Alaska Fisheries Science Center of the National Marine Fisheries Service

2015 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

April 2016

Compiled by Wayne Palsson, Tom Wilderbuer, and Jon Heifetz

VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2015

I. Agency Overview

Essentially all groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, the Fisheries Monitoring and Analysis (FMA) Division, and the Auke Bay Laboratories (ABL). The RACE and REFM Divisions are divided along regional or disciplinary lines into a number of programs and tasks. The FMA Division performs all aspects of observer monitoring of the groundfish fleets operating in the North Pacific. The ABL conducts research and stock assessments for Gulf of Alaska and Bering Sea groundfish. All Divisions work closely together to accomplish the missions of the Alaska Fisheries Science Center. A review of pertinent work by these groups during the past year is presented below. A list of publications pertinent to groundfish and groundfish issues is included in Appendix I. Yearly lists of publications and reports produced by AFSC scientists are also available on the AFSC website at [http://www.afsc.noaa.gov/Publications/yearlylists.htm](http://www.afsc.noaa.gov/Publications/yearlylists.htm), where you will also find a link to the searchable AFSC Publications Database.

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

A. RACE DIVISION

The core function of the Resource Assessment and Conservation Engineering (RACE) Division is to conduct quantitative fishery surveys and related ecological and oceanographic research to measure and describe the distribution and abundance of commercially important fish and crab stocks in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska and to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat. The staff is comprised of fishery and oceanography research scientists, geneticists, pathobiologists, technicians, IT Specialists, fishery equipment specialists, administrative support staff, and contract research associates. The status and trend information derived from both regular surveys and associated research are analyzed by Center stock assessment scientists and supplied to fishery management agencies and to the commercial fishing industry. RACE Division Programs include Fisheries Behavioral Ecology, Groundfish Assessment Program (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes, Shellfish Assessment Program (SAP), and Research Fishing Gear/Survey Support. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.
In 2015 one of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish 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). Two Alaskan bottom trawl surveys of groundfish and invertebrate resources were conducted during the summer of 2015 by RACE Groundfish Assessment Program (GAP) scientists: the annual Eastern Bering Sea Shelf Bottom Trawl Survey, and the biennial Gulf of Alaska Bottom Trawl Survey.

RACE scientists of the Habitat Research Team (HRT) continue 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, investigating activities with potentially adverse effects on EFH, such as bottom trawling, and benthic community ecology work to characterize groundfish habitat requirements and assess fishing gear disturbances.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock abundance during the summer in the Gulf of Alaska as well as winter acoustic trawl surveys in the Gulf of Alaska. Research cruises investigating bycatch issues also continued.

For more information on overall RACE Division programs, contact acting Division Director Jeffrey Napp at (206)526-4148.

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. Specifically, REFM's activities are organized under the following Programs: Age and Growth Studies, Economics and Social Sciences Research, Resource Ecology and Ecosystem Modeling, and Status of Stocks and Multispecies Assessment. REFM scientists prepare stock assessment documents for groundfish and crab stocks in the two management regions of Alaska (Bering Sea/Aleutian Islands and Gulf of Alaska), conduct research to improve the precision of these assessments, and provide management support through membership on regional fishery management teams.

For more information on overall REFM Division programs, contact Division Director Ron Felthoven at (206) 526-4114.

C. AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL’s Marine Ecology and Stock Assessment Program (MESA) is the primary group at ABL involved with groundfish activities. Major focus of the MESA Program is on research and assessment of sablefish, rockfish, and sharks in Alaska and studies on benthic habitat. Presently, the program is staffed by 13 scientists and 2 post docs. ABL’s Ecosystem Monitoring and Assessment Program (EMA) and Recruitment Energetics and Coastal
Assessment Program (RECA) also conduct groundfish-related research.

In 2015 field research, ABL’s MESA Program, in cooperation with the AFSC’s RACE Division, conducted the AFSC’s annual longline survey in Alaska. Other field and laboratory work by ABL included: 1) continued juvenile sablefish studies, including routine tagging of juveniles and electronic archival tagging of a subset of these fish; 2) satellite tagging and life history studies of spiny dogfish and sablefish; 3) recompression experiments on rougheye and blackspotted rockfish; 4) age of maturity and reproductive of sablefish; 5) large-scale, integrated ecosystem surveys of Alaska Large Marine Ecosystems (LME) including the Gulf of Alaska, southeastern Bering Sea and northeastern Bering Sea conducted by the EMA Program and; 6) analysis of juvenile groundfish collected on AFSC surveys to assess their growth, nutritional condition and trophodynamics conducted by the RECA Program.


For more information on overall programs of the Auke Bay Laboratories, contact Laboratory Director Phil Mundy at (907) 789-6001 or phil.mundy@noaa.gov.

D. FMA DIVISION

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

For further information or if you have questions about the North Pacific Groundfish and Halibut Observer Program please contact Chris Rilling, (206) 526-4194.

II. Surveys

2015 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP

The thirty-fourth in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 3 August 2015 aboard the AFSC chartered fishing vessels Vesteraalen and Alaska Knight, which together bottom trawled at 376 stations over a survey area of 492,898 km². Researchers processed and recorded the data from each trawl catch by
identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. Supplementary biological and oceanographic data collected on the bottom trawl survey was also collected to improve understanding of life history of the groundfish and crab species and the ecological and physical factors affecting their distribution and abundance.

Survey estimates of total biomass on the eastern Bering Sea shelf for 2015 were 6.3 million metric tons (t) for walleye pollock, 1.1 million t for Pacific cod, 1.93 million t for yellowfin sole, 1.41 million t for northern rock sole, 25.2 thousand t for Greenland turbot, and 172 thousand t for Pacific halibut. There were decreases in estimated survey biomass for most major fish taxa compared to 2014 levels. Walleye pollock biomass decreased 14%, arrowtooth flounder 12%, yellowfin sole 23%, northern rock sole 24%, for Alaska plaice 21%, and Greenland turbot 10%. There was little or no change in the biomass (<1%) for Pacific cod and Pacific halibut (0.5%).

The summer 2015 survey period was warmer than the long-term average for the second consecutive year. The mean bottom temperature was 3.4°C, which was only slightly warmer than 2014 (3.2°C); however, the mean surface temperature was 7.2°C, which was a full degree lower than 2014 (8.2°C).

For further information, contact Robert L. Lauth, (206)526-4121, Bob.Lauth@noaa.gov.

2015 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska – RACE GAP

The National Marine Fisheries Service Alaska Fisheries Science Center (AFSC) Resource Assessment and Conservation Engineering (RACE) Division chartered the fishing vessels Alaska Provider, Cape Flattery, and Sea Storm to conduct the 2015 Gulf of Alaska Biennial Bottom Trawl Survey of groundfish resources. This was the fourteenth survey in the series which began in 1984, was conducted triennially for most years until 1999, and then biennially since. Two vessels were chartered for 79 days, and the F/V Cape Flattery was chartered for 60 days. The cruise originated from Dutch Harbor, Alaska on May 19th and concluded at Ketchikan, Alaska on August 18th. After the vessels were loaded and other preparations (e.g., wire measuring, wire marking, and test towing) were made before the first survey tows were conducted on 26 May. The vessels surveyed from the Island of Four Mountains (170° W longitude) proceeded eastwards through the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern management areas (Figure 1). Sampled depths range from approximately 15 to 1000 m. The cruise was divided into four legs with breaks in Sand Point, Kodiak, and Seward to change crews and re-provision.

A primary objective of this survey is to continue the data time series begun in 1984 to monitor trends in distribution and abundance of important groundfish species. During these surveys, we measure a variety of physical, oceanographic, and environmental parameters while identifying and enumerating the fishes and invertebrates collected in the trawls. Specific objectives of the 2015 survey include: define the distribution and estimate the relative abundance of principal groundfish and important invertebrate species that inhabit the Aleutian archipelago, measure biological parameters for selected species, and collect age structures and other samples. We also conducted a number of special studies and collections for investigators both from within the AFSC and from elsewhere.

The survey design is a stratified-random sampling scheme based 54 strata of depths and regions and applied to a grid of 5x5 km² cells. Stations that were previously identified as untrawlable were
excluded from the sampling frame. Stations were allocated amongst the strata using a Neyman scheme weighted by stratum areas, cost of conducting a tow, past years’ data, and the ex-vessel values of key species. Stations were sampled with the RACE Division’s standard four-seam, high-opening Poly Nor’Eastern survey trawl equipped with rubber bobbin roller gear. This trawl has a 27.2 m headrope and 36.75 m footrope consisting of a 24.9 m center section with adjacent 5.9 m “flying wing” extensions. Accessory gear for the Poly Nor’Eastern trawl includes 54.9 m triple dandylines and 1.8 × 2.7 m steel V-doors weighing approximately 850 kg each. The charter vessels conducted 15-minute trawls at pre-assigned stations. Catches were sorted, weighed, and enumerated by species. Biological information (sex, length, age structures, individual weights, stomach contents, etc.) were collected for major groundfish species. Specimens and data for special studies (e.g., maturity observations, tissue samples, photo vouchers) were collected for various species, as requested by researchers at AFSC and other cooperating agencies and institutions. Specimens of rare fishes or invertebrates, including corals, sponges, and other sessile organisms were collected on an opportunistic basis.

Biologists completed 772 of 800 planned stations in the entire shelf and upper slope to a depth of 1000 m. Biologists collected 213 fish taxa that weighed 496,632 kg and numbered 885,191 individuals. There were 535 invertebrate taxa collected that weighed a total of 12,635 kg. During the 2015 survey, biologists collected 117 taxa of fish and invertebrates as 231 vouchered lots for identification, permanent storage, or other laboratory studies (see table below). Other collected samples included over 13,100 otoliths for ageing, special collections for ecological studies, and others samples for life history characterization. A validated data set was finalized on 30 September (http://dragonfish.afsc.noaa.gov/RACE/groundfish/survey_data/), and final estimates of abundance and size composition of managed species and species groups were delivered to Groundfish Plan Team of the NPFMC. The survey data and estimates are also available through the AKFIN system (www.psmfc.org). The Plan Team incorporated these survey results directly into Gulf of Alaska stock assessment and ecosystem forecast models that form the basis for groundfish harvest advice for ABCs and TAC for 2015.

For further information contact Wayne Palsson (206) 526-4104, Wayne.Palsson@noaa.gov
Figure 1. Occupied stations during the 2015 Gulf of Alaska Biennial Bottom Trawl Survey.

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

Two AT surveys of walleye pollock (*Gadus chalcogrammus*) were conducted. The first (cruise DY2015-02) surveyed the Shumagin Islands area (comprised of Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Sanak Trough, and the Kenai Peninsula Bays (i.e., Resurrection Bay, Day Harbor, Port Bainbridge, Aialik Bay, Harris Bay, Nuka Bay, Nuka Passage, Port Dick). The Shumagin Islands area and Sanak Trough were surveyed on 13, 20-24 February, and the Kenai Peninsula Bays were surveyed 27 February -1 March. The Shumagins survey was halted 13-19 February due to vessel mechanical problems. Acoustic-trawl surveys of Morzhovoi Bay, Pavlof Bay, and Prince William Sound were planned, but were not completed due to these mechanical issues. A second AT survey (cruise DY2015-03) covered Shelikof Strait (17-23 March), Marmot Bay (15-16 March), and the Chirikof shelf break (23-24 March). Finally, three trawl-resistant bottom-mounted (TRBM) echosounders were deployed in Shelikof Strait and TRBM sounder AT survey assessment work was conducted on 11-12 February, 25-26 February, 2 March, and March 27-30.

All surveys were conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and on-bottom backscatter was sampled with a poly Nor’easter (PNE) bottom trawl.
In the Shumagin Islands, acoustic backscatter was measured along 756 km (408 nmi) of transects. The survey transects were spaced 1.9 km (1.0 nmi) apart directly south and east of Renshaw Point and in the eastern half of Unga Strait, 4.6 km (2.5 nmi) apart in Stepovak Bay and West Nagai Strait, and 3.7 km (2.0 nmi) the western half of Unga Strait, and 9.3 km (5.0 nmi) apart in Shumagin Trough. The majority of walleye pollock in the Shumagin Islands were between 10 and 15 cm fork length (FL) and 20 and 45 cm FL, which is characteristic of age-1 and age-2-4 walleye pollock, respectively. Smaller fish (10-15 cm FL) made up a very small portion of the biomass (2.5%), which was similar to 2014 (3% of the total biomass), and much less than 2013 (48% of the total biomass). Large adults (≥ 40 cm) contributed little to overall biomass in 2015, as well. The dominance of walleye pollock with lengths representative of age-3 fish in the Shumagin Islands area (85% biomass in 2015) suggests the continued success of the 2012 year class. The maturity composition of males > 40 cm FL (n = 34) was 3% immature, 9% developing, 82% pre-spawning, 0% spawning, and 6% spent. The maturity composition of females longer than 40 cm FL (n = 105) was 0% immature, 11% developing, 86% pre-spawning, 0% spawning, and 4% spent. Age-2 and -3 walleye pollock were abundant throughout the outer portion of Shumagin Trough, off Renshaw Point, and in the West Nagai Strait area. Although adult pollock have historically been detected off Renshaw Point, only a few large adults were captured in trawl hauls in this area in 2015. The majority of the pollock (mainly age-3 fish with fewer age 1-2 year olds) formed dense layers approximately 25 m above the bottom during the day. The biomass estimate of 61,369 t, based on data and specimens collected from eight AWT hauls conducted in midwater and one on-bottom PNE haul, is nearly twice last year’s estimate (37,346) and 81% of the historical mean of 75,269 t for this survey.

Sanak Trough was surveyed on 22-23 February. The majority of walleye pollock biomass for fish ≥ 40 cm was generally located in the northwestern portion of the Trough; whereas most biomass for fish < 40 cm was located along the eastern side of the Trough. Acoustic backscatter was measured along 196 km (105.5 nmi) of transects spaced 3.7 km (2 nmi) apart, and biological data and specimens were collected from three AWTs. Walleye pollock ranged between 25 and 75 cm FL with two modes at 34 and 60 cm FL.. The mode at 34 cm likely represents age-3 fish. The majority of pollock in Sanak Trough in 2014 were between 42 and 78 cm FL with a mean of 59 cm FL (mostly age-8 fish). The maturity composition for males > 40 cm FL (n = 32) was 0% immature, 6% developing, 13% pre-spawning, 3% spawning, and 78% spent. The maturity composition for females longer than 40 cm FL (n = 57) was 2% immature, 7% developing, 33% pre-spawning, 5% spawning, and 53% spent. The fact that over half of the females were already spent indicates that survey timing was likely late, and did not coincide with the onset of spawning for the majority of fish that spawn in Sanak. The biomass estimate of 17,863 t is 39% of the historic mean of 45,604 t for this survey and more than twice last year’s biomass estimate (7,319 t).

The Kenai bays, specifically Port Dick, Nuka Passage, Nuka Bay, Harris Bay, Aialik Bay, Resurrection Bay, Day Harbor, and Port Bainbridge, were surveyed from 27 February to March 1. Acoustic backscatter was measured along 405.6 km (219 nautical miles (nmi)) of zig-zag transects, and biological data and specimens were collected from one PNE and eight AWTs. The majority of the adult walleye pollock biomass (FL ≥ 40 cm) was located in Aialik Bay, Resurrection Bay, and Port Bainbridge, with as much as 28% in Resurrection Bay alone. The small amount of biomass observed for fish < 40 cm FL was located in a small area of the west arm of Nuka Bay. Walleye pollock ranged between 22 and 69 cm FL with a mean of 52 cm FL, and the majority of the biomass in this region was composed of fish with lengths characteristic of fish 7-10 years old. The maturity
composition for males > 40 cm FL (n = 218) was 1% immature, 1% developing, 33% pre-spawning, 61% spawning, and 4% spent. The maturity composition for females longer than 40 cm FL (n = 206) was 0% immature, 5% developing, 93% pre-spawning, 1% spawning, and 0% spent. The fact that almost all of the females were prespawning indicates that survey timing was appropriate as it coincided with the onset of spawning for the majority of the fish that likely spawn in this area.

The Shelikof Strait sea valley was surveyed from 15 to 22 March at a transect spacing of 13.9 km (7.5 nmi), acoustic backscatter was measured along 1,355 km (731.5 nmi) of transect, and biological data and specimens were collected in the Shelikof Strait area from 26 AWT hauls. As in previous years, the highest walleye pollock biomass was observed along the northwest side of the Strait near Kukak Bay, although dense aggregations of 40-60 cm FL fish also extended southward into the center of the Strait as far as Agripina Bay. Discrete, dense midwater pollock schools (“cherry balls”) were occasionally encountered throughout the survey area, especially on the northern and southern transects in the Strait, consisting mostly of fish with an average FL of 30 cm. The majority of pollock biomass within Shelikof Strait was characterized by two length modes: one clear mode at 30 cm FL representing age-3 fish from the 2012 year class, and second mode consisting of fish > 40 cm FL. The maturity composition in the Shelikof Strait area for males longer than 40 cm FL (n = 690) was 5% immature, 1% developing, 6% pre-spawning, 87% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL (n = 724) was 7% immature, 4% developing, 78% pre-spawning, 10% spawning, and 2% spent. The small fraction of spawning and spent females relative to pre-spawning females suggests that the survey was reasonably well-timed to coincide with the onset of spawning for the majority of fish that spawn in Shelikof. The Shelikof Strait biomass estimate of 845,306 t is the second largest reported for the region since 1985, and similar to the 2014 estimate of 842,138 t. The 2015 estimate is 1.28 times the historic mean of 659,635 t.

Marmot Bay was surveyed from 15 to 16 March along transects spaced 3.7 km (2.0 nmi) apart in the outer Bay and 1.9 km (1.0 nmi) apart in the Spruce Island Gully and inner Bay. Acoustic backscatter was measured along 315 km (170 nmi) of transects, and biological data and specimens were collected in Marmot Bay from two AWT hauls in midwater, and two PNE trawl hauls. The majority of the pollock biomass occurred in aggregations between Whale and Spruce Islands and in inner Marmot Bay. The aggregations included pollock both from 20 to 40 cm FL and pollock ≥ 40 cm FL, and were vertically stratified with smaller fish higher in the water column. Walleye pollock in the Marmot region ranged from 20 to 70 cm FL with a clear mode at 27 cm FL and two weaker modes at 46 and 60 cm FL. The maturity composition in Marmot Bay for males > 40 cm FL (n = 125) was 4% immature, 1% developing, 35% pre-spawning, 58% spawning, and 2% spent. The maturity composition of females > 40 cm FL (n = 90) was 0% immature, 1% developing, 92% pre-spawning, 3% spawning, and 3% spent. The high percentage of pre-spawning adult females suggests that peak spawning had not occurred and that survey timing was likely appropriate. The biomass estimate for Marmot Bay was 22,470 t; this estimate is the highest in the history of the Marmot survey and 11,400 t higher than the historic mean for this survey (11,049 t).

Chirikof shelf break was surveyed from 23 to 24 March along transects spaced between 7.4 km (4.0 nmi) and 11.1 km (1.0 nmi) apart, acoustic backscatter was measured along 324 km (174.5 nmi) of transects, and biological data and specimens were collected from 5 AWTs. Walleye pollock schools comprising the majority of pollock biomass in Chirikof were mixed lengths and scattered sparsely along the shelf break, they ranged from 27 to 70 cm FL with a clear mode at 31 cm FL. The maturity composition in Chirikof for males > 40 cm FL (n = 10) was 30% immature, 0%
developing, 10% pre-spawning, 60% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 27) was 15% immature, 19% developing, 67% pre-spawning, 0% spawning, and 0% spent. The high percentage of pre-spawning adult females suggests that peak spawning had not occurred, and that survey timing was likely appropriate. The biomass estimate for Chirikof was 12,685 t; 50,000 t less than the 2013 estimate and much less than the historic mean for this survey (40,182 t).

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

Summer Acoustic-Trawl Survey of the Gulf of Alaska — MACE Program

The MACE Program completed a summer 2015 acoustic-trawl (AT) survey of walleye pollock (*Gadus chalcogrammus*) across the Gulf of Alaska (GOA) shelf from the Islands of Four Mountains eastward to Yakutat Trough aboard the NOAA ship *Oscar Dyson* (cruise DY2015-06). The summer GOA shelf survey also included smaller-scale surveys in several bays and around islands. Previous surveys of the GOA have also been conducted during the summers of 2003, 2005, 2011, and 2013 by MACE. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and on-bottom backscatter was sampled with a poly Nor’eastern (PNE) bottom trawl. A Methot trawl was used to target midwater macro-zooplankton, age-0 walleye pollock, and other larval fishes. Conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts were conducted to characterize the physical oceanographic environment. A trawl-mounted stereo camera (“Cam-Trawl”) was used during the survey to aid in determining species identification and size of animals encountered by the AWT at different depths. During night operations small scale grid surveys were also performed across the shelf based on the AFSC groundfish survey’s trawlability grid. Trawlable (n=19) and untrawlable (n=19) grids were surveyed using the EK60 acoustic system (18-, 38-, 70-, 120-, and 200-kHz ) and a Simrad ME70 multibeam sonar to assess the trawlability designation of the grid. Grid sampling was augmented with stereo-video drop camera deployments (n=92) to groundtruth bottom classification and estimate species abundance.

The biomass estimate for the entire survey area was 1,482,668 t. The majority of the walleye pollock observed during the survey were located on the continental shelf (64%), Shelikof Strait (19%), east of Kodiak Island in Chiniak (2%) and Barnabas Troughs (6%), and in Marmot Bay (3%). The vast majority (80%) of the biomass for the entire survey was from age-3 fish (~30-45 cm fork length). Surface water temperatures across the GOA shelf averaged 12.2° C, approximately 1.6° C warmer overall than in 2013.

The survey of the GOA shelf and shelfbreak was conducted between 11 June and 16 August 2015 and consisted of 43 transects spaced 25 nautical miles (nmi) apart. Walleye pollock distribution was patchy across the shelf. The areas of greatest walleye pollock density on the shelf transects were south of Unimak Pass, between the Shumagin Islands and Shelikof Strait, south of the Trinity Islands, and east of the Kenai Peninsula on the Northwest portion of Portlock Bank. Based on catch data from 34 AWT, 18 PNE, and two Marinovich hauls, one major length group of walleye pollock was observed on the GOA shelf which ranged from 30 to 48 cm FL with a mode of 37 cm FL. The walleye pollock biomass estimate for the GOA shelf of 946,681 t from the 1,739 nmi of trackline surveyed was approximately 64% of the total walleye pollock biomass observed for the entire survey and 3.5 times larger than the 2013 estimate.

Sanak Trough was surveyed 20 June along transects spaced 4 nmi apart. The sparse backscatter
attributed to walleye pollock in Sanak Trough was patchy and scattered throughout the 47 nmi of transects surveyed. Pollock captured in the one AWT haul in Sanak Trough were primarily in the 27 to 44 cm FL with a major mode at 31 cm FL, resulting in a biomass estimate of 3,098 t, roughly three times what was seen in both 2011 and 2013.

Morzhovoi Bay was surveyed 20 June along transects spaced 4 nmi apart. Backscatter in Morzhovoi Bay attributed to walleye pollock was fairly evenly scattered throughout the bay with the greatest density located in the south east corner over the deepest part of the bay. Walleye pollock captured in 2 AWT hauls in Morzhovoi Bay ranged from 15 to 73 cm with a dominant mode of 41 cm FL. The biomass estimate for the 20 nmi of trackline surveyed in Morzhovoi Bay was 4,855 t, about 1,000 t greater than what was seen in Morzhovoi Bay in 2013.

Pavlof Bay was surveyed 21 June along transects spaced 4 nmi apart. The acoustic backscatter attributed to walleye pollock in Pavlof Bay was observed throughout the survey area but primarily near the mouth of the bay. Walleye pollock captured in Pavlof Bay from 1 AWT ranged from 16 to 69 cm FL, with most fish in the 26 to 43 cm FL range and a major mode at 32 cm FL and a smaller mode at 37 cm FL. The biomass estimate in Pavlof Bay from the 20 nmi of trackline surveyed was 2,576 t, slightly higher than in 2013.

The Shumagin Islands were surveyed on 22-24 June along transects spaced 3.0 nmi apart in West Nagai Strait, Unga Strait, and east of Renshaw Point, and 6 nmi apart in Shumagin Trough. In the Shumagin Islands walleye pollock were most abundant found near the mouth of Stepovak Bay and the outer West Nagai Strait areas. Walleye pollock from 5 AWT hauls ranged in length from 12 to 68 cm FL with the majority of fish in the 35 to 45 cm FL range and a mode of 39 cm FL. The biomass estimate for the Shumagin Islands along the 151 nmi of tracklines surveyed was 15,074 t, approximately half the amount seen in 2013.

Mitrofania Island was surveyed 22-23 June along transects spaced 8 nmi apart. The majority of acoustic backscatter attributed to walleye pollock near Mitrofania Island was highest on transects to the north and west of Mitrofania Island. The vast majority of walleye pollock captured in the one AWT haul near the island ranged between 27 and 66 cm FL with a mode at 39 cm, representing age-3 fish. The biomass estimate in Mitrofania along the 47 nmi of tracklines surveyed was 14,742 t, approximately six times more than in 2013 and twice the amount seen in 2011.

Shelikof Strait was surveyed from 7-13 July along transects spaced 15 nmi apart. Walleye pollock were distributed fairly evenly throughout Shelikof Strait with more fish generally on the southern and eastern side of the trough and also along the central part of the western side of the trough. Lengths were obtained from 11 AWT hauls and ranged from 24 to 65 cm FL with a mode of 35 cm FL. The biomass estimate for the 471 nmi of trackline surveyed in Shelikof Strait was 287,804 t, which accounted for approximately 19% of the entire GOA summer survey pollock biomass and was approximately half the 2013 estimate, but still the second highest in the summer time series (since 2003). Approximately 84% of the biomass detected in Shelikof Strait were age-3 walleye pollock (89% by number).

Nakchamik Island was surveyed 12 July along transects spaced 8 nmi apart. Backscatter attributed to walleye pollock near Nakchamik Island was evenly dispersed across the 15 nmi of surveyed transects. Walleye pollock captured in the one AWT haul near Nakchamik Island from 14 and 69 cm with modes at 29 and 43 cm FL. The biomass estimate for the Nakchamik Island area was 9,147 t,
approximately the same as was seen in 2013.

Alitak and Deadman Bays were surveyed 15-16 July along transects spaced 3.0 nmi apart in the outer bay, and along zig-zag transects in the inner Deadman Bay area because of the narrowness of the bay. The densest pollock aggregations in Alitak Bay occurred in the inner part of Deadman Bay. From the 3 AWT hauls conducted in the area walleye pollock ranged in length from 18 to 72 cm FL with modes at 27, 35, and 50 cm FL. The biomass estimate along the 57 nmi of trackline surveyed in Alitak/Deadman Bay area was 7,244 t, approximately half the amount that was seen in the 2013 survey. A total of 2,088 t (29%) of the overall biomass from this area was from Deadman Bay, similar to 2013 when 23% of the total biomass from this region was from Deadman Bay.

Marmot and Izhut Bays were surveyed 16-17 July along transects spaced 2 nmi apart in the inner bay and Spruce Gully, and 4 nmi apart in the outer bay. Izhut Bay was surveyed along zig-zag transects because of the narrowness of the bay. Walleye pollock were detected throughout the Bays with the greatest densities found in the outer bay and lengths from the 5 AWT hauls in Marmot Bay ranged from 18 to 67 cm FL with modes at 32 cm and 39 cm FL. The biomass estimate for Marmot Bay along the 100 nmi of trackline surveyed was 45,429 t, more than 5 times greater than the estimate in 2013. In Izhut Bay the biomass estimate along the 7 nmi of trackline surveyed was 374 t, approximately half the estimate from 2013.

Barnabas Trough was surveyed 18-20 July along transects spaced 6 nmi apart. Large aggregations of adult walleye pollock were detected in Barnabas Trough. Walleye pollock caught in 4 AWT hauls and 2 PNE hauls in Barnabas Trough ranged in size from 28 to 73 cm FL but were dominated by a single mode at 41 cm FL. The biomass estimate for the 123 nmi of trackline surveyed in Barnabas Trough was 88,906 t, approximately 6% of the entire GOA summer survey biomass estimate, and 40% greater than the amount seen in 2013, and the highest observed in the summer time series for this area (since 2003).

Chiniak Trough was surveyed 21-22 July along transects spaced 6 nmi apart. Large aggregations of adult walleye pollock were detected in Chiniak Trough. Walleye pollock caught in 4 AWT hauls in Chiniak Trough had ranged in length from 16 to 62 cm FL, with a mode at 37 cm FL. The biomass estimate for the 83 nmi of trackline surveyed in Chiniak Trough was 34,980 t, approximately 2.4% of the entire GOA summer survey biomass estimate and similar to the 2011 estimate, making the 2015 estimate the second highest in the time series (since 2003).

The Kenai Peninsula bays including Port Dick, Nuka Passage, Nuka Bay, Harris Bay, Aialik Bay, Resurrection Bay, Day Harbor, and Port Bainbridge were surveyed between 30 July and 5 Aug. All bays were surveyed using a zig-zag pattern because of the narrowness of the bays. Backscatter was relatively light but found throughout the Kenai Peninsula Bays with the densest backscatter attributed to pollock found in Harris and Resurrection Bays. Walleye pollock caught in 8 AWT and one midwater PNE haul in the Bays ranged in length from 15 to 66 cm FL and had modes at 19 cm, 25 cm, and 52 cm FL. In contrast to all other areas of the summer GOA survey, age-2 fish were most abundant by number (42%) in the Kenai Peninsula Bays and age-3 fish most abundant in biomass (23%). The biomass estimate for the 257 nmi of trackline surveyed in Kenai Peninsula Bays was 7,135 t.

Prince William Sound was surveyed 5-8 Aug along transects spaced 8.0 nmi apart. Backscatter in Prince William Sound was very sparse, with most fish located in the trough south of Montague
Island. Three AWT hauls were conducted within Prince William Sound and two AWT hauls were conducted in the trough south of Montague Island from which walleye pollock ranging in length primarily from 26 to 65 cm FL with a major mode at 37 cm FL and a minor mode at 57 cm FL. The biomass estimate for the 169 nmi of trackline surveyed in Prince William Sound was 13,308 t, of which only 5,596 t was within the sound proper, roughly the same as in 2013.

Yakutat Trough was surveyed 12-13 Aug. along transects spaced 12 nmi apart. Backscatter was relatively light and diffuse in Yakutat Trough. Walleye pollock caught in the two AWT hauls in the Yakutat Trough ranged in length from 47 to 66 cm FL with a mode of 56 cm FL. The biomass estimate for the 64 nmi of transects surveyed in Yakutat Trough is 5,538 t, approximately the same amount that was seen in 2013.

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

Longline Survey – ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2015. The survey is a joint effort involving the AFSC’s Auke Bay Laboratories and Resource Assessment and Conservation Engineering (RACE) Division. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978 to 1994 and also samples gullies not sampled during the cooperative longline survey. In 2015, the thirty-seventh annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Bering Sea was conducted. One hundred-fifty-two longline hauls (sets) were completed during May 28 – August 26, 2014 by the chartered fishing vessel Ocean Prowler. Total groundline set each day was 16 km (8.6 nmi) long and contained 160 skates and 7,200 hooks except in the eastern Bering Sea where 180 skates with 8,100 hooks were set.

Giant grenadier (Albatrossia pectoralis) was the most frequently caught species, followed by sablefish (Anoplopoma fimbria), Pacific cod (Gadus macrocephalus), shortspine thornyhead (Sebastolobus alascanus), and Pacific halibut (Hippoglossus stenolepis). A total of 58,064 sablefish, with an estimated total round weight of 174,732 kg (385,218 lb), were caught during the survey. This represents a decrease of nearly 5,000 sablefish over the 2014 survey catch. Sablefish, shortspine thornyhead, and Greenland turbot (Reinhardtius hippoglossoides) were tagged with external Floy tags and released during the survey. Pop-up satellite tags (PSAT) were implanted in 34 sablefish. Length-weight data and otoliths were collected from 1,662 sablefish. Killer whales (Orcinus orca) depredating on the catch occurred at nine stations in the Bering Sea and five stations in the western Gulf of Alaska. Sperm whales (Physeter macrocephalus) were observed during survey operations at 25 stations in 2015. Sperm whales were observed depredating on the gear at six stations in the central Gulf of Alaska, six stations in the West Yakutat region, and seven stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2015 longline survey. Satellite pop-up tags were deployed on sablefish throughout the Gulf of Alaska. Information from these tags will be used to investigate movement patterns within and out of the Gulf of Alaska and potentially help identify spawning areas for sablefish. Livers, ovaries, and maturity stage information were collected from all sablefish sampled for specimen data. This information will be used to help evaluate sablefish maturity and to validate visual maturity stage classifications recorded during the survey. Finally, opportunistic photo identification of both sperm and killer whales were collected for use in whale
identification projects.

Longline survey catch and effort data summaries are available through the Alaska Fisheries Science Center’s website: [http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.php](http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.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 provided. These estimates are available for all species caught in the survey. Previously RPN’s were only available for depths that corresponded to sablefish habitat but in 2013 these depths were expanded to 150m - 1000m. Inclusion of these shallower depths provides expanded population indices for the entire survey time series for species such as Pacific cod, Pacific halibut, and several rockfish species.

For more information, contact Chris Lunsford at (907) 789-6008 or chris.lunsford@noaa.gov.

**2015 Northern Bering Sea Integrated Ecosystem Survey – ABL**

A surface trawl survey was conducted by the Ecosystem Monitoring and Assessment program of the Alaska Fisheries Science Center from Aug 28 to Sep 21, 2016 aboard the F/V Alaskan Endeavor and included the collection of data on pelagic fish species and oceanographic conditions in the Northern Bering Sea shelf from 60°N to 65.5°N (Fig. 1). Overall objectives of the survey were to provide an integrated ecosystem assessment of the northeastern Bering Sea to support 1) the Alaska Fisheries Science Center's, Loss of Sea Ice Program and Arctic Offshore Assessment Activity Plan, 2) the Alaska Department of Fish and Game Chinook Initiative Research Initiative program, 3) the North Pacific Research Board proposal #1423, Defining critical periods for Yukon and Kuskokwim river Chinook salmon, that includes expanding the southeastern Bering Sea integrated ecosystem model to the Northeast Bering Sea shelf, and 4) sample collections within Region 2 of the Distributed Biological Observatory. Vessel support (350K) and Chinook Salmon stock composition (20K) was provided by the Alaska Department of Fish and Game as part of the Chinook Initiative Research program (370K). Operational support (41K), diet analysis (15K), CTD analysis (15K), and zooplankton processing (21K) was provided by by AFSC Loss of Sea Ice research program. Participating institutions included: 1) Alaska Fisheries Science Center (AFS), Auke Bay Laboratories, Juneau, AK, 2) Alaska Department of Fish and Game (ADFG), Commercial Fisheries Division, Anchorage, AK, 3) U.S. Fish and Wildlife Servic (USFWS), Office of Migratory Bird Management, Anchorage, AK, and 4) Ocean Associates (contracting agency for AFSC).

Physical and biological data were collected from 37 surface trawl stations and oceanographic data were collected at 5 Distributed Biological Observatory stations in 2015. Headrope and footrope depth and temperature were monitored with temperature and depth loggers (SBE39) at each station. Average headrope depth was 1.6 m, average footrope depth was 21.3 m. Average headrope temperature was 8.8°C, average footrope temperature was 7.6°C. A total of 38 different species of fish and jellyfish were captured in surface trawls and included 6 species of jellyfish, 6 species of forage fish, 13 species of groundfish, 5 species of salmon, and 8 misc. fish species.

Surface trawl stations resulted in a total catch weight of 4,717, jellyfish comprised the largest catch by weight at 2,896 kg. Jellyfish species included *Chrysaora melanaster* (2,565 kg), *Cyanea* sp. (169 kg), *Aequorea* sp. (74 kg), *Aurelia* sp. (23 kg), *Phacellophora camtschatica* (164 kg), and *Staurophora mertensi* (17 kg). The second largest species group in surface trawl catches by biomass were forage fish species (955 kg), and included Herring (834 kg), Capelin (134 kg),
Sandlance (16 kg), Rainbow Smelt (11 kg), and squid (1 kg). Groundfish species comprised the next largest biomass at 474 kg, and included age0 Walleye Pollock (396 kg), age1 Walleye Pollock (49 kg), age0 saffron cod (25 kg), yellowfin sole (3 kg), and 10 other species each with a total catch less than 1 kg. Salmon had the smallest catch biomass of all species groups at 396 kg, and included 125 kg of juvenile Chum Salmon, 86 kg of juvenile Pink Salmon, 42 kg of Juvenile Chinook Salmon, 36 kg of immature Sockeye Salmon, 28 kg of juvenile Coho Salmon, 16 kg of immature Chum Salmon, 4 kg of juvenile Sockeye Salmon, and 3 kg of maturing Coho Salmon. Miscellaneous species catch (23 kg), included 12 kg of nine spine stickleback, 7 kg of Artic lamprey, 2 kg of shorthorn sculpin, and 5 other species with a total catch weight less than 1 kg.

A total catch of 258,366 individual fish and jellyfish were captured in the northern Bering Sea surface trawl stations in 2015. Groundfish species catch were the largest at 157,138 individuals, with age 0 Walleye Pollock comprising the largest percentage at 149,043 fish, followed by age0 saffron cod at 7,887 fish. All other groundfish species catch were below 100 individuals. The second most abundant species group were forage fish species with a total catch of 81,196 fish, with Pacific Herring accounting for the largest catch in numbers at 57,493, followed by capelin (20,388), Pacific Sandlance (1,290), Squid sp. (1,264), and Rainbow Smelt (760). Miscellaneous species catch (12,693) were predominately Ninespine Stickleback (12,562) and Arctic Lamprey (115), the remaining six Miscellaneous species has catches less than 10. Salmon were the least numerically abundant species with a total catch of 4,312. Juvenile Pink Salmon had the largest catch at 2,154, followed by juvenile Chum Salmon (1,627), juvenile Chinook Salmon (322), juvenile Coho Salmon (84), immature Sockeye Salmon (62), immature Chinook Salmon (36) juvenile Sockeye Salmon (20), immature Chum Salmon (6), and maturing Coho Salmon (1).

Stock-specific estimates of juvenile Chinook Salmon abundance were generated from trawl catch data, genetic stock composition, and mixed layer depth expansions. A total of 4.511 million juvenile Chinook Salmon were estimated to be present in the northern Bering Sea and 44% of the juveniles were estimated to be from the Canadian-origin stock group, resulting in an abundance estimate for juvenile Canadian-origin Chinook Salmon at 1.992 million Chinook Salmon. This is an above average abundance (average abundance 1.495 million, 2003-2015) and the highest estimates of juveniles-per-spawner (70) observed since 2003 (average 34 juveniles-per-spawner). This indicates excellent early life-history survival of juvenile Chinook Salmon from the Canadian-origin stock group within the Yukon River.
Figure 1. Stations sampled during the August 28 to September 21, 2015 integrated ecosystem survey in the northern Bering Sea.

For more information, contact Jim Murphy at jim.murphy@noaa.gov.

2015 Gulf of Alaska Integrated Ecosystem Survey – ABL
The Gulf of Alaska assessment is a fisheries and oceanographic survey conducted in the eastern Gulf of Alaska during the summer season (June 26 – September 4, 2015). This survey has been completed each year since 2010, and is a continuation of the monitoring efforts established by the Gulf of Alaska Integrated Ecosystem Research Project. The survey design covered the coastal and offshore eastern Gulf of Alaska in federal waters up 100 miles offshore extending roughly from Sitka Sound north to Yakutat Bay (56.5° N - 59.7° N, 136° W – 141.5° W). A Cantrawl 400/601 trawl was rigged with 6 A4 polyform bouys to fish the top 30 meters of the water column. A 250# tom weight was added to each side of the footrope to extend the vertical opening of the net. Additional sampling equipment included a Seabird Electronics CTD and associated sensors for measurement of physical water properties and water collections at depth, as well as an array of 60cm and 20cm bongo nets (zooplankton nets) equipped with 505 micron and 153 micron mesh nets, respectively. All collection locations for fish, plankton, and oceanography were made at predetermined master station locations. A total of 66 stations were occupied and sampled, all sampling occurred during daylight hours. Approximately half way through the survey (station 36 or 66), the CTD was lost and water collections were no longer possible. The scientific objective of the survey is to assess Young of the Year (YOY) groundfish, salmon, zooplankton, and oceanographic conditions in the coastal, shelf, slope, and offshore waters of the eastern Gulf of Alaska. In 2015, the chartered fishing vessel Northwest Explorer (B&N Fisheries) was the sampling platform used to
provide information on species distribution, ecosystem structure, and marine productivity in response to changes in climate patterns and temperature anomalies (i.e. the warm blob, and El Niño).

Physical and biological data and specimens were collected from all 66 trawl hauls. Samples collected included: genetic tissue, stomachs, coded wire tags, fish parasites, whole A0 groundfish for laboratory study (arrowtooth flounder, Pacific cod, Sebastes spp., and walleye pollock), zooplankton, chlorophyll a, water column nutrients, and salinity. Other physical measurements included beam transmission, light attenuation, and dissolved oxygen. Spiny dogfish sharks (*Squalus acanthias*) accounted for 82.8% of the total biomass captured in all surface hauls. This is almost entirely due to abnormally large catches during a single day over the Fairweather Fishing Grounds. If dogfish sharks are not considered, the hydrozoan jellyfish *Aequorea* sp. accounts for nearly 36% of the total biomass captured in all surface hauls, followed by Pacific pomfret (*Brama japonica*, 20%), and adult pink salmon (*Oncorhynchus gorbuscha*, 8.5%). The hydrozoan jellyfish *Aequorea* sp. accounts for 25% of the total number of animals captured in all surface hauls, followed by spiny dogfish sharks 25%, squids 12%, and the moon jellyfish (*Aurelia* sp., 10%). Removal of the total number of dogfish sharks does not change the order of percent number captured for other species.

Water temperatures in 2015 were warmer than average, especially in surface waters. Surface temperatures near the coast were approaching 16° C and typically above 14° C at the offshore stations. In 2010 – 2012, temperatures were in the range of 10 - 12° C. The total catch of A0 pollock during the 2015 survey was 244 fish, compared to 5,586 in 2014 and and 3,965 in 2013. The 2015 catch of A0 pollock is the lowest (by an order of magnitude) than any observed since the inception of the survey in 2010. This is similar to number reported from the central and western Gulf of Alaska during summer A0 pollock surveys conducted by the Fisheries-Oceanography Cooperative Investigations program, also at AFSC.

For more information contact Wess Strasburger at wes.strasburger@noaa.gov

Figure 1. Station locations for the 2015 Gulf of Alaska integrated ecosystem survey conducted during July to August.
The Gulf of Alaska (GOA) Assessment completed its first year of fisheries oceanographic surveys during July and August 2014. This new long-term monitoring project was developed from the GOA Project, a North Pacific Research Board Integrated Ecosystem Project, which was designed to understand ecological processes across years, seasons, and regions in the GOA. The GOA Assessment is focused on furthering understanding of biophysical processes as well as monitoring the health and abundance of select groundfish and salmon species in the southeast region of the GOA. These objectives will be accomplished by focusing on the early life history of Chinook salmon, chum salmon, pollock, rockfishes, and Pacific cod. These objectives will be addressed via identifying and quantifying the major ecosystem processes that regulate survival by monitoring interannual variability in distribution, energetic condition, and food habits.

The GOA Assessment was conducted during July 2015 off southeast Alaska by the F/V Northwest Explorer, a chartered commercial trawler. Fish samples were collected using a midwater rope trawl (Cantrawl model 400/601) that was fished at surface by stringing buoys along the headrope, with the footrope typically descending to a depth of 30m. Surface tows were made at predetermined grid stations and were 30 minutes in duration. Immediately after the trawl was retrieved, catches were sorted by species and standard biological measurements (length, weight, and maturity) were recorded. Whole age-0 marine fish, juvenile salmon, and forage fish were collected and frozen for transportation to the laboratory for food habits, energetic, and genetic analyses.

Physical oceanographic data were collected at gridded survey stations by deploying a conductivity, temperature, and depth meter (CTD) with ancillary sensors. These provided vertical profiles of salinity, temperature, fluorescence, and photosynthetic available radiation (PAR). Zooplankton and ichthyoplankton samples were collected at gridded stations using double oblique bongo tows from the surface to within 5 meters of bottom, or to a maximum depth of 200 m.

We sampled a reduced sample grid that spanned from Sitka Sound north to Yakutat Bay during summer 2015 in order to accommodate other AFSC sampling. The five species of marine fish captured with the highest frequency in surface trawls during the 2015 field season were age-0 rex sole, Pacific pomfret, age-0 walleye pollock, juvenile wolf eel, and prowfish (Fig. 1-3). For more information, contact Wesley Strasburger at (907)-789-6009 or wes.strasburger@noaa.gov.
Figure 1. Catch per 30 minute net tow for age-0 rex sole and Pacific pomfret in the eastern Gulf of Alaska during July 2015.
Due to an unusual warming anomaly, we requested special funding for a 2015 southeastern Bering Sea (SEBS) survey to collect ecosystem data during the second warm year (2014, 2015), following a series of cool years (2007 – 2013). Scientists from the Recruitment Processes Alliance (RPA) of the Alaska Fisheries Science Center (AFSC) conducted a fisheries-oceanographic survey in the (SEBS) during the early fall aboard the NOAA Vessel Oscar Dyson from September 5 to October 3 2015. The survey design covered the SEBS shelf between roughly the 50 m and 200 m isobaths, from 162° W to 171° W (Figure 1). A new midwater trawl was used to obliquely sample the entire water column (200 m maximum) for fishes and jellyfishes, in contrast to the larger midwater trawls that were used to sample the surface (top 20 m) in past years. In addition, the survey included sampling the 70 m isobath and the Distributed Biological Observatory (DBO) stations, two long-term time series describing the physical and biological properties of the Bering Sea shelf, from approximately 56.5° N to 63.5° N. Prior to the RPA surveys, fisheries-oceanographic surveys were conducted annually (2002-2012, 2014) as part of the Bering-Aleutian Salmon International Survey (BASIS) and eventually Bering Sea Project (BSP). The main objective of RPA surveys in the SEBS
is to collect ecosystem data with a priority to provide mechanistic understanding of the factors that influence recruitment of walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*).

Physical and biological data were collected from 49 pelagic trawl stations and at an additional 68 70 m isobath stations. Poor weather and unexpected delays resulted in the decision to not sample the DBO stations. Samples for laboratory studies of fishes, jellyfishes, and zooplankton were collected for age, diet, energetics, genetics, and isotopes. In addition, samples for physical and biological measurements were collected for chlorophyll a, water column nutrients, and salinity.

Midwater trawl station catches were comprised of over 25 fish species and over 8 jellyfish species. Jellyfish dominated the catches by weight (89.0%), followed by age-1+ pollock (9.1%) and age-0 pollock (0.8%). Jellyfish species included *Chrysaora melanaster* (60.0% by weight), *Aequorea* sp. (22.6% by weight), *Cyanea capillata* (5.3% by weight), *Aurelia* sp. (0.6% by weight), and other miscellaneous jellyfishes (0.5% by weight). Age-0 pollock was the most abundant by number (36,902), followed by *Aequorea* sp. (21,711) and *Chrysaora melanaster* (8,298). Other miscellaneous fish and invertebrate species that contributed to the catch by number were age-1+ pollock (2920), *Cyanea capillata* (2111), *Hydromedusae* sp. (1827), *Aurelia* sp. (212), squid (*Gonatus* sp., 163), eulachon (*Thaleichthys pacificus*, 82), shrimp (Caridea, 73), lantern fish (Mytophidae, 71), Pacific herring (*Clupea pallasi*, 47), yellowfin sole (*Limanda aspera*, 34), and capelin (*Mallotus villosus*, 31). For more information contact Wess Strasburger at
Figure 1. Station locations for the August to October 2015 southeastern Bering Sea integrated ecosystem survey also known as BASIS.

North Pacific Groundfish and Halibut Observer Program (Observer Program) – FMA

The North Pacific Groundfish and Halibut Observer Program (Observer Program) provides the regulatory framework for NMFS-certified observers to obtain information necessary to conserve and manage the groundfish and halibut fisheries in the Gulf of Alaska (GOA) and the Bering Sea and Aleutian Islands (BSAI) management areas. Data collected by well-trained, independent observers are a cornerstone of management of the Federal fisheries off Alaska. These data are needed by the North Pacific Fishery Management Council (Council) and NMFS to comply with the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the Marine Mammal Protection Act, the Endangered Species Act, and other applicable Federal laws and treaties.

Observers collect biological samples and fishery-dependent information used to estimate total catch
and interactions with protected species. Managers use data collected by observers to manage groundfish and prohibited species catch within established limits and to document and reduce fishery interactions with protected resources. Scientists use observer data to assess fish stocks, to provide scientific information for fisheries and ecosystem research and fishing fleet behavior, to assess marine mammal interactions with fishing gear, and to assess fishing interactions with habitat. Although NMFS is working with the Council and industry to develop methods to collect some of these data electronically, currently much of this information can only be collected independently by human observers.

In 2013, the Council and NMFS restructured the Observer Program to place all vessels and processors in the groundfish and halibut fisheries off Alaska into one of two categories: (1) the full coverage category, where vessels and processors obtain observers by contracting directly with observer providers, and (2) the partial coverage category, where NMFS has the flexibility to deploy observers when and where they are needed based on an annual deployment plan (ADP) developed in consultation with the Council. Some vessels and processors may be in full coverage for some of the fisheries in which they participate and in partial coverage in other fisheries. Funds for deploying observers in the partial coverage category are provided through a system of fees based on the ex-vessel value of retained groundfish and halibut in fisheries and landings that are not in the full coverage category.

The purpose of restructuring the Observer Program was to:

- reduce the potential for bias in observer data,
- authorize the collection of observer data in fishing sectors that were previously not required to carry observers,
- allow fishery managers to provide observer coverage to respond to the scientific and management needs, and
- assess a broad-based fee to more equitably distribute the costs of observer coverage.

Under the restructured Observer Program, all vessels and processors in the groundfish and halibut fisheries off Alaska are assigned to one of two observer coverage categories (1) a full coverage category; or (2) a partial coverage category.

The full coverage category includes:

- catcher/processors (with limited exceptions),
- motherships,
- catcher vessels while participating in programs that have transferable prohibited species catch (PSC) allocations as part of a catch share program,
- inshore processors when receiving or processing Bering Sea pollock.

NMFS recommended that all catcher/processors and motherships be placed in full coverage to obtain independent estimates of catch, at-sea discards, and PSC for these vessels. At least one observer on each catcher/processor eliminates the need to estimate at-sea discards and PSC based on industry provided data or observer data from other vessels.
Catcher vessels participating in programs with transferable PSC allocations as part of a catch share program also are included in the full coverage category while they are participating in these programs. These programs include Bering Sea pollock (both American Fisheries Act and Community Development Quota [CDQ] programs), the groundfish CDQ fisheries (CDQ fisheries other than halibut and fixed gear sablefish), and the Central GOA Rockfish Program.

Under the catch share programs, quota share recipients are prohibited from exceeding any allocation, including, in many cases, transferable PSC allocations. All allocations of exclusive harvest privileges create some increased incentive to misreport as compared to open access or limited access fisheries. Transferable PSC allocations present challenges for accurate accounting because these species are not retained for sale and they represent a potentially costly limitation on the full harvest of the target species. To enforce a prohibition against exceeding a transferable target species or PSC allocation, NMFS must demonstrate that the quota holder had catch that exceeded the allocation. Supporting a quota overage case for target species or PSC that could be discarded at sea from an unobserved vessel requires NMFS to rely on either industry reports or estimated catch based on discard rates from other similar observed vessels. These indirect data sources create additional challenges to NMFS in an enforcement action. In addition, the smaller the pool from which to draw similar observed vessels and trips, the more difficult it is to construct representative at-sea discard and PSC rates for individual unobserved vessels.

Inshore processors taking deliveries of Bering Sea pollock are in the full coverage category because of the need to monitor and count salmon under transferable PSC allocations.

The partial observer coverage category includes:
- catcher vessels designated on a Federal Fisheries Permit when directed fishing for groundfish in federally managed or parallel fisheries, except those in the full coverage category;
- catcher vessels when fishing for halibut individual fishing quota (IFQ) or sablefish IFQ (there are no PSC limits for these fisheries);
- catcher vessels when fishing for halibut CDQ, fixed gear sablefish CDQ, or groundfish CDQ using pot or jig gear (because any halibut discarded in these CDQ fisheries does not accrue against the CDQ group’s transferable halibut PSC allocation);
- catcher/processors that meet criteria that allows assignment to the partial coverage category;
- shoreside or stationary floating processors, except those in the full coverage category.

For more information on the North Pacific Groundfish and Halibut Observer Program contact Chris Rilling at (206) 526-4194 or chris.rilling@noaa.gov

III. Reserves

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

A. Hagfish
B. Dogfish and other sharks
Research

**Spiny Dogfish Ecology and Migration - ABL**
A total of 183 satellite pop-off tags have been deployed on spiny dogfish since 2009. Data has been successfully recovered from 153 tags. Seven tags have been physically recovered and complete data sets are being downloaded from them. Six spiny dogfish tagged in Puget Sound were tagged with acoustic tags in addition to the pop-off tags, to attempt to compare the light based geolocation with known positions from the acoustic receivers. Recovered data from the pop-off tags, which includes temperature, depth, and geographic location, are still being analyzed. 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 near Dutch Harbor to Southern California in 9 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 near shore, with the near shore 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. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

**Spiny Dogfish Improved Aging Methods - ABL**
Staff from ABL, AFSC REFM Division, and the University of Alaska Fairbanks have completed a North Pacific Research Board funded project (project #1106) to investigate alternative ageing methods for spiny dogfish. Three manuscripts are in preparation, one of which has been accepted for publication to Marine Fisheries Review, as well as a final report to NPRB (available at: http://project.nprb.org/view.jsp?id=c899f0ae-4f0c-46a9-898d-757688579a1c). The project objectives were to compare the previous method of ageing the dorsal fin spines with a new technique developed that uses the vertebrae. Sample processing and ageing criteria were standardized and a manual has been created. Preliminary results suggest that the vertebrae may be suitable for ageing, however, more research is necessary before that method can be supported (e.g., validating ages). This project has been discussed at workshops at the last two CARE meetings (2013 and 2015), and presented at many scientific conferences. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

**Population Genetics of Pacific Sleeper Sharks - ABL**
Two species of the subgenus *Somniosus* are considered valid in the northern hemisphere: *S. microcephalus*, or Greenland shark, found in the North Atlantic and Arctic, and *S. pacificus*, or Pacific sleeper shark, found in the North Pacific and Bering Sea. The purpose of this study is to investigate the population structure of sleeper sharks in Alaskan waters. Tissue samples have been opportunistically collected from ~200 sharks from the West Coast, British Columbia, the Gulf of Alaska, and the Bering Sea. Sequences from three regions of the mitochondrial DNA, cytochrome oxidase c- subunit 1 (CO1), control region (CR), and cytochrome b (cytb), were evaluated as part of a pilot study. A minimum spanning haplotype network separated the 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%. Greenland sharks were found to diverge from the 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. The consistent divergence from multiple sites within the mtDNA between the two groups of Pacific sleeper sharks indicates a historical physical separation. There appears to be no phylogeographic pattern, as both types were found throughout
the North Pacific and Bering Sea. Continued sample collection and development of nuclear markers (microsatellites) is currently underway and will allow for a better understanding of the level of introgression, if any, between these two 'populations' of sharks. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Stock Assessment

Sharks - ABL

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) are on biennial cycles. The GOA assessment coincides with the biennial trawl survey in odd years and the BSAI assessment is in even years. A full assessment for the BSAI sharks and an executive summary for the GOA sharks is planned for the fall of 2016.

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. Catch estimates from 2003-2015 were updated from the NMFS Alaska Regional Office’s Catch Accounting System. In the GOA, total shark catch in 2015 was 1,414 t, which is down from the 2014 catch of 1,553 t (the greatest catch of the full time series). An impact of observer restructuring (beginning in 2013) was that estimated shark catches in NMFS areas 649 (Prince William Sound) and 659 (Southeast Alaska inside waters) for Pacific sleeper shark and spiny dogfish by the halibut target fishery has increased. In the last two years, the average Pacific sleeper shark and spiny dogfish catch in NMFS areas 649 and 659 has been 75 t and 119 t, respectively, compared to the historical average of < 1 t and ~14 t average (SD = 23), respectively. There was approximately 2 t of salmon shark and other shark catch estimated in these areas as well. The catch in NMFS areas 649 and 659 does not count against the federal TAC, but if it were included the total catch of sharks in 2015 would be 1,567 t, which is still below the recommended acceptable biological catch (ABC) for the shark complex.

Survey biomass was updated for the 2015 GOA assessment. The trawl survey biomass estimates are only used for spiny dogfish. The 2015 survey biomass estimate (51,916 t, CV = 25%) is about a third of the 2013 biomass estimate of 160,384 t (CV = 40%); this variability is typical for spiny dogfish. The random effects model for survey averaging was used for calculating the spiny dogfish ABC and OFL, 56,181 t.

In the BSAI, estimates of shark catch from the Catch Accounting System from 2014 were 106 t. Pacific sleeper shark are the primary species caught. These catch estimates do incorporate the restructured observer program, but the impact appears to be minimal for BSAI sharks. The survey biomass estimates on the BSAI are highly uncertain and not informative for management purposes.

For the GOA assessment, spiny dogfish are a “Tier 6” species, but a “Tier 5” calculation is used (this is due to the “unreliable” nature of the biomass estimates) and all other sharks a “Tier 6” species. The 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 ABC=4,514 t and OFL= 6,020 t for 2014. In the BSAI, all shark species are considered “Tier 6” with the 2015 ABC = 1,020 t and OFL = 1,360 t.

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

1. Research
2. Stock Assessment

Bering Sea

This chapter was presented in executive summary format, as a scheduled “off-year” assessment. The following new data were included in this year’s assessment:

Updated 2014 and preliminary 2015 catch and 2015 EBS shelf survey data. No changes were made to the assessment model. The projection model for Alaska skate was re-run with the most recent catch data (the 2015 EBS shelf survey data are not included in the projection model) and the Tier 5 random effects model was re-run for the other sharks component of the assemblage.

The 2015 biomass estimates from the shelf survey increased slightly from 2014. In the case of Alaska skates, survey biomass estimates, though variable, are basically trendless since species identification began in 1999. Model estimates of spawning biomass are also basically trendless over the 1992-2014 period covered by the model.

Since 2011, the Alaska skate portions of the ABC and OFL have been specified under Tier 3, while the “other skates” portions have been specified under Tier 5. Because projected spawning biomass for 2016 (115,378 t) exceeds $B_{40\%}$ (74,769 t), Alaska skates are managed in sub-tier “a” of Tier 3. Other reference points are $maxF_{ABC} = F_{40\%} = 0.077$ and $F_{OFL} = F_{35\%} = 0.090$. The Alaska skate portions of the 2016 and 2017 ABCs are 34,358 t and 32,167 t, respectively, and the Alaska skate portions of the 2016 and 2017 OFLs are 39,847 t and 37,306 t. The “other skates” component is assessed under Tier 5, based on a natural mortality rate of 0.10 and a biomass estimated using the random effects model that fits survey abundance estimates. The “other skates” portion of the 2016 and 2017 ABCs is 7,776 t for both years and the “other skates” portion of the 2016 and 2017 OFLs is 10,368 t for both years. For the skate complex as a whole, OFLs for 2016 and 2017 total 50,215 t and 47,674 t, respectively, and ABCs for 2016 and 2017 total 42,134 t and 39,943 t, respectively.

GOA

Skates are assessed on a biennial schedule with full assessments presented in odd years to coincide with the timing of survey data. A full assessment was completed for 2015.

New inputs this year were the biomass estimates and length composition data from the 2015 GOA bottom trawl survey, updated groundfish fishery catch data, and fishery length composition data through 2015. The random effects (RE) model was used to estimate survey biomass. In response to Plan Team and SSC requests, a separate RE model was run for each managed group, and for each regulatory area. The 2015 survey biomass estimates for big skates increased substantially, mainly due to an increase in the Central GOA estimate. This reversed a decline in Central GOA big skate biomass that began in 2003. The biomass for longnose skate and "other skates" decreased slightly relative to 2013, but in general the biomass for both groups has remained stable since 2000.

The application of the RE model to the survey data for each skate category continues to provide reasonable results for biomass estimates.
The catches of all skate species groups are substantially lower than in the years preceding 2014 (particularly 2009-2013). This decrease likely is due to prohibitions on retention of big skates in the CGOA (beginning in 2013), which discouraged “topping-off” behavior that resulted in high levels of catch, particularly for big skates in the CGOA.

Skates are managed in Tier 5 in the Gulf of Alaska. Applying $M=0.1$ and $0.75M$ to the estimated biomass from the random effects models for each stock component, gives stock specific OFLs and ABCs. Catch as currently estimated does not exceed any gulf-wide OFLs, and therefore, is not subject to overfishing. It is not possible to determine the status of stocks in Tier 5 with respect to overfished status.

D. Pacific Cod

1. Research

Genetic variation among Pacific cod is being used to investigate wide-scale seasonal and ontogenetic movement patterns. Analyses of 6442 single nucleotide polymorphisms (SNPs) from the cod genome showed a strong isolation-by-distance (IBD) pattern along a geographic gradient. The large number of genetic markers, along with the strong IBD relationship, provided significant power to assign individuals to putative genetic ‘stocks’ obtained from samples collected at or near spawning time, when population site fidelity is assumed to be highest. Correct assignment of individuals to putative source populations ranged from 88-100%, suggesting the potential use of this approach to estimate wide-scale migration patterns. By genetic assignment of individuals spanning multiple year classes collected during the summer, when cod are known to go on feeding migrations, to putative source populations, we anticipate resolving seasonal and ontogenetic migration patterns in cod that have not been obtained with conventional physical tagging efforts.

2. Stock Assessment

**Bering Sea**- For the 2015 stock assessment, all survey and commercial data series on CPUE, catch at age, and catch at length were updated. There were no changes in the assessment model and the 2016 specifications were based on the same model used in 2011-2014. Last year the Plan Team expressed serious reservations about this model’s poor retrospective performance and continued reliance on a fixed value of survey catchability that lacks credibility.

The Plan Team requested a different model for this year, and the author presented a version that has been in development for a few years, but he judged it not yet ready for use. It produces OFL/ABC estimates much lower than the present model. The EBS assessment will receive a CIE review in February 2016, and the Plan Team looks forward to seeing an improved model next year.

Survey biomass in 2015 was about the same as in 2014: just above a million tons, which is at the upper end of the range of values observed since 1977. As estimated in the current model, the spawning biomass of 409,000 t is well above $B_{40\%}(330,000 t)$ and increasing briskly, driven by a number of strong year-classes beginning in 2006 and also in 2008, 2011 and 2013. This increasing trend can be counted on despite any weaknesses in the present assessment model because the relative year-class strengths are well determined even if the scale is not. That is, even if the recommended ABC is somewhat high, spawning biomass will be higher next year than it is this year.
This stock is assigned to Tier 3a. The maximum 2016 ABC in this tier as calculated using the present model fit is 332,000 t, but the author recommended that ABC be held at the 2014 level of 255,000 t, as it was last year, to compensate for the poor retrospective behavior of the present model and the continuing concerns about the fixed survey catchability. The same value was recommended for the preliminary 2017 ABC. The corresponding OFLs (from the model) are 390,000 t and 412,000 t.

EBS Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Aleutian Islands** - This stock has been assessed separately from Eastern Bering Sea cod since 2013, and managed separately since 2014. Both age-structured (Tier 3) and survey-based (Tier 5) assessments have been considered, but to date it has not been possible to obtain a usable fit from any of the age-structured models that have been attempted. This year’s assessment is the same Tier 5 method used since the 2013 assessment: a simple random effects model of the trawl survey biomass trajectory. The Aleutians cod assessment will receive a CIE review in February 2016.

After declining by more than half between 1991 and 2002, survey biomass has since stayed in the range of 50-100 kilotons. The last Aleutians survey was in 2014. The author recommended using the Tier 5 assessment again for 2016 where ABC=17,600 t and OFL=23,400 t. These are the same as last year because there was no Aleutian Islands trawl survey in 2015. This stock is not being subjected to overfishing.

**Gulf of Alaska**

The fishery catch data series was updated for 2014 and 2015 (projected for 2015 expected total year catch). Fishery size composition data were updated for 2014, and preliminary fishery size composition were included for 2015. Estimates of biomass, numbers, and length compositions from the 2015 bottom trawl survey were also included. The 2015 trawl survey biomass estimate was 50% lower than the 2013 estimate.

The assessment evaluated three models. Model 1 is identical to the final model configuration from 2014. Model 2 and 3 differed from Model 1 by using only the 27 cm plus trawl survey abundance, length, and age compositions, 4 blocks of survey selectivity instead of 3, capping sample sizes for fishery length composition data at 400, and lowering likelihood weights for fishery length compositions.

Model 3 differed from Model 2 by including an additional block for fishery selectivity-at-length for 2013 through 2015 for all gear-season combinations except for pot gear in season three (data were limited in that category). This selectivity change was made to account for possible changes in the characteristics of the fishery length data since the fishery observer program was restructured in 2013. The authors recommended Model 3.

**Spawning biomass and stock trends**

According to Model 3, $B_{00}$ for this stock is estimated to be 130,000 t, and projected spawning biomass in 2016 is 165,600 t. The estimated recruitment was well above average for the 2005-2008 year classes and mostly below average for the 2009-2014 year classes. Spawning biomass is expected to decline in the near term.
Tier determination/ Plan Team discussion and resulting ABC and OFL recommendations

Models 2 and 3 with the likelihood weight on fishery length compositions reduced from 1 to 0.25 were preferred over Model 1 because Models 2 and 3 fit the trawl survey abundance index better than Model 1 or other Model 2 and 3 configurations with higher weights on fishery length data. Model 3 fit the survey index and most fishery length compositions better than Model 2. The Plan Team accepted the author’s recommendation to use Model 3 (with 0.25 weight on fishery length data) as the preferred model.

Since 2016 spawning biomass is estimated to be greater than $B_{40\%}$, this stock is in Tier 3a. The estimates of $F_{35\%}$ and $F_{40\%}$ are 0.495 and 0.407, respectively. The maximum permissible ABC estimate (98,600 t) is a 4% decrease from the 2015 ABC of 102,850 t.

Status determination

The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

For further information, contact Dr. Grant Thompson at (541) 737-9318 (BSAI assessment) or Dr. Teresa A’Mar (GOA assessment) (206) 526-4068.

E. Walleye Pollock

1. Research

Energy Density and Recruitment of Walleye Pollock - ABL

In 2015 calorimetric analysis of pollock samples collected in 2014 and 2015, including those collected north 60 degrees. Previous analysis had indicated that energy densities tracked climate conditions in the southeastern Bering Sea so that warm conditions (2003-2005) were associated with low energy densities and cool conditions (2006-2012) were associated with high energy densities. These variations in energetic status have been shown to correlate with pollock recruitment in the Bering Sea. In 2014 the eastern Bering Sea south of 60° N shifted back to warm conditions following a prolonged cool period. Accordingly, we observed a decrease in energy density between 2012 and 2014 (no survey was conducted in 2013). In 2015 the eastern Bering Sea continued to be very warm, although retreating sea ice left a large pool of cold water north of 60°, creating conditions much like those observed in the southern Bering Sea between 2006-2012. We observed a strong latitudinal pattern of energy densities in walleye pollock, suggesting conditions in the northern Bering Sea were more conducive to pollock production than those to the south.

For more information contact Ron Heintz Ron.Heintz@noaa.gov.

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 pre- and post-winter thermal conditions experienced by walleye pollock ($Gadus chalcogramma$) 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) and August (t-1) (Figure 1) in an area of the southern region of the eastern Bering Sea (56.2°N to 58.1°N latitude by
166.9°W to 161.2°W longitude). Time series of average monthly sea surface temperatures were obtained from the NOAA Earth System Research Laboratory Physical Sciences Division website. Sea surface temperatures were based on NCEP/NCAR gridded reanalysis data (Kalnay et al., 1996, data obtained from http://www.esrl.noaa.gov/psd/cgi-bin/data/timeseries/timeseries1.pl). Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock.

**Status and trends:** The 2015 TC index value is -5.96, lower than the 2013 TC index value of -3.84. Both the late summer and following spring sea temperatures were warmer than average. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-6 for based on abundance estimates from Table 1.25 in Ianelli et al. 2014 (Table 1). Over the longer period (1964-2014), the TC index was more statistically significant for the age-1, age-2, and age-3 pollock, than for the older pollock (Table 1). For years 2002-2014, this relationship was less statistically significant.

Figure 1: The Temperature Change index values from 1950 to 2015.
Figure 2: Normalized time series values of the temperature change index (t-2) and the estimated abundance of age-3 walleye pollock in the eastern Bering Sea (t) from Table 1.25 in Ianelli et al. 2014.

Table 1: Pearson's correlation coefficient relating the temperature change index to subsequent estimated year class strength of pollock (Age-x+1). Bold values are statistically significant (p < 0.05).

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Age 1 (t)</th>
<th>Age 2 (t+1)</th>
<th>Age 3 (t+2)</th>
<th>Age 4 (t+3)</th>
<th>Age 5 (t+4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964-2014</td>
<td>0.38</td>
<td>0.38</td>
<td>0.36</td>
<td>0.31</td>
<td>0.28</td>
</tr>
<tr>
<td>2002-2014</td>
<td>0.29</td>
<td>0.29</td>
<td>0.21</td>
<td>0.21</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Factors causing observed trends: The age-0 pollock are 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). Warmer spring temperatures lead to an earlier ice retreat, 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, 2011; Coyle et al., 2011). Colder later summers during the age-0 phase followed by warmer spring temperatures during the age-1 phase are assumed favorable for the survival of pollock from age-0 to age-1.

Implications: In 2013, the TC index value of -3.89 was above the long-term average of -4.60, therefore we expect slightly above average numbers of pollock to survive to age-3 in 2015 (Figure 2). In the future, the TC values of -5.96 in 2015 indicate an expected below average abundances of age-3 pollock in 2017.

Literature Cited
Large zooplankton abundance as an indicator of pollock recruitment to age-3 in the southeastern Bering Sea – ABL

Description of indicator: Interannual variations in large zooplankton abundance (sum of all large zooplankton taxa, excluding euphausiids) were compared to age 3 walleye pollock abundance (millions of fish) per biomass (thousands of tons) of spawner for year classes 2003-2010 on the southeastern Bering Sea shelf. Zooplankton samples were collected with oblique bongo tows over the water column (60 cm, 505 µm mesh nets) on BASIS fishery oceanography surveys during mid-August to late September, for three warm years (2003-2005) followed by one average (2006) and four cold years (2007-2010) (Eisner et al., 2014). Pollock abundance and biomass was available from the stock assessment report for the 2006-2013 year classes (Ianelli et al., 2014).

Status and trends: For the 2003-2010 year classes of pollock, a positive significant (P= 0.011) linear relationship was found between mean abundances of large zooplankton at year t (when pollock were age-0), and age3 pollock abundance at year t+3 (Fig. A). A strong relationship (P = 0.004) was also observed for large zooplankton and age 3 pollock abundance (t+3)/ spawner biomass (t) (Fig. B). These results suggest that increases in the availability of large zooplankton prey during the first year at sea were favorable for age-0 pollock survival and recruitment into the fishery at age 3.

Factors influencing observed trends: Increases in sea ice extent and duration were associated with increases in large zooplankton abundances on the shelf (Eisner et al., 2014), increases in large copepods and euphausiids in pollock diets (Coyle et al., 2011) and increases in age-0 pollock lipid content (Heintz et al., 2013). The increases in sea ice and associated ice algae and phytoplankton blooms may provide an early food source for large crustacean zooplankton reproduction and growth (Baer and Napp 2003; Hunt et al., 2011). These large zooplankton taxa contain high lipid concentrations (especially in cold, high ice years) which in turn increases the lipid content in their
predators such as age-0 pollock and other fish that forage on these taxa. Increases in energy density (lipids) in age-0 pollock allow them to survive their first winter (a time of high mortality) and eventually recruit into the fishery. Accordingly, a strong relationship has been shown for energy density in age-0 fish and age-3 pollock abundance (Heintz et al., 2013).

**Implications:** If the relationship between large zooplankton and age 3 pollock remains robust as more years are added to the analysis, this index could be used to predict the survival of pollock three years in advance of recruiting to age 3, the year pollock enter the fishery, from zooplankton data collected 3 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).

![Graph showing linear relationships between mean large zooplankton abundance and age-3 pollock biomass.](image)

Figure 1. Linear relationships between A) mean large zooplankton abundance (t) and A) age 3 pollock abundance (t+3) and between B) mean large zooplankton abundance (t) and age-3 pollock abundance (t+3)/Spawner biomass (t). Orange symbols are warm (low ice) years, blue are cold (high ice) years and white is an average year. Year classes (when pollock were age 0) and
zooplankton were collected are shown next to symbols.

Literature cited:


Contact Lisa Eisner at lisa.eisner@noaa.gov

Salmon, Sea Temperature, and the Recruitment of Bering Sea Pollock – ABL

Description of indicator: Chum salmon growth and sea temperature were used to predict the recruitment of pollock to age-1 in 2014 and 2015 (Yasumishii et al. 2015). Chum salmon are incidentally captured in the commercial fisheries for walleye pollock (Gadus chalcogrammus) in the Bering Sea (Stram and Ianelli, 2009). We used the intra-annual growth in body weight of these immature and maturing age-4 chum salmon from the pollock fishery as a proxy for ocean productivity experienced by age-0 pollock on the eastern Bering Sea shelf. Adult pink salmon are predators and competitors of age-0 pollock (Coye et al. 2011). We modeled age-1 pollock recruitment estimates from 2001 to 2010 as a function of chum salmon growth, sea temperatureBering Sea and used the model parameters and biophysical indices from 2013 and 2014 to predict age-1 pollock abundances in 2014 and 2015. Estimates of age-1 pollock abundance were from Ianelli et al. (2014).

Status and trends: Pollock recruitment was highly variable within the 10-year time series, 2001-2010 (Figure 1). In a multiple regression model, age-1 pollock recruitment was negatively related to spring sea temperatures during their age-1 stage and positively related to chum salmon growth during the pollock age-0 stage ($R^2 = 0.73$; $p$–value = 0.008). Model residuals (Figure 2) had an alternating year pattern. A slight alternating year pattern was observed in the time series, with higher recruitment to age-1 in odd-numbered years. The higher than expected (positive residuals) recruitment to age-1 in odd-years (age-0 in even-numbered years) may be associated with fewere adult pink salmon (a predator and competitor) in even-years as age-0s or as a predator buffer in odd-years during the early spering age-1 stage of pollock.
Factors influencing observed trends: The model parameters (2001-2010) and biophysical indices (2013 and 2014) were used to predict the recruitment of Bering Sea pollock in 2014. The 2013 biophysical indices (chum salmon growth = 0.969 kg, spring sea temperature = 3.95°C) produced a forecast of 14 million (3,837 standard error, c.v. = 0.22) age-1 pollock in 2014. The 2014 biophysical indices (chum salmon growth = 0.80 kg, spring sea temperature = 4.00°C) produced a forecast of 5 million age-1 pollock in 2015. The 2014 biophysical indices indicated below ocean productivity (chum salmon growth) and warm spring sea temperatures (less favorable). These factors are expected to result in below average age-1 pollock recruitment in 2015.

Implications: The model predicts a below average recruitment of pollock to age-1 in 2015.
Figure 1. Age-1 pollock modeled as a function of the intra-annual growth in body weight of chum salmon during the age-0 stage ($t-1$) and spring sea temperature during the age-1 stage ($t$).
Figure 2. Residuals of the regression model relating age-1 pollock abundance (t) to spring sea surface temperature (t) and chum salmon growth (t-1).

**Literature Cited**


2. Stock Assessment

GULF OF ALASKA - REFМ
The 2015 pollock assessment features the following new data: 1) 2014 total catch and catch-at-age from the fishery, 2) 2015 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2015 biomass and length composition from NMFS bottom trawl survey, 4) 2015 biomass and 2014 age composition from the ADFG crab/groundfish trawl survey, and 5) 2013 and 2015 biomass estimates, 2013 age composition, and 2015 length composition from the summer acoustic survey.

The age-structured assessment model used for GOA W/C/WYAK pollock assessment implemented two model changes relative to the model used for the 2014 assessment. These changes were necessary to include the summer acoustic survey in the assessment, and to estimate a power coefficient for the age-1 winter acoustic survey index catchability. The 2015 assessment compared the following models to the 2014 model with the new data, each added to sequential models in a cumulative manner: 1) adding the summer acoustic survey data, 2) adding a power term for age-1 winter acoustic catchability, and 3) revising the Shelikof Strait acoustic survey estimates for net selectivity. Last year’s base model used iterative re-weighting for composition data based on the harmonic mean of effective sample size. An initial “tuning” step was conducted after incorporating new data. However, to facilitate model comparison, subsequent models were not tuned until a potential base model was identified, and then a final tuning step was done for that model. To add the summer acoustic data as a new survey time series, the authors used simple approach for modeling selectivity due to the limited amount of data; this approach will need to be revisited as additional data become available. Adding a power term for age-1 significantly improved the model fit and is the authors’ recommended model. Adding a power term for age-2 resulted in a value close to zero and failed to improve the model fit so was excluded. Improvement to the model fit by revising the Shelikof Strait acoustic survey estimates for net selectivity was equivocal. Before using the net-selectivity corrected estimates, the Team noted that the method should be fully documented and reviewed. The Plan Team accepted the authors’ recommended final model configuration that incorporated the summer acoustic survey data and a power term for age-1 winter acoustic catchability.

Model fits to fishery age composition data appeared to be reasonable in most years. The largest residuals tended to be at ages 1-2 in the NMFS bottom trawl survey due to inconsistencies between the initial estimates of abundance and subsequent information about year class size. Model fits to biomass estimates are similar to previous assessments, and general trends in survey time series are fit reasonably well. It is difficult for the model to fit the rapid increase in the Shelikof Strait acoustic survey and the NMFS bottom trawl survey in 2013 since an age-structured pollock population cannot increase as rapidly as is indicated by these surveys. The model is unable to fit the extreme low value for the ADFG survey in 2015, though otherwise the fit to this survey is quite good. The fit to the age-1 and age-2 Shelikof acoustic indices appeared adequate though variable.

The model estimate of spawning biomass in 2016 is 321,626 t, which is 42.9% of unfished spawning biomass (based on average post-1977 recruitment) and above the B40% estimate of 300,000 t. The 2015 Shelikof Strait acoustic survey estimate of age-3+ pollock is 1.64 billion,
which is the largest age-3+ estimate in the time series. There was a large and unexplained decline in pollock biomass in the 2015 ADFG survey (58% decline), which is a concern, especially since this time series has shown relatively little variability compared to the others. The 2012 year class still appears to be very strong based on recent information. The estimated abundance of mature fish is projected to peak in 2017, and then decline as the strong 2012 year class passes through the population. Over the years 2009-2013 stock size has shown a strong upward trend from 25% to 50% of unfished stock size, but declined to 33% of unfished stock size in 2015. The spawning stock is projected to increase again in 2016 as the strong 2012 year class starts maturing.

The author’s recommendation to reduce $F_{ABC}$ from the maximum permissible using the “constant buffer” approach (first accepted in the 2001 GOA pollock assessment) was employed. Because the model projection of female spawning biomass in 2016 is above $B_{40\%}$, the W/C/WYAK Gulf of Alaska pollock stock is in Tier 3a. The projected 2016 age-3+ biomass estimate is 1,937,900 t (for the W/C/WYAK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock dropping below $B_{20\%}$ will be negligible in all years.

The 2016 ABC for pollock in the Gulf of Alaska west of 140° W longitude (W/C/WYAK) is 254,310 t which is an increase of 33% from the 2015 ABC. In 2017, the ABC based on an adjusted $F_{40\%}$ harvest rate is 250,544 t. The OFL is 322,858 t in 2016 and 289,937 t in 2017. The 2016 Prince William Sound (PWS) GHL is 6,358 t (2.5% of the 2016 ABC of 254,310 t); the 2017 PWS GHL is 6,264 t (2.5% of the 2017 ABC of 250,544 t).

For more information contact Dr. Martin Dorn 526-6548.

**EASTERN BERING SEA - REFM**

The following new data were incorporated into the 2015 stock assessment:

1) A “corrected index” (formerly known as the Kotwicki index) for the summer bottom trawl survey (BTS) biomass and abundance at age time series (1982-2015) was included for the first time, after having been tested for several years; 2) 2014 and 2015 acoustic vessels-of-opportunity (AVO) data; 3) Age compositions from the 2014 NMFS summer acoustic-trawl survey (ATS) were updated; 4) Catch at age and average weight at age from the 2014 fishery; and 5) Updated total catch, including a preliminary estimate for 2015. The only methodological change was the use of a new random effects model for projecting future weight at age.

Spawning biomass in 2008 was at the lowest level since 1980, but has increased by 114% since then, with a 3% decrease projected for next year. The 2008 low was the result of extremely poor recruitment from the 2002-2005 year classes. Recent and projected increases are fueled by recruitment from the very strong 2008 year class and the above average 2012 year class, along with reductions in average fishing mortality (ages 3-8) from 2009-2010 and 2013-2015. Spawning biomass is projected to be 78% above $B_{MSY}$ in 2016.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates of $B_{MSY}$ and the probability density function for $F_{MSY}$. The updated estimate of $B_{MSY}$ from the present assessment is 1.984 million t, up 2% from last year’s estimate of 1.948 million t. Projected spawning biomass for 2016 is 3.540 million t, placing EBS walleye pollock in sub-tier “a” of Tier 1. As in recent assessments, the maximum permissible ABC harvest rate was
based on the ratio between MSY and the equilibrium biomass corresponding to MSY. The harmonic mean of this ratio from the present assessment is 0.401, down 22% from last year’s value of 0.512. The harvest ratio of 0.401 is multiplied by the geometric mean of the projected fishable biomass for 2016 (7.610 million t) to obtain the maximum permissible ABC for 2016, which is 3.050 million t, up 5% and almost identical to the maximum permissible ABCs for 2015 and 2016 projected in last year’s assessment, respectively. However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. The rationale for this recommendation, that results in an ABC well below the maximum permissible level, is: 1) The fleet was able to operate with reasonably good catch rates and 2) the fleet was able to maintain salmon bycatch at relatively low levels.

From 2010-2013, harvest recommendations were based on the most recent 5-year average fishing mortality rate. Last year, the Team and SSC felt that stock conditions had improved sufficiently that an increase in the ABC harvest rate was appropriate. Specifically, they recommended basing the 2015 and 2016 ABCs on the harvest rate associated with Tier 3, the stock’s Tier 1 classification notwithstanding. This method gives a 2016 and 2017 ABC of 2.090 million t and 2.019 million t, respectively. The OFL harvest ratio under Tier 1a is 0.514, the arithmetic mean of the ratio between MSY and the equilibrium fishable biomass corresponding to MSY. The product of this ratio and the geometric mean of the projected fishable biomass for 2016 determines the OFL for 2016, which is 3.910 million t. The current projection for OFL in 2017 given a projected 2016 catch of 1.350 million t is 3.540 million t.

The walleye pollock stock in the EBS is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Aleutian Islands:
This year’s assessment estimates that spawning biomass reached a minimum level of about B_{29%} in 1999 and has since slowly increased to a projected value of B_{36%} for 2016. The increase in spawning biomass since 1999 has resulted more from a dramatic decrease in harvest than from good recruitment, as there have been no above-average year classes spawned since 1989. Spawning biomass for 2016 is projected to be 74,377 t. The model estimates B_{80%} at a value of 82,785 t, placing the AI pollock stock in sub-tier “b” of Tier 3. The model estimates the values of F_{35%} as 0.40 and F_{40%} as 0.32. Under Tier 3b, with the adjusted value of F_{40%}=0.27, the maximum permissible ABC is 32,227 t for 2016. Following the Tier 3b formula with the adjusted value of F_{35%}=0.34, OFL for 2016 is 39,075 t. If the 2015 catch is 1,500 t and 1,188 t for 2016 (i.e., equal to the five year average for 2010-2014), the 2017 maximum permissible ABC would be 36,664 t and the 2017 OFL would be 44,455 t. The Team recommended setting 2017 the ABC and OFL at these levels.

The walleye pollock stock in the Aleutian Islands is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Bogoslof Pollock

Estimated catches for 2014 and 2015 were updated and 2014 survey age data were completed and included. The only change in assessment methodology from 2014 was to accept the estimate of natural mortality from the age-structured assessment that was introduced in 2014. The new estimate is 0.3, up from the estimate of 0.2 used previously.
Survey biomass estimates since 2000 have all been lower than estimates prior to 2000, ranging from a low of 67,063 t in 2012 to a high of 301,000 t in 2000. The estimate of current biomass from the random effects model is 106,000 t.

The SSC has determined that this stock qualifies for management under Tier 5. The maximum permissible ABC value for 2016 would be 23,850 t (assuming $M = 0.3$ and $F_{ABC} = 0.75 \times M = 0.225$): $ABC = B_{2014} \times M \times 0.75 = 106,000 \times 0.3 \times 0.75 = 23,850$ t. The projected ABC for 2017 is the same. Following the Tier 5 formula with $M=0.301$, OFL for 2016 is 31,906 t. The OFL for 2017 is the same.

The walleye pollock stock in the Bogoslof district is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

For further information contact Dr. James Ianelli, (206) 526-6510

F. Pacific Whiting (hake)

G. Rockfish

Research

**Long-term Survival and Healing of a Deep-water Rockfish After Barotrauma and Subsequent Recompression in Pressurized Tanks - ABL**

Movement patterns and stock structure of deep-water rockfish (*Sebastes spp.*) are difficult to study because rockfish are physoclystic, i.e. their gas bladders are closed off from the gut, and so they often suffer internal injuries from rapid, internal air expansion when caught. From 2011-2013, we sampled blackspotted and rougheye rockfish with longline gear at depths from 123-279 m. Barotrauma was assessed immediately after capture and then fish were recompressed in tanks onboard the fishing vessel. After re-pressurization in the tanks, the great majority of fish no longer had external signs of barotrauma.

Survival was highest when fish were given four days to acclimate from 70 psi to atmospheric pressure in the tanks (77.8% in 2013), opposed to two days (50% in 2011 and 60% in 2012). There were delayed mortalities of fish caught in 2011 and 2012, but none in 2013. Increased experience with the tanks improved our ability to control water flow, keep pressure consistent, and reduce handling time. This experience as well as an increase in the decompression time in 2013 (4 days to acclimate to surface pressure instead of 2) helped to increase survival. The time required for decompression will likely be species specific. Both the presence of barotrauma and the depth of capture were not associated with survival. However, as fish length increased mortality increased significantly (fish length ranged from 275 to 685 mm).

The healing of eyes was tracked for 40 fish in the laboratory. The majority of fish put into recompression tanks had both exophthalmia and corneal emphysema at-sea (34 out of 40; 85%). Of these 34 fish, 76% had clear eyes after holding in the lab. It sometimes took several months to over a year for eyes to become clear. All fish that had clear eyes at sea or only exophthalmia had clear
eyes directly after recompression (6 out of 40; 15%). Eye health did not always improve with holding. Ruptured swim bladders were observed in 41% (14 of 34) of fish dissected after long-term holding (6-18 months). All but one of the fish with ruptures (13 of 14) had healed and their swim bladders were inflated.

Fish not recompression in tanks were tagged and released at ~75 m using a weighted cage. Video of fish being released demonstrated that all fish were negatively buoyant and 67% swam away. A rockfish that was tagged with an external spaghetti tag in July, 2012 was recaptured in March, 2013 in the Pacific halibut (Hippoglossus stenolepis) longline fishery 58 km from the capture/release location. To swim to the recapture location, the fish had to cross over areas that reach depths of 590 m. Blackspotted and rougheye rockfish are closely associated with the bottom, so it may have descended to deeper depths than the capture/release depths in order to reach the recapture location.

Figure: Photos of a blackspotted or rougheye rockfish immediately after capture (top) and the same fish after being recompressed at-sea and then held long term in captivity (bottom).

For more information, contact Cara Rodgveller, ABL, at (907) 789-6052 or cara.rodgveller@noaa.gov.

**First Behavioral Observations of a *Sebastes* Using Pop-up Satellite Archival Tags (PSATs) Post Barotrauma – ABL**

Pop-up satellite archival tags (PSATs) were deployed on 8 blackspotted rockfish (*Sebastes melanostictus*) (37-54 cm fork length) caught at depths from 148-198 m after incurring barotrauma. The 6 fish released immediately after capture in a weighted cage descended quickly to what was assumed to the bottom depth. Tags ascended to the surface before the preprogrammed pop-up date after only 11-14 days. Two fish were held in captivity for 8 months or 4 years after capture and then released at the surface. One tag came to the surface after only 12 days and a tag deployed on a 37 cm fish was retained for 190 days. Both fish made dives initially and then quickly moved to more shallow depths, indicating that rockfish may require time to acclimate to increased pressure. For the tag that was retained for 190 days, we identified six phases of vertical movement behavior. During
the longest phase (123 days) the fish made rapid, 16-39 m dives (sometimes in less than 15 minutes), which were significantly deeper during the day and during high tide. During some of the shorter phases the fish was more sedentary or was deeper at night. Our results show that a Sebastes as small as 37 cm can be tagged with PSATs, if recompression and recovery are allowed to occur in captivity.

![Graphs showing depth readings from a PSAT deployed on a blackspotted rockfish during 6 behavioral phases over 190 days. White bars are daytime hours and dark bars encompass the time after sunset and before sunrise.](image)

**Deepwater Rockfish Tagging – ABL**

In the Gulf of Alaska, Aleutian Islands, and Bering Sea, commercial rockfish (Sebastes spp.) landings have exceeded 43,500 t annually since 2002. A large percentage of these landings are attributed to Pacific ocean perch (POP) *S. alutus*. This species occupies deep water on the continental shelf and slope and is taken in directed fisheries as well as in non-directed fisheries as bycatch. Despite the value of this fishery, many life history and biological characteristics of the fish remain poorly understood by scientists and managers.

Since rockfish are physoclystic, i.e., their swim bladder is not directly connected with their gut, rockfish often suffer barotrauma injuries when brought up from depth. These injuries occur because rockfish cannot rapidly eliminate expanding gas from internal spaces during ascent. The gas expansion can cause everted stomachs, exophthalmia (pop-eye), and damage to internal tissues. Because of these barotrauma-induced injuries, post-release survival of many rockfish species has previously been assumed to be negligible and large-scale deep-water rockfish tagging efforts have
therefore not been undertaken. Without tagging studies, research avenues that elucidate rockfish movement and migration patterns, behavior, and stock structure are limited. However, recent research at the Alaska Fisheries Science Center in Juneau, Alaska, and elsewhere, has demonstrated that deep-water rockfish can survive barotrauma injuries if the fish are recompressed soon after capture. If substantial numbers of rockfish were captured, tagged, and released quickly, information on movement and stock structure could be generated from subsequent tag recoveries. This information is important for understanding rockfish biology and ultimately for managing rockfish stocks. Furthermore, if this method of tagging is successful, this protocol could be used to study not only deep-water rockfish in Alaska, but other physoclystic fish in oceans worldwide. The objective of this project is to investigate movement patterns, distribution, stock structure, and life history parameters of Pacific ocean perch.

In August of 2015, we trawled in the Gulf of Alaska near Kodiak Island with a livebox (aquarium codend) attached to a midwater trawl. POP caught in the trawl passed into the livebox and were shunted into a calm, water-filled compartment. This compartment protected the fish from being crushed while the net was pulled through the water and while the livebox was retrieved to the deck of the vessel. Once on deck, rockfish were removed from the livebox, quickly measured and tagged. Most tagged fish were loaded into a weighted mesh cage, lowered to approximately 90 m, and released at depth. In total, 28 tows were made on Albatross Bank and 2,527 POP were tagged and released. Cameras were installed on the release cage to observe POP behavior at-depth post-capture. External signs of barotrauma were significantly reduced as the fish descended and a small percentage of POP swam away from the cage but most were lethargic. A subsample of tagged fish were recompressed on board the vessel in portable recompression chambers. After the initial pressurization, pressure was slowly reduced over 24-48 hours. Survival of recompressed POP was low (4.2%) but fish were subjected to significant thermal stress in the recompression chambers that may have adversely affected survival. Temperatures at capture depths averaged 5.7º C while temperatures in the recompression chambers were at least as high as 16.4º C.

This work was completed in an area that receives substantial commercial fishing effort. By tagging in these areas, the probability of recovering tagged fish was maximized. Tag recovery data will allow us to describe rockfish movements between release and recapture locations and will elucidate distribution and migration patterns. This information is critical for understanding stock composition and habitat requirements. Additionally, recoveries will allow for growth calculations which are important for stock assessments.

For more information, contact Patrick Malecha at (907) 789-6415 or pat.malecha@noaa.gov.

Habitat use and productivity of commercially important rockfish species in the Gulf of Alaska - RACE GAP
The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. This project examined the productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. poly-spinis*, and dusky rockfish, *S. variabilis*) in three different habitat types during three seasons. Low relief, high relief rocky/boulder, and high relief
sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska will be sampled using both drop camera image analysis and modified bottom trawls. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types. All field work for this project has been completed and sample processing and data analysis will be completed within the next year.

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

**Rockfish Reproductive Studies - RACE GAP Kodiak**

RACE groundfish scientists initiated a multi-species rockfish reproductive study in the Gulf of Alaska with the objective of providing more accurate life history parameters to be utilized in stock assessment models. There is a need for more detailed assessment of the reproductive biology of most commercially important rockfish species including: the rougheye rockfish complex (rougheye and blackspotted rockfish, *S. aleutianus* and *S. melanostictus*), shortraker rockfish, *S. borealis* and other members of the slope complex. The analysis of maturity for these deeper water rockfish species has been complicated by the presence of a significant number of mature females that skip spawning. Preliminary results for rougheye rockfish, blackspotted, and shortraker rockfish are presented below. To complete these studies samples are needed from additional areas and time periods.

In addition, there is a need to examine the variability of rockfish reproductive parameters over varying temporal and spatial scales. It remains unknown if there is variability in rockfish reproductive parameters at either annual or longer time scales however, recent studies suggest variation may occur for the three most commercially important species, Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish *S. variabilis*. Researchers at the AFSC Kodiak Laboratory will be examining annual differences in reproductive parameter estimates of Pacific ocean perch and northern rockfish in the upcoming years. Sampling for this study was initiated in 2012 and additional samples will be collected through the 2017 reproductive season.

**Rougheye and Blackspotted Rockfish-GAP Kodiak**

The recent discovery that rougheye rockfish are two species, now distinguished as ‘true’ rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further accents the need for updated reproductive parameter estimates for the members of this species complex. Current estimates for age and length at maturity for this complex in the GOA are derived from a study with small sample sizes, few samples from the GOA, and an unknown mixture of the two species in the complex. A critical step in improving the management of this complex is to understand the reproductive biology of the individual species that comprise it, as it is unknown if they have different life history parameters. This study re-examines the reproductive biology of rougheye rockfish and blackspotted rockfish within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Maturity analyses for these species and other deepwater rockfish species within this region are complicated by the presence of mature females that are skip spawning. Preliminary results from this study indicate age and length at 50% maturity for rougheye rockfish are 15.5 years and 43.9 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. Preliminary results indicate length at 50% maturity for blackspotted rockfish is 44.3 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.

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

**Shortraker rockfish (in collaboration with Charles Hutchinson, AFSC Age and Growth laboratory)**

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 49.5 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.

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

**Assessment**

Dusky rockfish, *Sebastes variabilis*, have one of the most northerly distributions of all rockfish species in the Pacific. They range from southern British Columbia north to the Bering Sea and west to Hokkaido Is., Japan, but appear to be abundant only in the Gulf of Alaska (GOA). Rockfish in the GOA are assessed on a biennial stock assessment schedule to coincide with the availability of new AFSC biennial trawl survey data. In 2015, a full assessment document with updated assessment and projection model results were presented.

We use a statistical age-structured model as the primary assessment tool for Gulf of Alaska dusky rockfish which qualifies as a Tier 3 stock. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels.

A substantive change was made in the assessment in 2015 which was to use a geostatistical estimator for determining survey biomass in favor of the traditional design-based estimator. The survey biomass time series for dusky rockfish is characterized by high variability because the survey does a poor job at sampling untrawlable habitat where dusky rockfish are encountered. The geostatistical estimator described by Thorson et al. (2015) is a preferred method to the design-based methodology for estimating biomass as it uses the available survey catch data more efficiently than
conventional estimators and reduces the inter-annual variability in the biomass estimates by over 63% compared to the design-based estimates. The Plan Team and Science and Statistical Committee (SSC) endorsed this methodology, which provided alternative survey biomass estimates based on the geostatistical estimator.

For the 2016 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 54,686 t. This ABC is 8% less than last year’s ABC of 5,109 t. The decrease in ABC is supported by a decline in the trawl survey biomass estimate in 2015 from 2013. The stock is not overfished, nor is it approaching overfishing status.

For more information, contact Chris Lunsford, ABL, at (907)789-6008 or chris.lunsford@noaa.gov.

Pacific Ocean Perch (POP) - BERING SEA AND ALEUTIAN ISLANDS - REFM

This chapter was presented in executive summary format, as a scheduled “off-year” assessment as full assessments are scheduled to coincide with years when an Aleutian Islands trawl survey is conducted. Therefore, only the projection model was run, with updated catches. New data in the 2015 assessment included updated 2014 catch and estimated 2015 and 2016 catches. No changes were made to the assessment model.

The survey biomass estimates in the Aleutian Islands were high in 2014. New projections were very similar to last year’s projections because observed catches were very similar to the estimated catches used last year. Spawning biomass is projected to be 222,369 t in 2016 and to decline to 211,339 t in 2017. These projections indicate that the stock is at an abundant level.

The SSC has determined that reliable estimates of B40%, F40%, and F35% exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of B40%, F40%, and F35% are 169,203 t, 0.089, and 0.109, respectively. Spawning biomass for 2016 (222,369 t) is projected to exceed B40%, thereby placing POP in sub-tier “a” of Tier 3. The 2016 and 2017 catches associated with the F40% level of 0.089 are 33,320 t and 31,724 t, respectively, and are the authors’ recommended ABCs. The 2016 and 2017 OFLs are 40,529 t and 38,589 t.

ABCs are set regionally based on the proportions in combined survey biomass as follows (values are for 2016): EBS = 8,353 t, Eastern Aleutians (Area 541) = 7,916 t, Central Aleutians (Area 542) = 7,355 t, and Western Aleutians (Area 543) = 9,696 t. The recommended OFL for 2016 and 2017 is not regionally apportioned. Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

POP - GULF OF ALASKA - ABL

Pacific ocean perch (POP), *Sebastes alutus*, is the dominant fish in the slope rockfish assemblage and has been extensively fished along its North American range since 1940. Since 2005, Gulf of Alaska rockfish have been moved to a biennial stock assessment schedule to coincide with the biennial AFSC trawl survey that occurs in this region. In odd years (such as 2015’s assessment for the 2016 fishery) there is new trawl survey data available from the GOA bottom trawl survey and a full assessment is completed. In the 2015 full assessment the notable changes to the assessment model included estimating growth information using length-stratified methods (following from the manner in which age observations are collected in the GOA bottom trawl survey), and constructing a new ageing error matrix that extends the modeled ages past the ages fit in the age composition.
Spawning biomass is above the $B_{40\%}$ reference point and projected to be 157,080 t in 2016 and to increase to 158,124 t in 2017. 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 114,131 t, 0.102, and 0.119 respectively. Spawning biomass for 2016 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier “a” of Tier 3. The 2016 and 2017 catches associated with the $F_{40\%}$ level of 0.102 are 24,437 t and 24,189 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2016 and 2017 OFLs are 28,431 t and 28,141 t.

A random effects model was used to regionally set ABC based on the proportions of model-based estimates of ending year survey biomass that were for 2016: Western GOA = 2,737 t, Central GOA = 17,033 t, and Eastern GOA = 4,667 t. The Eastern GOA is further subdivided 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 2016 is 2,847 t and for E. Yakutat/Southeast the ABC in 2016 is 1,820 t. The recommended OFL for 2016 is apportioned between the Western/Central/W. Yakutat area (26,313 t) and the E. Yakutat/Southeast area (2,118 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

**Northern Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM**

This chapter was presented in executive summary format, as a scheduled “off-year” assessment. Therefore, only the projection model was run, with updated catches. New data in the 2015 assessment included updated 2014 catch and estimated 2015 and 2016 catches. No changes were made to the assessment model.

The 1980s cooperative surveys in the Aleutian Islands had low biomass estimates relative to the remainder of the time series, and removal of these data in last year’s assessment increased the estimated population size. Spawning biomass has been increasing slowly and almost continuously since 1977 until recent years, when it appears to be leveling off. Female spawning biomass is projected to be 91,648 t and 88,326 t in 2016 and 2017, respectively. Recent recruitment has generally been below average. The catch of northern rockfish more than tripled from 2014 to 2015 because of changes in management measures and increased retention, although 2015 catch is still well below the ABC.

The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$ (57,768 t), $F_{40\%}$ (0.070), and $F_{35\%}$ (0.087). Because the projected female spawning biomass of 91,648 t is greater than $B_{40\%}$, sub-tier “a” is applicable, with maximum permissible $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Under Tier 3a, the maximum permissible ABC for 2016 is 11,960 t, which is the authors’ and Team’s recommendation for the 2016 ABC. Under Tier 3a, the 2016 OFL is 14,689 t for the Bering Sea/Aleutian Islands combined. The Plan Team continues to recommend setting a combined BSAI OFL and ABC, resulting in a 2017 ABC of 11,468 t and a 2016 OFL of 14,085 t.
Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

**Northern Rockfish - GULF OF ALASKA-ABL**

The northern rockfish, *Sebastes polyspinis*, is a locally abundant and commercially valuable member of its genus in Alaskan waters. As implied by its common name, northern rockfish has one of the most northerly distributions among the 60+ species of *Sebastes* in the North Pacific Ocean. Since 2005, Gulf of Alaska (GOA) rockfish have been moved to a biennial stock assessment schedule to coincide with the AFSC trawl survey. An age-structured assessment (ASA) model is used to assess northern rockfish in the GOA; the data used in the ASA model includes the trawl survey index of abundance, trawl survey age and length composition, fishery catch biomass, and fishery age and length composition. In odd years (such as 2015’s assessment for the 2016 fishery) there is new trawl survey data available from the GOA bottom trawl survey and a full assessment is completed. In the 2015 full assessment the notable changes to the assessment model included estimating growth information using length-stratified methods (following from the manner in which age observations are collected in the GOA bottom trawl survey), constructing a new ageing error matrix that extends the modeled ages past the ages fit in the age composition data to more precisely fit the plus age group and age classes adjacent to the plus age group with the model, and extending the plus age group of the data to 45+ (from 33+) to ensure the proportion of fish in the plus age group was not too large.

Spawning biomass is above the $B_{40\%}$ reference point and projected to be 31,313 t in 2016 and to decrease to 29,033 t in 2017. 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. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 27,983 t, 0.062, and 0.074 respectively. Spawning biomass for 2016 is projected to exceed $B_{40\%}$, thereby placing northern rockfish in sub-tier “a” of Tier 3. The 2016 and 2017 catches associated with the $F_{40\%}$ level of 0.062 are 4,008 t and 3,772 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2016 and 2017 OFLs are 4,783 t and 4,501 t.

A random effects model was used to regionally set ABC based on the proportions of model-based estimates of ending year survey biomass that were for 2016: Western GOA = 457 t, Central GOA = 3,547 t, and Eastern GOA = 4 t (note that the small ABC in the Eastern GOA is included with ‘other rockfish’ for management purposes). The recommended OFL for 2016 and 2017 is 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 Pete Hulson, ABL, at (907) 789-6060 or pete.hulson@noaa.gov.

**Shortraker Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM**

2015 is an off year for the shortraker rockfish (Tier 5) assessment; therefore the management specifications are unchanged. The remainder of this section is last year’s description of last year’s assessment.
The 2014 biomass estimate is based on the Aleutian Island survey data through 2014 as well as the 2002-2012 eastern Bering Sea slope survey data. The EBS slope survey data had not been included in previous biomass estimates for this species. For estimation of biomass, the assessment methodology was changed from a Kalman filter version of the Gompertz-Fox surplus production model to a simple random effects model.

The 2015 estimated shortraker rockfish biomass is 23,009 t, increasing from the previous estimate of 16,447 t primarily due to the inclusion of the 2002-2012 EBS slope survey biomass estimates. The modern EBS slope survey time series began in 2002. For the period 2002-2014, EBS slope survey biomass estimates ranged from a low of 2,570 t in 2004 to a high of 9,299 in 2012 (which was the year of the most recent EBS slope survey). For the period 1991-2014, the AI survey biomass estimates ranged from a low of 12,961 t in 2006 to a high of 38,497 t in 1997. According to the random effects model, total biomass (AI and EBS slope combined) from 2002-2014 has been very stable, ranging from a low of 20,896 t in 2006 to a high of 23,938 t in 2002. The time series from the random effects model is much smoother than the time series for the raw data, due to large standard errors associated with the data.

The SSC has previously determined that reliable estimates of only biomass and natural mortality exist for shortraker rockfish, qualifying the species for management under Tier 5. The Team recommends basing the biomass estimate on the random effects model. The Team recommended setting \( F_{ABC} \) at the maximum permissible level under Tier 5, which is 75 percent of \( M \). The accepted value of \( M \) for this stock is 0.03 for shortraker rockfish, resulting in a \( maxF_{ABC} \) value of 0.0225. The ABC is 518 t for 2015 and 2016 and the OFL is 690 t for 2015 and 2016.

Shortraker rockfish is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

**Shortraker Rockfish - GULF OF ALASKA – ABL**

Rockfish in the Gulf of Alaska (GOA) are assessed on a biennial assessment schedule to coincide with new data from the AFSC biennial trawl surveys in the GOA. For 2016, the biomass estimate was updated with 2015 survey data. Estimated shortraker rockfish biomass is 57,175 t, which is a decrease of 3% from the previous estimate in the 2015 assessment. Catch data were updated as well.

Shortraker rockfish has always been classified into “tier 5” in the North Pacific Fishery Management Council’s (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, the methodology used to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2016 fishery has changed this year to the use of a random effects model applied to the trawl survey data from 1984-2015. Estimated shortraker biomass is 57,175 mt, which is a decrease of 3% from the 2015 estimate. Shortraker biomass in the GOA has generally shown a progressive increase since 1990. The NPFMC’s “tier 5” ABC definitions state that \( F_{ABC} \leq 0.75M \), where \( M \) is the natural mortality rate. Using an \( M \) of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 1,286 t for the 2016 fishery. Gulfwide catch of shortraker rockfish was 685 t in 2014 and estimated at 538 t in 2015. Shortraker rockfish in the GOA is not being subjected to overfishing. It is not possible to determine whether this stock is
overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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

Blackspotted/rougheye Rockfish Complex - BERING SEA AND ALEUTIAN ISLANDS - REF

This chapter was presented in executive summary format for the 2015 assessment, as a scheduled “off-year” assessment. New data included updated catch for 2014 and estimated catches for 2015 and 2016. The projection model for the Tier 3 component of the assessment was re-run using the results from last year’s full assessment. The complex is assessed by combining results from the age-structured population model applied to the fishery and survey data from the AI management area with a Tier 5 approach of smoothing recent survey biomass estimates in the EBS management area using a random effects model.

Total biomass for the AI component of the stock in 2015 is projected to be 42,605 t. The available survey biomass estimates for EBS blackspotted/rougheye rockfish include the southern Bering Sea (SBS) portion of the AI survey and the EBS slope survey estimates. There are no new survey data from these two subareas; thus, the EBS biomass estimate is identical to last year at 1,339 t.

For the Aleutian Islands, this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$. Because the projected female spawning biomass for 2016 of 9,076 t is less than $B_{40\%}$, (11,403 t) the stock qualifies as Tier 3b and the adjusted $F_{ABC} = F_{40\%}$ values for 2016 and 2017 are 0.037 and 0.042, respectively. The maximum permissible ABC for the Aleutian Islands is 528 t, which is the authors’ and Plan Team’s recommendation for the AI portion of the 2016 ABC. The apportionment of 2016 ABC to subareas is 382 t for the Western and Central Aleutian Islands and 179 t for the Eastern Aleutian Islands and Eastern Bering Sea. The Team recommends an overall 2016 ABC of 561 t and a 2016 OFL of 693 t. Given on-going concerns about fishing pressure relative to biomass in the Western Aleutians, the SSC requested that the apportionment by sub-area be calculated and presented. The maximum subarea species catch (MSSC) levels within the WAI/CAI, based on the random effects model, are as follow: MSSC (2016) 58 and 324 and MSSC (2017) 73 and 405 for the western and central Aleutian Islands, respectively.

Blackspotted/rougheye Rockfish Complex - GULF OFALASKA - ABL

Rougheye (Sebastes aleutianus) and blackspotted rockfish (S. melanostictus) have been assessed as a stock complex since the formal verification of the two species in 2008. We use a statistical age-structured model as the primary assessment tool for the Gulf of Alaska rougheye and blackspotted rockfish (RE/BS) stock complex which qualifies as a Tier 3 stock. Rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. In this odd year, there was a new bottom trawl survey as well as the annual longline survey and a full assessment was completed. New and updated data added to this model include updated catch estimates for 2014, new catch estimates for 2015-2017, new fishery ages for 2010, new fishery lengths for 2013, a new trawl survey estimate for 2015, new trawl survey ages for 2013, new longline survey relative population numbers (RPNs) for 2015, and new longline survey lengths for 2015.

In 2015, we incorporated several changes to the assessment methodology which resulted in seven
models being presented. Model 0 was the last full assessment base model from 2014. The remaining models were hierarchal in that each subsequent model includes the changes from the previous model. Models 1 and 2 incorporated changes to the treatment of samples based on the appropriate sampling design and adjustment to the ageing error matrix. In past assessments the trawl survey age samples have been treated as if they were randomly collected which incurs bias in the growth parameters since age samples are collected using a length-stratified sampling design. We now account for this design in the growth estimation by weighting the age samples by the total number of fish measured at a given length. The ageing error transition matrix was updated to appropriately model the ages at or near the plus age group which heretofore were consistently overestimated. The new matrix extends the modeled ages compared to ages fit in the data until >99.9% are in the plus age group of the data. The final two models also include sub-models to explore sensitivity to the trawl survey selectivity functional form and the interaction with the age composition plus group. The plus age group extension and new functional forms for the trawl survey selectivity were explored. Selection of the final plus age group and trawl survey selectivity curve balanced (1) reducing the plus age group proportion to no more than 10-15% of the total samples, (2) ensuring the plus age group was less than the maximum proportion in the remainder of the age composition data, (3) minimizing age bins with zero samples, (4) examining model fits and residuals, and (5) sensitivity to selectivity changes while adding age bins.

The 2015 trawl survey estimate increased 25% from the low 2013 estimate and was 24% below average. The 2015 longline survey abundance estimate (RPN) decreased about 6% from the 2014 estimate and was 10% above average. Since 2005, the total allowable catches (TACs) for RE/BS rockfish have not been fully taken, and are generally between 20-60% of potential quota. This is particularly true for the Western GOA since 2011, where catches have been between 20-35% of potential quota.

For the 2016 fishery, we recommended the maximum allowable ABC of 1,328 t from the author preferred model. This was an 18% increase from last year’s ABC of 1,122 t. Recent recruitments are steady and near the median of the recruitment time series. This was evident in the ages for the trawl survey with more young fish over time. Female spawning biomass is well above $B_{40\%}$, and projected to be stable. The stock is not overfished, nor is it approaching overfishing status.

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

**Other Rockfish Complex - GULF OF ALAKSA – ABL**

The Other Rockfish complex in the Gulf of Alaska (GOA) is comprised of 25 species, but the composition of the complex varies by region. The species that are included across the entire GOA are the 15 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, and redstripe 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 schedule to coincide with data from the AFSC biennial trawl surveys in the GOA. The next full assessment will be completed in the fall of 2015.

All species in the group have previously been classified into “tier 5” or “tier 4” (only sharpchin
rockfish is “tier 4”) in the NPFMC definitions for acceptable biological catch (ABC) and overfishing level (OFL), in which the assessment is mostly based on biomass estimates from trawl surveys, instead of modeling. However, in the 2015 assessment, some of the species which are rarely encountered in trawl gear were classified as “tier 6”. Also beginning in the 2015 assessment, the Tier 4/5 species exploitable biomass was estimated using the random effects model. This results in a current exploitable biomass of 104,826 t for Other Rockfish. Applying either an $F_{ABC} \leq F_{40\%}$ rate for sharpchin rockfish or an $F_{ABC} \leq 0.75 M$ ($M$ 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 4,079 t, which was combined with the tier 6 ABC of 127 t for a total complex ABC of 5,769 t for 2016 and 2017. The large increase in exploitable biomass was due to increases in biomass estimates of redstrip, sharpchin, and silvergray rockfish. The biomass estimate of harlequin rockfish was the lowest of the time series (2,326 t).

Gulfwide catch of Other Rockfish was 988 t and 1,111 t in 2014 and 2015, 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.

Catch composition is quite different from survey composition. There are three species which are poorly sampled by the survey, but occur in the catch, and ABC was exceeded in the last two years (harlequin, widow, and yelloweye). Widow rockfish is a species with relatively low biomass in the complex and the ABC = 3 t, but annual catch averages ~ 16 t. Catch of harlequin and yelloweye rockfish average ~ 450 t and 156 t, respectively, exceeding the ABCs of 320 t and 120 t, respectively. These species tend to inhabit untrawlable habitat, and thus, the biomass indices are likely an underestimate. Yelloweye rockfish is mostly caught in hook and line fisheries, as well as Alaska state fisheries, thus catch in the federal assessment may not capture all sources of catch. Harlequein, on the other hand, are the major species caught in the Other Rockfish complex and are mostly caught in the rockfish trawl fishery. This could be a conservation concern because it unknown to what degree the trawlable/untrawlable habitat impacts the survey biomass estimates. Species specific ABCs are not used for management, they are summed to create a complex ABC/OFL, which is used for management. For more information contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov

H. Thornyheads

Research

Stock Assessment

**GULF OF ALASKA - ABL**

Gulf of Alaska thornyheads (*Sebastolobus* species) 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, the methodology used to estimate the exploitable biomass that is used to calculate the ABC and OFL
values for the 2016 fishery has changed this year to the use of a random effects model applied to the trawl survey data from 1984-2015. Estimated thornyhead biomass is 87,155 mt, which is an increase of 6% from the 2015 estimate. Thornyhead biomass in the GOA has generally shown an increasing pattern since 2011. This follows a steady decline since 2003. The NPFMC’s “tier 5” ABC definitions state that $F_{ABC} \leq 0.75M$, where $M$ is the natural mortality rate. Using an $M$ of 0.03 and applying this definition to the exploitable biomass of thornyhead rockfish results in a recommended ABC of 1,961 t for the 2016 fishery. Gulfwide catch of thornyhead rockfish was 1,131 t in 2014 and estimated at 931 t in 2015. 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.

I. Sablefish Research

**Sablefish Tag Program - ABL**

The ABL MESA Program continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database during 2015. Total sablefish tag recoveries for the year were around 755. Twenty five percent of the recovered tags in 2015 were at liberty for over 10 years. About 40 percent of the total 2015 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 37 percent within 100 – 500 nm, 17 percent within 500 – 1,000 nm, and 6 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 36 years, and the greatest distance traveled of a 2015 recovered sablefish tag was 1,730 nm. Two adult sablefish and seven juvenile sablefish tagged with archival tags were recovered in 2015. Data from these electronic archival tags, which will provide information on the depth and temperature experienced by the fish, are still being analyzed.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye rockfish are also maintained in the Sablefish Tag Database. Eighteen thornyhead and one archival thornyhead were recovered in 2015.

Releases in 2015 on the groundfish longline survey totaled 2,503 adult sablefish, 871 shortspine thornyheads, and 26 greenland turbot. Pop-up satellite tags (PSAT) were implanted on 35 sablefish. An additional 702 juvenile sablefish (642 spaghetti and 60 archival) and 40 adult sablefish (28 with internal electronic archival tags and 20 with pop-off satellite tags) were tagged during additional cruises in 2015. For more information, contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

**Juvenile Sablefish Studies – ABL**

Juvenile sablefish studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2015. A total of 570 juvenile sablefish were caught and tagged and released in St John Baptist Bay near Sitka, AK over 4 days (May 26th – May 29th) with 90 rod hrs. Seventy six of these tags were electronic archival tags, collecting data on depth and temperature. Total catch-per-unit-effort (CPUE) equaled 4.01 sablefish per rod hour fished. This was up significantly from 2014 (2.29), but lower than the millennial size catch in 2011 (7.63). However, the recent 5-
year trend is positive. The St. John Baptist Bay juvenile sablefish tagging cruise will likely be conducted again in 2016 from July 13-16.

In addition to the annual juvenile sablefish tagging in St John Baptist Bay, three tagging trips in southcentral Alaska occurred following several reports of sablefish catch by sport fishermen. These rare reports indicate that 2014 has the potential to be a larger than average year class. Three days (7/24 - 7/26/15) were spent fishing within Kachemak Bay. A broad spatial distribution including various habitat types and depths were fished, but sablefish were only found on soft bottom near Homer. Two days (7/28 – 7/29/15) were spent fishing three locations both inside and outside of Resurrection Bay out of Seward, AK. Outside of Resurrection Bay, sablefish were caught in unlikely habitat approximately 10 m below the surface intermixed with adult coho salmon. Inside Resurrection Bay, sablefish were found on soft bottom in glacial silt waters. Two days (8/24 – 8/25/15) were spent fishing off Kodiak Island in Kalsin Bay and near the Port Lions’ dock. Total CPUE (8.9 sablefish per rod hour fished) during the two days sampling off Kodiak was one of the highest seen in the time series of juvenile sablefish tagging.

Juvenile sablefish ranged in size from approximately 31 - 41 cm fork length. Average fork length was 37 cm. A total of 60 archival tags were implanted and 519 spaghetti tags were deployed. The electronic archival tags will record temperature, depth, and total magnetic field intensity every 2 minutes, providing data on the fish’s ontogenetic migration into deeper, colder slope waters. These archival tags are the first to be released on juvenile sablefish in waters outside the eastern GOA, and should be available for recovery within approximately 4 years as they recruit to the commercial fishery.

These were the first successful tagging trips in areas outside of the eastern Gulf of Alaska (EGOA) and will provide information regarding movement of juvenile fish in the central Gulf of Alaska. For more information, contact Dana Hanselman at dana.hanselman@noaa.gov.

**Age at maturity, Skipped Spawning, and Fecundity, of Female Sablefish - ABL**

It is preferable to gauge maturity status (if a fish will spawn in the future spawning season) just prior to spawning when oocytes are easily discernable. For a study of age at maturity, female sablefish were sampled in December of 2011, immediately before the spawning season, nearby Kodiak Island, which is near the center of their Alaska distribution. Skipped spawning was documented in sablefish for the first time. These could be identified by the combination having only immature oocytes and a much thicker ovarian wall than immature fish, measured from histological slides (Figure). Age at maturity estimates were influenced by whether these skipped spawners were classified as mature or immature; the age at 50% maturity when skipped spawners were classified as mature was 6.8 years and 9.9 when classified as immature. Skipped spawning fish were identified primarily on the shelf and ranged in age from 4-15 (sablefish max age is 94 years old). Four satellite tags were deployed during the cruise and programmed to pop-off after a month to two months. Despite being highly migratory throughout their lives, all four of the sablefish exhibited sight fidelity within the spawning season; the two tagged on the slope remained on the slope and the two caught on the slope and released on the shelf, moved back to where they were caught on the slope.

In December 2015 female sablefish were sampled in the same areas as in 2011, gullies and the slope nearby Kodiak Island. There were 490 female sablefish sampled ranging in length from 440-1,010. Pictures of ovaries were taken at-sea and histology and aging will be completed in 2016. Liver
weights were also taken for a comparison of energy storage in skipped spawning, spawning, and immature fish. Fecundity measurements were performed for fish ranging in length from ~500-1,000 mm. Results from this study will be compared to those from the 2011 study (described above).

ABL conducts a bottom longline survey in Alaska every summer. Sablefish maturity data is collected at-sea each year, without histology. Because these samples are not taken at the ideal time of year, which is just prior to spawning, the data has not been used for stock assessment. Because skipped spawning fish that were identified in the winter did not produce vitellogenic oocytes, skipped spawning fish can be identified during the summer when fish that will spawn have developed vitellogenic oocytes. It is currently unknown when during the summer this occurs. The goals of this project include determining what dates of the survey are late enough in the reproductive cycle to correctly classify maturity, see if skipped spawning fish are sampled during the summer, and to determine if energy storage in the liver or relative gonad size are related to whether a fish will spawn in the coming winter. In 2015 594 female sablefish were collected in the Gulf of Alaska during June-August. Ovaries were assigned a maturity status at-sea, photos were taken, and livers and ovaries were saved for analyses. Maturity staging from histology slides, aging, and fecundity measurements will be completed in 2016. In addition to investigating ovarian development during the summer months, these data will be a good comparison to the samples collected in December 2015 in the Gulf of Alaska.

For more information, contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

Juvenile Sablefish Ecology – ABL and UAF

Although the range of depths inhabited by Sablefish throughout their life history have been documented, very little is known about fine-scale patterns in habitat use. Adults are demersal, inhabiting deep continental slope and outer shelf waters in the Gulf of Alaska and Bering Sea, where they are commercially caught by longlines and pot gear. They spawn offshore near the continental shelf and eggs have been found at depths >200m. Larval and pre-settlement juvenile Sablefish are caught in surface trawls in shelf waters and are associated with the neuston layer. We analyzed fine-scale vertical movement patterns of post-settlement juvenile Sablefish during their nearshore residence period using an acoustic telemetry dataset collected by NOAA in 2003.
Specifically, we aimed to 1) quantify the vertical distribution of juvenile Sablefish in St. John Baptist Bay (SJBB), Southeast Alaska; and 2) describe vertical movement patterns in relation to daylight and tidal cycles within SJBB. We hypothesized that juvenile Sablefish would be detected at a range of depths, reflecting their use of both benthic and pelagic prey resources in SJBB. Furthermore, we hypothesized that Sablefish would be more active during crepuscular periods to exploit prey while avoiding predation and that they would display higher rates of vertical movement in the water column during flood events, due to the potential influx of pelagic prey.

Thirteen juvenile Sablefish were implanted with acoustic transmitters and monitored by 2 acoustic receivers from 5 Oct to 14 Nov 2003 within St. John Baptist Bay, Baranof Island, Alaska. The six fish that remained within range of the receivers spent the majority of time near the bottom, but made periodic vertical excursions. Generalized linear mixed effects models were used to determine the relationship between excursion frequency and environmental factors. Excursions were influenced by tide and diel conditions, with a higher excursion frequency at dawn and during slack and flood stages and a lower excursion frequency at night. Flood and slack tide may create an influx of pelagic prey resources, which could lead to the more frequent vertical movement of juvenile Sablefish during these tidal stages. Higher probability of excursions at dawn may be due to factors such as predator avoidance or increased prey densities in the water column during crepuscular periods. This is the first study describing vertical migration of juvenile Sablefish in the wild and reveals that environmental conditions have the potential to influence the fine-scale movements of juvenile Sablefish within nearshore habitats.

For more information, contact Karson Coutré at (907) 789-6020 or karson.coutre@noaa.gov.

Sablefish Archival Tagging Study - ABL

During the 1998, 2000, 2001, and 2002 AFSC longline survey, 600 sablefish were implanted and released with electronic archival tags that recorded depth and temperature. These archival tags provide direct insight into the vertical movements and occupied thermal habitat of a fish. 127 of these tags have been recovered and reported from commercial fishing operations in Alaskan and Canadian waters. Analysis of these data began in 2011 continued in 2012 and 104 of these tags have been analyzed to date. Temporal resolution of depth and temperature data ranged from 15 minutes to one hour, and data streams for an individual fish ranged from less than a month to greater than five years. After a hiatus during 2013-2015, data analysis will resume in 2016 or 2017. For more information, contact Mike Sigler mike.sigler@noaa.gov or Pete Hulson pete.hulson@noaa.gov.

Sablefish Satellite Tagging - ABL

The fourth year of extensive tagging of sablefish with pop-up satellite tags (PSATs) was conducted on the AFSC annual longline (LL) survey in 2015. Pop-off satellite tags were deployed on 35 sablefish throughout the Gulf of Alaska (GOA) and the Bering Sea (BS) to study daily and large-scale movements. These tags were programmed to release from the fish 1 January 2016 and 1 February 2016, in hopes of determining spawning locations and ultimately areas which may be used to help assess recruitment. Data from these tags will also provide an improved picture of the daily movements and behavior patterns of sablefish. The 2015 released tags join the 43 tags that were released in the GOA and AI on the LL Survey in 2014, the 27 tags that were released in the GOA on the LL Survey in 2013, the 48 tags that were released throughout the GOA and AI on the 2012 longline survey, and 4 tags that were released during a sablefish winter maturity cruise in December
2011. With just four years of data acquired from summer survey released tags and still in the early stages of analysis of the data that has been received, it is still too early to determine if there is any directed movement by sablefish for spawning purposes. Admittedly, tags should be programmed to remain on the fish for an entire year in order to determine if sablefish are exhibiting any homing behavior for spawning purposes. Ideally, the fish would be tagged just before the spawning season in the winter and programmed to release the following winter during the spawning season. However, having the release location of the tag and the pop up location (location of the fish when the tag released) has provided great insight into (relatively) short term and winter behavior of sablefish.

The following is an example of the data received from one tag, and how it may be utilized.

**Tag 632**

The following is a figure showing the estimated daily locations of tagged fish #632, overlayed on a heat map of the earth’s magnetic field. Green dots are the release and pop off locations. The bars indicate the area where the fish was located during suspected time of pre spawning/spawning. This fish was tagged just southeast of Kodiak Island on 8/24/2014, and was programmed to release from the fish on 1/1/2015.

The fish exhibits constant daily movement from its release location off the coast of Kodiak toward its end location in the Aleutians (note there are days with missing data). Movement remains consistent until around mid-November through the end of December. At this time (presumably the time in which the fish is preparing to spawn), daily movement following the shelf break towards the Aleutians ceases. The fish remains within a bounded location displaying sporadic movement. The following figure of the average daily depth (m) of the fish shows a change in the depth distribution during the suspected “pre spawning” time as well.
Daily average depth (m) readings collected by tag #632.

The fish displays movement towards shallower depths during the assumed pre spawning period, with a return to deeper depths following this time period. The shallow movements may represent pre spawning to spawning behavior. The following figure displays the average daily temperatures from tag #632.

Daily average temperature (C) readings collected by tag #632. The fish, on average, stayed in temperatures between 4 and 4.5 degrees C. These are typical bottom temperatures in this area.

Photo of sablefish with attached pop-off satellite tag (PSAT) prior to deployment on the summer longline survey. This tag was programmed to remain on the fish for close to one year, releasing in the winter during the presumed spawning season.

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

Life History Model for Sablefish - ABL
In 2015 RECA completed a life history model for energy allocation of sablefish. This is a composite
model developed from samples obtained from various efforts. The model charts the lipid content of sable fish from the earliest post-metamorphic stages to adult. The model for sable fish is very similar to the model developed for arrowtooth flounder and is unlike most other species. There is virtually no change in energy density with length until the fish begin maturing. Most other species reveal a positive relationship between length and energy density among age-0s. Demersal species often show a drop in energy density following settlement. Sablefish and arrowtooth flounder do not display either of these patterns. It is worth noting that both these species have similar life histories during the larval stage.

For more information contact Ron Heintz at Ron.Heintz@noaa.gov

Southeast Coastal Monitoring Survey Indices and the Recruitment of Alaska Sablefish to Age-2 – ABL

Description of indicator: Biophysical indices from surveys and fisheries were used to predict the recruitment of sablefish to age-2 from 2011 to 2016 (Yasumiishi et al., 2015). The southeast coastal monitoring project has an annual survey of oceanography and fish in inside and outside waters of northern southeast Alaska (Orsi et al. 2012). Oceanographic sampling included, but was not limited to, sea temperature and chlorophyll a. These data are available from documents published through the North Pacific Anadromous Fish Commission website from 1999 to 2012 (www.npafc.org) and from Emily Fergusson. These oceanographic metrics may index sablefish recruitment, because sablefish use these waters as rearing habitat early in life (late age-0 to age-2). Estimates of age-2 sablefish abundance are from (Hanselman et al., 2013). We modeled age-2 sablefish recruitment estimates from 2001 to 2010 as a function of sea temperature, chlorophyll a, and pink salmon productivity during the age-0 stage for sablefish.

Status and trends: Estimated recruitment to sablefish to age-2 was described as a function of late August sea temperature, late August chlorophyll a, and a juvenile pink salmon productivity index (based on adult salmon returns to southeast Alaska during the age-1 stage) during the age-0 stage for sablefish (Figure 93). A multiple regression model indicated that chlorophyll a during the age-0 phase was most strongly correlated with sablefish recruitment ($R^2 = 0.88$; $p$-value $= 0.00006$) with a three-fold increases in chlorophyll a in 2000 and recruitment (age-2) in 2002. Sea temperature and pink salmon productivity explained an additional 10% of the variation in sablefish recruitment ($R^2 = 0.98$; $p$-value $< 0.00001$).

Factors influencing observed trends: Warmer sea temperatures were associated with high recruitment events in sablefish (Sigler and Zenger Jr., 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: The model parameters (2001-2010) and biophysical indices (2009-2014) were used to predict the recruitment of Gulf of Alaska sablefish (2011-2016). Above average recruitment of sablefish to age-2 is expected in 2016.
For more information contact Ellen Yasumiishi at ellen.yasumiishi@noaa.gov

Stock Assessment

**BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA - ABL**

A full sablefish stock assessment was produced for the 2016 fishery. We added relative abundance and length data from the 2015 AFSC longline survey, relative abundance and length data from the 2014 longline and trawl fisheries, biomass and length compositions from the 2015 Gulf of Alaska bottom trawl survey, age data from the 2014 longline survey and 2014 fixed gear fishery, updated 2014 catch, and estimated catches for 2015-2017.

The longline survey abundance index decreased 21% from 2014 to 2015 following a 15% increase from 2013 to 2014 and is at the lowest point of the time series. The fishery abundance index increased 6% from 2013 to 2014 (the 2015 data are not available yet). The Gulf of Alaska trawl survey index was at its lowest point in 2013 but increased 12% in 2015. Spawning biomass is projected to decrease from 2016 to 2019, and then stabilize. Sablefish are currently slightly below the spawning biomass limit reference point and well below the target, which automatically lowers the potential harvest rate. We recommended a 2016 ABC of 11,795 t. The maximum permissible ABC for 2016 is 14% lower than the 2015 ABC of 13,657 t. The 2014 assessment projected a 10% decrease in ABC for 2016 from 2015. This slightly larger decrease is supported by a new low in the
domestic longline survey index time series that offset the small increases in the fishery abundance index seen in 2014 and the Gulf of Alaska trawl survey index in 2015. The fishery abundance index has been trending down since 2007. The 2014 IPHC GOA sablefish index was not used in the model, but was similar and trending low in 2013 and 2014. The 2008 year class showed potential to be large in previous assessments based on patterns in the age and length compositions. However the estimate in this year’s assessment is only just above average because the recent large overall decrease in the longline survey and trawl indices have lowered the overall scale of the population. Spawning biomass is projected to decline through 2018, and then is expected to increase assuming average recruitment is achieved in the future. ABCs are projected to decrease in 2017 to 10,782 t and 10,869 t in 2018.

Projected 2016 spawning biomass is 34% of unfished spawning biomass. Spawning biomass had increased from a low of 33% of unfished biomass in 2002 to 42% in 2008 and has now declined back to 34% of unfished biomass projected for 2016. The 1997 year class has been an important contributor to the population; however, it has been reduced and is predicted to comprise less than 6% of the 2016 spawning biomass. The last two above-average year classes, 2000 and 2008, each comprise 15% of the projected 2016 spawning biomass. The 2008 year class will be about 75% mature in 2016.

For more information, contact Dana Hanselman at dana.hanselman@noaa.gov.

J. Lingcod

K. Atka Mackerel

The following new data were included for the 2015 assessment: The 2014 fishery and survey age composition data were added. Total 2014 year-end catch was updated, and the projected total catch for 2015 was set equal to the 2015 TAC. In addition, the estimated average selectivity for 2011-2015 was used for projections.

Atka mackerel spawning biomass reached an all-time high in 2005, but thereafter decreased by 55% through 2015, and is projected to increase through 2028 under Scenario 3 (average 2011-15 $F$, a reasonable scenario to choose since recent TACs have been lower than ABCs). Addition of new data in 2015 increased the estimated abundances of the 2006, 2007, and 2011 year classes, all of which are above the long-term mean. The projected female spawning biomass for 2016 is 166,407 t, which is above $B_{40\%} (135,654 \text{ t})$. The stock is projected to remain above $B_{40\%}$ through 2018 at the recommended harvest levels.

The projected female spawning biomass under the recommended harvest strategy is estimated to be above $B_{40\%}$, thereby placing BSAI Atka mackerel in Tier 3a. The projected 2016 yield (ABC) at $F_{40\%} = 0.30$ is 90,340 t, down 15% from the 2015 ABC and 8% from last year’s projected ABC for 2016. The projected 2016 overfishing level at $F_{35\%} = 0.35$ is 104,749 t, down 16% from the 2015 OFL and 10% from last year’s projected OFL for 2016. The decreases in ABC and OFL are due primarily to drops in the $F_{40\%}$ and $F_{OFL}$ reference fishing mortality rates (last year’s $F_{40\%} = 0.40$ and $F_{35\%} = 0.49$) which resulted from increased selectivity of younger fish (primarily age 3 in the 2014 fishery).
The random effects model was used in this assessment to apportion the ABC among areas, replacing the weighted average of the four most recent surveys used previously. The recommended ABC apportionments by subarea for 2016 are 30,832 t for Area 541 and the southern Bering Sea region, 27,216 t for Area 542, and 32,292 t for Area 543.

Atka mackerel is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition. Atka mackerel are the most common prey item of the endangered western Steller sea lion throughout the year in the Aleutian Islands. Analysis of historic fishery CPUE revealed that the fishery may create temporary localized depletions of Atka mackerel, and fishery harvest rates in localized areas may have been high enough to affect prey availability for Steller sea lions. The objectives of having areas closed to Atka mackerel fishing around Steller sea lion haulouts and rookeries, and time-area ABC/TAC allocations, are to maintain sufficient prey for the recovery of Steller sea lions in the Aleutian Islands while also providing opportunities to harvest Atka mackerel. Steller sea lion surveys indicate that counts of adults, juveniles, and pups continue to decline in the Aleutian Islands, particularly in the western Aleutians (area 543) where counts of pups and non-pups declined 9%/year and 7%/year, respectively.

L. Flatfish

Research

**Bering Sea Infauna Communities and Flatfish Habitats - RACE GAP**

Research continues in characterizing and assessing the productivity of flatfish habitat in the eastern Bering Sea (EBS) under the Essential Fish Habitat provision of the fishery management plan. Recent studies focus on the habitat of juvenile yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS). In 2011 and 2012, field sampling was conducted in conjunction with the EBS bottom-trawl survey along the southern boundary of the EBS, where juvenile flatfish have historically been relatively abundant. Juvenile flatfish of ≤20 cm and adults of ≥30 cm total length were collected from bottom trawl catch samples at stations located 10 to 120 km from the Alaska Peninsula coast, and in bottom depths of 28 to 85 m. Stomach contents and stable isotopes of carbon and nitrogen from muscle tissue were analyzed to describe diet composition. The spatial correlations between body condition, diet, and the prey field were examined to assess habitat quality. The quantity and quality of prey did not significantly affect the distribution of juvenile NRS and YFS. Spatial mismatch in diet and prey compositions suggested that prey availability was not limiting across the area. The body condition of juvenile NRS was higher in the east – the Bristol Bay area, where they cohabited with juvenile YFS, than in the west – the Unimak Island area, where juvenile YFS were largely absent, suggesting that habitat quality may be higher in Bristol Bay (Yeung and Yang, In review). Investigations are extending to other areas of high concentrations of juvenile flatfish, such as the northern EBS area around Nunivak Island- a hypothesized juvenile NRS “hotspot”, which was sampled in 2014. Continual monitoring of possible juvenile hotspots is being planned to test the hypothesis of alternate habitat use during periods of “warm” and “cold” oceanographic environment in the EBS.

Contact: Cynthia Yeung

**Estimating the survey catchability of Rock Sole in the Gulf of Alaska-RACE and REFM**

Rock soles are captured in trawl and other groundfish fisheries in the Gulf of Alaska (GOA) and yield 7 to 9 million dollars in ex-vessel value per year. They are a component of shallow-water and other flatfish species principally targeted by catcher and catcher-processor trawl vessels. An age-structured stock assessment model has been developed for rock soles and this model is related to fishery-independent estimates of abundance from the Gulf of Alaska (GOA) Biennial Bottom Trawl Survey. Direct comparisons, however, are difficult because the catchability of the survey is not completely known, and survey selectivity and availability of groundfishes is identified as a frequent and important data gap in the stock assessment process. Through a grant from NOAA Fisheries’ Improve a Stock Assessment (ISA) Program, we are attempting to estimate the total catchability for rock soles captured during the bottom trawl surveys in order to provide a direct comparison to age-structure stock assessments in the GOA. To estimate total catchability, we will combine estimates of trawl efficiency, or how many rock soles are captured that were in the path of the net, with a new estimate of how many rock soles were available to the survey gear.

We used acoustic data obtained from 38kHz Simrad ES-60 echosounders deployed on all AFSC bottom trawl survey vessels since 2005 to determine whether acoustic data can be used to characterize trawlable and untrawlable sea floors. To date, we have collected about 200,000 nautical miles of acoustic trackline data in the GOA alone, but we have never explored these data for their suitability to determine roughness or hardness of the seafloor. We evaluated and analyzed acoustic trackline data with a newly available acoustic Bottom Classification module by Echoview. Output variables from this module were used to estimate the proportion of trawlable to untrawlable habitat within suitable rock sole habitat. Combined with other availability information and estimates of trawl efficiency, we aim to estimate the total catchability of rock soles to the survey trawl and to estimate the total rock sole biomass.

Several AFSC researchers and contractor Neal McIntosh have been focusing effort on this project. To date, they found that the Echoview bottom typing software could be applied to ES-60 acoustic data, and metrics produced by the software could differentiate a series of areas that were clearly trawlable from those that were clearly untrawlable. Based upon this result, we are refining and testing the prediction power of the software and underlying GAM model on a wider range of grid cells with acoustic observations. We have evaluated the data frame of 10,667 ES-60 acoustic files collected since 2005. This evaluation consisted of several labor-intense activities including indexing these data to the station numbers of the GOA sampling grid and the times of previous vessel visits, calibrating the data, removing the systematic dithering “triangle wave” from suitable acoustic files, determining whether a second return echo was present in the file, and developing a database for the GOA acoustic files. We have found that the ES-60 acoustic data will not be as informative as we desired. Acoustic data from 2005 and 2007 were not usable because of the single beam transducers and poor calibrations. Acoustic data were better calibrated beginning with one boat in 2009 and each of two vessels during the 2011 and 2013 surveys. Additionally, we discovered that the critical second echo return of seafloor was only recorded in 31% of the ES-60 data stream. At present the nature of this limitation is not understood, but between the lack of a second echo and uncalibrated echo returns, only 16% of the ES-60 may provide usable information on the nature of the seafloor.
Regardless of these limitations, 1,663 files contained calibrated, undithered acoustic data with second echo returns. We selected 26, fifteen minute segments of acoustic data in previously visited grid cells that were either classified as trawlable (at least two successful trawl samples) or as untrawlable (determined by the skipper’s classification of echo returns). Nine variables of seafloor characteristics were obtained by applying the Bottom Classification module of Echoview, and these were entered into a stepwise General Linear Model (GLM) to determine the best set of bottom type variables for predicting trawlability. When used without any other environmental information, these bottom type variables correctly predicted trawlable or untrawlable seafloors 83% of the time. This indicates that the trawlability model may be quite informative for predicting the likelihood of trawlability in areas of the sampling grid that have never been examined, and thus predict the proportion of the GOA that is trawlable and therefor included in the survey sampling frame. The bottom type data are also being used, along with other environmental variables, in a companion study using GLM models to predict the presence/absence and abundance of rock sole based on GOA survey catches. If both modeling approaches are successful, the rock sole habitat model will then be used to estimate the proportion of the area within untrawlable grid elements that comprises suitable rock sole habitat. Further work is being conducted to expand the sample size of the reference test and to see if other variable combinations improves the predictability of the GLM. Work during the next few months will define proportions of trawlable and untrawlable habitat in the depth range of rock soles where acoustic data exist and to see if other information from hydrographic smooth sheets, other acoustic data, and a habitat occupancy model can be used to define the amount of habitat available to rock sole.

With support of other AFSC funds, we have been collecting new information on the herding and escapement terms of trawl efficiency. Together, the estimates of availability obtained from this project and trawl efficiency obtained from other projects will be used to estimate total rock sole biomass in the Gulf of Alaska, and these survey biomass estimates will be compared and evaluated against the stock assessment biomass obtained from catch-at-age analysis.

Contact Wayne Palsson, David Somerton, or Peter Munro for more information (wayne.palsson@noaa.gov).

**Bering Sea drifter deployment study to discern northern rock sole larval advection -REFM**

In an effort to better understand the physics of the eastern Bering Sea shelf current as it relates to flatfish advection to favorable near-shore areas, sets of multiple, satellite-tracked, oceanic drifters were released in 2010, 2012 and 2013. The release sites and dates were chosen to coincide with known spawning locations for northern rock sole (*Lepidopsetta polyxystra*) and known time of larval emergence. The drifters were drogued 5-each at 20 and 40 meters in 2010 and 2012, and 4 at 40 meters and 2 at 20 meters in 2013. The locations of drifters were used to calculate divergence over a 90-day period that corresponds to the larval pelagic duration of Bering Sea shelf northern rock sole. Results indicate that there are alternating periods of positive and negative divergence with an overall trend toward drifter separation after 90 days, roughly the end of the rock sole planktonic larval period. Examination of the drifter behavior at the hourly scale indicates that semi-daily tidal forcing is the primary mechanism of drifter divergence and convergence. Field observations of early-stage northern rock sole larval distributions over the same period indicate that predominant oceanographic advection is northerly over the continental shelf among prefexion stages, though juveniles are predominantly found in nursery areas located ~400 km eastward and inshore. Evidence from drifter deployments suggests that behavioral movements during the postflexion and early juvenile larval phases that optimize eastward periodicity of tidal cycles is a viable mechanism to enhance eastward movement of northern rock sole larvae to favorable nursery
grounds. A regional ocean modeling system (ROMS) was implemented to track the different rates of dispersion in simulations both with and without tidal forcing, and was used to estimate effective horizontal eddy diffusion in the case of both isobaric (fixed-depth) and Lagrangian (neutrally buoyant) particles. The addition of tidal forcing had a pronounced effect on horizontal eddy diffusion, increasing its value by a factor of five in the case of fixed-depth floats, as compared with a factor of two in the case of neutrally buoyant floats. Further, the incorporation of diurnal vertical behavior in phase with favorable (on shelf) tides transported the “larvae” ~ 400 km within 40 days of their release date. Empirical drifter data coupled with model evidence suggest that semi-diurnal tidal forcing is the primary mechanism of eastward advection over the Bering Sea shelf, and larval observational data suggest that northern rock sole larvae can maximize their eastward transport to nursery grounds by synchronizing their vertical movements to tidal periodicity during the postflexion stage. Paper available at DOI: 10.1016/j.seares.2016.03.003.

Tom Wilderbuer (REFM), Janet Duffy-Anderson (FOCI), Phyllis Stabeno (PMEL) and Al Hermann (JISAO)

Assessment

Yellowfin sole Stock Assessment - BERGING SEA - REFM

The 2015 EBS bottom trawl survey resulted in a biomass estimate of 1.93 million t, compared to the 2014 survey biomass of 2.51 million t (a decrease of 10 percent). The stock assessment model indicates that yellowfin sole have slowly declined over the past twenty years, although they are still at a fairly high level (60% above B_{MSY}), due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 8 of the past 26 year classes have been at or above the long term average. However, the 2003 year class appears to be as strong as any observed since 1983 and the 2006 is also an above average contributor to the reservoir of female spawners. The 2015 catch of 124,000 t represents the largest flatfish fishery in the world and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

New data for this year’s assessment include:

2014 fishery and survey age compositions
2015 trawl survey biomass point estimate and standard error estimates of the discarded and retained portions of the 2014 catch estimate of total catch through the end of 2015.

The current assessment model allows for the input of sex-specific estimates of fishery and survey age composition and weight-at-age and provides sex-specific estimates of population numbers, fishing mortality, selectivity, fishery and survey age composition and allows for the estimation of sex-specific natural mortality and catchability. It also features the inclusion of estimates of time varying fishery selectivity, by sex. New for 2015 was the smoothing of weights at ages from 11 to 20 in the assessment model and an updated maturity schedule.

The projected female spawning biomass estimate for 2016 of 702,200 t is a 9% increase from last year’s 2016 estimate (648,600 t). Although there was an increase in projected spawning biomass for 2016, the overall trend continues to be a general decline that has prevailed since 1994. The total stock biomass was relatively stable through the early 2000s, but had been steadily approaching B_{40%} since 2007 (currently 11% above B_{40%}).
The SSC has determined that reliable estimates of $B_{MSY}$ and the probability density function for $F_{MSY}$ exist for this stock. The estimate of $B_{MSY}$ from the present assessment is 435,000 t, and projected spawning biomass for 2016 is 702,200 t, meaning that yellowfin sole qualify for management under Tier 1a. Corresponding to the approach used in recent years, the 1978-2006 stock-recruitment data were used this year to determine the Tier 1 harvest recommendation. This provided a maximum permissible ABC harvest ratio (the harmonic mean of the $F_{MSY}$ harvest ratio) of 0.098. The current value of the OFL harvest ratio (the arithmetic mean of the $F_{MSY}$ ratio) is 0.105. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2016 biomass estimate produced the 2016 ABC of 211,700 t recommended by the author and Plan Team, and the corresponding product using the OFL harvest ratio produces the 2016 OFL of 228,100 t. For 2017, the corresponding quantities are 203,500 t and 219,200 t, respectively.

Yellowfin sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Northern Rock Sole - BERING SEA - REFМ**

The northern rock sole stock is currently at a high level due to strong recruitment from the 2001, 2002, 2003 and 2005 year classes which are now contributing to the mature population biomass. The 2015 bottom trawl survey resulted in a biomass estimate of 1.41 million t, a 24% decrease from the 2014 point estimate. The northern rock sole harvest primarily comes from a high value roe fishery conducted in February and March which usually takes only a small portion (25%) of the ABC because it is constrained by prohibited species catch limits and market conditions.

The stock assessment model indicates that the stock declined in the late 1990s and early 2000s due to poor recruitment during the 1990s but is now at a high level and is projected to decline in the near future due to the lack of good observed recruitment since 2003. The stock is currently estimated at over twice the $B_{MSY}$ level.

New information for the 2014 analysis include:
1) 2014 fishery age composition. 2) 2014 survey age composition. 3) 2015 trawl survey biomass point estimate and standard error. 4) updated fishery discards through 2014. 5) fishery catch and discards projected through the end of 2015.

Northern rock sole are managed as a Tier 1 stock using a statistical age-structured model as the primary assessment tool. Model results indicate that spawning biomass increased almost continuously from a low of 58,000 t at the beginning of the model time series in 1975 to a peak of 794,000 t in 2001. Spawning biomass then declined to 521,000 t in 2008, but has increased continuously since then, reaching 665,000 t in 2015. The 2000-2006 year classes are all estimated to be above average, with the 2002 year class estimated to be at about twice the long-term average. The stock assessment model projects a 2016 spawning biomass of 635,000 t. This was slightly less than the 2015 value projected in last year’s assessment.

The 2015 assessment contains summaries for two assessment models. The Plan Team recommended retaining Model 1, which is the model that has been used for the last several years. The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning biomass for 2016 is projected to be well above the $B_{MSY}$ estimate of 265,000, placing northern rock
sole in sub-tier “a” of Tier 1. The Tier 1 2016 ABC harvest recommendation is 161,100 t ($F_{ABC} = 0.148$) and the 2016 OFL is 165,900 t ($F_{OFL} = 0.153$). The 2017 ABC and OFL values are 145,000 t and 149,400 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 3.5 percent of the northern rock sole stock. Northern rock sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Northern Rock Sole - GULF OF ALASKA Shallow Water Complex - REFM**

Shallow-water and deep-water flatfish are assessed on a biennial schedule to coincide with the timing of survey data. A full assessment for shallow water flatfish was conducted in 2015 which included updated 2014 catch and the partial 2015 catch as well as projections using the updated results from the northern and southern rock sole assessment. 2015 catches of northern and southern rock sole were substantially lower than catches in 2014, and comprised about 80% of the shallow water complex.

The shallow water complex is comprised of northern rock sole, southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole and Alaska plaice. Northern and southern rock sole are assessed with an-age structured model. The 2015 trawl survey biomass estimates were used for tuning the rock sole models and random effects model were used for apportionments and the tier 5 components of this complex. Specific changes to the rock sole assessment models included adding catch-at-length for 2015 and adding GOA bottom trawl survey biomass and length composition data from 2015. The model was the same as in 2014 (stock synthesis version 3.24S).

The rock sole assessment model estimates are used for trend and spawning biomass estimates whereas the remaining species in this complex are based solely on the NMFS bottom trawl surveys. The complex total current biomass estimate is 303,299 t an increase from the 2015 value of 287,534 t due primarily to an increase in the model estimate of southern rock sole and 2015 survey estimates that were higher for yellowfin sole and butter sole (estimated from the random effects model). The random effects model estimates for current biomass of Starry flounder, English sole, Sand sole, Alaska plaice were lower than estimated for 2015 in the 2014. The model estimate of current biomass for northern rock sole was lower than last year as well.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. The GOA Plan Team agrees with authors’ recommended ABC for the shallow water flatfish complex which was equivalent to maximum permissible ABC. For the shallow water flatfish complex, ABC and OFL for southern and northern rock sole are combined with the ABC and OFL values for the rest of the shallow water flatfish complex. This yields a combined ABC of 44,364 t and OFL of 54,520 t for 2016.

Information is insufficient to determine stock status relative to overfished criteria for the complex as a whole. For the rock sole species, the assessment model indicates they are not overfished nor are they approaching an overfished condition. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

**Flathead Sole - BERING SEA - REFM**
The flathead sole assessment also includes Bering flounder, a smaller, less abundant species with a more northern distribution relative to flathead sole. The 2015 shelf trawl biomass estimate decreased 25% from 2014 for flathead sole. Survey estimates indicate high abundance for both stocks for the past 30 years. The 2007 year class is estimated to be above average, but it follows 3 years of poor recruitment. The assessment employs an age-structured stock assessment model.

This assessment was changed to a bi-annual cycle beginning with the 2013 assessment; this is an offcycle year and only a projection model was run. Changes to the input data in this analysis include: Updated 2014 fishery catch and estimated 2015 and 2016 fishery catch. The age 3+ biomass is projected to increase through 2017, although spawning biomass is projected to decline. The 2015 survey biomass estimate was 25% below the 2014 estimate (22% below 2013 estimate).

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying flathead sole for management under Tier 3. The current values of these reference points are $B_{40\%} = 127,682$ t, $F_{40\%} = 0.28$, and $F_{35\%} = 0.35$. Because projected spawning biomass for 2016 (240,427 t) is above $B_{40\%}$, flathead sole is in sub-tier “a” of Tier 3. The authors recommend setting ABCs for 2016 and 2017 at the maximum permissible values under Tier 3a, which are 66,250 t and 64,580 t, respectively. The 2016 and 2017 OFLs under Tier 3a are 79,562 t and 77,544 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Flathead Sole - GULF OF ALASKA - REFM**

Flathead sole are assessed on a biennial schedule to coincide with the timing of survey data. This year a full assessment was conducted and updated the most recent model presented in 2013 and includes the 2015 NMFS bottom trawl survey data. Minor changes included iteratively re-weighting length and age composition data using a new methodology and effective sample sizes were changed to equal the number of hauls samples were taken from. Harvest apportionments were computed using the random effects model and included the 2015 NMFS bottom trawl survey biomass distributions.

The 2016 spawning biomass estimate (82,375 t) is above $B_{40\%} (36,866 t)$ and projected to be stable through 2017. Total biomass (3+) for 2016 is 265,088 t and is projected to increase in 2017. Flathead sole are determined to be in Tier 3a. For 2016 the authors recommended to use the maximum permissible ABC of 35,020 t which is down from the 2015 ABC (41,349 t). The $F_{OFL}$ is set at $F_{35\%} (0.40)$ which corresponds to an OFL of 42,840 t.

The Gulf of Alaska flathead sole stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. Catches are well below TACs and below levels where overfishing would be a concern.

**Area apportionment**
Area apportionments of flathead sole ABC’s for 2016 and 2017 are based on the random effects model applied to GOA bottom trawl survey biomass in each area.

For further information, contact Ingrid Spies (206) 526-4786, Teresa A’Mar (206) 526-4068 or Cary McGillard (206) 526-4693

**Alaska Plaice - REFM**

The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2015 Bering Sea shelf survey biomass estimate for Alaska plaice was 355,640 t, a
21% decrease from the 2014 biomass point estimate and the lowest point-estimate for the survey time-series since it began in 1982. The combined results of the 2010 eastern Bering Sea shelf survey and the northern Bering Sea survey indicate that 38% of the Alaska plaice biomass was found in the northern Bering Sea. The stock is expected to remain at an abundant level in the near future due to the presence of a strong year class estimated from 2002. Exploitation occurs primarily as bycatch in the yellowfin sole fishery and has averaged only 1% from 1975-2015.

This assessment was changed to a biennial cycle beginning with the 2013 assessment; thus 2015 is an off-cycle year and only a projection model was run. Changes to the input data in this analysis include: Updated 2014 fishery catch and estimated 2015 and 2016 fishery catch.

Last year’s assessment indicated that above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002 have contributed to recent highs level of female spawning biomass. The spawning stock biomass is projected to decline as these year classes exit the population. Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3. The current estimates are $B_{40\%} = 138,100$ t, $F_{40\%} = 0.143$, and $F_{35\%} = 0.175$. Given that the projected 2016 spawning biomass of 204,600 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2016 were calculated under sub-tier “a” of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2016 ABC of 41,000 t and a 2017 ABC of 39,100 t. The recommended Tier 3a OFLs are 49,000 t and 46,800 t for 2016 and 2017.

Alaska plaice is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Greenland Halibut (Turbot)**

The 2015 Greenland turbot assessment was updated as follows:


Analyses of new data (namely size and age composition data for 2013 – 2015) made available in September 2015 revealed a data conflict with the NMFS EBS Shelf and Slope trawl surveys necessitating unexpected model configuration changes to resolve what are clear structural misspecifications. The assessment included three new models, in addition to last year’s accepted model (Model 14.0): Model 14.1. Used refined sample size estimates for the slope survey composition data and re-weighted other data. The shelf survey size composition data and size at age data were used but the age composition data were not. Model 15.1. Same configuration as Model 14.1 except the selectivity for the fixed gear fishery was changed from logistic to the “double normal” to account for a perceived change in fishing behavior in 2008; also the 2006 and 2007 trawl fishery size composition data were excluded due to very small sample sizes. Model 15.3. Same configuration and data as Model 15.1 except the fisheries and shelf and slope survey selectivities were allowed to vary using a penalized random walk process.

The authors and Team recommend use of Model 15.1 for harvest specification purposes.

The projected 2016 female spawning biomass is 31,028 t, which is a 0.6% increase from last year’s 2015 estimate of 30,853 t. Female spawning biomass is projected to increase to 41,015 t in 2017.
While spawning biomass continues to be near historic lows (currently at \( B_{18\%} \)), increases have been estimated or are projected for the years following 2013, and large 2008 and 2009 year classes are being observed in both the survey and fishery size composition data. These year classes are both estimated to be stronger than any other year class spawned since the 1970s. The SSC has determined that reliable estimates of \( B_{40\%} \), \( F_{40\%} \), and \( F_{35\%} \) exist for this stock. Greenland turbot therefore qualifies for management under Tier 3. Updated point estimates of \( B_{40\%} \), \( F_{40\%} \), and \( F_{35\%} \) from the present assessment are 50,577 t, 0.139, and 0.169, respectively. The stock remains in Tier 3b. The maximum permissible value of \( F_{ABC} \) under this tier translates into a maximum permissible ABC of 3,462 t for 2016 and 6,132 t for 2017, and an OFL of 4,194 t for 2016 and 7,416 t for 2016. These are the authors’ and Plan Team’s ABC and OFL recommendations.

As in previous assessments, apportionment recommendations are based on unweighted averages of EBS slope and AI survey biomass estimates from the four most recent years in which both areas were surveyed. The authors’ and Team’s recommended 2016 and 2017 ABCs in the EBS are 2,673 t and 4,734 t, respectively. The authors’ and Team’s recommended 2015 and 2016 ABCs in the AI are 789 t and 1,398 t, respectively. Area apportionment of OFL is not recommended.

Greenland turbot is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Arrowtooth Flounder - BERING SEA AND ALEUTIAN ISLANDS- REFM**

Because the 2015 assessment is an “off-year” for the BSAI ATF, new survey information is not incorporated into the assessment model for this update. Instead, a projection model is run with updated catch information. This projection model run incorporates the most recent catch information and provides estimates of 2016 and 2017 ABC and OFL without re-estimating the stock assessment model parameters and biological reference points. The projection model is based on last year’s assessment model results.

The following new data were included in the projection model: Final 2014 catch and estimates of 2015 - 2017 catch. Projection model results estimate age 1+ total biomass for 2016 at 910,012 t, a slight decrease from the value of 911,652 t projected for 2016 in last year’s assessment. The projected female spawning biomass for 2016 is 535,350 t which is an increase from last year’s 2016 estimate of 528,020 t, and at the highest level estimated since 1975.

The SSC has determined that reliable estimates of \( B_{40\%} \), \( F_{40\%} \), and \( F_{35\%} \) exist for this stock. Arrowtooth flounder therefore qualifies for management under Tier 3. The point estimates of \( B_{40\%} \) and \( F_{40\%} \) from last year’s assessment were 222,019 t and 0.153, and are carried over for this year. The projected 2016 spawning biomass is far above \( B_{40\%} \), so ABC and OFL recommendations for 2016 were calculated under sub-tier “a” of Tier 3. The authors and Team recommend setting \( F_{ABC} \) at the \( F_{40\%} \) level, which is the maximum permissible level under Tier 3a, resulting in 2016 and 2017 ABCs of 80,701 t and 72,216 t, respectively, and 2016 and 2017 OFLs of 94,035 t and 84,156 t.

Arrowtooth flounder is a largely unexploited stock in the BSAI. Arrowtooth flounder is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Ecosystem Considerations**

In contrast to the Gulf of Alaska, arrowtooth flounder is not at the top of the food chain on the EBS.
Arrowtooth flounder in the EBS are an occasional prey in the diets of groundfish, being eaten by Pacific cod, walleye pollock, Alaska skates, and sleeper sharks. However, given the large biomass of most of the predator species in the EBS, these occasionally recorded events translate into considerable total mortality for the arrowtooth flounder population in the EBS ecosystem.

**Arrowtooth Flounder - GULF OF ALASKA - REFM**

For the 2015 assessment, several improvements were made to the input data and the model structure. Fishery length composition data was updated for all years from 1977-2015, which included adding the length compositions for 1982 and 1983. The age-length transition matrix and weight at age vector were re-estimated based on data from 1977-2015, and the maturity-at-age ogive was updated based on the most recent GOA arrowtooth maturity study. Model changes included development of a generalized ADMB model used for both the BSAI and GOA arrowtooth flounder assessments, which resulted in the modeled ages for the GOA arrowtooth flounder changing from 3-15+ to 1-21+, with selectivity estimated non-parametrically for ages 1-19.

Arrowtooth flounder biomass estimates from the current model are very similar to those estimated in the last full assessment in 2013. The generalized model estimates biomass for two additional ages, ages 1 and 2. The model estimates of total (age 1+) biomass increased from a low of 390,626 t in 1970 to a high of 2,109,820 t in 2009 and slight decrease to 2,103,860 t in 2016. Female spawning biomass in 2016 was estimated at 1,175,240 t, which is above B40%, and represents a 1% decrease from the 2015 estimate in last year’s assessment.

Arrowtooth flounder is estimated to be in Tier 3a. The 2016 ABC (F40%=0.171) is 186,188 t, which is a small decrease from the 2015 ABC of 192,921 t. The 2016 OFL (F35%=0.204) is 219,430 t. The stock is not overfished nor approaching an overfished condition. Catch levels for this stock remain below the TAC and below levels where overfishing would be a concern.

The recommended area apportionment by the random effects model was used to provide apportionments for the 2016 and 2017 ABCs. Percentages and area apportionments of arrowtooth flounder for 2016 and 2017 are based on the fraction of the 2015 survey biomass occurring in each area from the random effects model.

**Other Flatfish - BERING SEA - REFM**

The “other flatfish” complex currently consists of Dover sole, rex sole, longhead dab, Sakhalin sole, starry flounder, and butter sole in the EBS and Dover sole, rex sole, starry flounder, butter sole, and English sole in the AI. Starry flounder, rex sole, and butter sole comprise the vast majority of the species landed. Starry flounder, rex sole and butter sole comprise the majority of the fishery catch with a negligible amount of other species caught in recent years. In 2015 Starry flounder continued to dominate the shelf survey biomass in the EBS and rex sole was the most abundant “other” flatfish in the Aleutian Islands.

The biomass of the other flatfish complex on the eastern Bering Sea shelf was relatively stable from 1983-1995, averaging 54,274 t, and then increased from 1996 to 2003, averaging 84,137 t. Since 2003, the biomass estimates have been at a higher level, averaging 125,800 t. The 2014 shelf and Aleutian Islands (slope survey not conducted in 2014) surveys combined estimate of 143,000 t is at the highest level of the past 7 years and third highest overall for the time-series. The EBS survey
estimate for 2015 was 102,300 t, well below that of last year. The estimated increases from the past five years are primarily due to the higher estimates of starry flounder on the Eastern Bering Sea shelf. Sakhalin sole biomass, which has no pattern in fluctuation, had a high of 1,410 t in 1997 and a low of 37 t in 2012. Sakhalin sole are primarily found north of the standard survey area. Distributional changes, onshore-offshore or north-south, might affect the survey biomass estimates of other flatfish.

The SSC has classified “other flatfish” as a Tier 5 species complex with harvest recommendations calculated from estimates of biomass and natural mortality. Natural mortality rates for rex (0.17) and Dover sole (0.085) borrowed from the Gulf of Alaska are used, along with a value of 0.15 for all other species in the complex. Projected harvesting at the 0.75 $M$ level (average $F_{ABC} = 0.117$) gives a 2015 ABC of 13,061 t for the “other flatfish” complex. The corresponding 2015 OFL (average $F_{OFL} = 0.155$) is 17,414 t.

This assemblage is not being subjected to overfishing. It is not possible to determine whether this assemblage is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

**Deep-water flatfish - REFМ GULF OF ALASKA**

The deepwater flatfish complex is comprised of Dover sole, Greenland turbot, and deepsea sole. This complex is assessed on a biennial schedule to coincide with the timing of survey data. Dover sole are assessed as a Tier 3a species. The 2015 model was updated to include the most recent data and implemented several model changes relative to the model used for the 2013 assessment. Length and age composition data were iteratively re-weighted using a new methodology, effective sample sizes were changed to equal the number of hauls samples were taken from, and fishery selectivity was estimated using an asymptotic selectivity curve rather than dome-shaped.

Greenland turbot and deepsea sole fall under Tier 6. ABCs and OFLs for Tier 6 species are based on historical catch levels and therefore these quantities are not updated. ABCs and OFLs for the individual species in the deepwater flatfish complex are determined as an intermediate step and then summed for calculating complex-level OFLs and ABCs. Dover sole apportionment was computed using the random effects model and included the 2015 NMFS bottom trawl survey biomass distributions. Greenland turbot and deepsea sole apportionments were computed using historical survey biomass distributions of both species.

The model estimate of 2016 spawning stock biomass for Dover sole is 49,179 t, which is well above $B_{40\%}(22,692$ t). Spawning stock biomass and total biomass are expected to remain stable through 2017. Stock trends for Greenland turbot and deepsea sole are unknown.

Starting in 2013, the Dover sole stock has been assessed using an age-structured model and is determined to be in Tier 3a. Both Greenland turbot and deepsea sole are determined to be in Tier 6. The 2016 and 2017 Dover sole ABCs are 9,043 t and 9,097 t, respectively. The Tier 3a calculations for Dover sole result in 2016 and 2017 OFLs of 10,858 t and 10,924 t, respectively. The Tier 6 calculation (based on average catch from 1978–1995) for the remaining species in the deepwater flatfish complex ABC is 183 t and the OFL is 244 t for 2016 and 2017. The GOA Plan Team agrees with the authors’ recommendation to use the combined ABC and OFL for the deepwater flatfish complex for 2016 and 2017. This equates to a 2016 maximum permissible ABC of 9,226 t and OFL
of 11,102 t for the deepwater flatfish complex.

Gulf of Alaska Dover sole is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. Information is insufficient to determine stock status relative to overfished criteria for Greenland turbot and deepsea sole. Catch levels for this complex remain well below the TAC and below levels where overfishing would be a concern.

The recommended apportionment for the deepwater flatfish complex is based on the random effects model applied to survey biomass (percentage by area for all survey years) of Dover sole and the historical survey. This approach results in apportionments based on the relative abundance (biomass) of each species in the stock complex in each management area.

M. Pacific halibut

Research

**Halibut Excluders-RACE MACE Conservation Engineering**

In 2015 halibut bycatch quota in the Bering Sea/Aleutian Islands (BSAI) groundfish fisheries was significantly reduced by 21% across four different fishing sectors. CE scientists collaborated with fishing gear manufacturer’s and fisherman to test different halibut excluder designs. The basic design concept is a squared mesh tunnel inside the net, target species pass through the tunnel and into the codend, species (halibut, skates, etc) that can’t fit through the square mesh tunnel stay inside of the tunnel and escape out the escape hole. The design tested in pollock trawl fleet showed too high a loss of target catch and the manufacturer is working to redesign it. There are several different configuration of the base concept being tested in the bottom trawl fleet with very promising results to so far. We hope to do more rigorous testing in 2017.

Contact: Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)

N. Other Groundfish Species

**Selectivity ratio: a useful tool for comparing size selectivity of multiple fishing gear _ RACE GAP**

Selectivity studies have found applications in the wide range of topics within fishery science, such as fishery management, stock assessments, and ecological process studies. However, obtaining selectivity functions can often be a difficult and costly endeavor. Because of this difficulty, many studies are limited to the catch comparison of 2 fishing gears. These studies usually result in the length-dependent selectivity ratio function defined as the quotient of the selectivity of one gear versus selectivity of another gear. Literature review indicates that although selectivity ratio has been a subject of many studies, there is generally a lack of standard methods for its estimation and general lack of standard naming conventions. In this study we propose a new general approach to estimate selectivity ratio and present examples of its practical application in three case studies: a comparison of fine-and large mesh bottom trawls used in Arctic surveys in the recent several decades, a study testing an assumption of full selectivity of the Bering Sea Fisheries Research Foundation Nephrops bottom trawl for snow crab in the Bering Sea, and a comparison of 2 survey midwater trawls for pollock in the Bering Sea. We show that selectivity ratio statistics can be used as generalization of selectivity studies, where one gear is fully selective, as well as in catch

74
comparison studies where selectivity of both gears is unknown. We provide advice on methods for comparing alternative modelling approaches for the selectivity ratio. We advocate for standardization of the naming conventions and methods used in catch comparison studies.

Contact: Stan Kotwicki (stan.kotwicki@noaa.gov), Robert R Lauth, Kresimir Williams, and Scott E. Goodman

The effect of variable sampling efficiency on reliability of observation error as a measure of uncertainty in abundance indices from scientific surveys - RACE GAP and REFM

One of the main goals of fisheries surveys (hereafter referred to as surveys) is to obtain indices of abundance of fish populations. These indices can be directly used in fishery stock assessments to infer about the stock status and provide advice for fisheries management. Survey abundance estimates are often used in the assessment models with multiple data inputs such as integrated analyses. However, integrated analyses require independent inputs to be assigned appropriate weights as the outcomes and their uncertainty may be strongly influenced by the choice of weights. The most common approach to weighting the abundance estimates from surveys is to use survey sampling variance (observation error) as a measure of uncertainty. However the variance estimates derived from samples alone may not represent total variance of the index of abundance. Sampling variance is usually estimated accordingly to the survey design assuming equal and constant efficiency across all samples. However, sampling efficiency studies indicate that sampling efficiency vary between samples and can be a source of additional variation in the observed abundance trends. In such cases, both observation error and variability in sampling efficiency must be accounted for to fully evaluate the uncertainty of an abundance estimate.

The main goals of this study were to examine the effect of variable sampling efficiency on the estimates of survey sampling variance and on the total variance of the abundance index. To achieve this, we simulated realistic fish distributions based on walleye pollock distributions in the eastern Bering sea (EBS) over the last 10 years and multiple fishery surveys with varying sampling efficiency and varying variance in sampling efficiency. Our results indicate that variable sampling efficiency can result in bias and loss of precision in both abundance estimates and survey variance estimates. The degree of these effects depends on the mean value of sampling efficiency as well as the variance in sampling efficiency.

Contact: Stan Kotwicki (stan.kotwicki@noaa.gov) and Kotaro Ono

1Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2015. Orr and Wildes are continuing their work on sandlances by including Atlantic species in a global analysis and conducting more detailed population-level studies in the eastern Pacific. A guide to cods and cod-like fishes (Gadiformes) was published (Hoff, Orr, and Stevenson, 2015). A taxonomic revision of snailfishes in the Careproctus rastrinus species complex, including the description of a new species from the Beaufort Sea, was published (Orr et al., 2015). An additional study testing the hypothesis of cryptic speciation in northern populations of the eelpout genus Lycodes (Stevenson) is underway. Also in progress are studies examining identifications of rockfishes (Sebastes aleutianus and S. melanostictus) off the West Coast (Orr, with NWFSC); morphological variation related to recently revealed genetic heterogeneity in rockfishes (Sebastes crameri; Orr, with NWFSC) and flatfishes (Hippoglossoides; Orr, Paquin, Raring, and Kai); a partial revision of the lumpsucker genus Eumicrotremus (Stevenson); and a study of the developmental osteology of the bathymasterid Ronquilus jordani (Stevenson, with Hilton and Matarese). A description of two new species of snailfishes from the Aleutian Islands has
been accepted (Orr, in press). Work on the morphology of the pectoral girdle of snailfishes (Orr, with UW), and other new species continues.

In addition to taxonomic revisions, descriptions of new taxa, and guides, RACE systematists have collaborated with molecular biologists at the University of Washington and within AFSC to identify snailfish eggs in king crabs, a publication now in press (Gardner, Orr, Stevenson, Somerton, and Spies, in press), a project also unexpectedly leading to the recognition of at least one new snailfish in Alaska. Also with AFSC geneticists, we will examine population-level genetic diversity in the Alaska Skate, *Bathyraja parmifera*, especially as related to its nursery areas, to be undertaken with NPRB support (Hoff, Stevenson, Spies, and Orr). Molecular and morphological studies on *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies), *Eumicrotremus* (Kai and Stevenson), and *Lycodes* (Stevenson and Paquin) are also underway. In addition to systematic publications and projects, RACE systematists have been involved in works on the zoogeography of North Pacific fishes, including collaborations with the University of Washington on a checklist of the fishes of the Salish Sea, now published (Pietsch and Orr, 2015), and a paper documenting the first occurrence of two rare manefish species from Japanese waters (Okamoto and Stevenson, 2015). Stevenson recently completed a section on manefishes for the upcoming FAO guide to the living marine resources of the Eastern Central Atlantic, to be published later in 2016 (Stevenson et al., in Press).

Orr and Stevenson have also conducted work with invertebrates. With the support of NPRB and JISAO, an annotated checklist of the marine macroinvertebrates of Alaska, comprising over 3500 species, is now in press (Drumm et al., in press). A report on a pilot study to collect coral bycatch data from the Alaska commercial fishing fleet was also completed (Stone et al., 2015). Collections are now being made to evaluate the population- and species-level genetic variation among populations of the soft coral *Gersemia* (Orr and Stevenson, with NWFSC).

Contact Jay Orr (james.orr@noaa.gov) and Duane Stevenson

**Salmon Excluders – RACE Conservation Engineering (CE)**

We continued our collaboration with industry on new designs for salmon excluders. Efforts have focused on testing and improving a new design that would allow escape from both above and below, resulting from a previous flume tank workshop. We began by participating in a model testing/development workshop at the flume tank in St. Johns, Newfoundland. The North Pacific Fisheries Research Foundation placed a technician aboard Gulf of Alaska vessels to demonstrate correct tuning and operation of the new excluder design to promote transfer of this technology to that fleet. The AFSC provided the camera systems used by this technician from our CE “loaner pool.” Tests in 2013 and 2014 of the new over/under design in the Gulf of Alaska trawl fleet show escapement rates for salmon between 35-54%. Pollock escape was insignificant at less than 1%. In 2015 and early 2016 the over/under design was tested in the Bering Sea pollock fleet with only about 10% escapement of salmon and about 1% pollock escapement. It is unclear at this time why the salmon escape rates are so different between the two different fleets. Because the new excluder system includes more and larger escape portals, escapes are being monitored with video instead of the more cumbersome recapture nets. The CE program developed a much more compact camera system for this work and up to six of these have been used during the same tow.

Contact: Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)
Develop Alternative Trawl Designs to Effectively Capture Pollock Concentrated Against the Seafloor While Reducing Bycatch and Damage to Benthic Fauna – RACE CE
The Alaska pollock fishery requires the use of pelagic trawls for all tows targeting that species. During some periods of the pollock fishery, these fish concentrate against the seafloor and, to capture them, fishermen have to put nets designed for midwater capture onto the seafloor. We are developing footropes raised slightly off of the seafloor to have less effect on seafloor habitats than the continuous, heavy footropes (generally chains) currently required on pelagic trawls. We have held several workshops with 20+ participants, including captains of pollock trawlers and industry representatives, as well as federal and university scientists to come up with ideas for alternative footropes to test. In May 2014 we began exploring these possibilities with experiments to compare the seafloor effects of the different alternative footropes. Preliminary results show that we reduced footrope contact with the seafloor by at least 90%. We are still working on analyzing the data to determine impacts to benthic structure forming organisms. CE cooperative research moving forward includes work with industry to adapt the prototype footropes tested in 2014 for regular commercial use and full scale tests of the resulting designs to confirm commercial effectiveness in 2017.

Contact: Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)

Provide Underwater Video Systems to Fishermen and Other Researchers to Facilitate Development of Fishing Gear Improvements – RACE
We have continued to provide underwater video systems to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. Beyond their direct use, exposure to NMFS systems has motivated many companies to procure similar systems for dedicated use on their vessels. Either way, the goal of better understanding of fishing gear operation and quicker development of improvements is being realized. While the existing camera systems have been maintained, a significant advance in this area has been the development and testing of much more compact and inexpensive camera systems for use on commercial fishing gear. All camera system components are enclosed in a single 3.5 inch diameter acrylic tube mounted on a plastic plate. The entire system measures 21 x 9 x 5 inches and is of nearly neutral buoyancy in water. These systems have been in use for about 3 years now and have proven to be very easy to use, durable and flexible. Six new systems have been built for our use and as replacements of the older loaner systems. While this design is so inexpensive and functional that many vessels have acquired their own systems, there is still a need for loaner systems.

Contact: Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)

V. Ecosystem Studies

Energetic Condition Juvenile Groundfish in the Gulf of Alaska – ABL
In 2015 the synthesis we began synthesizing data describing the energetic condition of juvenile Pacific cod, pollock, arrowtooth flounder and Pacific Ocean Perch collected during the GOAIERP and Gulf Surveys. The analyses largely corroborated the conclusions drawn by the GOAIERP that environmental indices predicting future recruitment need to be species specific. A spatially explicit
growth potential model that directly compared the growth of cod and pollock sampled from pelagic trawls indicated that pollock employ a “sweepstakes” strategy to early life history and future recruitment is likely dependent on spatial matches between juveniles and optimal growing conditions. “Hot spots” for pollock growth are ephemeral and their spatial distribution is highly variable. Features defining these hotspots are, in order of importance, prey quality and temperature. In contrast, Pacific cod are more tuned to average conditions. Consequently, growing conditions for cod are more consistently located around the Gulf and they are less sensitive to variations in prey quality or temperature.

A second analysis examined the energy allocation strategy of Pacific Ocean Perch juveniles with their length during their pelagic residence. A distinct trade-off between growth and energy storage was detected at about 25 mm, the size at which predation by Chinook and coho salmon begins decreasing. Examination of catch records for Pacific Ocean Perch on the GOAIERP and Gulf surveys indicates that in cool years, fish are vulnerable to predation for a longer time and have less time to store energy.

A third analysis indicates that juvenile fish sampled from the epipelagic in the GOA are storing energy for different reasons. Data mining of the RECA energy database provided plots of energy density versus length for the entire life history for many of the species encountered in AFSC surveys. The plots revealed distinct life history patterns suggesting appropriate periods for monitoring juveniles to predict recruitment. For example, Pacific Ocean Perch and Pacific cod both demonstrated significant losses in energy associated with settling out of the water column. For both species the low energy densities observed after settling out were maintained until fish began maturing several years later. This suggests constraints on survival for post-settlement care different than those of earlier life stages. The similarity of energy allocation strategy with older aged juveniles indicates survival of post-settlement age-0’s is constrained by the same factors as those constraining older juveniles. This story is very different from that of walleye pollock, which appear to store energy as age-0 to forestall starvation in winter when prey supplies are diminished.

For more information contact Ron Heintz ron.heintz@noaa.gov ACES RECA completed its last field season sampling the nearshore areas around Pt Barrow. The nearshore area around Pt. Barrow, Alaska offers a variety of habitats making it an ideal location for understanding the ecological dependencies of juvenile fish in the arctic. Pt. Barrow demarks the boundary between the Chukchi and Beaufort Seas. On the Chukchi side the shallow continental shelf is deeply incised by Barrow canyon. In contrast, the shelf on the Beaufort side of Pt. Barrow is broad and shallow extending eastward. The Beaufort coast is lined with a series of barrier islands that bound brackish inland lagoons. In summer, predominantly easterly winds drive the warm brackish water out of the lagoons and along the Beaufort coast towards Pt. Barrow, although energetic wind-driven flow reversals are common. The energetic and continually adjusting flows around Pt. Barrow support productive waters. Our project is focusing on monitoring the current structure in the nearshore including influx and efflux from Elson Lagoon. In addition we are sampling the zooplankton community and nearshore fish community in the marine and lagoon waters with a combination of beach seines and nearshore trawling. Laboratory analysis of retained samples include diets, isotopic analysis, energy densities and elemental analysis of otoliths of fish and invertebrate species typically encountered. These include Arctic cod, saffron cod, capelin, sand lance, and various sculpins.

ACES – ABL
The last field season of sampling the nearshore areas around Pt. Barrow was completed. The nearshore area around Pt. Barrow, Alaska offers a variety of habitats making it an ideal location for understanding the ecological dependencies of juvenile fish in the arctic. Pt. Barrow demarks the boundary between the Chukchi and Beaufort Seas. On the Chukchi side the shallow continental shelf is deeply incised by Barrow canyon. In contrast, the shelf on the Beaufort side of Pt. Barrow is broad and shallow extending eastward. The Beaufort coast is lined with a series of barrier islands that bound brackish inland lagoons. In summer, predominantly easterly winds drive the warm brackish water out of the lagoons and along the Beaufort coast towards Pt. Barrow, although energetic wind-driven flow reversals are common. The energetic and continually adjusting flows around Pt. Barrow support productive waters. Our project is focusing on monitoring the current structure in the nearshore including influx and efflux from Elson Lagoon. In addition we are sampling the zooplankton community and nearshore fish community in the marine and lagoon waters with a combination of beach seines and nearshore trawling. Laboratory analysis of retained samples include diets, isotopic analysis, energy densites and elemental analysis of otoliths of fish and invertebrate species typically encountered. These include Arctic cod, saffron cod, capelin, sand lance, and various sculpins.

Alaska Coral and Sponge Initiative – RACE & ABL
Deep-sea coral and sponge ecosystems are widespread throughout most of Alaska’s marine waters. In some places, such as the western Aleutian Islands, these may be the most diverse and abundant deep-sea coral and sponge communities in the world. Deep-sea coral and sponge communities are associated with many different species of fishes and invertebrates in Alaska. Because of their biology, these benthic invertebrates are potentially vulnerable to the effects of commercial fishing, climate change and ocean acidification. Since little is known of the biology and distribution of these communities, it is difficult to manage human activities and climate impacts that may affect deep-sea coral and sponge ecosystems.

Beginning in FY2012 the NOAA Deep Sea Coral Research and Technology Program (DSCRTP) initiated a field research program in the Alaska region for three years (FY2012-2014) to better understand the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats. The research priorities of this initiative include:

- Determine the distribution, abundance and diversity of sponge and deep-sea coral in Alaska;
- Compile and interpret habitat and substrate maps for the Alaska region;
- Determine deep-sea coral and sponge associations with FMP species and their contribution to fisheries production;
- Determine impacts of fishing by gear type and testing gear modifications to reduce any impacts;
- Determine recovery rates of deep-sea coral and sponge communities from disturbance; and,
- Establish a monitoring program for the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

Fieldwork for the AKCSI project was completed in FY15 with a remotely operated vehicle cruise in Southeast Alaska to examine Primnoa thickets at two study sites. Data analysis and image analysis is underway. It is anticipated that the final report for this project will be completed by September 2016 and delivered at the International Coral Symposium in Boston, MA.

Contact: Chris Rooper (chris.rooper@noaa.gov)
Defining EFH for Alaska Groundfish Species using Species Distribution Modeling-RACE

Principal Investigators: Chris Rooper, Ned Laman, Dan Cooper (RACE Division, AFSC)

In Alaska, most EFH descriptions for groundfish are limited to qualitative statements on the distribution of adult life stages. These are useful, but could be relatively easily refined both in terms of spatial extent and life history stage using species distribution models and available data. Distribution models have been widely used in conservation biology and terrestrial systems to define the potential habitat for organisms of interest (e.g. Delong and Collie 2004, Lozier et al. 2009, Elith et al. 2011, Sagarese et al. 2014). Recently species distribution models have been developed for coral and sponge species in the eastern Bering Sea and Aleutian Islands (Rooper et al. 2014, Sigler et al. in review). The models themselves can take a number of forms, from relatively simple frameworks such as generalized linear or additive models to complex modeling frameworks such as boosted regression trees, maximum entropy models, two-stage models or other formulations. The models can be used to predict potential habitat, probability of presence or even abundance, but they all have some features in common.

- the underlying data consists of some type of independent variables (predictors) and a dependent response variable (presence, presence/absence or abundance)
- raster maps of independent variables are used to predict a response map
- confidence bounds on the predictions and partitioning of the data can produce test statistics useful for evaluating the model

We used species distribution modeling framework to refine the descriptions (to level 2) of Essential Fish Habitat for Alaskan groundfish species. This was completed for each of the Alaska regions and for all groundfish species for four seasons separately. The independent variables were variables (such as depth, slope, bottom water temperature, current speeds, etc.) widely available from remote sensing or long-term monitoring programs at the AFSC. The dependent variables were survey catches (primarily bottom trawl, but we will include pelagic surveys and ichthyoplankton surveys where available) of the Alaska FMP species. Where no scientific survey data were available (in the winter spring and fall seasons), observer catches were also used for distribution modeling. Where possible, the species were divided by life history stage into egg/larval, juvenile and adult groups.

Three types of models were used, depending on the catch data characteristics. The ichthyoplankton data and the observer data were treated as presence-only and Maximum Entropy modeling was used. For bottom trawl data, generalized additive models, hurdle models or maximum entropy models were used depending on the number of zero catches in the data set.

Over 400 different models were completed (for example see the models for yellowfin sole in the eastern Bering Sea shown in Figure 1). The results were generally consistent and the models generally fit the data well. Validation data sets and diagnostic plots were produced and examined for each of the models.

The most important variables explaining the distribution of fish species tended to be depth for juvenile and adult life history stages that were on or near the seafloor and surface currents for the early life history stages found in the water column (Figure 2). The model-based EFH maps produced were different for most species than the maps produced in 2010 (Figure 3).
The new maps and descriptions were reviewed by stock authors in late 2015 and were delivered to the North Pacific Fishery Management Council in early 2015.

References:

Contact: Chris Rooper (chris.rooper@noaa.gov)
Figure 1. Yellowfin sole distribution models for all life history stages and seasons where data was available. Yellow-red colors indicate higher CPUE or probability of suitable habitat.
Figure 2. Word clouds for important habitat variables (explaining the most variance) summarized for each region and across life history stages.
Figure 3. Essential fish habitat for adult arrowtooth flounder in the eastern Bering Sea as predicted by models (yellow-red scale) and the 2010 polygons (cross-hatched areas).

Smooth sheet bathymetry of the Norton Sound - RACE GAP
As a continuation of work in Alaskan waters (http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/default.htm), scientists with the AFSC’s Groundfish Assessment Program (GAP) have published smooth sheet bathymetry for Norton Sound, Alaska. This work is part of a project using smooth sheets to provide better seafloor information for fisheries research.

The Norton Sound project includes smooth sheet bathymetry editing, the digitizing of sediments, inshore features, and shoreline, as well as incorporating higher resolution multibeam bathymetry data, where available, to supersede some areas of older, lower resolution smooth sheet bathymetry (http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Norton_Sound.htm).
Over 230,000 National Ocean Service (NOS) bathymetric soundings from 39 smooth sheet surveys in Norton Sound were corrected, digitized, and assembled, as well as over 6000 soundings from a GAP research cruise, and three NOS multibeam surveys. The bathymetry compilation ranged geographically from the eastern point of St. Lawrence Island, southeast to the Yukon River delta and north along the Seward Peninsula and around the point of Cape Prince of Wales.

Our Norton Sound coverage is very shallow, with a maximum depth of 63 meters in the outer waters along the Bering Sea, while the sound itself, bounded by the westernmost point on the Yukon River delta along the south and Nome on the North, has an average depth of just 13 meters. The original, uncorrected smooth sheet bathymetry data sets are available from the National Geophysical Data Center (NGDC), which archives and distributes data that were originally collected by the NOS and others. These data are not to be used for navigational purposes.

Funding from the NMFS Alaska Regional Office's Essential Fish Habitat (AKR EFH: http://www.afsc.noaa.gov/HEPR/docs/Sigler_et_al_2012_Alaska_Essential_Fish_Habitat_Research_Plan.pdf) made this work possible. This Norton Sound bathymetry and sediment work was done in response to a NMFS AKRO (Alaska Regional Office) request to provide information for a new predictive modeling effort examining Norton Sound red king crab and potential effects of offshore marine mining activities on their habitat. The Alaska Regional Office will also investigate use of the bathymetry and sediment information to oversee sustainable fisheries, conduct Essential Fish Habitat (EFH) reviews, and manage protected species. This Norton Sound bathymetry compilation is part of a GAP (Groundfish Assessment Program) effort to create more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their

Contact Mark.Zimmermann@noaa.gov

**RACE Recruitment Processes (RPP)**

The Recruitment Processes Program's (RPP) overall goal is to understand the mechanisms that determine whether or not marine organisms survive to the age of “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 that we study, we attempt to learn what biotic and abiotic factors cause or contribute to the observed 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 applied by us and by others at the Alaska Fisheries Science Center to better manage and conserve the living marine resources for which NOAA is the steward. Below are research activities focusing on multiple species and ecosystem effects.

Contact: Janet Duffy-Anderson

**Icthyoplankton Assemblages and Distribution in the Chukchi Sea 2012-2013 - RPP**

There is significant interest in the effects of climate change on the Pacific Arctic ecosystem, and in determining influences on resident biota. In summer 2012 and 2013, large-scale fisheries oceanographic surveys that included ichthyoplankton tows were conducted in the northern Bering and eastern Chukchi Seas as part of the Arctic Ecosystem Integrated Survey (Arctic Eis). Collections of pelagic fish eggs found high concentrations of *Limanda* spp. (probably yellowfin sole *L. aspera*) along the north shore of Seward Peninsula and also near Point Hope and Cape Lisburne in both 2012 and 2013 with greater abundances collected in 2012 (Fig 1). *Hippoglossoides robustus* (Bering flounder) eggs were caught to the west and offshore from Point Barrow in 2012. Similar but less pronounced trends in egg distribution were observed in 2013. These localized concentrations of eggs of both species suggest the presence of aggregations of spawning adults in those immediate areas.
Figure 1. Abundance and distribution of *Limanda* spp. and *Hippoglossoides robustus* eggs in 2012 and 2013

Contact: M. Busby, J. Duffy-Anderson, K. Mier (NOAA/AFSC/EcoFOCI Program) and H. Tabisola (UW/JISAO)
Redesigning a survey to capture the early life stages of groundfishes in the Bering Sea - RPP

The Eco-FOCI program conducts biennial spring surveys in the Bering Sea to study the early life stages of groundfishes, in particular Walleye Pollock, in order to better understand the ecosystem processes underlying fisheries recruitment and productivity. Studies have shown that the spatial distribution of Walleye Pollock larvae differs in cold and warm years, and that the existing survey design was failing to capture the full extent of their distribution. In 2015-16 we reassessed our survey design to ensure it covers the major known spawning areas of Walleye Pollock on the SE Bering Sea shelf, captures the variable spatial extent of larvae, and can be used to create an index of larval abundance for ongoing studies of early life stage survival. We considered three possible alterations to the survey grid in order to reduce sampling intensity and increase spatial coverage: 1) dropping every other station in the cross shelf direction, 2) dropping every other station in the along-shelf direction, and 3) dropping every other station from each line to create an evenly spaced, staggered grid. An analysis of the spatial autocorrelation in pollock larvae counts from 2012 and 2014 provided no consistent support for reducing sampling intensity in one direction versus the other. We used geostatistical delta generalized linear mixed models to construct an abundance index from the survey data in 2012 and 2014, and compared the mean estimates and their precision with those resulting from analyzing subsets of the data corresponding to the three candidate grids. The skip-across-shelf design had the highest precision, whereas the stagger design was most accurate. We decided on a stagger design, with stations spaced approximately 22 nm apart (the existing design had 15 nm spacing). The new design has two types of stations: core sampling stations that are always sampled, and adaptive sampling stations on the edges of the core that can be added dynamically during a survey if the edge of the distribution of larvae has not yet been reached (Figure 1). A stopping rule, based on counts of larvae at sea, will be used to determine whether sampling should continue along a line beyond the core stations. We anticipate that this survey design will result in a minor loss of precision, while greatly improving our ability to census the full spatial extent of pollock larvae, ultimately improving our understanding of early life history dynamics and pollock recruitment variability.

Contact:  L. Rogers, K. Mier, S. Porter (NOAA/AFSC/EcoFOCI Program)
Figure 1: The new sampling grid for the Eco-FOCI spring survey in the SE Bering Sea consists of core stations (red) that are sampled every survey, and adaptive stations (black) that are sampled if the edge of the distribution of Walleye Pollock larvae has not been reached, as indicated by at-sea counts.
New midwater trawl for the Recruitment Processes Alliance - RPP

EMA and Eco-FOCI completed an integrated ecosystem survey from 6 September to 6 October 2016. We evaluated a new midwater trawl which will be adopted for future surveys. The trawl gear was a NETS 156 small mesh midwater trawl designed and built by NETS Systems to attempt to create a durable trawl with high catch efficiency of age-0 pollock in late summer and early fall. Oblique tows to 10 meters off bottom or 200 meters maximum depth were conducted on the BASIS survey grid. Age-0 pollock abundances were highest over the middle shelf.

![Figure 1. Age-0 Pollock per 100m² surface area from oblique midwater tows.](image)

The trawl was equipped with an FS-70 third wire to measure vertical and horizontal opening to quantify the mouth opening and the volume of the water filtered by the trawl.

![Figure 2. Vertical opening (left panel) and horizontal opening (right panel) at trawl warp wire out for the NETS 156 midwater trawl.](image)

A camera was mounted at various places in the net to observe how the net fished and to look for fish escapement. A bulge was observed in the trawl body forward of the connection to the codend, and some age-0 pollock were observed escaping the net at this bulge. The trawl is currently being modified to reduce the constriction causing the bulge to improve water flow through the net and net catch efficiency. Future work with pocket nets will evaluate the catch efficiency of the trawl.
The trawl fished well at depths near the bottom up to a headrope depth of about 10 meters, but would not fish at depths more shallow than 10 meters. Additional floats are being added to include in an attempt to fish oblique tows all the way to the surface in 2016.

Contact: D. Cooper, A. Spear (NOAA/AFSC/EcoFOCI Program), A. Andrews (NOAA/AFSC/EMA Program)

Gulf of Alaska Ichthyoplankton Abundance Indices 1981–2013 - RPP
The Alaska Fisheries Science Center’s (AFSC) EcoDAAT Database includes data from collections in the Gulf of Alaska (GOA) from 1972 to the present with annual sampling 1981–2011 and biennial sampling thereafter. Since 1985 these collections have been part of AFSC’s recruitment processes research under the Ecosystems and Fisheries Oceanography Coordinated Investigations Program (EcoFOCI). The primary sampling gear used for these collections is a 60-cm bongo sampler fitted with 333 or 505-µm mesh nets; oblique tows are carried out mostly from 100 m depth to the surface or from 10 m off bottom in shallower water (Ichthyoplankton Information System (http://access.afsc.noaa.gov/ichthyo/). Historical distribution of sampling effort extends from the coastal area to the east of Prince William Sound southwestwards along the Alaska Peninsula to Umnak Island, covering coastal, shelf and adjacent deep water, but sampling has been most intense in the vicinity of Shelikof Strait and Sea Valley during mid-May through early June (Fig. 1A). From this area and time, a subset of four decades of data has been developed into a time-series of ichthyoplankton species abundance and it is now updated through 2013.

The 2013 time series data suggest that environmental conditions in the Gulf of Alaska favored high abundances of certain species of fish larvae in May 2013 (7 out of 12 show positive anomalies, the remaining 5 are neutral to slightly negative). Abundance of walleye pollock larvae displayed a moderately positive anomaly for 2010, a slightly negative response in 2011 and then a very high positive anomaly in 2013. The abundance of larvae in 2013 was the second largest of the time series after 1981. For rockfish larvae, a moderate positive anomaly in 2010 was followed by a very high positive anomaly in 2011 and an even higher one in 2013. Pacific cod also showed a high positive anomaly in 2013. For flatfishes in 2013, moderately positive anomalies occurred in starry flounder, northern and southern rock sole and Pacific halibut while moderately negative anomalies occurred in flathead sole and arrowtooth flounder.

Increases in observed abundances across some species in 2013 may be due to: 1) circulation features that favored retention of larvae over the shelf; it was noted that satellite-tracked drifter trajectories indicated the presence of eddies in the region in spring, 2) improved growth and survival mediated by moderate temperature (see Dougherty, this document, for survey temperatures in 2013 and 2015), and 3) robust feeding conditions (NPRB/GOAIERP zooplankton data analyses in progress, Hopcroft personal communication). More information on factors influencing larval abundance and distribution will be made available through the GOAIERP Synthesis program (2015–2018).
Figure 1. (A) Distribution of historical ichthyoplankton sampling in the Gulf of Alaska. (B) Interannual variation in late spring larval fish abundance for the most abundant species. For each year and taxon, the larval abundance index is expressed as the mean abundance (no. 10 m$^{-2}$) normalized by the time-series mean and standard deviation.

Contact: A. Matarese and K. Mier (NOAA/AFSC/EcoFOCI Program)
Temperature and Gulf of Alaska Larval Walleye Pollock Survival - RPP

The 2015 Eco-FOCI Gulf of Alaska larval survey was conducted from May 14 to June 5 aboard the NOAA research vessel Oscar Dyson. A total of 276 stations were sampled using the 20/60 cm bongo array with 0.153/0.505 mm mesh to collect larvae and zooplankton. A rapid assessment of the zooplankton community was conducted at sea from each mesh size throughout the survey (see results presented by N. Ferm in the 2015 Ecosystem Considerations). Plankton tows for larval fish, especially walleye pollock, were conducted to 10 meters off bottom or 100 meters maximum. A Sea-Bird FastCat was mounted above the bongo array to acquire gear depth, temperature, and salinity profiles. Temperature at 40 meters (depth of larval residence) was selected at each station to represent the temperature field. Abundance and temperature maps were constructed to illustrate the distribution of larval pollock throughout the survey area. Larval walleye pollock rough counts for 2015 were consistently lower throughout the grid compared to the counts in 2013 (note drastic reduction in RCountL scale range for 2015). The temperature field at 40 meters in 2015 was 3-5°C warmer than in 2013. The rapid assessment of the 2015 zooplankton community showed an abundance of small copepods, the preferred prey of larval pollock, suggesting that the larvae were not food limited during this life stage.

The 2013 year-class was reported to have resulted in slightly below average numbers of age-1 recruits in the 2014 Stock Assessment and Fish Evaluation document (Table 1.18). Preliminary results from the MACE survey, conducted in March of 2016 to assess adult pollock abundance in the Gulf of Alaska, reported very few 1 year-old pollock (2015 year-class).
Figure 1. Temperatures at depth (color ramp) and larval abundance estimates (at-sea rough counts, circles) for walleye pollock in the Shelikof Sea valley in 2013 and 2015.

Contact: A.B. Dougherty (NOAA/AFSC/EcoFOCI Program)

The Eco-FOCI late-summer Gulf of Alaska small-mesh trawl survey, August-September 2015 - RPP
The EcoFOCI late-summer time series of small neritic fishes in the western Gulf of Alaska now extends from 2000 – 2015. Most recently, we observed relatively few age-0 walleye pollock, which reflected low abundance of larvae in May. This extends the recent spate, since 2012, of low-abundance year classes. Juvenile rockfishes were comparatively abundant; presumably, these were mostly Pacific ocean perch, which were once quite abundant in the Gulf and as adults may compete with pollock for krill. Water temperatures were higher than in previous years; however, the geographic patterns of temperature and salinity were similar to past observations and consistent with known circulation patterns. Possible temperature-mediated ecosystem responses are being investigated.

Contact: M. Wilson, S. Porter (NOAA/AFSC/EcoFOCI Program) and W. Strasburger (NOAA/AFSC/EMA Program)
Figure 1. Water temperature and salinity, at 40-m depth, and abundance of age-0 juvenile walleye pollock and rockfishes as estimated in the western Gulf of Alaska during August-September 2015.
Using cell-cycle analysis to measure growth of Walleye Pollock *Gadus chalcogrammus* larvae - RPP

Preliminary results of a new method using cell-cycle analysis of muscle cell nuclei with flow cytometry for measuring the growth rate of Walleye Pollock *Gadus chalcogrammus* larvae collected as eggs from the Gulf of Alaska are presented here. This method is based on the premise that cell proliferation is related to growth. An advantage of using flow cytometry is that it is faster than counting otolith daily increments, particularly when increments are difficult to discern due to slow growth. Walleye Pollock larvae were reared in the laboratory using different prey ration diets. A generalized additive model (GAM) to estimate growth rate (mm/d) was formulated beginning from when those larvae initiated feeding. The best fit model had standard length (SL), proportion of cells in the S phase of the cell cycle, and proportion of cells in the G2 and mitosis phases for covariates, and $R^2 = 0.84$. The model calculated growth rates more accurately for larvae > 7.5 mm SL (5% mean error), than for smaller larvae where accuracy was much more variable and in some cases error was > 100% (Table 1). A future model will include multiple temperatures that larvae can experience in the field. Accurate growth measurements of Walleye Pollock larvae will lead to better understanding of the relationship between environmental variability and larval survival in Alaskan waters.

Table 1. Growth model accuracy tested with an independent group of larvae.

<table>
<thead>
<tr>
<th>Standard length (mm)</th>
<th>Actual growth rate (mm/d)</th>
<th>Model growth rate (mm/d)</th>
<th>SE</th>
<th>% error</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.61</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>5.85</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>6.05</td>
<td>0.08</td>
<td>0.06</td>
<td>0.01</td>
<td>34</td>
</tr>
<tr>
<td>6.08</td>
<td>0.04</td>
<td>0.06</td>
<td>0.01</td>
<td>70</td>
</tr>
<tr>
<td>6.55</td>
<td>0.11</td>
<td>0.10</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>6.56</td>
<td>0.05</td>
<td>0.09</td>
<td>0.01</td>
<td>71</td>
</tr>
<tr>
<td>7.44</td>
<td>0.06</td>
<td>0.11</td>
<td>0.01</td>
<td>81</td>
</tr>
<tr>
<td>7.76</td>
<td>0.14</td>
<td>0.14</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>9.35</td>
<td>0.14</td>
<td>0.14</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>9.45</td>
<td>0.14</td>
<td>0.14</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>9.93</td>
<td>0.16</td>
<td>0.18</td>
<td>0.01</td>
<td>12</td>
</tr>
</tbody>
</table>

Contact: S. Porter (NOAA/AFSC/EcoFOCI Program)
How many species are represented in a sample of several hundred *Bathymaster* spp. specimens collected in ichthyoplankton surveys? - -RPP

As part of a long-term multi-disciplinary project to identify larvae of three species of ronquils from the genus *Bathymaster* (family Bathymasteridae) routinely collected in the northeastern Pacific Ocean and Bering Sea, we developed a rapid restriction fragment length polymorphism (RFLP) protocol. Larvae from the genus *Bathymaster* have one of the highest average abundances in spring and summer ichthyoplankton surveys from the Bering Sea and Gulf of Alaska. Because these larvae are presently unidentifiable to species using morphological characters, a subsample ($n = 260$) of specimens were identified using a PCR-amplified portion of the mitochondrial DNA cytochrome $c$ oxidase I (COI) gene region scored to species type based on an RFLP protocol with restriction enzyme *Cac*8I. Of these samples 259 of 260 were correctly identified and the results revealed that 137 of 260 were Searcher, *Bathymaster signatus*, 101 were Alaskan Ronquil, *B. caeruleofasciatus*, and 22 Smallmouth Ronquil, *B. leurolepis* (Figure 1). Information on larval distribution is a critical component to understanding the dynamics of ecosystems where larvae occur. Multivariate statistical analysis showed that seasonal timing and water bottom depth may be correlated to species occurrence for two of the species, *B. signatus* and *B. caeruleofasciatus*. A chi-square statistical test performed for independence of these two species and bottom depth revealed that spring samples are significantly related to species occurrence for the samples tested, $\chi^2$(d.f. = 1, $N = 133$) = 37.7, $p <0.001$, with *B. caeruleofasciatus* more likely to occur at sampling stations with a bottom depth exceeding 180 m and *B. signatus* at shallower depths of $\leq$100 m.

Figure 1. Collection date plotted against the number of bathymasterid (ronquils) specimens
identified using genetic analyses \((N = 260)\).

Contact: M.M. Paquin, M.F. Canino, A.C. Matarese (NOAA/AFSC/EcoFOCI Program)

**Gulf of Alaska Project: Benthic Habitat Research - ABL**

The primary goal of the Gulf of Alaska (GOA) benthic habitat research project is to characterize the preferred settlement habitat for the five focal groundfish species specified by the GOA Project Upper Trophic Level component. There are five main objectives for the habitat project: 1) conduct a literature review and synthesis of early life (EL) preferred habitat and observational data of five focal species, 2) collect, validate, digitize, and grid available benthic habitat data, 3) create benthic metrics from habitat data, 4) model species-specific habitat by early life stage, and 5) generate species-specific suitability maps of the literature and modeling results. All objectives for this project have been completed and the final report has been submitted to the North Pacific Research Board (NPRB). Additionally, a draft manuscript by Pirtle et al. (In Review) was submitted for review in a special issue of Deep-Sea Research II describing the work on the early juvenile stage habitat suitability models for the five species.

The Final Report to the NPRB (100+ pgs) included the following information for the five focal species: 1) extensive literature review of habitat preferences with life stage tables, 2) methods and maps of the high resolution suite of benthic habitat variables, 3) methods and database of the field observations for the early juvenile stages, 4) methods and maps for the literature based habitat suitability, 5) methods, model selection, model results, and final maps for the model-based habitat suitability 6) regional based habitat suitability estimates, and 7) extensive discussion of project. The follow up Essential Fish Habitat (EFH) project (Pirtle, Shotwell, Rooper) was also completed this year. The baseline habitat suitability framework from the GOA Project was extended to include new biophysical habitat metrics (e.g. production, temperature, corals) and applied to a variety of groundfish species from the early juvenile life stage through adults (including the five focal species). The results from this project were included in the 2016 EFH update which was submitted to stock assessment scientists for review. These EFH results are also planned for inclusion in the new species-specific ecosystem considerations sections of the stock assessment fishery evaluation (SAFE) process and may assist fishery managers in future decisions regarding survey planning and habitat assessment. During the next phase of the GOA Project Synthesis, the baseline habitat suitability models will be combined with individual based models (IBMs) in a novel approach to delineating survival trajectories for understanding recruitment of groundfish. The case study for this approach will be Alaska sablefish. We will also be developing a habitat metrics geodatabase for future research.

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

**Habitat use and productivity of commercially important rockfish species in the Gulf of Alaska - RACE GAP**

The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. This project examined the
productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish, *S. variabilis*) in three different habitat types during three seasons. Low relief, high relief rocky/boulder, and high relief sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska will be sampled using both drop camera image analysis and modified bottom trawls. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types. All field work for this project has been completed and sample processing and data analysis will be completed within the next year.

**RACE Habitat Research Group (HRG)**

Scientists in the RACE Habitat Research Group (HRG) continue research on essential habitats of groundfish, including identifying informative predictor variables for building quantitative habitat models, developing efficient tools to map these variables over large areas, investigating activities with potentially adverse effects on Essential Fish Habitat (EFH), such as bottom trawling, and conducting benthic community ecology studies to characterize groundfish habitat requirements and assess fishing gear disturbances. Research in 2015 was primarily focused on evaluating acoustic backscatter as a quantitative predictor of groundfish distributions in the eastern Bering Sea (EBS) and the development of next generation habitat-utilization models for managed species. The acoustic data are also being studied to improve trawl-survey catchability models for stock assessment purposes. A global investigation of mobile bottom-contact fishing gears continued as part of an international effort.

For additional information, see [http://www.afsc.noaa.gov/RACE/groundfish/hrt/default.php](http://www.afsc.noaa.gov/RACE/groundfish/hrt/default.php) or contact Bob McConnaughey, bob.mcconnaughey@noaa.gov, 206-526-4150. Other members of the HRG are Steve Intelmann, Keith Smith, Theresa Smith, and Steve Syrjala.

**Habitat Modeling - HRG**

The HRG is building numerical models to explain the distribution and abundance of groundfish and benthic invertebrates in the EBS. Abundance estimates from annual bottom trawl surveys are being combined with synoptic environmental data to produce basin-scale continuous-value habitat models that are objective and have quantifiable uncertainty. The resulting quantitative relationships not only satisfy the Congressional mandate to identify and describe EFH, but may also be used to gauge the effects of anthropogenic disturbances on EFH, to elevate stock assessments to SAIP tier 3, and to predict the redistribution of species as a result of environmental change. In practice, we use systematic trawl-survey data to identify EFH as those areas supporting the highest relative abundance. This approach assumes that density data reflect habitat utilization, and the degree to which a habitat is utilized is considered to be indicative of habitat quality. The models are developed with an iterative process that assembles existing data to build 1st generation expressions. Promising new predictors are then evaluated in limited-scale pilot studies, followed by a direct comparison of alternative sampling tools. Finally, the most cost-effective tool is used to map the new variable over the continental shelf and the existing model for each species is updated to complete the iteration.

Current research (the “FISHPAC” project) is investigating whether quantitative information about seafloor characteristics can be used to improve existing habitat models for EBS species. Preliminary
work\(^1\) demonstrated that surficial sediments affect the distribution and abundance of groundfish, however direct sampling with grabs or cores is impractical over large areas and spatial interpolations of limited data are imprecise and potentially biased. Subsequent pilot studies\(^2,^3\) showed that acoustic systems were suitable for broad-scale seafloor surveys and that processed acoustic data can be used to improve the numerical habitat models.

A major field experiment in 2012 collected more than 3,800 gigabytes of acoustic data and groundtruthing information on multiple tracklines spanning strong gradients in groundfish and crab abundances (Fig. 1). Five different sonars were deployed on multiple passes over each line and these data were post-processed in 2015, for multiple purposes. Bathymetric data were cleaned and submitted for nautical charting (registry D00169, D00170). Backscatter data were post-processed to produce standardized statistics, using quantitative sediment properties from grab samples to normalize the values. Still-image mosaics of the seafloor were generated from towed video to serve as additional groundtruthing for the acoustic data.\(^4\) Thirty-four years of trawl survey data (catch per unit effort, kg ha\(^{-1}\)) have been assembled and statistical analyses with the backscatter statistics are being conducted to compare the contributions of the different sonar systems in the habitat models. The most cost–effective sonar system will be used to systematically map and characterize the seabed of the EBS shelf in August 2016 (Fig. 2), and will be the basis for improved EFH models for multiple species.

---


Figure 2. Completed FISHPAC 2012 survey tracklines. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom trawl survey stations for the Bering Sea shelf. Each line was surveyed with five different sonar systems, with the exception that only multibeam echosounder data were collected over the northeast section of line 14 and during the transits to and from the numbered tracklines. For additional information, see http://www.afsc.noaa.gov/RACE/surveys/cruise_archives/cruises2012/results_Fairweather_FISHPAC-2012.pdf.

Figure 3. The Bering Sea shelf will be systematically mapped to improve groundfish habitat models and fishery stock assessments. Quantitative sonars will be used to characterize the seafloor for the eastern half of the NMFS trawl-survey stations during a multi-mission cruise. In addition to quantitative backscatter data, the survey will also produce IHO-quality bathymetric data for updating nautical charts of areas with outdated or non-existent information, as well as continuous measurements of chemical and physical properties in the pelagic and benthic environments.

**Tool Development for Broad-scale Habitat Mapping - HRG**

The Klein 7180 long-range side scan sonar (LRSSS) is new technology that was purpose-built for HRG fish-habitat research. It is distinguished from all other sonar systems by its ability to collect fully adjusted quantitative information about seafloor characteristics and is thus ideally suited for modeling applications. The very large swath coverage (to 1.0 km) and high maximum tow speed
(12 kts) of the LRSSS greatly increase the efficiency of survey operations thereby reducing costs and the time required to complete missions. Multiple acoustic, environmental, and navigational sensors generate co-registered high-resolution backscatter and bathymetry from a dynamically focused multibeam side scan sonar and integrated nadir-filling sonars. Secondary acoustic systems, including a 38 kHz single-beam echosounder, a Mills-cross-configured downward-looking sonar, and a pair of scatterometers also provide bathymetric and/or backscatter data for interpretation. Calibrated backscatter is available across the entire survey area with an innovative “cascade calibration” that uses overlapping swaths of data to transfer the calibrated backscatter from a simple downward-looking sonar (altimeter) to the other acoustic subsystems covering the nadir (under the towfish) and the outlying side-scan regions. This Mills-cross type altimeter is easily removed for tank calibration and can then be readily reinstalled in a fixed position as needed for periodic recalibration of the LRSSS system.

There was considerable interaction with commercial software developers in 2015, related to the continuing development of LRSSS capabilities and the need for high-quality backscatter data in next-generation habitat models. In particular, the HRG worked closely with the new owners of Fledermaus (QPS, Inc, a division of Saab Maritime) and IMPACT (renamed IMPULSE, Maritime Way Scientific, Ltd.) software in order to improve the accuracy of statistical outputs and to enable processing of very large data sets with their commercially available products.

The Rolls Royce free-fall cone penetrometer (FFCPT) is a 52 kg instrumented probe that is designed to free fall through the water column and can penetrate up to 3 meters into the seabed. Measurements of deceleration and pore pressure allow for the determination of undrained sheer strength and a profile of sediment types. Sensor data are captured 2000 times per second on flash memory and transmitted to topside computers where they can be quickly processed with specialized software. In addition to sediment data, an instrument in the tail fin of the FFCPT acquires sound velocity profiles for use by the ship’s acoustic systems. When combined with an appropriate winch, it is possible to yo-yo the instrument through the water column and into the seafloor while the ship is underway at speeds up to 6 kts, thereby improving surveying efficiency over more traditional sediment- and sound-velocity-sampling methods that require the ship to slow or even stop headway for data acquisition. The geotechnical data are being evaluated as new predictor variables for use in the HRG habitat and trawlability models.

A triplet of optical sensors (Wet Labs Puck; 660 nanometer wavelength) incorporated into the LRSSS towfish continuously measures colored dissolved organic matter (370/460 nm excitation/emission), turbidity by particle scattering (660 nm), and chlorophyll-a fluorescence (470/680 nm) in the pelagic environment. These properties show considerable spatial variability, may be related to fish-habitat quality, and are being considered for use in next generation models.

**Seabed Characterization to Improve Stock Assessment Models - HRG**

The HRG is also investigating whether acoustic backscatter from the seafloor can be used to improve stock assessments. In stock assessment models, catchability is the link between an index of relative abundance from a fishery-independent survey and the modeled population size. For bottom
trawl surveys that estimate the population size using swept-area methods, catchability can be estimated because it is largely determined by sampling efficiency (i.e., the proportion of animals within the sampled area that is caught) which can be experimentally measured. However, estimating survey catchability is complicated because trawl efficiency has been shown to vary over a survey area in response to variation in bottom-sediment type. Catchability experiments have been conducted on the bottom trawl used for the annual EBS survey, resulting in a survey-wide estimate of catchability for snow crab (*Chionoecetes opilio*) which, when included in the stock assessment model, produced significant changes in the Allowable Catch Limit. This catchability model accounted for spatial variation in trawl efficiency as a function of crab size, sex, water depth, and sediment type. Unfortunately, sediment data over the geographic distribution of snow crab are quite fragmentary due to the remoteness of the area, and direct estimates of sediment properties such as grain size are generally unavailable at the trawl-sampling locations. In some cases, estimates were based on sediments collected over 60 miles away. The option to collect physical sediment samples at all 270 trawl-sampling stations included in the snow crab distribution is prohibitively expensive considering the additional ship time required and the sample processing costs.

This project is examining whether indices of bottom type, derived from standardized and calibrated ES-60 acoustic data collected at each snow crab sampling station, are more informative in the snow crab bottom trawl catchability model than measured values of sediment type that were broadly extrapolated. This determination will be based solely on the amount of spatial variation in the snow crab efficiency model that is explained by the two kinds of sediment information. While the currently used data are based on a directly measurable attribute of the sediment (mean grain diameter), the acoustically derived index is related to this attribute but also to a variety of previously unmeasured variables affecting the time-dependent shape of the bottom echo. Although there is not a simple mathematical relationship between the two types of information, we believe an acoustic index is sufficiently related, will be more reliable, can be collected more efficiently, and will result in a better fitting catchability model for EBS snow crab. Preliminary analyses with generalized additive models indicate that bottom characteristics described by the principal components of the acoustic data after processing with *IMPULSE* software (i.e., Q-values) increased the deviance explained by 6% for males and 35% for females, relative to the previous catchability model using mean grain size values that were interpolated (kriged) to the locations of the trawl stations. In cooperation with industry, this research topic is being expanded in 2016 to

6 For additional information, see [http://www.afsc.noaa.gov/RACE/groundfish/ebs.htm](http://www.afsc.noaa.gov/RACE/groundfish/ebs.htm)


9 Formerly IMPACT software by Quester Tangent Corporation; see Maritime Way Scientific: [http://www.maritimeway.ca/seabed-classification/impulse15/net](http://www.maritimeway.ca/seabed-classification/impulse15/net)
investigate the catchability of Bristol Bay red king crab using three different sonars, including the LRSSS (Fig. 2).

**Effects of Bottom Trawling: Global Study of Bottom-trawling and Dredging Effects - HRG**

There is considerable evidence that mobile bottom-contact gears (MBCG) such as trawls and dredges affect the integrity of benthic environments that support prey and provide habitat for managed populations of fish and crab. Widespread use of these gears could thus have substantial effects on the growth, survival, and productivity of these stocks. There is, however, considerable variability in the magnitude and characteristics of the effects. Hard-bottom areas with surface-dwelling invertebrate fauna are particularly sensitive, whereas soft-bottom areas with frequent natural disturbances are relatively insensitive. Given that approximately 25% of world fish catch comes from the use of these gears, a clear understanding of the overlap between trawling effort and different benthic habitats is of considerable global importance.

An international group has formed to summarize the global use of mobile fishing gears, their impacts on marine habitats and the productivity of fish stocks, and related management practices. The committee is comprised of individuals from both academia and government and is being led by Professors Ray Hilborn (University of Washington, Seattle), Simon Jennings (Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, U.K.), and Michel Kaiser (Bangor University, Bangor, U.K.). Other members of the committee are Drs. Jeremy Collie (University of Rhode Island, Narrangansett), Jan Hiddink (Bangor University, Bangor, U.K.), Bob McConnaughey (NOAA Alaska Fisheries Science Center, Seattle), Ana Parma (Argentine Council for Science and Technology, Chubut, Argentina), Roland Pitcher (Commonwealth Scientific and Industrial Research Organization, Brisbane, Australia), Adriaan Rijnsdorp (Wageningen University and Research Center, IJmuiden, Netherlands), and Petri Suuronen (United Nations FAO, Rome, Italy). Two post-doctoral research associates (Drs. Ricardo Amaroso and Tessa Mazor) are working full-time on the project.

The full project consists of five phases. Phase 1 of this project is systematically mapping MBCG effort (Fig. 3) and its distribution with respect to benthic habitats (Fig. 4). Phase 2 has compiled data and conducted a meta-analysis to evaluate the impacts of MBCG on the abundance and diversity of biota. Phase 3 will use information from the first two phases to conduct a risk assessment of the effects of trawling and to illustrate trends in the risk of change to seabed habitats and communities. Phase 4 is studying the medium- and long-term impact of trawling on the productivity and sustainable yield of different target species and ecosystems. Phase 5 will identify and test a range of management options and industry practices that may improve the environmental performance of trawl fisheries, with a view to defining ‘best practices.’ The scope of the Phase 5 effort was broadened in 2015 to include a closer look at trawl-fishery management in south and

---


southeast Asia, where approximately 80,000 trawlers operate under a variety of management practices and contrasting policy drivers. This focus entailed collaborative interactions with trawl-fishery scientists and management experts from India, Indonesia, Malaysia, the Philippines, and Vietnam, and included an extended site visit to Vietnam to conduct structured interviews about industry practices and management decision processes. Additional details about the project, products, and the study group are available at [http://trawlingpractices.wordpress.com/](http://trawlingpractices.wordpress.com/).

Figure 4. Distribution of trawling effort in the eastern Bering Sea, based on VMS data. Percentages indicate the total area swept in each 1 km$^2$ grid cell during 2008. Values greater than 100% indicate the total area swept in a cell exceeded 1 km$^2$. (Summary produced by S. Intelmann using the Catch In Area database developed by S. Lewis, NOAA.)

Figure 5. The distribution of trawling effort in different habitat types of the eastern Bering Sea in 2008. A total of 6.7%, 5.5%, and 4.0% of available mud, sand, and gravel habitats at depths <1,000 m was trawled with bottom-contact gear.

**Effects of Bottom Trawling: Characterization of Korean Trawling Effort - HRG**

Another international collaboration is determining the types and quantities of bottom habitats in
Korea that are being affected by trawling, thereby informing sustainable management of multiple demersal stocks. Working with Dr. Junghwa Choi at the National Fisheries Research and Development Institute in Busan, South Korea, effort data for Korean trawl fisheries in the Yellow Sea and the East Sea regions are being combined with standardized benthic-habitat information to describe the trawling footprint by habitat type for three different classes of bottom-contact gear: (1) otter trawls, (2) single trawls, and (3) pair trawls (Fig. 5). This work is being conducted under the guidance of the Fisheries Panel that is part of the Joint Project Agreement between NOAA and the Korean Ministry of Oceans and Fisheries for scientific and technical cooperation in integrated coastal and ocean resources management.

Figure 6. System of 0.5 degree sea blocks used to report catch and effort data for Korean trawl fisheries.

**Benthic Invertebrate Ecology: Consistent Taxonomic Classification of Invertebrates Caught in AFSC Bottom Trawl Surveys - HRG**

The RACE Division’s annual bottom trawl survey of fish and invertebrates spans the EBS shelf from the Alaska Peninsula on the southeast to approximately 62° N near St. Matthew Island in the northwest, and extends cross-shelf from the 20 m isobath to the 200 m isobath. Thanks to consistent gear and sampling methods used from 1982 to the present, the survey data constitute an invaluable time series of distribution and abundance. However, there have been inconsistencies in the taxonomic resolution to which a particular species has been identified and these inconsistencies can easily contribute to errors when compiling data for analysis.

A specialized software query and lookup tables have been developed to address cases where classification has varied among years, vessels, cruises, or hauls. For a user-selected set of years, the tool accesses data in the Division’s Oracle database and objectively groups the aggregate weights and numbers of invertebrate caught by the lowest accountable inclusive taxon (LAIT). As an example, inconsistent classification of the neptunid snails as *Neptunea heros*, *Neptunea pribilofensis*, and *Neptunea* spp. over three survey years would be consolidated as *Neptunea* spp. for reporting purposes.
A great variety of biotic and abiotic factors define the habitats of marine species such that knowledge of their spatial and temporal variability can be used to understand biological patterns of distribution and abundance. The importance of habitats for the sustainable management of fishery stocks was formally acknowledged in the United States with passage of the Sustainable Fisheries Act in 1996. At that time, the Magnuson-Stevens Fishery Conservation and Management Act was amended to include new requirements to identify and protect EFH. By legal definition, EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Using the best scientific information, federal fishery management plans must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. In so doing, the plans should explain the physical, biological, and chemical characteristics of EFH and must also identify the specific geographic location or extent of habitats described as EFH.

The broad scope of the EFH mandate requires an efficient process for describing and mapping the habitats of federally managed species. Factors such as temperature, salinity, and depth are generally accepted as habitat-defining characteristics for marine fish and invertebrates, and synoptic data sets are frequently available. Research also indicates that surficial sediments are an important habitat factor for many species, with both direct and indirect effects on survival and growth. Traditional sampling with grabs and cores is, however, impractical over large areas and the availability of geo-referenced data is usually limited as a result. Acoustic methods, on the other hand, are suitable for large-scale surveying and show great promise as a substitute for direct-sampling methods, but they are still at a “nascent” stage of development and have not been proven for EFH purposes.

The complex relationship between acoustic returns and seafloor sediments has been actively studied for decades. According to Holliday, as many as 80 different parameters have been used to describe the physical and material properties of the seafloor, of which 6 to 12 of these may have major influence on acoustic returns from the seabed. However, many of these parameters are confounded such that an area of seabed has a characteristic return but that acoustic return is not unique to that particular seabed type. As a result, various combinations of grain size, surface roughness, and slope, for example, may be indistinguishable with acoustics (the so-called “inverse problem”). In actual practice, the situation is even more complex, given the seabed frequently is not static due to time-varying forces such as waves, currents, certain fishing activities, and natural biological processes. Notwithstanding the challenges of interpretation, many useful applications of sonars for habitat mapping have been reported in the scientific literature.

The primary focus of this bibliography is benthic habitat characterization using backscatter and


bathymetric data from single-beam echo sounders, multibeam echo sounders, and side scan sonars. The coverage ranges from methods for acquiring and processing data, data extraction and synthesis from imagery, production and use of habitat maps for fishery management and other purposes, modeling species distributions using processed data, and some relevant theoretical treatments. The bibliography was compiled from extensive searches of online literature databases, as well as secondary reviews of literature cited in the selected references. The collection includes peer-reviewed articles, as well as state and federal reports, conference papers, and books. The abstracts and keywords for each reference were obtained from the original source whenever possible. If one or the other was not available for use, a brief summary and/or keywords were added. This bibliography will be published as a NOAA Technical Memorandum and posted on the AFSC website as a searchable, dynamic database.

**Miscellaneous Projects Benthic Mapping Specialist Billet - HRG**
NOAA Corps hydrographer LTJG Theresa Smith was billeted to the HRG for a three-year assignment as a Benthic Mapping Specialist. This is the first such cross-over billet between NOAA hydrography and fisheries. She will be replaced in winter 2016 by the 5th officer in this post, ENS Kathryn

**Resource Ecology and Ecosystem Modeling Program (REFM/REEM)**
Multispecies, foodweb, and ecosystem modeling and research are ongoing. Documents, symposia and workshop presentations, and a detailed program overview are available on the Alaska Fisheries Science Center (AFSC) website at: http://www.afsc.noaa.gov/REFM/REEM/Default.php.

**Groundfish Stomach Sample Collection and Analysis – REFM/REEM**
The Resource Ecology and Ecosystem Modeling (REEM) Program continued regular collection of food habits information on key fish predators in Alaska’s marine environment. During 2015, AFSC personnel analyzed the stomach contents of more than 40 species sampled from the eastern Bering Sea and Gulf of Alaska. The contents of 12,589 stomach samples were analyzed including 3,557 stomach samples analyzed at sea during the Gulf of Alaska groundfish survey. This resulted in the addition of 32,044 records to AFSC’s Groundfish Food Habits Database. In addition to stomach samples from groundfish, bill-load and regurgitation samples from 1,285 seabirds were analyzed for the Alaska Department of Fish and Game. REEM also analyzed 48 zooplankton samples and nine benthic-grab samples for special investigations comparing food habits with prey types available in the environment.

In 2015, REEM published a useful Stomach Examiner's Tool that can now be found at: http://access.afsc.noaa.gov/REEM/set/.

Collection of additional stomach samples was accomplished through resource surveys, research surveys, and special studies comparing stomach contents with prey-sampling. Over 7,500 stomach samples were collected from large and abundant predators during the eastern Bering Sea bottom trawl survey of the continental shelf. Over 1,700 stomach samples were collected from the Gulf of Alaska to supplement the 3,557 stomach contents that were analyzed at sea in that region. No stomach samples were collected from Alaskan fishing grounds by Fishery Observers in 2015, but seven buckets of samples collected in previous years were returned to the AFSC. In cooperation with a special tag-recovery study conducted by the Fisheries Interaction Team (FIT) Program in the Aleutian Islands, stomach samples were collected from 1,080 Atka mackerel and 1,336 samples.
were collected from other species.

**Predator-Prey Interactions 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](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](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](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](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](http://access.afsc.noaa.gov/reem/lhweb/index.php).

**Ecosystem Considerations 2015: the Status of Alaska’s Marine Ecosystems completed and posted online**

The Ecosystem Considerations report is produced annually for the North Pacific Fishery Management Council as part of the Stock Assessment and Fishery Evaluation (SAFE) report. The goal of the Ecosystem Considerations report 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. The ecosystems under consideration include the Arctic, the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska. The report is now available online at the Ecosystem Considerations website at: [http://access.afsc.noaa.gov/reem/ecoweb/index.php](http://access.afsc.noaa.gov/reem/ecoweb/index.php).

The report includes additional new and updated sections, including the 2015 Eastern Bering Sea and Aleutian Islands Report Cards and ecosystem assessments. This year, the report presented a new Gulf of Alaska Report Card and ecosystem assessment. Over 40 experts participated via an online poll in the selection of ecosystem indicators that were included in the report card. The indicator list will be refined over the coming year with participation from the scientists involved with the NPRB-funded Gulf of Alaska Integrated Ecosystem Research Project. Overall, there were seven new and 51 updated indicator contributions from scientists.

During 2015, most of the physical indicators showed the continuation of the warm conditions present in 2014, but biological indicators suggest overall lower productivity in 2015 compared to 2014. In 2014, ocean temperatures were warmer than usual over a large area of the Northeast Pacific – this was “The Blob” that received much media attention – a condition that persisted through 2015. In 2014, many of the monitored ecosystem indicators indicated increased overall productivity. For example, groundfish sampled in the bottom trawl survey were heavier per length that average, and seabirds in the Pribilof Islands produced higher than average numbers of chicks. These indicators indicated average or lower productivity in 2015, with groundfish of average to low weight per length and poor reproductive success of seabirds.

**VI - AFSC GROUND FISH-RELATED PUBLICATIONS AND DOCUMENTS**

Published January 2015 through December 2015 (AFSC authors in bold text)

RUST, V. SABA, M. SIGLER, C. TOOLE, E. THUNBERG, R. WAPLES, and S. SYKORABODIE.

PASSOW, B. A. SEIBEL, A. E. TODGHAM, and A. M. TARRANT.
2015. And on top of all that... Coping with ocean acidification in the midst of many stressors.

CALL, I. L., and D. K. LEW.
2015. Tradable permit programs: What are the lessons for the new Alaska halibut catch sharing

DAWSON, M., K. CIECIEL, M. DECKER, G. HAYS, C. LUCAS, and K. PITT.
2015. Population-level perspectives on global change: Genetic and demographic analyses indicate

DEROBA, J. J., D. S. BUTTERWORTH, R. D. METHOT, J. A. A. De OLIVEIRA, C.
FERNANDEZ, A. NIELSEN, S. X. CADRIN, M. DICKEY-COLLAS, C. M. LEGAULT, J.
IANELLI, J. L. VALERO, C. L. NEEDLE, J. M. O’MALLEY, Y.-J. CHANG, G. G.
THOMPSON, C. CANALES, D. P. SWAIN, D. C. M. MILLER, N. T. HINTZEN, M.
BERTIGNAC, L. IBAIBARRIAGA, A. SILVA, A. MURTA, L. T. KELL, C. L. De MOOR, A. M.
PARMA, C. M. DICHMONT, V. R. RESTREPO, Y. YE, E. JARDIM, P. D. SPENCER, D. H.
HANSELMAN, J. BLAYLOCK, M. MOOD, and P.-J. F. HULSON.
2015. Simulation testing the robustness of stock assessment models to error: Some results from the

DUFFY-ANDERSON, J. T., K. M. BAILEY, H. N. CABRAL, J. NAKATA, and H. W. van der
VEER.
2015. The planktonic stages of flatfishes: Physical and biological interactions in transport
Sussex, U.K.

EDWARDS, A. E., S. M. FITZGERALD, J. K. PARRISH, J. L. KLAVITTER, and M. D.
ROMANO.
2015. Foraging strategies of Laysan albatross inferred from stable isotopes: Implications for
(.pdf, 849 KB, open access).

EISNER, L., E. SIDDON, and W. STRASBURGER.
2015. Spatial and temporal changes in assemblage structure of zooplankton and pelagic fish across
varying climate conditions in the eastern Bering Sea. Izvestia TINRO. 181:141-160.

ERSHOVA, E. A., R. R. HOPCROFT, K. N. KOSOBOKOVA, K. MATSUNO, R. J. NELSON, A.
YAMAGUCHI, and L. B. EISNER.

FAUNCE, C. H.

FAUNCE, C. H.

FAUNCE, C. H., J. CAHALAN, J. BONNEY, and R. SWANSON.

FAUNCE, C., J. GASPER, J. CAHALAN, S. LOWE, R. WEBSTER, and T. A’MAR.

FISSEL, B. E.

FISSEL, B., R. FELTHOVEN, S. KASPERSKI, and C. O’DONNELL.

FOWLER, C. W., and L. K. JOHNSON.

GRAY, A. K., C. J. RODGVELLER, and C. R. LUNSFORD.

GUTHRIE, C. M. III, HV. T. NGUYEN, and J. R. GUYON.


LAMAN, E. A., S. KOTWICKI, and C. N. ROOPER.  

EHNERT, H., and R. P. STONE.  
2015. New species of sponges (Porifera, Demospongiae) from the Aleutian Islands and Gulf of Alaska. Zootaxa 4033:451-483. DOI: 10.11646/zootaxa.4033.4.1

LEW, D. K., and D. M. LARSON.  

LEW, D. K., A. HIMES-CORNELL, and J. LEE.  

LEW, D. K., G. SAMPSON, A. HIMES-CORNELL, J. LEE, and B. GARBER-YONTS.  

MASUDA, M. M., and R. P. STONE.  

NICHOL, D. G., and D. A. SOMERTON.  

OKAMOTO, M., and D. E. STEVENSON.  


ORR, J. W., Y. KAI, and T. NAKABO.  

ORR, J. W., S. WILDES, Y. KAI, N. RARING, T. NAKABO, O. KATUGIN, and J. GUYON.

PIETSCH, T. W., and J. W. ORR.

PIRTLE, J. L., T. C. WEBER, C. D. WILSON, and C. N. ROOPER.

PRESCOTT, M. M., and M. ZIMMERMANN.

RESSLER, P. H., P. DALPADADO, G. J. MACAULAY, N. HANDEGARD, and M. SKERN-MAURITZEN.

ROOPER, C. N., K. WILLIAMS, A. De ROBERTIS, and V. TUTTLE.

SCHMIDT, J. H., D. S. JOHNSON, M. S. LINDBERG, and L. G. ADAMS.

SIGLER, M., D. DeMASTER, P. BOVENG, M. CAMERON, E. MORELAND, K. WILLIAMS, and R. TOWLER.

SIGLER, M. F., C. N. ROOPER, G. R. HOFF, R. P. STONE, R. A. McCONNAUGHEY, and T. K. WILDERBUER.

SINCLAIR, E. H., W. A. WALKER, and J. R. THOMASON.

SOMERTON, D., S. GOODMAN, R. FOY, L. RUGOLO, and L. SLATER.
STEVENSON, D. E.

STONE, R. P., M. M. MASUDA, and J. F. KARINEN.

STONE, R., D. STEVENSON, and S. BROOKE.

SZYMKOWIAK, M., and A. HIMES-CORNELL.

TENBRINK, T. T., and T. K. WILDERBUER.


VANCE, T. C., S. SONTAG, and K. WILCOX.

von BIELA, V., G. KRUSE, F. MUETER, B. BLACK, D. DOUGLAS, T. HELSER, and C. ZIMMERMAN.

von SZALAY, P. G.

WEINBERG, K. L., and S. KOTWICKI.

WHITTLE, J. A., S. C. VULSTEK, C. M. KONDZELA, and J. R. GUYON.
2015. Genetic stock composition analysis of chum salmon bycatch from the 2013 Bering Sea


APPENDIX I. RACE ORGANIZATION CHART
APPENDIX II. REFM ORGANIZATION CHART
APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART