated habitat covariate rasters) and advances in EFH information levels (e.g., availability of additional species response data and habitat-related vital rates) meet the two Research Plan objectives above. For Objective #1, we will develop EFH maps for FMP species' life stages that were not described in the 2015 EFH review because there were insufficient or no data to support modeling efforts at that time, but for which sufficient data currently exist and new data sources have been identified (e.g., small mesh trawl surveys). For Objective #2, we will raise EFH information Level 1 (L1) or Level 2 (L2) to Level 3 (L3) by integrating habitat-related vital rates generated from field and laboratory studies into updated, model-based EFH maps for those species. In addition to meeting these Research Plan objectives, we will introduce alternative SDM approaches for describing EFH both to incorporate new data sources and to optimize our modeling approaches through skill testing and simulation.

Ned Laman (RACE Division, AFSC, Seattle, WA), Jodi Pirtle (Alaska Regional Office, Juneau, AK), Chris Rooper (DFO Canada, Nanaimo, B.C.), Tom Hurst (FBEP, AFSC, Newport, OR)

At-Sea Backdeck Electronic Data Entry--GAP

The RACE groundfish group has been working on an effort to digitally record their survey data as it is collect on the back deck of survey vessels. This new method will eventually replace the original method of recording biological sampling data on paper forms (which then needed to be transcribed to a digital format at a later time). This effort has involved the development of in-house Android applications. These applications are deployed on off-the-shelf Android tablets.

The first application developed was a length recording app, which replaced the obsolete and unsustainable "polycorder" devices already in use. The "Length App" is now used on all groundfish surveys. A specimen collection app was deployed in 2017 and is now used on all survey vessels in 2019. A new "At Sea" editing application will be tested at sea in 2021.

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

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

Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2020. Duane Stevenson recently published a study of the population structure and demographic history of the pelagic smooth lumpsucker (Okazaki, Stevenson, and others, 2020), and has a taxonomic revision of the agonid genus *Pallasina* in press (Stevenson, Orr, and Kai). Jay Orr, along with Stevenson and others, published descriptions of two new species of snailfishes of the genus *Careproctus* (Orr, 2020; Orr et al., 2020), and has another paper describing three more new species in press. He continues to collaborate with Jenny Gardner and Luke Tornabene of the University of Washington on the description of two additional species of *Careproctus*. Orr also contributed to the description of a new species of the snailfish genus *Elassodiscus* (Kai et al., 2020) from the western North Pacific and Bering Sea. Orr and Sharon Wildes are continuing their work on sandlances by including Atlantic species in a global analysis and conducting more detailed population-level studies in the eastern and western Pacific. Similarly, they are collaborating on a study of capelin and in particular on the taxonomic status of the Gulf of Alaska populations. Continuing progress has also been made in examining morphological variation related to recently revealed genetic heterogeneity in rockfishes (*Sebastes crameri*; Orr, with NWFSC) and flatfishes (*Hippoglossoides*; Orr, Stevenson, Spies, Paquin, Raring, and Kai).

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

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

2020 Publications:

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

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

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

Okazaki, T., D. E. Stevenson, Y. Kai, Y. Ueda, T. Hamatsu, and Y. Yamashita. 2020. Genetic population structure and demographic history of a pelagic lumpsucker, *Aptocyclus ventricosus*. Environmental Biology of Fishes 103:283-–289.

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

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

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

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

Spies, I., K. Gruenthal, D. Drinan, A. Hollowed, D. Stevenson, C. Tarpey, and L. Hauser. 2020. Genetic evidence of a northward range expansion in the eastern Bering Sea stock of Pacific cod. Evolutionary Applications 13:362–375.

Spies, I., J. W. Orr, P. Goddard, G. R. Hoff, D. E. Stevenson, M. Hollowed, C. Rooper, and J. Guthridge. In press. A mosaic of genetic diversity in skate egg case nursery sites and adults in the Bering Sea. *Marine Ecology Progress Series*, 30 ms pp.

Stevenson, D. E., J. W. Orr, and Y. Kai. In press. Revision of the tubenose poacher genus *Pallasina* Cramer (Perciformes: Cottoidei: Agonidae). Ichthyology and Herpetology

V. Ecosystem Studies

Ecosystem and Socioeconomic Profiles (ESP) – REFM

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

Over the past several years, we have developed a new standardized framework termed the Ecosystem and Socioeconomic Profile or ESP that facilitates the integration of ecosystem and socioeconomic factors within the stock assessment process and acts as a proving ground for use in management advice (Shotwell et al., 2020). The ESPs are a commitment to a process that allows for creating a proactive strategy in response to change. Here we are building on the rich history of identifying ecosystem pressures on stocks in the Alaska region and designing a research template that tests these linkages for providing advice. The ESPs serve as a corollary stock-specific process to the large-scale ecosystem status reports, effectively creating a two-pronged system for ecosystem based fisheries management at the AFSC.

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

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

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

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

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

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Shotwell, S.K., K., Blackhart, C. Cunningham, B. Fissel, D., Hanselman, P., Lynch, and S., Zador. In Review. Introducing the Ecosystem and Socioeconomic Profile, a national framework for including stock-specific ecosystem and socioeconomic considerations within next generation stock assessments. Frontiers in Marine Science or Marine Policy (Anticipated submission 2021)

2020 Groundfish ESPs:
Shotwell, S.K., S. Barbeaux, B. Ferriss, B. Fissel, B. Laurel, and L. Rogers. 2020. Ecosystem and socioeconomic profile of the Pacific cod stock in the Gulf of Alaska. Appendix 2.1 In Barbeaux, S., B. Ferriss, W. Palsson, S.K. Shotwell, I. Spies, M. Wang, and S. Zador. 2020. Assessment of the Pacific cod stock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Mngt. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. Pp. 144-183. Available online: https://archive.fisheries.noaa.gov/afsc/refm/stocks/plan_team/2020/GOApcod.pdf

Shotwell, S.K., M. Dorn, A. Deary, B. Fissel, L. Rogers, and S. Zador. 2020. Ecosystem and socioeconomic profile of the walleye pollock stock in the Gulf of Alaska. Appendix 1A In Dorn, M.W., A.L. Deary, B.E. Fissel, D.T. Jones, M. Levine, A.L. McCarthy, W.A. Palsson, L.A. Rogers, S.K. Shotwell, K.A. Spalinger, K. Williams, and S.G. Zador. 2020. Assessment of the walleye pollock stock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Mngt. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. Pp. 104-135. Available online: https://archive.fisheries.noaa.gov/afsc/refm/stocks/plan_team/2020/GOApollock.pdf

Shotwell, S.K., D. Goethel, A. Deary, K. Echave, K. Fenske, B. Fissel, D. Hanselman, C. Lunsford, K. Siwicke, and J. Sullivan. 2020. Ecosystem and socioeconomic profile of the Sablefish stock in Alaska. Appendix 3C In D.R. Goethel, D.H., Hanselman, C.J. Rodgveller, K.H. Fenske, S.K. Shotwell, K.B. Echave, P.W. Malecha, K.A. Siwicke, and C.R. Lunsford. 2020. Assessment of the Sablefish stock in Alaska. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea Aleutian Islands and Gulf of Alaska. North Pacific Fishery Management Council, 1007 W 3rd Ave, Suite 400 Anchorage, AK 99501. Pp. 190-218. Available online: https://archive.fisheries.noaa.gov/afsc/refm/stocks/plan_team/2020/sablefish.pdf

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2020 Crab ESPs:
Fedewa, E., B. Garber-Yonts, K. Shotwell. 2020. Ecosystem and Socioeconomic Profile of the Bristol Bay Red King Crab stock. Appendix E. In J. Zheng and M.S.M. Siddeek. 2020. Bristol Bay Red King Crab Stock Assessment in Fall 2020. Stock assessment and fishery evaluation report for the Bering Sea/Aleutian Islands king and Tanner crabs. North Pacific Fishery Management Council, 1007 W 3rd Ave, Suite 400 Anchorage, AK 99501. 31 p. Available online: https://meetings.npfmc.org/CommentReview/DownloadFile?p=ea0403bc-6544-4241-bf8c-b9c7a8ebf17d.pdf&fileName=SAFE_2020_App_E_BBRKC_ESP_2020.pdf

Fedewa, E., B. Garber-Yonts, K. Shotwell. 2020. Ecosystem and Socioeconomic Profile of the Saint Matthew Blue King Crab stock. Appendix F. In K. Palof, J. Zheng, and J. Ianelli. 2020. Saint Matthew Island Blue King Crab Stock Assessment 2020. Stock assessment and fishery evaluation report for the Bering Sea/Aleutian Islands king and Tanner crabs. North Pacific Fishery Management Council, 1007 W 3rd Ave, Suite 400 Anchorage, AK 99501. 14 p. Available online: https://meetings.npfmc.org/CommentReview/DownloadFile?p=f82852c5-2b1f-44a3-90c8-159b269077d6.pdf&fileName=SAFE_2020_App_F_SMBKC_ESP_2020_Exec_Summ.pdf

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

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

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

Project activities

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

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

Resource Ecology and Ecosystem Modeling Program (REEM)

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

Ecosystem Status Report 2020: The Status of Alaska's Marine Ecosystems (REFM)
The status of Alaska's marine ecosystems is presented annually to the North Pacific Fishery Management Council as part of the Stock Assessment and Fishery Evaluation (SAFE) report. There are separate reports for each of four ecosystems: the eastern Bering Sea, Aleutian Islands, Gulf of Alaska, and the Arctic. Comprehensive environmental data are gathered from a variety of sources. The goal of these Ecosystem Considerations reports is to provide the Council and other readers with an overview of marine ecosystems in Alaska through ecosystem assessments and by tracking time series of ecosystem indicators. This information provides ecosystem context to the fisheries managers' deliberations. The reports are now available online at: https://www.fisheries.noaa.gov/alaska/population-assessments/2020-north-pacific-groundfish-stock-assessments#ecosystem-status-reports.

Groundfish Stomach Sample Collection and Analysis - REFM

The REEM Program continues regular collection of food habits information on key fish predators in Alaska's marine environment. Much of this information comes from samples collected during standard assessment surveys, most of which were canceled in 2020 due to the pandemic. As a results, no stomach samples were collected by REEM in 2020.

Online sources for REEM data on food habits and fish ecology

- Accessibility and visualization of the predator-prey data through the web can be found at http://www.afsc.noaa.gov/REFM/REEM/data/default.htm.
- The predator fish species for which we have available stomach contents data can be found at http://access.afsc.noaa.gov/REEM/WebDietData/Table1.php.
- Diet composition tables have been compiled for many predators and can be accessed, along with sampling location maps at http://access.afsc.noaa.gov/REEM/WebDietData/DietTableIntro.php.
- The geographic distribution and relative consumption of major prey types for Pacific cod, walleye pollock, and arrowtooth flounder sampled during summer resource surveys can be found at http://www.afsc.noaa.gov/REFM/REEM/DietData/DietMap.html.
- REEM also compiles life history information for many species of fish in Alaskan waters, and this information can be located at http://access.afsc.noaa.gov/reem/lhweb/index.php.

Economics and Social Sciences Research (ESSR)

Annual economic SAFE report - ESSR

The ESSR program annually produces an economic counterpart to the stock assessment and fishery evaluation reports (SAFE) published by the North Pacific Fishery Management Council (NPFMC). Published as an appendix to the omnibus SAFE document (https://www.fisheries.noaa.gov/alaska/population-assessments/2020-north-pacific-groundfish-stock-assessments), the Economic Status Report presents summary statistics on catch, discards, prohibited species catch, ex-vessel and first- wholesale production and value, participation by small entities, and effort in these fisheries. Because of the lag in data availability and ensuing analysis, the 2020 Economic SAFE largely focuses on the results of the fisheries in 2019. The economic SAFE is summarized briefly below; the full document is available at: https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/econGroundfishSafe.pdf.

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

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

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

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

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

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

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

VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

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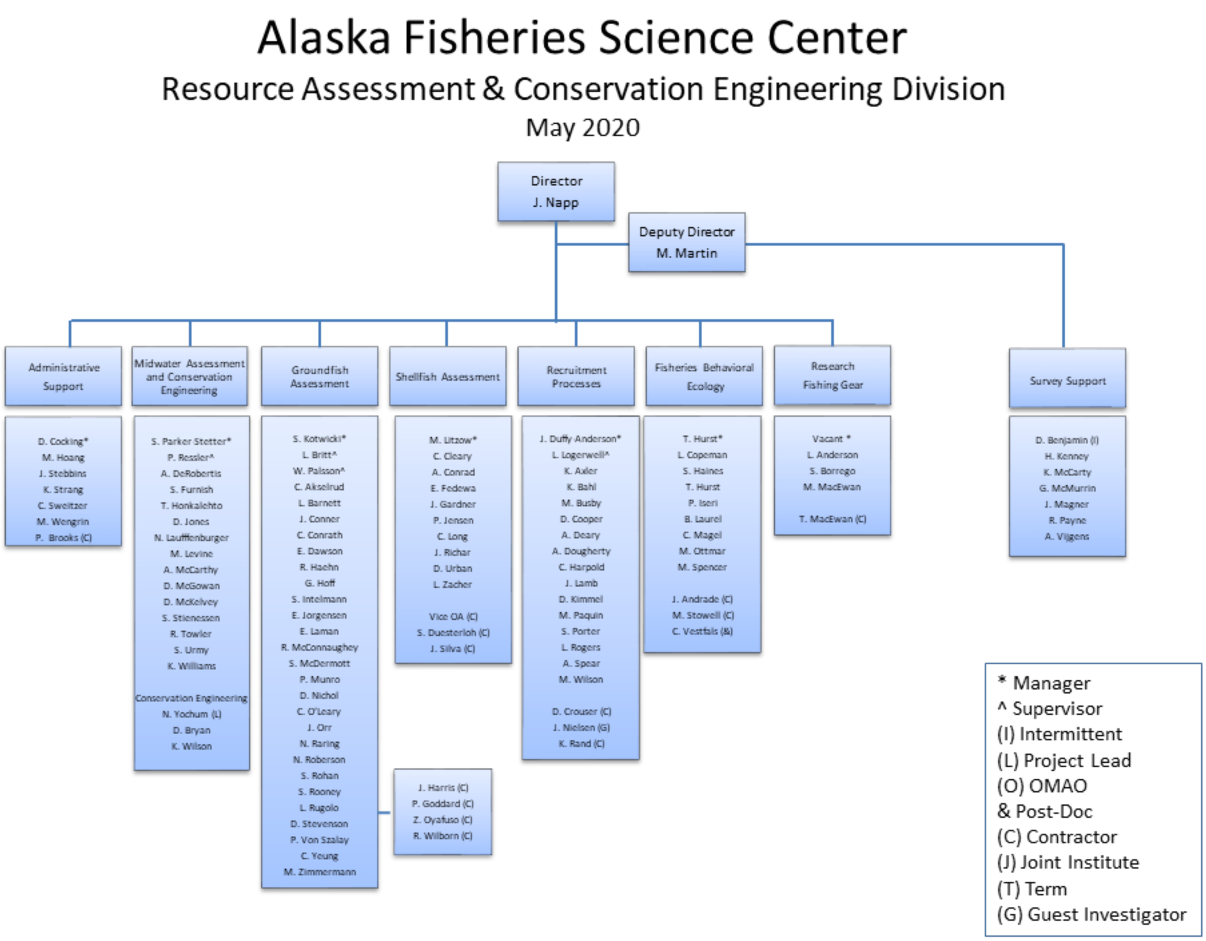
APPENDIX I. RACE ORGANIZATION CHART



APPENDIX II. REFM ORGANIZATION CHART

Division Director
Ron Felthoven

Deputy Director
Stephani Zador

Status of Stocks and Multispecies Assessment (SSMA)

Anne Hollowed (PM)

FTEs

A Hollowed (S/RO)	S Lowe (S/RO)
J Ianelli	M Bryan
M Dorn	O Ormseth
G Thompson	I Spies
S Barbeaux	C McGilliard
P Spencer	C Monnahan
W Stockhausen	K Shotwell
C Szuwalski	

Contractors, postdocs, etc

A Havron
C Tarpay
E Bors
M Olmos
M Veron

Resource Ecology and Ecosystems Modeling (REEM)

Kerim Aydin (PM)

FTEs

K Aydin (S/RO)
J Reum
S Fitzgerald
K Holsman
G Lang
M Yang
B Ferriss

Contractors, postdocs, etc

R Hibpshman	S Wang
K Kearny	
I Ortiz	
A Whitehouse	
G Carroll	
K Dill	
K Gunther	

Economics and Social Science Research (ESSR)

Stephen Kasperski (PM)

FTEs

S Kasperski (S/RO)	M Szymkowiak
M Dalton	
B Fissel	
B Garber-Yonts	
A Haynie	
D Lew	
C Seung	
S Wise	

Contractors, postdocs, etc

B Huang	M Rhodes-Reese
S Devereaux	
A Faig	
M Harsh	
J Lee	
K Sparks	
B McManus	

Age and Growth Program (AG)

Thomas Helser (PM)

FTEs

T Helser (S/RO)	Anderl (S/RO)
I Benson	C Hutchinson
B Matta	J Pearce
C Kastelle	K Stone
J Short	J Brogan
T TenBrink	C Gburski
S Neidetcher	C Piston
E. Goldstein	D Nadjkovic

Contractors, postdocs, etc

B Groom
M Arrington
J Healy

Admin (supports RACE and REFM)

Dona Cocking (S/PM)

FTEs

M Hoang
K Strang
J Stebins
C Sweitzer
M Wengrin

Contractors, etc

P Brooks

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

APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART

LABORATORY DIRECTOR
Hanselman

MESA	RECA	EMA	GENETICS	OM	FACILITIES
MARINE ECOLOGY & STOCK ASSESSMSENT PROGRAM	RECRUITMENT, ENERGETICS & COASTAL ASSESSMENT PROGRAM	ECOSYSTEM MONITORING & ASSESSMENT PROGRAM	GENETICS PROGRAM	OPERATIONS MANAGEMENT PROGRAM	FACILITIES PROGRAM
LUNSFORD (PM)	VICE HEINTZ (PM)	FARLEY (PM)	LARSON (PM)	HAGEN DD (PM)	COOPER (PM)

MESA

Malecha (S/RO)	Lunsford (S/RO)
Dimond (T)	Fenske
Echave	Goethel
Hulson	Malecha
Siwicke	Rodgveller
Vice stock assess	Tribuzio
Contractor	Williams
Jeans	Contractor
Koyuk	Stone (V)

RECA

Vice Heintz (S/RO)	Miller (S/RO)
Vice Brawshaw	Fergusson
Lindeberg	Vice Fugate
Maselko	Vice Holland
Miller T	Jarvis
Moran	Masuda
Sewall	Miller K
Suryan (T)	Rogers
Vollenweider	Masterman (St)
Contractor	Contractor
King	Cormack
Licht	Platt
Neff	
Sreenivasan	

EMA/SOEBA

Farley (S/RO)	Gray (S/RO)
Andrews	Eiler
Cieciel	★ Foley (T)
✚Eisner	Murphy
Gray (S/RO)	Russel
Gann	Waters
Moss	Watson
Siddon	Vulstek
Strasburger	Contractor
Yasumiishi	Landback
Contractor	Hughes
Grange (V)	
Nicolls	

GENETICS

Larson (S/RO)
D'Amello
Guthrie
Kondzela
Nguyen
Wildes
Whittle
D'Amello
Contractor
Karpan

ADMIN

Hagen (S/RO)
Cooper
Vice Johnston
Jones
Mahle
Piotrowski
Williams -OFIS
Contractor
Bornemann -OFIS
Prabhu -OFIS
Wheeler

FACILITIES

Cooper (PM/S/RO)
Anderson
Reynolds
★Wall
Weinlaeder
Contractor
Heckler
Mattson

ABBREVIATIONS

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

ABL Organization Totals	
FTE	64
Contractors	26
Volunteer	2
TOTAL Active	**92**
VICE	3

FACILITIES

TSMRI
★ Little Port Walter Marine Station
✪ Auke Creek Research Station
✗ Pribilof/St Paul /St. George Islands
✚ Bldg 4, Sand Point, Seattle
● Juneau Support

CODES

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

F/AKC4✤ **AUKE BAY LABORATORIES ORGANIZATIONAL CHART** **■ FS7400**
March 8, 2019

APPENDIX IV – FMA ORGANIZATIONAL CHART