Alaska Fisheries Science Center of the National Marine Fisheries Service

2013 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

April 2014

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2013

A. 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 , 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.

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 2013 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 2013 by RACE Groundfish Assessment Program (GAP) scientists: the annual eastern Bering Sea shelf survey, and the biennial Gulf of Alaska 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 of 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.

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 . Patricia Livingston at (206) 526-4172.

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, sharks, and grenadiers in Alaska and studies on benthic habitat. Presently, the program is staffed by 14 scientists and 1 post doc. ABL’s

Ecosystem Monitoring and Assessment Program (EMA) has also been conducting groundfish-related research for the past few years.

In 2013 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) a large-scale, epipelagic trawl survey of the northern Bering Sea shelf conducted by ABL's EMA Program; and 5) an upper trophic level fisheries oceanography survey of the Gulf of Alaska.

Ongoing analytic activities in 2013 involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of eleven status of stocks documents for Alaska groundfish: Alaska sablefish, Gulf of Alaska Pacific ocean perch, northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "Other Rockfish", and thornyheads, and Gulf of Alaska and Eastern Bering Sea sharks and grenadiers. Other analytic activities in 2013 included analysis of sablefish maturity and calculation of estimates of bycatch in the unobserved Pacific halibut fishery.

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.

B. Multispecies Studies

1. Stock Assessment and Surveys

2013 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP
The thirty-second in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 9 August 2013 aboard the AFSC chartered fishing vessels *Aldebaran* and *Alaska Knight*, which bottom trawled at 376 stations over a survey area of 144,600 square nautical miles. 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 2013 were 4.6 million metric tons (t) for walleye pollock, 81 thousand t for Pacific cod, 2.3 million t for yellowfin sole, 1.8 million t for rock sole, 24.9 thousand t for Greenland turbot, and 184 thousand t for Pacific halibut. There were slight increases in estimated total biomass compared to 2012 levels for walleye pollock, yellowfin sole, and Greenland turbot, and slight decreases for Pacific cod, rock sole, and Pacific halibut.

Average surface and bottom temperatures increased in 2013, from 5.1°C to 6.4°C for the surface and from 0.9°C to 1.7°C for the bottom. Both average surface and bottom temperatures were the 1982-2012 long-term averages (6.5°C and 2.3°C, respectively).

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

2013 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska – RACE GAP

The thirteenth in a series of comprehensive bottom trawl surveys of groundfish resources in the Gulf of Alaska (GOA) region was conducted from May 24 through August 6, 2013 with actual trawling occurring from May 29th to August 4th. This regional survey began in 1984 and was conducted triennially until 1999 and was then conducted biennially thereafter. The standard GOA survey area begins at the Islands of the Four Mountains (170° W longitude) and extends east along the shelf and upper slope of the GOA and then south to Dixon Entrance. Sampled depths range from approximately 15 to 1000 m during a typical survey but during the past two surveys the upper slope has only been sampled to a depth of 700 m. Commercially and ecologically valuable species of flatfish, roundfish, rockfish, and invertebrates inhabit the area. The major survey objective is to continue the time series to monitor trends in distribution, abundance, and population biology of important groundfish species and to describe and measure various biological and environmental parameters. Secondary objectives include investigating fish and invertebrate life histories (trophic relationships, reproductive biology, groundfish and invertebrate systematics, etc) and improving survey methodology.

The survey design is a stratified-random sampling scheme based 54 strata of depths and regions and applied to a grid of 5x5 km^2 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. The preferred amount of stations (825) was reduced by one third during 2013 Survey fishing because of budget limitations. Instead of three vessels, only two chartered commercial trawlers, the F/V *Alaska Provider* and the F/V *Sea Storm*, were used to conduct trawling operations at 550 pre-planned stations during the 75 day sampling period. Occupied stations were sampled with 15-minute tows using standardized RACE Poly Nor'Eastern four-seam bottom trawls rigged with roller gear. Catches were brought aboard and sorted, counted, and weighed by species. Individual length measurements, age structures, and other biological data and specimens are collected from samples of important species in each catch.

Successful hauls were made at 548 stations at original or nearby alternate sites, ranging in depth from 17 to 688 m. Just over 354 mt fish of fish and 6.5 mt of invertebrates were captured during the survey, and the catch consisted of 185 fish taxa and 405 invertebrate taxa. Pacific ocean perch was the most abundant fish species found in the survey, followed by arrowtooth flounder, walleye pollock, Pacific cod, giant grenadier, and northern rockfish. The eight most abundant fish species comprised 94% of the sampled fish.

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

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

The MACE Program conducted winter acoustic-trawl (AT) surveys in 2013 aboard the NOAA ship *Oscar Dyson*, targeting walleye pollock (*Gadus chalcogrammus*) in Sanak Trough, the Shumagin Islands, Morzhovoi Bay, Marmot Bay, Shelikof Strait, and along the shelf break southeast of

Chirikof Island. 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.

The Shumagin Islands survey was delayed for 2.5 weeks from original plans due to vessel mechanical issues that required returning to Kodiak for repairs following initial acoustic system calibration. The survey was subsequently conducted 26 February through 1 March 2013 along parallel transects spaced 5 nautical miles (nmi) apart within Shumagin Trough, 1 nmi apart east of Renshaw Point, and 2.5 nmi apart elsewhere. The Sanak Trough survey was conducted 2 March 2013 along transects spaced 2 nmi apart, and the Morzhovoi survey was conducted 3 March 2013 along transects spaced 2.5 nmi apart.

Dense aggregations of walleye pollock were observed in the West Nagai Strait, Unga Strait, and Shumagin Trough portions of the Shumagin Islands survey. However, fish aggregations were low in the Renshaw Point area, where the highest quantities of adults have historically been detected. The vast majority of walleye pollock detected in the Shumagin Islands were age-1 walleye pollock (8-14 cm fork length (FL)). The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 14% developing, 67% pre-spawning, 8% spawning, and 11% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 24% developing, 69% pre-spawning, 3% spawning, and 4% spent. The combined percentage of spawning and spent female fish was low and together with the high percentage of pre-spawning females indicates that survey timing was appropriate. The mean gonadosomatic index (GSI: ovary weight/body weight) for mature pre-spawning females was 0.12. The pollock AT survey abundance estimate in the Shumagin Islands area was 91,295 t (48% of which was age-1 pollock), based on catch data from 9 trawl hauls and acoustic data from 408 nmi of survey transects.

The densest pollock aggregations in Sanak Trough were located over the northeast portion of the trough and consisted primarily of adult pollock 40-73 cm FL (mode 55 cm). A large number of age-1 walleye pollock, which have not been seen in Sanak Trough in significant numbers in the past, were also present in the southwest portion of the trough. The unweighted maturity composition for males longer than 40 cm was 1% immature, 6% developing, 66% pre-spawning, 12% spawning, and 15% spent. The unweighted maturity composition for females longer than 40 cm FL was 3% immature, 6% developing, 78% pre-spawning, 9% spawning, and 4% spent. The average GSI for pre-spawning females was 0.15. The abundance estimate for Sanak Trough of 13,282 t was the lowest in the survey's history and was based on catch data from 2 trawl hauls and acoustic data from 96 nmi of survey transects.

Walleye pollock were diffusely scattered throughout Morzhovoi Bay and mainly consisted of age-1 fish in the 9-14 cm FL range. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 0% developing, 30% pre-spawning, 4% spawning, and 65% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 10% developing, 40% pre-spawning, 0% spawning, and 50% spent. The average GSI for pre-spawning females was 0.16. The biomass estimate for Morzhovoi Bay was 2,476 t based on catch data from 1 trawl haul and acoustic data from 47 nmi of survey transects.

The MACE Program also conducted winter AT surveys in Marmot Bay, Shelikof Strait, and along the shelf break southeast of Chirikof Island. Marmot Bay was surveyed 15-16 March 2013 along parallel transects spaced 2 nmi apart in the outer bay and 1 nmi apart in the inner bay and in Spruce

Gully. The Shelikof Strait sea valley was surveyed from Black Cape on Afognak Island to due west of Chirikof Island 16-25 March 2013 along parallel transects spaced 7.5-nmi apart. The shelf break from Chirikof Island to the mouth of Barnabas Trough was surveyed 25-27 March 2013 along transects spaced 6-nmi apart along the 300 m contour.

In Marmot Bay dense schools of 45 to 70 cm FL walleye pollock were detected northwest of Spruce Island and in Spruce Gully. A large aggregation of fish was also detected near Whale Island that consisted of two smaller size groups, 10 to 16 cm FL (age-1 fish) and 25 to 35 cm FL. The unweighted maturity composition in Marmot Bay for males longer than 40 cm FL was 0% immature, 2% developing, 49% pre-spawning, 49% spawning, and 0% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 4% developing, 95% pre-spawning, 1% spawning, and 0% spent. The biomass estimate for Marmot Bay was 19,942 t from 5 trawl hauls and acoustic data from 150 nmi of survey transects.

As in previous years the highest walleye pollock densities found in Shelikof Strait were observed along the northwest side of the Strait near Kukak Bay. Within this deepest section of the strait along the steep banks of the Alaska Peninsula, dense aggregations of pre-spawning adult fish, primarily in the 45 to 65 cm FL range, were detected. These pre-spawning adult fish were predominantly between the ages of 5 and 9 years old, with some as old as 15 years. Dense midwater aggregations were detected throughout the remainder of the Strait. In the northeast near Afognak Island these aggregations consisted mainly of age-1 walleye pollock in the 9 to 16 cm FL range. Near bottom aggregations located in the north-central thru southern regions of the Strait also contained age-1 fish along with several different adult size groups up to 73 cm FL.

In Shelikof Strait, the unweighted maturity composition for males longer than 40 cm FL was 7% immature, 6% developing, 23% mature pre-spawning, 63% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL was 8% immature, 5% developing, 83% pre-spawning, 4% spawning, and < 1% spent. The small fraction of spawning and spent females relative to pre-spawning females suggests that the survey timing was appropriate. The average GSI for mature pre-spawning females was 0.14. The pollock abundance estimate for Shelikof Strait of 891,261 t is the largest seen in the region since 1985 and is 40% greater than the historical mean for this survey. The 2013 estimate was based on catch data from 27 trawl hauls and acoustic data from 683 nmi of survey transects. An additional 7 AWT experimental hauls were conducted in midwater at 2 locations in Shelikof Strait to quantify escapement of juvenile walleye pollock from the net.

Most walleye pollock backscatter in the Chirikof survey was detected on two separate transects, one due south of the Trinity Islands and east of Chirikof Island and the other just west of the mouth of Barnabas Trough. The walleye pollock caught were adults ranging in length from 47- 75cm FL. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 0% developing, 27% pre-spawning, 73% spawning, and 0% spent. The unweighted maturity composition for females longer than 40 cm FL was 0% immature, 0% developing, 92% pre-spawning, 8% spawning, and 0% spent. The average GSI for pre-spawning females was 0.2. The abundance estimate of 63,008 t is 1.7 times larger than the 2002-2012 mean for this survey and is based on catch data from 4 trawl hauls and acoustic data from 166 nmi of survey transects.

Summer Acoustic-Trawl Survey on the Eastern Bering Sea Shelf -- MACE Program
The MACE Program completed a summer 2013 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*. The summer GOA shelf survey also included smaller-scale surveys in several bays and around islands. 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) 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=18) and untrawlable (n=16) 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 to groundtruth bottom classification and estimate species abundance.

The survey of the GOA shelf and shelf break was conducted between 9 June and 5 August 2013 and consisted of 38 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 the Unimak Pass, between Mitrofania and Nakchamik Islands, south of the Trinity Islands, and south of the Kenai Peninsula in dense aggregations spread across the Portlock Bank area. Based on catch data from 29 AWT and 16 PNE hauls, two major length modes of walleye pollock were caught on the GOA shelf, one ranging from 13 to 22 cm FL with a mode of 18 cm FL representing age-1 fish, and the other ranging from 35 to 70 cm FL with a mode of 54 cm FL. The walleye pollock biomass estimate for the GOA shelf of 269,131 t from the 1,671 nmi of trackline surveyed was approximately 32% of the total walleye pollock biomass observed for the entire survey.

Sanak Trough was surveyed 15 June along transects spaced 4 nmi apart. The sparse backscatter attributed to walleye pollock in Sanak Trough was patchy and scattered throughout the 50 nmi of transects surveyed. Pollock captured in the one AWT haul in Sanak Trough were primarily in the 27 to 61 cm FL range with a mode of 44 cm FL, resulting in a biomass estimate of 927 t.

Morzhovoi Bay was surveyed 15 June along transects spaced 2.0 nmi apart. Backscatter in Morzhovoi Bay attributed to walleye pollock was diffuse and evenly scattered along the 48 nmi of survey transects. Walleye pollock captured in 2 AWT hauls in Morzhovoi Bay had 2 distinct length distributions, one ranging from 12 to 16 cm with a mode of 14 cm, and the other from 49 to 72 cm, with some larger fish up to 80 cm, and a mode of 59 cm. The biomass estimate for the 48 nmi of trackline surveyed in Morzhovoi Bay was 5,758 t.

Pavlof Bay was surveyed 16 June along transects spaced 2.0 nmi apart. The acoustic backscatter attributed to walleye pollock in Pavlof Bay was sparse and distributed throughout the bay with a large school observed at the mouth of the bay. Walleye pollock captured in Pavlof Bay from 1 AWT and 1 PNE haul were predominantly in the 10 to 16 cm FL range (age-1), with fewer fish in the 17 to 73 cm FL range. The biomass estimate in Pavlof Bay was 2,150 t from the 46 nmi of trackline surveyed.

The Shumagin Islands were surveyed on 19-23 June along transects spaced 3.0 nmi apart in West Nagai Strait, Unga Strait, and east of Renshaw Point, 7.5 nmi apart in Shumagin Trough, and 11 nmi apart on the outer shelf. In the Shumagin Islands walleye pollock were most abundant in the

Unga strait area and in the Shumagin Trough. Walleye pollock from 6 AWT hauls ranged in length from 10 to 70 cm FL, with the majority of fish in the 10 to 16 cm FL range, representing age-1 walleye pollock. The biomass estimate for the Shumagins Islands of 33,605 t was approximately 4.5 times higher than any previous summer Shumagin acoustic survey estimate and was 90% composed of age-1 fish. 280 nmi of tracklines were surveyed.

Mitrofania Island was surveyed 22-23 June along transects spaced 3.5 nmi apart. The majority of acoustic backscatter attributed to walleye pollock near Mitrofania Island was to the west and south of the island. The vast majority of walleye pollock captured in the 3 AWT hauls near the island ranged from 11 and 18 cm FL with a mode at 14 cm, representing age-1 fish. The biomass estimate in Mitrofania was 2,459 t along the 65 nmi of tracklines surveyed.

Nakchamik Island was surveyed 24-25 June along transects spaced 3.0 nmi apart. Backscatter attributed to walleye pollock near Nakchamik Island was evenly dispersed across the 48 nmi of surveyed transects. Walleye pollock captured in the one AWT haul near Nakchamik Island ranged from 44 and 64 cm with a mode at 54cm. The biomass estimate for the Nakchamik Island area was 8,861 t.

Shelikof Strait was surveyed from 1-7 July along transects spaced 15 nmi apart. The highest walleye pollock densities in Shelikof Strait were found in the north between Afognak Island and the Alaska Peninsula, and in the middle of the survey area between the western end of Kodiak Island and the Alaska Peninsula. Unlike the winter survey, the majority of the biomass in the northern half of the strait was age-1 walleye pollock. Age-1 pollock were also present in the middle of the survey area west of Kodiak Island, along with larger fish in the 35 to 45 cm FL range, while fish in the 40 to 65 cm FL range were primarily caught in the south of the strait. Lengths were obtained from 13 AWT hauls. The biomass estimate for the 578 nmi of trackline surveyed in Shelikof Strait was 423,031 t, which accounted for approximately 48% of the entire GOA summer survey pollock biomass estimate, and almost 3 times the biomass estimate of any previous summer survey of Shelikof Strait. Approximately 25% of the biomass detected in Shelikof Strait were age-1 walleye pollock (89% by numbers).

Alitak Bay was surveyed 9-10 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. Walleye pollock ranged in length from 25 to 35 cm FL in the one AWT haul conducted in Deadman Bay. Two PNE hauls conducted in the mouth of Alitak Bay resulted in walleye pollock between 45 and 70 cm FL. The biomass estimate for the Alitak/Deadman Bay area was 15,149 t along 59 nmi of trackline surveyed. Even though the aggregation in Deadman Bay was very dense, the overall Alitak/Deadman Bay biomass estimate was less than 2% of the entire summer survey biomass because of the small geographic area contained within the bay.

Barnabas and Chiniak Troughs were surveyed between 11 and 18 July along transects spaced 3.0 nmi apart. Large aggregations of adult walleye pollock were detected in Barnabas and Chiniak Troughs. Walleye pollock caught in 10 AWT hauls in Barnabas Trough and 8 AWT hauls in Chiniak Trough had bimodal size ranges, one from 16 to 24 cm FL, and another from 35 to 70 cm FL, with modes in both areas at 18-20 cm and 54-56 cm FL. The biomass estimate for the 300 nmi of trackline surveyed in Barnabas Trough was 62,818 t, approximately 7% of the entire GOA summer survey biomass estimate. The biomass estimate for the 184 nmi of trackline surveyed in

Chiniak Trough was 24,470 t, approximately 3% of the entire GOA summer survey biomass.

Marmot Bay was surveyed 16-17 July along transects spaced 2.0 nmi apart in the inner bay and spruce gully, and 4.0 nmi apart in the outer bay. Izhut Bay was surveyed 17 July along zig-zag transects because of the narrowness of the bay. Adult and juvenile walleye pollock were detected throughout the Marmot and Izhut Bay surveys. Walleye pollock lengths from the 4 AWT hauls in Marmot Bay and one AWT haul in Izhut Bay ranged from 15 to 70 cm FL with modes at 17 cm, 36 cm, and 60 cm FL. The biomass estimate for Marmot Bay was 8,210 t along the 97 nmi of trackline surveyed, and in Izhut Bay the biomass estimate was 803 t along the 6.5 nmi of trackline surveyed.

Prince William sound was surveyed 29 July-1 Aug. along transects spaced 8.0 nmi apart. Backscatter in Prince William Sound was very sparse, with most fish located on the outer shelf south of Montague Island. Trawl hauls were conducted within Prince William Sound with one AWT haul (adults ranging in length from 45 to 65 cm FL), and on the outer shelf south of Montague Island with two AWT hauls (age-1 fish ranging in length from 15 to 20 cm FL) and one PNE trawl (mix of 15 to 21 cm FL age-1 fish and larger fish 25-66 cm FL). The biomass estimate for the 218 nmi of trackline surveyed in Prince William Sound was 16,062 t, of which only 6,000 t was within the sound proper.

Kayak Island and Yakutat Troughs were surveyed 3-7 Aug. along transects spaced 12.0 nmi apart. Backscatter was relatively light and diffuse in both the Kayak Island Trough and Yakutat Trough with the densest backscatter detected along the transects near the mouth of Yakutat Bay. In the Kayak Island Trough one AWT trawl resulted in two length groups of pollock, one ranging from 13 to 22 cm FL with a mode at 18 cm FL, and another from 35 to 70 cm FL with a mode at 54 cm FL. In the Yakutat Trough four AWT and one PNE hauls resulted primarily in age-1 fish ranging in length from 14 to 22 cm FL and a few larger fish ranging in length from 28 to 69 cm FL with a mode of 54 cm FL. The biomass estimate for Kayak Island Trough was 5,005 t for the 46 nmi of transects surveyed, and the biomass estimate for Yakutat Trough is 5,441 t for the 91 nmi of transects surveyed.

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 2013. 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 2013, the thirty-fifth 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 30 – August 26, 2013 by the chartered fishing vessel *Ocean Prowler*. Total groundline set each day was 16 km long and contained 160 skates and 7,200 hooks baited with squid except in the eastern Bering Sea where 180 skates with 8,100 hooks were set.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), shortspine thornyhead (*Sebastolobus alascanus*), and Pacific halibut (*Hippoglossus stenolepis*). A total of 56,969 sablefish, with an estimated total round weight of 178,198 kg (392,859 lb), were caught during the survey. This represents a decrease of nearly 13,000 sablefish over the 2012 survey catch. Sablefish, shortspine thornyhead, and Greenland turbot (*Reinhardtius hippoglossoides*) were tagged with external Floy tags and released during the survey. Electronic archival tags were implanted in 36 Greenland turbot. Pop-up satellite tags (PSAT) were implanted in 27 sablefish, 6 spiny dogfish, and 4 lingcod. Length-weight data and otoliths were collected from 1,619 sablefish. Killer whales depredating on the catch occurred at eleven stations in the Bering Sea, two stations in the western Gulf of Alaska, and two stations in the central Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were observed at twenty-seven stations in 2013 and were reported depredating on the gear at twelve stations which is consistent to previous years.

Several special projects were conducted during the 2013 longline survey. Greenland turbot were tagged with archival temperature/depth tags in the Bering Sea and lingcod were tagged in the West Yakutat and central Gulf of Alaska regions. Satellite pop-up tags were deployed on spiny dogfish, sablefish, and lingcod 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. Additionally, genetic tissue and otoliths of giant grenadier were sampled to see if geographic stock structure exists and to determine if three distinct otoliths shapes identified in previous work correspond to different subspecies or subpopulations. Bubblegum coral genetic and specimen samples were collected to elucidate patterns of genetic connectivity among Paragorgid populations in the Gulf of Alaska. 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. 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.

Status of Stocks and Multispecies Assessment Task - REFM

The Status of Stocks and Multispecies Assessment Task is responsible for providing stock assessments and management advice for groundfish in the North Pacific Ocean and the Bering Sea. In addition, Task members conduct research to improve the precision of these assessments, and provide technical support for the evaluation of potential impacts of proposed fishery management measures.

During the past year, stock assessment documents were prepared by the Task and submitted for review to the Gulf of Alaska and Bering Sea/Aleutian Islands Groundfish Plan Teams of the North Pacific Fishery Management Council.

Assessment scientists provided analytic assistance on many current fisheries management issues. These included: 1) identification and prioritization of research activities intended to improve groundfish stock assessments; 2) continued refinement and review of Bering Sea crab stock assessments 3) research activities associated with the impacts of climate change 4) research activities associated with the incorporation of ecosystem variables in stock assessments 5) significant contribution and development of the analysis for the Chinook salmon bycatch Environmental Impact Statement and 6) various task members participated in numerous national and international committees and workshops on a variety of issues.

The Fishery Interaction Team (FIT), a part of the Status of Stocks and Multispecies Assessment Task, in the REFM Division, conducts studies to determine whether commercial fishing operations are capable of impacting the foraging success of Steller sea lions either through disturbance of prey schools or through direct competition for a common prey. The present research focus is on the three major groundfish prey of sea lions: walleye pollock, Pacific cod and Atka mackerel.

FIT investigates the potential effects of commercial fishing on sea lion prey in two ways. First, by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones. FIT research examines the hypothesis that large-scale commercial fisheries compete with sea lion populations by reducing the availability of prey in relatively localized areas. Since 2000 FIT has been conducting field studies to examine the impact of fishing on sea lion prey fields in all three major Alaska regions: the Gulf of Alaska, Bering Sea and Aleutian Islands.

The second way that FIT investigates the potential effects of commercial fishing on sea lion prey is by studying fish distribution, behavior and life history at spatial scales relevant to sea lion foraging (tens of nautical miles). This scale is much smaller than the spatial scales at which groundfish population dynamics are usually studied and at which stocks are assessed. This information is needed to construct a localized, spatially-explicit model of sea lion prey field dynamics that can be used to predict spatial and temporal shifts in the distribution and abundance of sea lion prey and potential effects of fishing on these prey fields.

FIT researchers collaborate with other AFSC scientists who are studying Steller sea lions and their prey, such as scientists in the Resource Ecology and Ecosystem Modeling program and the National Marine Mammal Lab. For more information on the FIT program, contact Dr. Libby Logerwell or access the following web link.

http://www.afsc.noaa.gov/REFM/Stocks/fit/FIT.htm

Projects and proposals

Heppell, Selina, Paul Spencer, Nathan Schumaker, Andi Stephens (FATE) An individual-based model for evaluation of maternal effects and spatio-temporal environmental variability on dynamics and management of Pacific ocean perch, *Sebastes alutus.* (Funded $116,216)

Quinn, T., P. Hulson, J. Ianelli (ASAM) Time-varying natural mortality: random versus covariate effects. (Funded $186,116)

Hollowed, A., Aydin, K., Holsman, K. (International Science) An international workshop for ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries. (Funded $24,900) (Part of future meeting)

Helser, T. TenBrink, T., Spencer, P., Conrath, C. (NPRB) Improving stock assessments and management for Tier 5 rockfish through ageing methods and maturity at age analysis for shortspine thornyhead, shortraker, harlequin, and redstripe rockfish.

Spies, I., TenBrink. T., Aydin, K. (NPRB) Filling critical data gaps for data-poor sculpins in the Gulf of Alaska: life history and diet information for stock assessment and ecosystem modeling.

Beaudreau,A. Hunsicker, M., Dorn, M., and Ciannelli, L. (PCCRC) Developing an index of predation to improve the assessment of walleye pollock in the Gulf of Alaska. (Funded)
This project will look at spatial overlap between pollock and arrowtooth (and halibut and cod) in the GOA, in addition to ideas about how to incorporate new information about spatial overlap into assessment models, e.g. ways to incorporate changes in natural mortality over time into assessment

models.

Hauser, L., Canino, M., Spies, I., Dorn, M. (FATE) Rapid genetic adaptation to changing climate and its effect on walleye pollock population dynamics and management in the Gulf of Alaska.

Heppell, S, P. Spencer, N. Schumaker, and A. Stephens. (FATE) An individual-based model for evaluation of maternal effects and spatio-temporal environmental variability on dynamics and management of Pacific ocean perch, Sebastes alutus.

Laurel, B., Thompson, G., and Canino, M. (ASAM) - Ben Laurel, Grant Thompson and Mike Canino. Comparing near shore and large scale surveys to estimate gadid recruitment. (FUNDED)

Conners, E. Cooperative Research - Developing pot survey gear for octopus. (FUNDED)

Logerwell, E., Dorn, M., Kruse, G., McDermott, S., Ladd, C., Cheng, Wei. (FATE). Spatial and temporal variability of walleye pollock fecundity estimates for the Gulf of Alaska and eastern Bering Sea. Sandi Neidetcher will be a project lead and Ben Williams, who is a UAK PhD student, will utilize part of this research for his dissertation. (FUNDED)

McDermott, S., Logerwell, L., and Todd Loomis. (NPRB). Small scale abundance and movement of Atka mackerel and other Steller sea lion groundfish prey in the Western Aleutian Islands. Field work starts in Summer of 2014. (FUNDED)

For further information on the SSMA task group, contact Dr. Anne Hollowed (206) 526-4223.

2. Research

Correcting Density Dependent Effects in Abundance Estimates from Bottom Trawl Surveys — RACE, REFM, Univ. of Washington

Indices of abundance are important for estimating population trends in stock assessment and ideally should be based on fishery-independent surveys to avoid problems associated with the hyperstability of the commercial catch per unit effort data (CPUE) data. However recent studies indicate that the efficiency of the survey bottom trawl for some species can be density dependent, which could potentially affect reliability of survey derived indices of abundance. A function $q_e \sim f(u)$, where q_e is bottom trawl efficiency and u is a catch rate, was derived using experimentally-derived acoustic dead zone correction and bottom trawl efficiency parameters obtained from combining a subset of bottom trawl catch data with synchronously collected acoustic data from walleye pollock in the eastern Bering sea (EBS). We found that q_e decreased with increasing bottom trawl catches resulting in hyperstability of the index of abundance derived from bottom trawl survey. Density-dependent q_e resulted in spatially and temporarily variable bias in survey CPUE and biased age structure derived from survey data.

We used $q_e \sim f(u)$ relationship to obtain new, corrected for density dependence, index of abundance. We also obtained variance-covariance matrix for a new index that accounted for sampling variability and the uncertainty associated with the q_e. We found that incorporating estimates of the new index of abundance changed outputs from stock assessment model. Although changes were minor, we advocate incorporating estimates of density dependent q_e into stock assessment as a precautionary measure that should be undertaken to avoid negative consequences of the density-dependent q_e. Stan Kotwicki, James N. Ianelli, André E. Punt

The Alaska Coral and Sponge Initiative (AKCSI): a NOAA Deep Sea Coral Research and

Technology Program regional fieldwork initiative in Alaska - RACE GAP
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.

FY13 Research Activities

In FY13, the primary focus of AKCSI researchers was to conduct remote operated vehicle surveys and sample collections in Primnoa thickets in Southeastern Alaska. In August 2013, concurrent cruises aboard the chartered fishing vessel *Alaska Provider* and Alaska Department of Fish and Game research vessel *Medeia* were conducted at previously mapped (in FY12) locations; Dixon Entrance, Prince of Wales, Fairweather Grounds, and Cape Ommaney, on the continental shelf and slope in the southeastern Gulf of Alaska . These cruises were to survey suspected areas of high density Primnoa habitats (thickets), collect size information from the thickets and collect samples for genetic analysis. Survey transects were completed at 3 of the 4 sites with the ROV aboard the *Alaska Provider* and at two sites with a stereo drop camera aboard the *Medeia*. Size data and images to estimate density of Primnoa habitats were collected at all four sites. Additionally, 8 settlement plates were deployed at locations in Primnoa thickets using the stereo drop camera. Samples for genetic analysis were collected at two of the four study sites. Samples were also collected to provide specimens for natural products studies and geological substrate interpretation.

Two other directed research cruises were planned for FY13, but were not completed due to contracting difficulties and the government-wide shutdown. The first of these was a research cruise to examine the ecology and production of FMP species from coral and non-coral habitats. Samples of rockfish for reproductive potential and bioenergetics were collected for this project during the Gulf of Alaska bottom trawl survey in July 2013. The final research cruise was to conduct underwater camera drops at 150 locations in the central and eastern Aleutian Islands from Unimak Pass to Petrel spur. Due to the government-wide shutdown, this research cruise has been postponed until April 2014.

In addition to these cruises funded by AKCSI, there were also a number of field data collections carried out in partnership with other research activities in Alaska. In FY13 the second phase of a pilot project was conducted to construct a camera system that could be attached to longline and pot fishing gear in Alaska to collect information on the impacts of these gears on benthic habitats. A prototype camera system was constructed by research partners in the RACE division and tested throughout the winter of 2013. It was successfully deployed in the Gulf of Alaska during the AFSC longline survey in July 2013. Cooperation with the longline survey allowed us to deploy the camera system on two longline sets during a two day gear experiment. The images collected during the deployment were suitable for measuring the distance the longline travelled over the seafloor during deployment, fishing and retrieval.

In FY13, with partners in the AFSC RACE division we collected O2, salinity, turbidity and pH measurements on the headrope of bottom trawls used to conduct annual stock assessment surveys. Oceanographic data were collected on 218 tows from the Islands of Four Mountains in the eastern Aleutian Islands to Dixon Entrance in the eastern Gulf of Alaska.

Oceanographic equipment to measure O2, pH, salinity and temperature were installed at a long-term study site in Tracy Arm (southeastern Alaska) and has been collecting oceanographic data since January 2013 on 6-hour intervals.

Field activities also included the collection of sponge and coral specimens for morphological taxonomic study and coral tissue samples for genetic analysis through collaboration with the Gulf of Alaska bottom trawl survey.

Additional work was conducted at the AFSC and U.S. Geological Survey to compile bathymetry and sediment maps from NOAA smooth sheets for the Aleutian Islands and Gulf of Alaska in anticipation of completing a geologically interpreted substrate map for these regions in FY14. The compiled sediment and bathymetry map for the Aleutian Islands region was released as a NOAA Technical Memorandum. The data compilation in the Gulf of Alaska has been completed for the majority of this region as well, thanks to collaboration with the NPRB-funded Gulf of Alaska-Integrated Ecosystem Research Program, which has similar needs for bathymetric data.

Planned FY14 Activities

In FY14 there will be three major field programs that will build on the activities from the FY12-13. First, the spatial distribution modeling project will focus its efforts on the western Aleutian Islands during another 15-day cruise. During this cruise, images will be collected at an additional 150 randomly selected sites. Once the fieldwork is complete and the images analyzed, the models will be re-evaluated with respect to their accuracy in predicting coral and sponge distribution, abundance and diversity.

Second, the FMP production project will collect fish and video data on the differences in production between sites with and without coral and sponge communities in the summer (August) of 2014. This project will collect a second year of data at the same locations as in FY12. Additional funding (from NPRB) to expand the sampling into winter and spring periods will be used to fund two additional cruises in April 2014 and January 2015. Samples and video collected in the field to date will be analyzed leading to data analysis scheduled for the summer of FY15.

Third, the main field effort in FY14 will again focus on projects at the Dixon Entrance, Prince of Wales, Fairweather Grounds, and Cape Ommaney sites. We will again use a remotely operated vehicle (ROV) to conduct transect surveys at two of the study sites in southeastern Alaska that were not completed in FY13 (Fairweather Grounds and Dixon Entrance). The stereo drop camera will again be used to measure size structure of *Primnoa* at these sites, plus some additional transects at the Prince of Wales site. Samples for genetics analysis will also be collected at two sites (Dixon Entrance and Fairweather Grounds) to complete the collections for that project. In addition, two of the settlement plates deployed in FY13 will be recovered in FY14 and any newly settled recruits collected. Then the plates will be redeployed for collection at a later date.

Other activities will also be continued in FY13. The project to deploy a camera system on commercial longline gear will go into production mode and data will be collected during an entire leg of the longline survey. Data and images resulting from this project should be available for analysis by late summer FY14.

In FY14, oceanographic data will be collected from the bottom trawl surveys scheduled for the Aleutian Islands and the eastern Bering Sea slope. The oceanographic instruments purchased and tested in FY12 will be deployed on the headrope of AFSC research trawls during all three legs of both bottom trawl surveys to collect O2, pH, turbidity and salinity from the Islands of Four Mountains to Stalemate Bank in the Aleutian Islands at depths to 500 m and from Bering Canyon to the U.S.-Russian border along the eastern Bering Sea slope at depths to 1000 m.

The instrument package at the long-term monitoring site at a shallow population of *Primnoa* (30 m depth) in Tracy Arm will be recovered. Since there are no funds available to routinely collect and deploy this instrumentation after FY14, we are attempting to develop a partnership with the USGS to deploy the instrument package at a similar site in Glacier Bay where it can be routinely serviced at little cost.

New partnerships will be developed and existing partnerships continued to collect specimens of corals and sponges for taxonomic resolution and for special studies of paleoclimatology and medicinal purposes. These collections will occur both during the ROV fieldwork as well as during the 2014 Aleutian Islands and eastern Bering Sea slope bottom trawl surveys.

Finally, in FY14, researchers at the University of Alaska Fairbanks and the Tombolo Institute will continue to collaborate with NOAA and USGS researchers to compile an interpreted (from geology) substrate and sediment map for Alaskan waters based on existing multibeam bathymetry, sidescan images, the new bathymetric and sediment database compiled from NOAA smooth sheets, other sediment and bedrock data, and available seafloor imagery.

Recruitment and Response to Damage of an Alaskan Gorgonian Coral - ABL

Benthic habitats in deep-water environments experience low levels of natural disturbance and recover slower than shallow-water habitats. Deep-water corals are particularly sensitive to disturbance from fishing gear, in part because they are long-lived, grow slowly, and are believed to have low rates of reproduction. Limited data describes recruitment and recovery of deep-water corals. This information is critical to understanding long-term effects of anthropogenic disturbances, such as commercial fishing, on the population dynamics of living benthic habitat.

In 2009, scientists from the Auke Bay Laboratories initiated a multi-year study to examine recruitment and recovery of the gorgonian coral *Calcigorgia spiculifera*, a species broadly distributed in the Gulf of Alaska and along the Aleutian Islands. *Calcigorgia spiculifera*, as well as many other gorgonian corals, is found in areas and depths that coincide with trawl and longline fisheries and is often damaged by these fisheries. The body plan of *C. spiculifera* is similar to many other gorgonian corals commonly found throughout the North Pacific Ocean. Therefore, sensitivity to disturbance, rate of recovery, and recruitment of *C. spiculifera* is likely to be similar to other coral species, and thus results from this research may be applied broadly. Recovery rate and recruitment data are necessary for modeling habitat impacts and forecasting recovery and will ultimately guide fisheries managers in making decisions regarding benthic habitat conservation measures. In this study, recruitment is being investigated by observing settlement of coral planulae onto rings equipped with natural stone tiles, and coral recovery is being examined by observing the response of colonies to damage treatments.

The study site, Kelp Bay, Southeast Alaska, offers hundreds of *C. spiculifera* colonies concentrated at depths easily accessible to scuba divers. Field operations in Kelp Bay began in August 2009 when a team of four divers located and tagged 48 *C. spiculifera* colonies. Of that total, 9 colonies were fitted with settlement rings equipped with removable tiles. The remaining 39 tagged colonies were ascribed to three damage treatment groups and a control group. The damage treatments were designed to mimic actual damage that can occur from a passing trawl. These treatments were performed *in situ* and included deflection, soft tissue excision, and branch severance. Video of each colony was recorded before and after the treatments were performed to establish baseline coral characteristics and to identify immediate treatment effects. Since the initial site visit, the dive team has returned to observe the tagged corals on three additional occasions (June 2010, September 2010, and August 2011). On each visit, subsamples of the stone tiles were collected and preserved in solution for subsequent inspection in the laboratory for adhesion of coral recruits. Damaged and control colonies were also videoed so that comparisons can be made to pretreatment images. A final site visit is planned for summer 2014 to allow additional tile collections and to capture long-term effects of disturbance.

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 will examine 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. We will sample these habitats examining differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success within the different habitat types. This research will enable us to examine the importance of different habitat types for these rockfish species providing data critical for both protecting essential habitat as well as effective management of these species. In the spring and summer of 2012 two research cruises were conducted in May and August. During these cruises 34 camera drops and 11 trawl tows were conducted. In the upcoming years additional research cruises will take place in spring 2014, summer 2014, and winter 2014/2015.

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

Bathymetry of the Aleutian Islands – RACE GAP

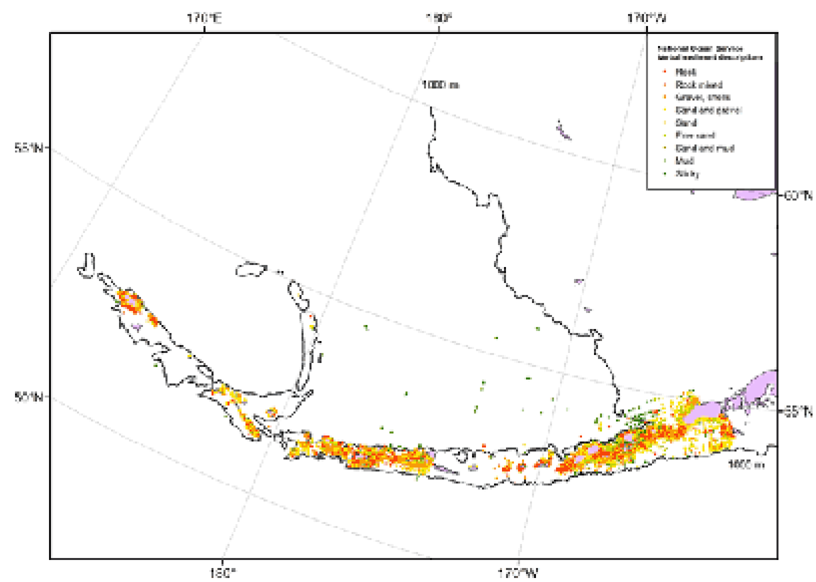
AFSC scientists with the RACE Groundfish Program corrected, digitized, and assembled 2.1 million National Ocean Service (NOS) bathymetric soundings from 290 hydrographic surveys represented by smooth sheets, extending 1,900 km along the Aleutian Islands from Unimak Island in the east to the Russian border in the west. 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. Details of our processing methods can be found in Smooth Sheet Bathymetry of the Aleutian Islands, NOAA Tech Memo NMFS-AFSC-250.

Sediments of the Aleutian Islands

We also digitized 25,000 verbal surficial sediment descriptions from 234 of the smooth sheets, providing the largest single source of sediment information for the Aleutian Islands.

Data Available for Download (NOTE: Data are not to be used for navigation).

- A zipped file of a 100-m resolution grid (raster surface) of the bathymetry.
- Bathymetry grid metadata.
- A zipped shape file of the sediment point data.
- Sediment metadata.



Map of National Ocean Service verbal sediment descriptions.

Users of the data should cite it as Zimmermann, M., M. M. Prescott, and C. N. Rooper. 2013. Smooth Sheet Bathymetry of the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-250, 43p.

Guide for Working with Alaskan Smooth Sheets--What are Smooth Sheets? - RACE GAP

Physically, a paper smooth sheet with muslin backing was the final product of a hydrographic survey. The soundings were drawn on a smooth sheet, along with the shoreline, geographic features (e.g., kelp beds, rocky reefs, islets, rocks), seafloor substrates (e.g., gravel, sand, mud), and the navigational signals in order to provide a visual record of the hydrographic survey, which could be annotated as new information became available.

Though more detailed than navigational charts, smooth sheets are **not** intended for use in navigation. Instead the smooth sheets, many dating back to the 1930s, were used as internal documents by the hydrographic agency. Only after they were scanned, digitized, and posted to NGDC (Wong et al. 2007) did they become widely used by non-hydrographers. The NOS navigational charts (not smooth sheets) are the legal standard for safe navigation on the ocean (Title 33 Code of Federal Regulations 164).

All scientists who conduct research on the ocean have probably used the small-scale navigational charts for a variety of cruise planning and data analysis tasks without knowing that perhaps ten times as much information was available from the precursor hydrographic surveys, represented by the smooth sheets. Others who are aware of the smooth sheet resource might not understand some of the details about successfully using this rich data resource. Therefore, now that electronic copies of the smooth sheets are readily available, it is worthwhile for non-hydrographers to understand how to use them.

The guide "Smooth sheets: How to work with them in a GIS to derive bathymetry, features and substrates" is intended to provide the user with enough information to understand and properly utilize the smooth sheets and their associated data. The guide should be cited as: Zimmermann, M. and J. Benson. 2013. Smooth sheets: How to work with them in a GIS to derive bathymetry, features and substrates. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-249, 52p.

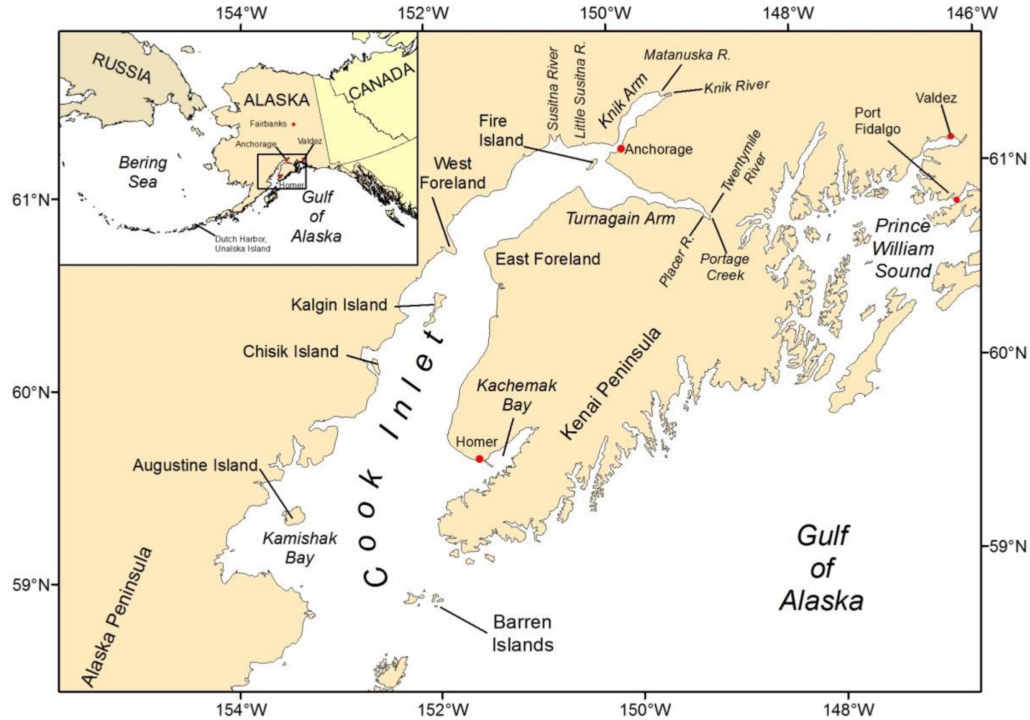
Contact Mark.Zimmermann@noaa.gov

Smooth sheet bathymetry of Cook Inlet, Alaska - RACE GAP

Scientists with the AFSC’s Groundfish Assessment Program (GAP) have expanded earlier mapping efforts for the Aleutian Islands to include Cook Inlet, Alaska. This work is part of an effort to provide better seafloor information for fisheries research. The Cook Inlet project included the same smooth sheet bathymetry editing and sediment digitizing as the Aleutian Islands effort, but also included:

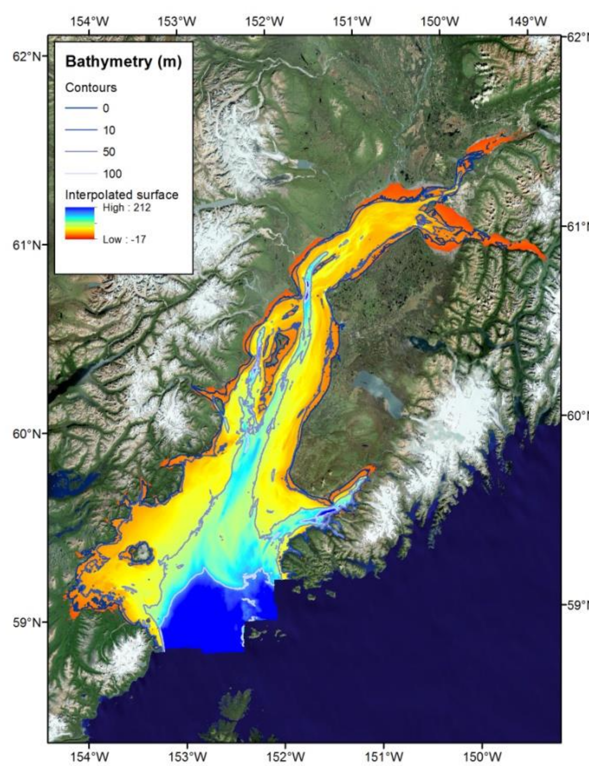
1) digitizing the inshore features, such as rocks, islets, rocky reefs, and kelp beds;
2) digitizing the shoreline; and
3) replacing some areas of older, lower resolution smooth sheet bathymetry data with more modern, higher resolution multibeam bathymetry data.

   The smaller area of Cook Inlet, greater amount of project time, and higher quality of smooth sheets than in the Aleutian Islands made these additions possible. The NMFS Alaska Regional Office's Essential Fish Habitat funding made much of this work possible.

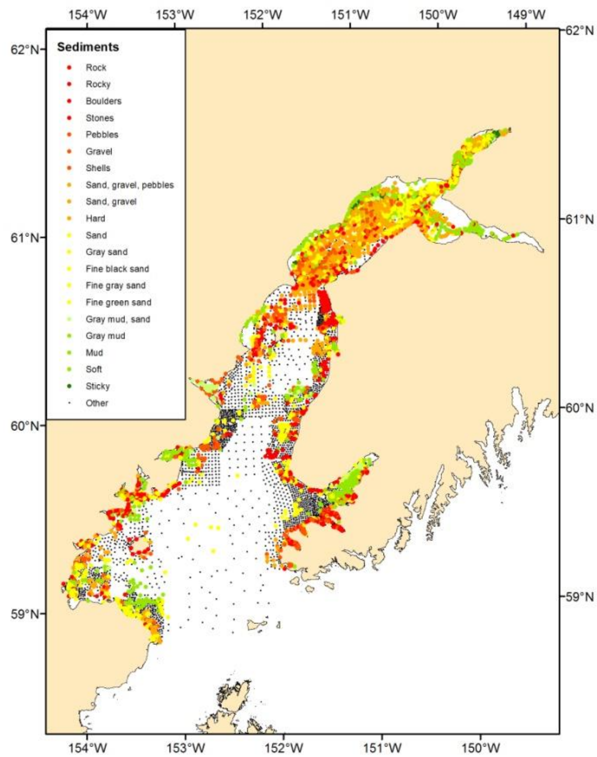


Bathymetry of Cook Inlet – RACE GAP

A total of 1.4 million National Ocean Service (NOS) bathymetric soundings from 98 hydrographic surveys represented by smooth sheets in Cook Inlet were corrected, digitized, and assembled. Overall, the inlet is shallow, with an area-weighted mean depth of 44.7 m, but is as deep as 212 m at the south end near the Barren Islands. 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.



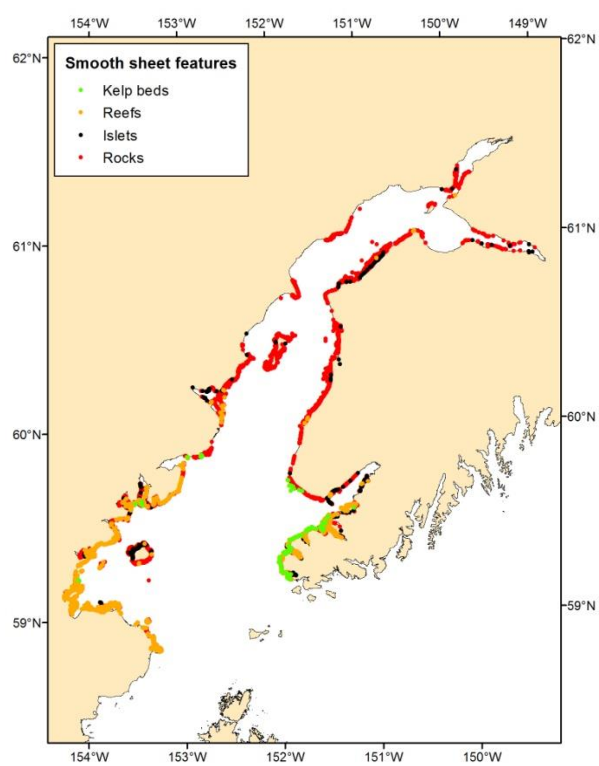
Sediments of Cook Inlet



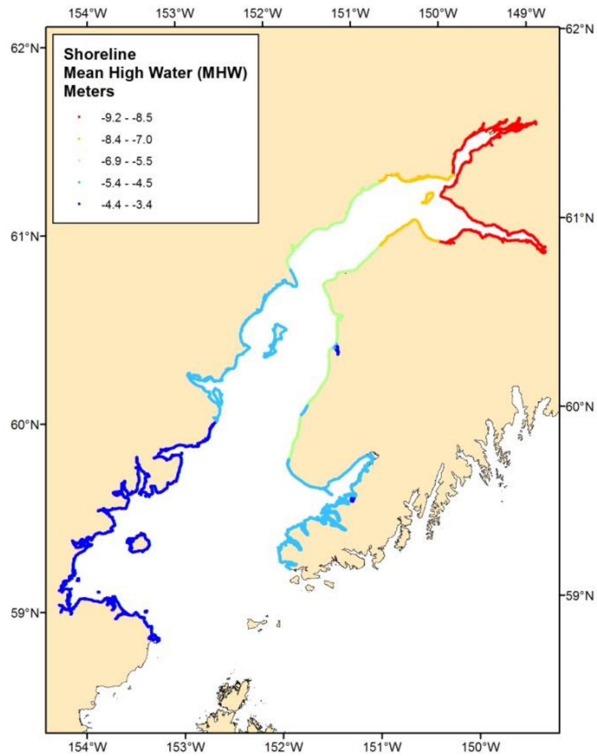
A total of 9,000 verbal surficial sediment descriptions from 96 smooth sheets were digitized, providing the largest single source of sediment information for Cook Inlet. There were 1,172 unique verbal descriptions, with most of the sediment description categories (58%) only having a single occurrence. That means that most descriptions were fairly lengthy and specific. Of the sediment descriptions which occurred more than once, Hard (n = 1335), Sand (n = 721), Rocky (n = 608), and Mud (n = 365) were the most common, which ranged from Rock to Clay, Sand ridges to Mud flats, Weeds to Stumps, and Mud to Coral. The 20 most common sediment categories are depicted along a color gradient in the Figure, where red shows larger/harder sediments such as Rock, Rocky, and Boulders, and green shows smaller/softer sediments such as Mud, Soft, and Sticky.

Smooth Sheet Features of Cook Inlet

A total of 12,000 features such as rocky reefs, kelp beds, rocks, and islets were digitized from the smooth sheets and added to the original files from NGDC, resulting in a total of 18,000 features. Almost 10,000 of these points indicated the edge of rocky reefs, covering much of the shore in Kamishak Bay, the southern shore of Kachemak Bay, and near Chisik Island, but reefs were rare north of there. More than 7,000 rocks and more than 800 islets were found along most of the Cook Inlet shore. There were less than 300 kelp beds, almost all of which occurred in outer Kachemak Bay. Altogether there were almost 18,000 rocks or rock ally features such as rocky reefs, kelp beds, and islets, which were added to the sediment data set.



Shoreline of Cook Inlet



A total of 95,000 individual shoreline points were also digitized, describing 2,418.3 km of mainland shoreline and 528.9 km of island shoreline from 507 individual islands, providing the most detailed shoreline of Cook Inlet. The shoreline is defined on the smooth sheets as MHW (Mean High Water), the same vertical tidal datum as the bathymetry, which typically ranges only as shallow as MLLW (Mean Lower Low Water), defined as zero meters depth. The MHW shoreline was highest in the northern end of Cook Inlet, ranging up to -9.2 m in Turnagain Arm, and -9.1 m in Knik Arm, and lowest at Augustine Island and Kamishak Bay (-4.4 to -3.4 m, respectively).

By adding the digitized shoreline to the digitized bathymetry, a complete bathymetry map for Cook Inlet was assembled without the typical gaps between the shallowest soundings and the shoreline. Thus, researchers were able to determine that at high tide (MHW) the total volume of the inlet is 1,024.1 km^3 and the total surface area is 20,540 km^2. When the tide drops from MHW to MLLW, the Inlet loses 99.7 km^3 of water, or 9.7% of its volume, and exposes 1,616 km^2 of seabed, or 7.9% of its surface area.

While the Alaska Fisheries Science Center has been conducting marine research for decades in Alaskan waters, a lot of basic information about the seafloor, such as depth, is generally not known beyond what is depicted on small scale (1:100,000) NOS Navigational Charts. Therefore GAP scientists have been creating more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their environment. This information is being used by NOAA's Deep Sea Coral Research and Technology Program to predict the presence/absence and abundance of corals and sponges (Rooper et al., 2013). GAP scientists who conduct stock assessment bottom trawl surveys are also using the information to delimit areas that cannot be sampled effectively with bottom trawls. The results from this project may result in a separate survey conducted by another method, such as underwater cameras or acoustics, to assess the abundance of fish in the untrawlable areas. An inter-agency collaboration called the Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP) sponsored by the North Pacific Research Board (NPRB) is using the detailed bathymetry and sediment information to predict the preferred settlement habitat juveniles of five important groundfish species. Results from GOA-IERP will be used towards developing a better understanding of the ecosystem processes that regulate stock recruitment. The Alaska Regional Office will investigate use of the bathymetry and sediment information to oversee sustainable fisheries, conduct Essential Fish Habitat (EFH) reviews, and manage protected species. The Bureau of Ocean Energy Management may use the information for preparing National Environmental Policy Act (NEPA), Essential Fish Habitat (EFH), and Endangered Species Act (ESA) documents for the possibility of a federal lease sale in lower Cook Inlet.

Details of the processing methods for the smooth sheet data for Cook Inlet will be published in the NOAA Technical Memorandum series.

Rooper, Chris, Mike Sigler, Gerald Hoff, Bob Stone, and Mark Zimmermann. 2013. Determining the Distributions of Deep-sea Corals and Sponges Throughout Alaska. AFSC Quarterly Report Feature (October-November-December 2013) 4 p.

Evaluating Smooth Sheet Bathymetry for Determining Trawlable and Untrawlable Habitats - RACE GAP

This project supported by NMFS' Habitat Assessment Improvement Plan (HAIP) evaluates whether enhanced bathymetric and other sea floor data obtained from hydrographic smooth sheets can predict whether the sea floor can be trawled during research surveys. Biennial bottom trawl surveys in the Gulf of Alaska (GOA) and Aleutian Islands (AI) provide fishery independent estimates of catch per unit effort, abundance, and biological parameters used in stock assessments for managed fisheries and species in the North Pacific. The quality and precision of these estimates depend, in part, on proper survey stratification and are likely affected by differential fish abundance between soft, flat and smooth areas where trawling is a good sampling tool and hard, steep and rough areas where trawling is not a good sampling tool. The AI/GOA bottom trawl surveys exclude known untrawlable areas determined from previous attempted survey tows and during surveys, stations may be dropped from the survey if they are found to be untrawlable. An analysis conducted in the GOA area by AFSC staff in 2006 determined that this trawl station history indicated strata trawlability ranged from 8.2% to 100%. Despite untrawlable stations being excluded from the sampling frame, mean catch per unit effort estimates are expanded by the total areas including both trawlable and untrawlable habitats. The assumption that fish are distributed without regard to trawlable and untrawlable habitat is likely to be violated by the behaviors of rockfishes, codfishes, flatfishes, and other species of management concern. Ideally, survey scientists would have a perfect delineation and sampling frame of untrawlable habitat in the GOA and AI. AFSC scientists and their colleagues have developed multi-frequency acoustic, optical, and fisher experiences to identify untrawlable habitats. However, these methods require extensive new surveys to map untrawlable habitats that are presently impractical or too expensive.

Hydrographic smooth sheets developed by Zimmerman (see above) and information obtained from AFSC GOA and AI Biennial Bottom Trawl Surveys are being used in predictive models to determine if factors such as slope, rugosity, and current relate to fishing success or sea floor characterizations from fishing echosounders. Project objectives are: 1. Identify criteria to predict untrawlable habitat from smooth sheet data, 2. Test criteria and predictive model with known areas of rocky habitat and unsuccessful bottom trawls, and 3. Assemble and interpret existing smooth sheet data into a map of untrawlable habitat that can be evaluated in future surveys and studies. If the predictive model is successful, smooth sheet data will be assembled and used to generate a preliminary sampling frame of trawlable and untrawlable habitat. This sampling frame would not be used immediately, but would be evaluated for data gaps, priorities for further mapping, and for possible field testing during upcoming bottom trawl surveys.

For further information, contact Matthew Baker (matthew.baker@noaa.gov), Mark Zimmermann or Wayne Palsson.

Bering Sea Infauna Communities and Flatfish Habitats - RACE GAP
Research continues on characterizing flatfish habitat and productivity on the eastern Bering Sea (EBS) shelf. Focus in recent studies was on juvenile habitats, specifically pertaining to the prey environment, of yellowfin sole (Limanda aspera) and rock sole (Lepidopsetta spp.). In 2011 and 2012, benthic samples and juvenile flatfish (<20 cm) were collected at bottom-trawl survey stations in the southernmost part of the EBS shelf along the Alaska Peninsula to evaluate juvenile habitat quality. High concentrations (hotspots) of both northern rock sole and yellowfin sole juveniles were found in Bristol Bay and near Unimak Pass. Analysis of prey fields and associated fish diets and conditions in and out of hotspots is in progress. A future study is planned to characterize another possible juvenile flatfish hotspot in the northern part of the EBS shelf near Nunivak Island. The main objective is to investigate whether northern and southern hotspots were utilized alternately – the former during periods of "warm" oceanographic environment in the EBS, and the latter during "cold" periods.

For more information, contact Cynthia Yeung, e-mail: cynthia.yeung@noaa.gov

Northern Rock Sole and Yellowfin Sole Nursery Habitats in the Bering Sea - RACE FBEP
The Fisheries Behavioral Ecology program is collaborating with the RACE-Recruitment Processes Program to examine the use of coastal nursery habitats by important flatfish species. Work in 2013 focused on processing of specimens collected in the vicinity of Port Moller along the Alaska Peninsula in Autumn 2012 and initial work on distributional patterns across species. Northern rock sole and yellowfin sole were the most common flatfishes encountered in coastal habitats.

Age-0 flatfish (northern rock sole and yellowfin sole <50 mm) were captured at high abundances (>50 per tow) at a small number of stations (n=4) along the Alaska Peninsula. Depths of these stations were 38, 33, 32, and 23 m. The age-0 cohort of these species was generally absent from deeper and shallower sites.

Age-1 and age-2 northern rock sole and yellowfin sole (50-150mm TL) were more widespread, using both coastal waters along the Peninsula and coastal embayments. They were more abundant in coastal samples near Port Moller (mean 43 NRS and 8 YFS per tow) than in the coastal embayments of Port Moller and Herendeen Bay (mean 7 NRS and 4 YFS per tow) and in offshore Bering Sea shelf samples (<5 fish per tow). Both species tended to be absent from shallow (<3 m) wave-swept areas along the coast. There was a trend for NRS to be found in higher abundances on sandier sediments with YFS on muddier sediments, both along the coast and in coastal embayments. The high abundances of these species in coastal waters is consistent with previous observations along other portions of the Alaska Peninsula.

Long-term Monitoring of Demersal Macrofauna in Alaskan Arctic Seas Using Bottom Trawls: A Comparison Study - RACE GAP
Long-term monitoring of the Arctic marine biota is needed to understand how community structure is changing in response to diminishing ice (i.e., climate change) and increasing anthropogenic stimuli. Dating back to 1959, bottom trawls (BT) have been a primary research tool for investigating bottom fishes, crabs and other demersal macrofauna in the Arctic (; however, the BTs used in past surveys have varied widely in terms of their construction, dimensions, mesh-sizes, etc. Moreover, the spatial and temporal coverage of past BT surveys has been patchy, and sampling procedures employed using various BTs have generally lacked standardization. Such

inconsistencies prohibit synthesizing results into a coherent time series for investigating changes in the community structure. By adhering to rigorous standards, BTs can be effective research tools for monitoring general population trends and detecting geographic shifts of bottom fishes, crabs and other demersal macrofauna. Although relatively limited in their application, two BT gears have been used in Arctic surveys employing moderately consistent sampling techniques: the University of Alaska Fairbanks 3 m plumb-staff beam trawl (PSBT) and the Alaska Fisheries Science Center 83-112 Eastern bottom trawl (EBT). The PSBT has been used periodically for small-scale surveys on the eastern Bering Sea shelf since 2000. North of the Bering Strait, the PSBT was first used in 2004 for a transboundary study of demersal fishes, crabs and other macrofauna in the eastern and western Chukchi Sea. Since 2007, there have been annual demersal surveys using the PSBT in either the Chukchi or Beaufort Seas. In comparison, the EBT's primary use has been for investigating the population dynamics of commercial bottom fishes and crabs on the eastern and northern Bering Sea shelf. North of the Bering Strait, the EBT has also been used for surveying demersal macrofauna in the eastern Chukchi Sea in 1976, 1990,1991, and 2012 and in the Beaufort Sea in 2008.

The objective of this study was to do a paired comparison experiment in the eastern Chukchi Sea to investigate differences between the PSBT and EBT in terms of catch composition and size selectivity of bottom fishes, crabs and other demersal macrofauna. Experimental results will help managers and scientists to interpret results from existing and future BT surveys, as well as underscore the importance of using standard gear and survey methods for long-term monitoring. Managers and scientists need to compare the catching characteristics of the PSBT and EBT compare to understand how data from the two bottom trawls can best be utilized for understanding ecosystem processes and for long-term monitoring of demersal macrofauna in the Alaskan Arctic region.

For more information, contact Bob Lauth, e-mail: bob.lauth@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 and research on individual species are found in Section C By Species.

Shelf-associated Flatfish Juveniles in the Bering Sea

Eco-FOCI studies on early life history stages of flatfishes help to understand mechanisms controlling recruitment variation. We continue to conduct field studies of juvenile distributions, habitat, and diet in the EBS of northern rock sole (*Lepidopsetta polyxystra*), flathead sole (*Hippoglossoides elassodon*), arrowtooth flounder (*Atheresthes stomias*), Pacific halibut (*Hippoglossus stenolepis*), and yellowfin sole (*Limanda aspera*).

Northern rock sole juvenile spatial distribution and abundance are correlated in RACE groundfish survey data. Large abundances small fish (ages 2 and 3) have more northwards distributions, suggesting density dependent spatial patterns or spatially dependent production. To date, age-0 distribution is reflected 2 years later in the groundfish survey of age-2 fish. A large area of the EBS between Cape Newenham and Nunivak Island served as age-0 northern rock sole habitat in 2003 (a warm year survey conducted by B. Norcross University Alaska, Fairbanks), but not in 2008 or 2010 (cold years), and in 2012 (another cold year) densities were low and age-0 northern rock sole were small. Age-2 and age-3 fish distributions were significantly correlated with EBS temperatures two and three years prior to the survey (i.e. in years when the small juveniles were age-0 fish), however distributions were not significantly correlated with current survey year temperatures, suggesting that temperature in the age-0 year controls distribution small juveniles more that temperature in the current year.

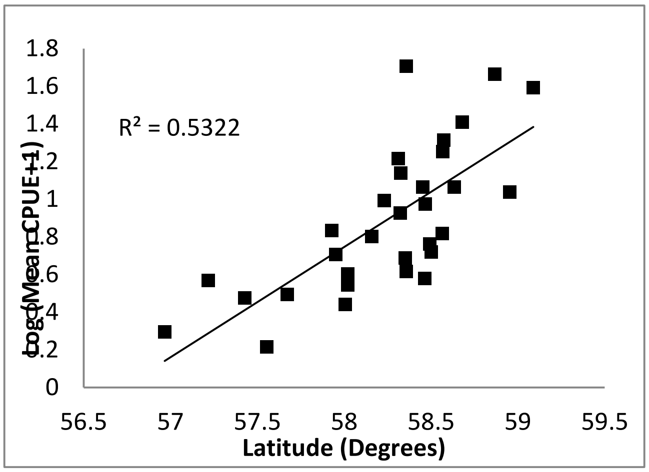


Figure 1. Relationship between annual mean catch per unit effort and the latitude of the catch-weighted center of age-2 and age-3 sized northern rock sole in the EBS groundfish survey from 1982 through 2012.

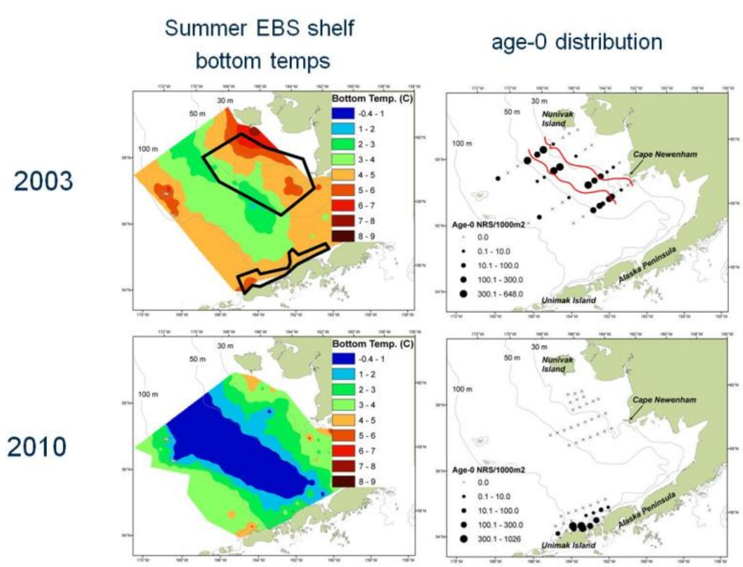


Figure 2. EBS Summer bottom temperatures in 2003 (upper left) and 2010 (lower left) and autumn age-0 northern rock sole distributions in 2003 (upper right) and 2010 (lower right).
Age-0 northern rock sole mean length is higher in warm, nearshore areas than in cold, offshore areas, suggesting temperature dependent growth and/or shoreward movement after settlement.

Contributed by D. Cooper, e-mail: Dan.Cooper@noaa.gov

Deep-sea Spawning Flatfishes in the Bering Sea

Eco-FOCI has been examining canyon and slope habitat utilization, and spawning to nursery area connectivity for Greenland halibut (*Reinhardtius hippoglossoides*) and Pacific halibut (*Hippoglossus stenolepis*), two deep-sea spawning flatfish in the eastern Bering Sea. Distribution and abundance of adults, larvae and juveniles are seasonally assessed using field surveys and results are compared to predominant circulation patterns. Transport along and across the Bering Slope was derived from 23 years (1982-2004) of simulations from an ocean circulation model (ROMS). It was hypothesized that changes in the strength and position of the Bering Slope Current would affect recruitment of Greenland halibut, Pacific halibut and arrowtooth flounder. Seasonal variations in flow were observed, with transport typically highest during fall and winter months. Significant correlations were found between transport, position, and recruitment. In particular, it was noted that Pacific halibut recruitment increased in relation to increased on-shelf transport through southern canyons.

Contributed by J. Duffy-Anderson, e-mail: Janet.Duffy-Anderson@noaa.gov

Shelf-associated Flatfishes in the Gulf of Alaska

Stations across the western GOA shelf were sampled in late summer 2011 for settled juvenile flatfish species, including age-0 arrowtooth flounder. These data were used to test the predictive ability of habitat models developed in GOA bays for application over the continental shelf. The models predict presence or absence of specific species-age groups of juvenile flatfishes depending on variables such as bottom temperature, bottom depth, and sediment composition (e.g., mud, sand, or gravel percent of total weight). The models performed well for two of the species-age groups. We are currently exploring whether model performance improves with the introduction of new independent variables and parameters. This study is increasing our knowledge of juvenile flatfish habitat in the GOA, including improving estimates of juvenile flatfish habitat for GOAIERP models.

Contributed by M. Wilson, e-mail: Matt.Wilson@noaa.gov

Synthesis of Gulf of Alaska Ichthyoplankton Data Illuminates the Recruitment Process Among Species with Variable Life History and Ecological Patterns

Data are from historical and ongoing collections of ichthyoplankton samples and associated oceanographic and climate measurements in the GOA. Ichthyoplankton surveys that sample the early ontogeny pelagic phase (eggs/larvae) of fish integrate information on a diverse range of species with variable adult habitats and ecologies. Synthesis of these ichthyoplankton and associated environmental data are being carried out in order to evaluate species pelagic exposure patterns and response outcome during early ontogeny. The research is contributing to a mechanistic understanding of environmental forcing on early life history aspects of recruitment processes among GOA fish species. Multivariate analysis of the historical GOA ichthyoplankton has revealed synchronicities and similarities among species early life history patterns and their links to the environment. This research has yielded an effective conceptual framework for evaluating the exposure and response of fish species to the pelagic environment during early life The working hypothesis for this ongoing research is that we can utilize similarities in reproductive and early life history characteristics among species to identify: 1) ecologically-determined species groups that are pre-disposed to respond to environmental forcing during early life in similar ways, and 2) plausible environmental predictors of early life history aspects of recruitment variation. Evaluation of the effectiveness of this conceptual framework will continue as the ichthyoplankton time-series (1981-2011) continues to be investigated in relation to interannual variation in the oceanographic environment. Application of this research to stock assessments is being explored. The objective is to determine which species-specific larval abundance data and environmental drivers should be incorporated into groundfish stock assessment models to best account for environmental forcing of recruitment

Multi-species Approaches – Development of DNA-based Methods for Identification of Fish Eggs, Larvae and Prey Remains

We developed a mitochondrial DNA (mtDNA) sequence database and restriction fragment length polymorphism protocols to accurately identify any life history stage of commercially important marine fish species, with special emphasis on select species that have been difficult or impossible to identify by conventional taxonomic means. Seven PCR-based restriction fragment length polymorphism (PCR-RFLP) protocols screening portions of the mitochondrial cytochrome *c* oxidase (COI) and cytochrome *b* (cyt *b*) genes were diagnostic for 19 species in five families Results from this study demonstrated the potential to fill important knowledge gaps for commercially and ecologically important species routinely studied at AFSC, with particular regard to species composition in fish diets and ichthyoplankton. The database provided the foundation for development of rapid, cost-effective, and accurate molecular protocols to identify species under circumstances where traditional taxonomic approaches founder or fail.

Recruitment Processes Contribution to the GOAIERP project

Synthesis of historical GOA ichthyoplankton data is included in the Retrospective component of the NPRB-sponsored GOAIERP program. Spatial, seasonal, and interannual patterns of variation in abundance and lengths of the early ontogeny stages of the five focal species (Pacific cod, walleye pollock, Pacific Ocean perch [represented by *Sebastes* spp. larvae], sablefish, and arrowtooth flounder) have been integrated into the construction of individual pelagic exposure profiles for each. Observed similarities and synchronies with other species, as well as evaluation of links between larval abundance patterns and the physical environment are also included in the exposure profiles. The early life history parameters have been incorporated into the development of Individual Based Models for each species by the Modeling component of GOAIERP. The comprehensive early life history reviews of these species are being developed into a manuscript for publication. This historical synthesis provides a comparative framework for interpreting the results of the 2010-2013 GOAIERP surveys from the eastern and western GOA with respect to identification of early life history habitat, connectivity between spawning and nursery grounds, and early ontogeny response to the pelagic environment.

As part of the Lower Trophic Level Component of the GOAIERP program, the Recruitment

Processes Program has been involved in the planning and carrying out of ichthyoplankton, and oceanographic sampling in the eastern and western GOA for the 2011 and upcoming 2013 field years. Results from the 2010 pilot study, and the 2011 surveys have been analyzed. New information has emerged regarding differences in spawning and early life history patterns between the eastern and western GOA for the focal species. In addition, genetic analysis of *Sebastes* spp. specimens in conjunction with larval length distributions indicates separate spring and summer cohorts of rockfish larvae with Pacific Ocean Perch likely being the dominant species in the spring group.

Lower Trophic Level Contributions to the GOAIERP Project

The Gulf of Alaska Integrated Ecosystem Program (GOA-IERP) is a four year (2011–2014) multi-disciplinary study examining the interactions between physical and biological oceanography to understand how the environment influences the survival of early life history stages (egg to age-0 juvenile) and recruitment of five commercially and ecologically important groundfishes: *Gadus chalcogrammus* (walleye pollock), *Gadus macrocephalus* (Pacific cod), *Atheresthes stomias* (arrowtooth flounder), *Anoplopoma fimbria* (sablefish), and *Sebastes alutus* (Pacific Ocean perch). The program has had two primary field years (2011 and 2013) to conduct biological and oceanographic surveys in the eastern and western Gulf of Alaska. More than 40 scientists (fishery biologists, oceanographers, and modelers) from 11 institutions are taking part in this study funded by the North Pacific Research Board.

As part of the Lower Trophic Level Component of the GOA-IERP program, the Recruitment Processes Program has been involved in the planning and execution of ichthyoplankton, and oceanographic sampling in the eastern and western Gulf of Alaska for the 2011 and 2013 field years. Currently, we are analyzing results from the 2011 surveys. In the spring (May), larvae of all five target taxa were collected, with all occurring in both the eastern and western Gulf of Alaska except for Pacific cod. Larval Pacific cod were only collected in the western Gulf of Alaska and only at the western most stations. In the summer months (July–August) only two target taxa were collected. *Sebastes* larvae were collected in both the eastern and western Gulf of Alaska and sablefish were collected in low abundance in the eastern Gulf of Alaska only. It should be noted that at this time we are unable to identify larval *Sebastes* collected in our samples to the species level due to ambiguous physical characters. Genetic analysis on specimens collected in the spring and summer has shown that in the spring Pacific Ocean perch make up the majority of *Sebastes* larvae collected, while in the summer it appears that another rockfish species is dominant. We are still processing samples from the 2013 field year with results expected by the end of this year.

Contributed by L. De Forest, e-mail: Lisa.DeForest@noaa.gov

Early Life History Ecology and Recruitment Processes of Fish Species in the Gulf of Alaska

Ichthyoplankton surveys that sample the early ontogeny phase of fish integrate information on a diverse range of species with variable adult habitats and ecologies. Synthesis of these ichthyoplankton and associated environmental data from historical (spanning four decades) and ongoing surveys in the Gulf of Alaska (GOA) ecosystem continue both at a single species and multiple species level. The broad objective is to evaluate species' pelagic environmental exposure patterns and response outcome during early ontogeny. This research provides a mechanistic understanding of environmental forcing on early life history aspects of recruitment processes. Results are applied to the development of models both at the level that represent the ontogenetic pathway of an individual from egg stage to recruitment (Individual Based Models), as well as at the level of integrating physical and biological processes across different trophic levels in the pelagic ecosystem (Integrated Ecosystem Assessments).

Historical sampling is concentrated in the western GOA and has been most intense during mid-May through early June in the vicinity of Shelikof Strait and Sea Valley from where data has been developed into a time series of larval abundance and length indices for the numerically dominant species (Fig. 1). This time series spans from 1981 through 2011 annually, and from 2013 onwards sampling occurs every other year. It has been updated through 2011 and is presented and reviewed in the 2013 Ecosystem Considerations chapter of the Stock Assessment and Fisheries Evaluation report. The time series continues to provide valuable information on interannual trends in early ontogeny stages of important commercial and ecologically important species, and associated ecological patterns and environmental forcing. It has been incorporated into the retrospective analysis component of the North Pacific Research Board sponsored Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), as well as the development of three new research proposals in 2013.

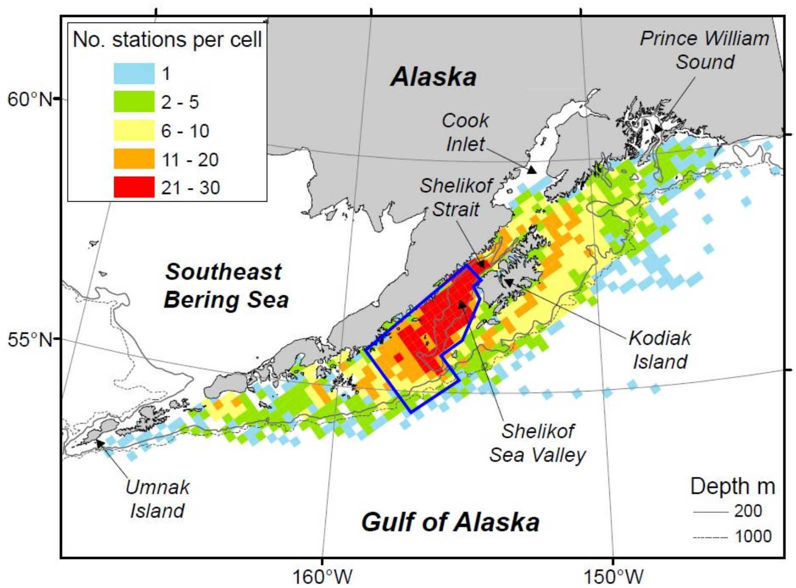


Figure 1. Distribution of historical ichthyoplankton sampling in the GOA by the Alaska Fisheries Science Center (1972, 1977-2009), based on 60-cm bongo net sampling of the upper 100 m of the water column. The polygon outlined in blue is the area from which the late spring ichthyoplankton time series has been developed.

Retrospective analysis of GOA historical ichthyoplankton data for the GOAIERP program has been completed this year. Syntheses of data for the five focal species (Walleye Pollock, Pacific Cod, Sablefish, Pacific Ocean Perch, and Arrowtooth flounder) have been incorporated into a) the development of Individual Based Models for each species by the Modeling component of the GOAIERP program, and b) a manuscript that presents a comprehensive review of the early life history patterns and processes for these species in the GOA. The manuscript is in review for submission to the GOAIERP special issue of Deep Sea Research II.

Synthesis of historical data continues with the investigation of phenology of the early ontogeny phase across GOA (and Bering Sea in the future) species and pelagic habitats. The timing and temporal extent of occurrence of eggs and larvae in the pelagic environment is a primary gradient of early life history variation among GOA fish species, and progression along this gradient is associated with variable patterns of exposure that modulate species response to environmental forcing[1]. For instance fish larvae of various species are present in the plankton during all seasons, and the period and extent of peak abundance varies (Table 1). For many species, larvae are temporally or spatially separated from the major spring production of copepod nauplii that are considered the primary source of nutrition for fish species during early ontogeny. This prompts many questions regarding the temporal and spatial availability of components of the zooplankton as food for fish larvae, and the feeding habits and prey selectivity among different species at different times of year and sub-intervals of early ontogeny. New research is proposed to address these questions by examining larval gut contents from archived samples.

Contributed by M. Doyle, e-mail: Miriam.Doyle@noaa.gov

Table 1. Schematic of monthly succession in occurrence and relative abundance of numerically dominant species of fish larvae in historical Gulf of Alaska ichthyoplankton samples (Doyle, unpublished data).

Species	**Common Name**	**H**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**
Hippoglossus stenolepis	Pacific Halibut												
Atheresthes stomias	Arrowtooth Flounder												
Leuroglossus schmidtii	Nrthrn. Smoothtongue												
Hemilepidotus hemilepidotus	Red Irish Lord #												
Hexagrammos decagrammus	Kelp Greenling #												
Pleurogrammus monopterygius	Atka Mackerel #												
*Ammodytes personatus**	Pacific Sand Lance												
Gadus macrocephalus	Pacific Cod												
Gadus chalcogrammus	Walleye Pollock												
Lepidopsetta polyxystra	Northern Rock Sole												
Stenobrachius leucopsarus	Northern Lampfish												
Pleuronectes quadrituberculatus	Alaska Plaice												
Anoplopoma fimbria	Sablefish #												
Ophiodon elongatus	Lingcod #												
Clupea pallasi	Pacific Herring												
Hippoglossoides elassodon	Flathead Sole												
Platichthys stellatus	Starry Flounder												
Glyptocephalus zachirus	Rex Sole												
Microstomus pacificus	Dover Sole												
Bathymaster spp.	Ronquils												
Lepidopsetta bilineata	Southern Rock Sole												
Isopsetta isolepis	Butter Sole												
Sebastes spp.	Rockfish												
Mallotus villosus	Capelin												
Limanda aspera	Yellowfin Sole												

[1] Doyle, M.J. and Mier, K.L. 2012. A new conceptual framework for evaluating the early ontogeny phase of recruitment processes among marine fish species. Can. J. Fish. Aquat. Sci. 69: 2112-2129.

*Used to be considered *A. hexapterus* prior to Mecklenberg et al. (2011)[2]
#Larvae associated with neuston

Level of abundance: Lowest, Moderate, Highest, Absent

Primary larval habitat (**H**): Coastal, Shelf, Slope/Deeper

Modeling Contributions to the GOAIERP Project

Eco-FOCI personnel have been involved in the Modeling Component of NPRB's Gulf of Alaska Integrated Ecosystems Research Program (GOAIERP, aka the GOA Project). This project is focused on examination of recruitment dynamics of five focal groundfish species in the GOA. Several types of models have been done for this project to complement the GOAIERP field work. A time series run of the 3km GOA implementation of the ROMS model (with integrated Nutrient-Phytoplankton-Zooplankton, NPZ, dynamics) has been run, from 1996 to 2011. This biophysical model has been used to show current patterns and patterns of scalars such as temperature and salinity, plus mesoscale dynamics such as eddies, all of which can influence transport of early life stages of fish. One product of the Modeling Component has been the development of a method to identify eddies in the ROMS output with the goal of examining the role of eddies in recruitment dynamics. At this initial stage, some correlations between indices based on these eddies, and recruitment has been found.

The output of this biophysical model is being used to drive individual-based models (IBMs) for the five GOAIERP focal species. These models are intended to allow us to examine connectivity between spawning and nursery areas, and also the environments encountered by the early life stages of the fish, for the purposes of examining how these factors affect recruitment variability. IBMs for Pacific cod and walleye pollock have been developed by Eco-FOCI personnel. A time series run (1996-2011) of the Pacific cod IBM has been completed, and initial connectivity analyses are done. Figure 1 shows the connectivity zones used for analyzing the output of the Pacific cod IBM.

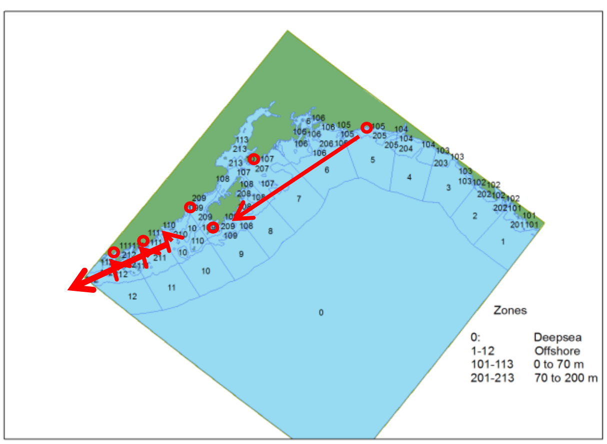


Figure 1. Connectivity zones for Pacific cod. Spawning zones are 101-113 and 201-213. Nursery zones are 101-113. Red circles and arrows indicate areas where variability in connectivity due la Nina may be high (see below).

Figure 2 shows the mean connectivity matrix for the years 1996-2011. From this figure it can be seen that retention (i.e. settlement in the same locations as spawning occurred, indicated by the white line) is important for Pacific cod. It is clear in this matrix that Pacific cod are not generally transported great distances between spawning zones and nursery areas. This is in accord with several other studies indicating that Pacific cod have very local distributions. It is also clear from this matrix that few Pacific cod seem to be transported to offshore areas.

[2] Mecklenburg, C.W., MØller, P.R., and Steinke, D. 2011. Biodiversity of arctic marine fishes: taxonomy and zoogeography. Mar. Biodiv. 41: 109-140.

Another analysis of connectivity showed that there may be an association between variability in connectivity in the western GOA (but not the eastern GOA) and La Nina (see Figure 1).
Results of analyses of IBM output will be incorporated into a Multispecies Model for the GOA, in an attempt to discover how recruitment variability affects other elements of the ecosystem.

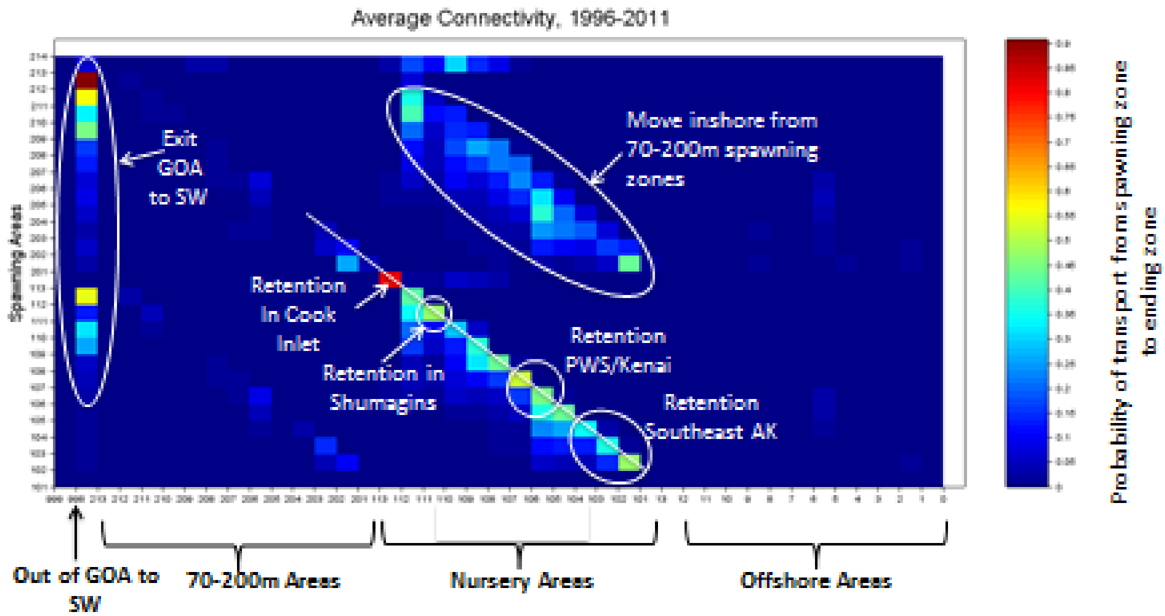


Figure 2. Mean connectivity matrix for the years 1996-2011 (right) from the Pacific cod IBM. The X-axis represents ending zones of individuals, the Y-axis indicates spawning (start) zones. Zones 101-113 represent nursery areas.

Scientific Exchange

The National Oceanic and Atmospheric Administration's Alaska Fisheries Science Center and the International Pacific Halibut Commission will co-host the 9th International Flatfish Ecology Symposium at Suncadia Lodge in Cle Elum, WA, from November 9-14, 2014. The Symposium is organized every 3 years and provides the international platform for flatfish scientists and managers to meet, share their research, and discuss management applications. There are six themes planned for the 9th IFS: *Flatfish and the Pelagic Realm: New Perspectives*, *The Influences of Flatfish on Trophic Interactions and Community Structure*, *Flatfishes and Climate Variability*, *Disentangling Multivariate Effects*, *Stock Assessment and Fisheries Management*, and *Physiology, Development, and Aquaculture*. The 9th IFS is generously supported by academic, state, federal, and industry representatives. For more information please visit: www.flatfishsymposium.com or contact Janet Duffy-Anderson (NOAA) at Janet.Duffy-Anderson@noaa.gov or Tim Loher (IPHC) at Tim@iphc.int.

Gulf of Alaska Project: Fisheries Oceanographic Surveys - ABL

The Gulf of Alaska Project completed the final Upper Trophic Level (UTL) fisheries oceanographic survey in 2013 as part of the North Pacific Research Board's (NPRB) Gulf of Alaska Integrated Ecosystem Research Program (GOA Project). The GOA Project is focused on comparing and contrasting ecological function in the southeast and central regions of the Gulf of Alaska (GOA). This interdisciplinary fisheries oceanographic study is investigating how environmental and anthropogenic processes affect trophic levels and dynamic linkages among trophic levels, with emphasis on fish and fisheries, marine mammals, and seabirds. It is interdisciplinary in nature and consists of four components that link together to form a fully integrated ecosystem study of the GOA. These components are the Upper Trophic Level (UTL), Middle Trophic Level (MTL), the Lower Trophic Level (LTL), and Ecosystem modeling.

The primary goal of the UTL component focuses on identifying and quantifying the major ecosystem processes that regulate recruitment strength of commercially and ecologically important groundfish species in the first year of life. Distribution, energetic condition, and transport during the early life history over the broad shelf of the central GOA are being contrasted with the narrower shelf adjacent to southeast Alaska (SEAK). Spatial and temporal overlap with seabirds, marine mammals, and piscivorous fish that prey upon the five focal species (arrowtooth flounder, Pacific ocean perch, sablefish, Pacific cod, and walleye pollock) during the age-0 life stage and upon other forage fishes are also being quantified. The MTL focuses on piscine competitors and early life history processes occurring in bays and fjords which influence productivity, abundance, and survival of the five focal species. The LTL focuses on physical and biological oceanographic properties, zooplankton, and ichthyoplankton that may influence the recruitment of the five species. Ecosystem Modeling links the dynamic processes being observed in the field with historical data in order to describe and predict the ecosystem responses (and variability therein) within the southeast and central GOA.

In addition to these four main components there is also a Retrospective component that is tasked with collecting all historical information relevant to this ecosystem synthesis and with exploring spatiotemporal patterns within the time series collected. An examination of EOF modes by the Retrospective Modeling team has shown that there is a spatial breakpoint around 148° W beyond which fish density increases, fish diversity decreases, and downwelling relaxes. Sea-surface temperature, phytoplankton production and salinity appear to co-vary from the eastern to western GOA within the vicinity of 148° W as well. This is the location where the two predominant currents change direction from northwest to southwest and the mean current flow velocity for the surface 50 m over the 1000 m isobaths from 1969-2005 shows a mean velocity of onshore flow to the east of 148° W and a mean offshore flow to the west. These flow patterns presumably support onshore flow of passive particles onto the narrow shelf in the eastern GOA and offshore diffusion across the broad shelf in the western GOA.

The 2013 UTL survey season of this integrated project was conducted during summer as field operations planned for fall were canceled due to the federal government shutdown. However, two fisheries oceanographic surveys were conducted off southeast Alaska and one off Kodiak Island during summer by the F/V Northwest Explorer, a chartered commercial trawler. Fish samples were collected using a midwater rope trawl (Cantrawl model 400). During the 2013 survey, the trawl was not fished at depth to verify acoustic targets or modified to fish at the water surface by stringing buoys along the headrope. Surface tows were made at predetermined grid stations and were 30 minutes in duration, while midwater trawls targeting specific layers varied 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.

Acoustic data was collected by a Simrad ES-60 echosounder and a hull-mounted 38 and 120 kHz splitbeam transducer. Thus, acoustic transects, orthogonal to shore, were not run between all rope trawling stations. Opportunistic trawls made to target midwater aggregations that the surface trawl would not sample. In years where acoustics are part of the survey, the acoustic echogram is monitored in real time for unusual or interesting aggregations along transects. And catches from midwater trawls were sorted by species and length and weight samples were measured whenever sufficient (>30) numbers were caught.

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, photosynthetic available radiation (PAR), and dissolved oxygen. Water samples for nutrients (N, P, Si), chlorophyll a, phytoplankton, and microzooplankton were also collected (surface 10m, 20m, 30m, 40m, and 50m depth). Zooplankton and ichthyoplankton samples were collected at gridded stations using double oblique bongo tows from the surface to within 5 meters of bottom, with a maximum depth of 200 m.

All five focal species were captured in surface trawls during the 2013 field season (Table 1). The 2013 focal fish surface trawl catch was dominated by YOY pollock which resulted in the largest sample retention for a species during the GOA Project (n>1000). The second most abundant species was rockfish, followed by P. cod, and arrowtooth flounder (ATF). Sablefish were the least abundant species. The summer catch of YOY pollock in the surface waters was 8 times higher in the Eastern Gulf and 3 times higher in the Central Gulf relative to 2012, while only a few individuals were encountered at 3 of 245 stations sampled in 2011 (Figure 1). During 2013 YOY pollock were uniformly distributed in the EGOA while the distribution in the CGOA was less homogeneous, and localized on the Portlock Bank. YOY pollock were absent in the surface trawls in the EGOA fall survey. Mid-water trawls, which were not conducted in 2012, encountered YOY pollock at depths of up to 200 meters and up to 80 miles offshore. YOY Pollock were only captured once during midwater trawling during 2011.

Catch of YOY rockfish in the summer surface waters increased relative to 2012 in the EGOA with dense patches at the outermost stations 80 miles offshore (Figure 1), and genetic analyses indicating that ~95% were Pacific Ocean Perch (POP). Fewer rockfish were captured during 2011 relative to 2012 and 2013; however, the survey grid only extended to 60 miles offshore and higher densities may have occurred between 70-80 miles offshore. YOY rockfish were only encountered at two stations in the CGOA, resulting in a total catch of 57 individuals compared to a catch of 6409 in 2012. Rockfish were the only focal species encountered in significant numbers at the surface during the fall EGOA survey, although the majority was identified as non-POP type onboard.

YOY Pacific cod were rarely encountered in the EGOA (Figure 1), which resembled the patterns observed in 2012 and 2011. The numbers caught in the CGOA decreased significantly from a catch of 469 in 2012 where they were abundant from the Portlock Bank south to the Albatross Bank to a catch of 72 in 2013. A total of 4 YOY P. cod were captured at two stations during 2011.

Arrowtooth flounder catch decreased in 2013 relative to 2012, with catches resembling those during the 2011 survey (Figure 1). Similar to 2013, ATF were primarily located in the EGOA and mostly absent in the CGOA (n=3), whereas they were distributed in both the CGOA and EGOA in 2012. The distribution of ATF in the EGOA spread from the innermost to the outermost stations and no large patches were encountered. Sablefish were, practically absent from the trawl catch (n=4) in 2013. Combined sablefish catches in 2011 and 2012 were fewer than 4 individuals however the

LTL have intercepted post-larval sablefish using neuston nets samples the surface 20 cm of the water column.

2013 was another record year for returning adult pink salmon to the EGOA and catches were similar in magnitude with our 2011 survey. The prolonged cold spring experienced by the riparian environment in Alaska delayed the emergence of juvenile pink and chum salmon and thus the catch of these species was significantly lower in July relative to years past. This is of interest to UTL researchers that have observed adult pink salmon predation on the GOAIERP focal fish and have also observed prey sharing and predation by juvenile pink salmon on focal species.

We intend to again sample the eastern region of the GOA during summer 2014. For more information, contact Jamal Moss at (907)-789-6609 or jamal.moss@noaa.gov

Table 1. 2013 Trawl catch summary of age-0 arrowtooth flounder (ATF), Pacific cod, walleye pollock, rockfish, and sablefish on UTL surveys in the eastern (EGOA) and central (CGOA) Gulf of Alaska

2013 GOAIERP Trawl Catch in Numbers

Region	Trawl type	Season	ATF	P. cod	W. pollock	Rockfish	Sablefish
EGOA	Surface	Summer	34	1	3964	1363	2
EGOA	Mid-water	Summer	12	1	3376	0	0
EGOA	Surface	Fall	0	0	1	60	2
EGOA	Mid-water	Fall	0	0	6	2	0
CGOA	Surface	Summer	3	72	1648	57	0
CGOA	Mid-water	Summer	3	164	6154	0	0
		Total	**52**	**238**	**15164**	**1482**	**4**

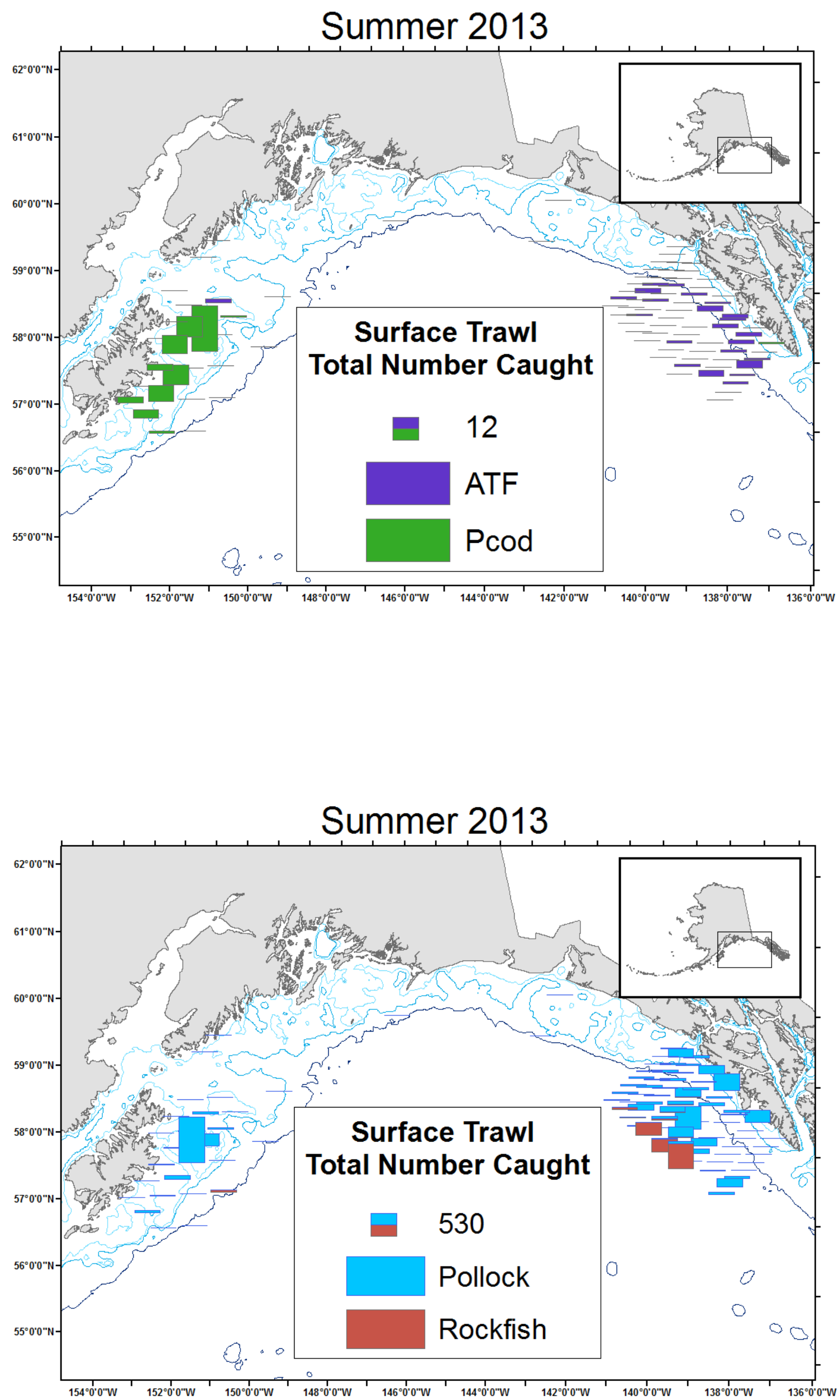


Figure 1. Surface catches for age-0 focal fish species in the eastern, gap, and central region for summer 2013 surveys. Note differences in scale between the top and bottom map.

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 modeling results. The first two objectives have been completed by the habitat team which includes ELH tables of habitat preference for the five focal species, extensive EndNote library of the literature synthesis, collection and validation of high resolution bathymetry (over 20 million soundings) and sediments (100 thousand plus points), GIS framework with digitized species observations, and preliminary derived benthic habitat metrics (e.g. slope and bathymetric position index, Figure 2).

Preliminary suitability models have been developed for the five focal species based on the literature information and draft suitability maps have been created. Our next step is to utilize available observational data to develop presence-only models of habitat suitability for the five focal species and include any newly available survey captures from the afore mentioned fisheries-oceanographic surveys. We are now coordinating with the modeling component to generate the appropriate scaled (3 km grid) habitat suitability maps to be useful for post-processing the survival indicators of their individual based model (IBM) particle trajectories. In the future, we plan to take the full trajectory locations from these models and update potential settlement indicators by using higher resolution habitat information from the habitat suitability maps. We are also coordinating with the middle trophic level component to determine if fine-scale suitability maps may be useful for understanding local pressures on survival and potentially utilizing their survey information to develop localized suitability models. For more information, please contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov

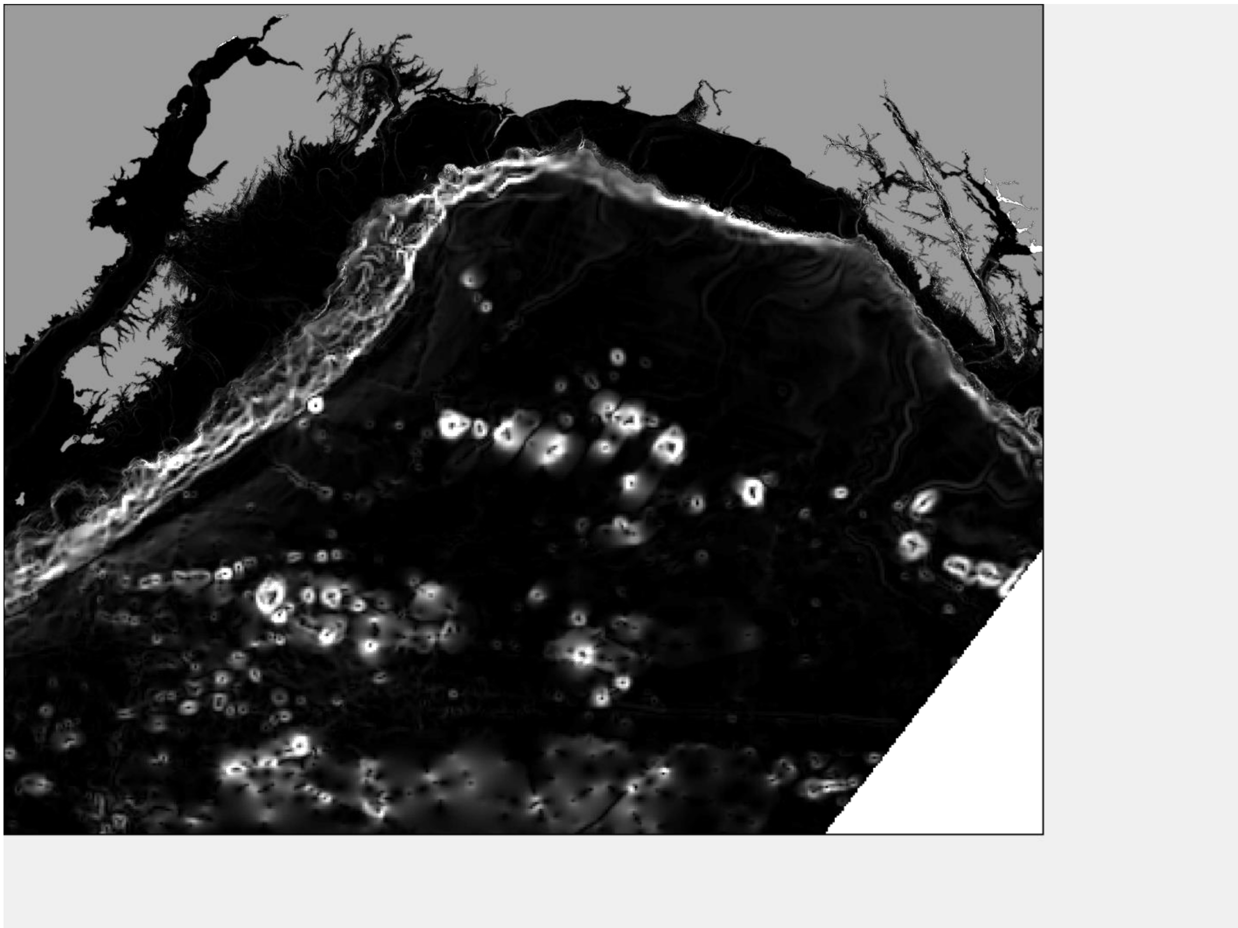


Figure 2. Draft GOA-wide slope derived from high resolution bathymetry data and shows rate of change of terrain in an area. Grid contributed by Jodi L Pirtle

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 EFH, such as bottom trawling, and conducting benthic community ecology studies to characterize groundfish habitat requirements and assess fishing gear disturbances. Research in 2013 was primarily focused on evaluating acoustic backscatter as a predictor of groundfish distributions in the eastern Bering Sea (EBS) and the development of next generation habitat-utilization models for managed species. An analysis of short-term trawling effects on soft-bottom benthos was completed, and a global study of mobile bottom-contact fishing gears was initiated as part of a 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 Dr. Bob McConnaughey, bob.mcconnaughey@noaa.gov, 206-526-4150.

Habitat Modeling

The HRG is building numerical models to explain the distribution and abundance of groundfish and benthic invertebrates in the eastern Bering Sea (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 essential fish habitat (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[3] demonstrated that surficial sediments affect the distribution and abundance of groundfish, however direct sampling with grabs or cores is impractical over large areas. Subsequent pilot studies[4,5] 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 2013, for multiple purposes. Bathymetric data were cleaned and submitted for nautical charting. Backscatter data have been 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.[6] Thirty-two years of trawl survey data (catch per unit effort, kg ha^{-1}) have been assembled and statistical analyses with the backscatter statistics are being prepared 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 (Fig. 2), and will be the basis for improved EFH models for multiple species.

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[3] McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.
[4] McConnaughey, R.A. and S.E. Syrjala. 2009. Statistical relationships between the distributions of groundfish and crabs in the eastern Bering Sea and processed returns from a single-beam echosounder. ICES J. Mar. Sci. 66: 1425-1432.
[5] Yeung, C. and R.A. McConnaughey. 2008. Using acoustic backscatter from a side scan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES J. Mar. Sci. 65: 242–254.
[6] Representative video and the corresponding geo-referenced mosaic are available at http://www.afsc.noaa.gov/Quarterly/jas2012/divrptsRACE4.htm.

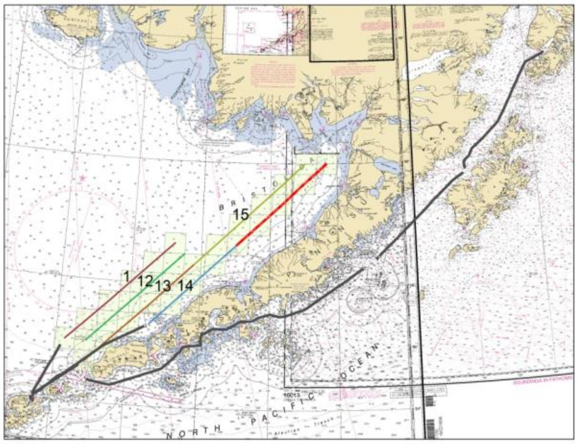

Figure 2. Completed FISHPAC 2012 survey tracklines. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom trawl survey stations for the Bering Sea shelf. Each line was surveyed with five different sonar systems, with the exception that only multibeam echosounder data were collected 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.

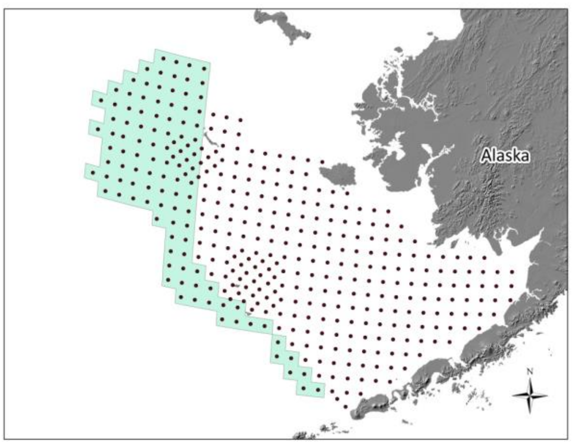

Figure 3. The first sector of the Bering Sea shelf that will be systematically mapped to improve groundfish habitat models and fishery stock assessments. Quantitative sonars will be used characterize the seafloor at the 104 trawl-survey stations in the shaded polygon, during a planned multi-mission cruise that will also produce IHO-quality bathymetric data for updating nautical charts of areas with outdated or non-existent information.

Tool Development for Broad-scale Habitat Mapping

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.

The Rolls Royce FFCPT[7] 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 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), chlorophyll-a fluorescence (470/680 nm), and turbidity by particle scattering (660 nm) in the pelagic environment. These properties show considerable spatial variability, may be related to fish-habitat quality, and are also being considered for use in next generation models.

HAIP-QTC Opilio

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[8], 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, depth, and sediment type. Unfortunately, sediment data over the

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[7] For additional information, see http://www.brooke-ocean.com/document/product_sheet-RRCLNM-FFCPT-660_(4-page)-2011-01-web_Rev1_(2012-05-02).pdf

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

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.[9] In some cases, estimates were based on sediments collected over 60 miles away. The option to collect sediment data 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. In the future, it may be possible to expand this study to other species after completion of the systematic acoustic survey of all EBS trawl-survey stations (Fig. 2).

Effects of Bottom Trawling

In 2013, the HRG completed an analysis of short-term effects of bottom trawling on soft-bottom benthos of the EBS.[10] In particular, a Before-After Control-Impact (BACI) experiment was conducted to investigate the effects of a commercial bottom trawl on benthic invertebrates in a sandy and previously untrawled area of the EBS. Six pairs of experimental and control corridors were sampled with a research trawl before and after four consecutive tows with the commercial otter trawl. A major storm event occurred during the experiment and it was possible to differentiate its effect from that of the trawling using the BACI model. Species composition changed very little; *Asterias amurensis* and *Paralithodes camtschaticus* comprised over 80% of the total invertebrate biomass (kg ha^{-1}) during each year of the study. In general, the commercial trawl did not significantly affect the biomass of the benthic invertebrate populations. The trawling effect after 4-14 d was statistically significant for three of the 24 taxa that were analyzed, a number expected due to nothing more than random variation with $\alpha = 0.10$. Biomass immediately after the trawling disturbance was lower for 15 of the taxa and higher for the other nine, with a median change of -14.2%. Similarly, the effect of trawling on invertebrate biomass after one year was not statistically significant for any of the taxonomic groups ($p \geq 0.23$), indicating no evidence of a delayed response to the commercial-trawl disturbance. Further analysis suggests that storms have an overall greater effect on the benthos than do bottom trawls at this location. Both the numbers of taxa significantly affected by trawling and the storm (3 *vs.* 12), as well as the median sizes of these effects (-14.2% *vs.* -22.0%), were greater for the storm event. Results from this study are combined with those from a

[9] Smith, K. R. and R. A. McConnaughey. 1999. Surficial sediments of the eastern Bering Sea continental shelf: EBSSED database documentation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-104. 41 p. For additional information, see http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-104.pdf

[10] McConnaughey, R. A. and S. E. Syrjala. 2014. Short-term effects of bottom trawling and a storm event on soft-bottom benthos in the eastern Bering Sea. ICES J. Mar. Sci. (in press).

related investigation of chronic trawling effects (Fig. 3) to propose an adaptive management strategy for the study region, including rotating area closures to mitigate for temporary trawling effects.

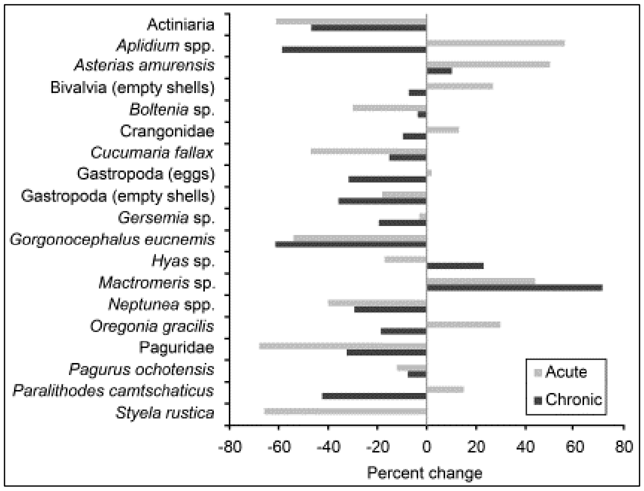

Figure 4. Changes in the biomass (kg ha^{-1}) of benthic invertebrate taxa 4-14 d after four consecutive passes of a commercial trawl (acute effects; present study) and after decades of intensive trawling by the fishery (prior HRG study of chronic effects). The chronic effect for *Styela rustica* was 0%.

International Committee Forms to Study Bottom-trawl Effects

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 lead 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. Adriaan Rijnsdorp (Wageningen University and Research Center, IJmuiden, Netherlands), Roland Pitcher (Commonwealth Scientific and Industrial Research Organization, Brisbane, Australia) , Bob McConnaughey (NOAA Alaska Fisheries Science Center, Seattle), Jeremy Collie (University of Rhode Island, Narragansett), Jan Hiddink (Bangor University, Bangor, U.K.), and Ana Parma (Argentine Council for Science and Technology, Chubut, Argentina). Two post-doctoral research associates (Drs. Ricardo Amaroso and Kathryn Hughes) are also actively working on the project. The full project will consist of five phases spread over the next 2 years. The first phase of this

project will systematically map MBCG effort and its distribution with respect to benthic habitats. Phase 2 will compile and evaluate data about the impacts of MBCG on the abundance and diversity of biota. [11] 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 will look at 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 practice.' Additional details about the project and the study group are available at http://trawlingpractices.wordpress.com/.
Benthic Invertebrate Ecology

Invertebrate Species Synopsis - *Asterias amurensis*
Invertebrates constitute an important element in the benthic ecology of the EBS continental shelf, playing an important part in the food web supporting not only the benthos, but also commercially important demersal fish species. The HRG is synthesizing sparse literature and reports to produce synopses of the life history and ecology of significant species. The second in a series of NOAA Technical Memoranda has been completed to aid the interpretation of mobile fishing gear effects on these invertebrates, their linkages to fishery production, and their overall role in the ecosystem.[12] The document presents a synopsis of the current knowledge of the life history and ecology of the *Asterias amurensis*; it includes detailed maps of its distribution in the EBS based on abundance data from the 1982-2013 RACE bottom trawl-surveys. The biological characterizations are from the available published literature and are based on observations of populations in the native and invaded ranges of the species.

The asteroid species *Asterias amurensis* represents a major portion of the benthic invertebrate biomass over most of the shelf, but it is especially prevalent in the inshore domain out to about the 50 m isobath. The species is also native to coastal areas of the northwestern Pacific, including the Tatar Strait, eastern and western Sea of Japan, and the east coast of Japan. It is a predator upon numerous shelled mollusk species, as well as other invertebrates of limited motility, and is also an opportunistic scavenger. Asteroids appear to have few predators, and in food webs *A. amurensis* is a terminal consumer. It therefore competes with some commercially important demersal fish species, as well as commercially important invertebrates such as the king crab *Paralithodes camtschaticus*. A possible mitigating circumstance in its ecological role is the large contribution to secondary production constituted by the release of potentially millions of eggs by each spawning female during the annual reproductive cycle. With its low susceptibility to predation, the species has proven a major threat to the ecological balance in areas where it is not native, but has been inadvertently introduced by such means as release of planktonic larvae in ballast water jettisoned by foreign ships in port; for example, in some coastal waters of southeastern Australia and Tasmania.

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[11] Hughes, K. M., M. J. Kaiser, A. S. Pullin, R. Amoroso, J. S. Collie, J. G. Hiddink, R. Hilborn, S. Jennings, R. A. McConnaughey, A. Palmer, R. C. Pitcher, A. D. Rijnsdorp. 201 . Investigating the effects of mobile bottom fishing on benthic biota: A systematic review protocol. Environmental Evidence (submitted).

[12] Smith, K. R. and C. E. Armistead. 2014. Benthic Invertebrates of the eastern Bering Sea: A synopsis of the life history and ecology of the sea star *Asterias amurensis*. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-273, 58 p.

Here native species of bivalves have proven especially vulnerable to the predator.

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) web site at: http://www.afsc.noaa.gov/REFM/REEM/Default.php.

Groundfish Stomach Sample Collection and Analysis

The Resource Ecology and Ecosystem Modeling (REEM) Program continued regular collection of food habits information on key fish predators in the North Pacific Ocean and Chukchi Sea. During 2013, AFSC personnel analyzed the stomach contents of a wide variety of species from the eastern Bering Sea, the Aleutian Islands, the Gulf of Alaska, the northern Bering Sea, and the Chukchi Sea regions. The contents of 10,359 stomach samples were analyzed in the laboratory and 4,710 stomach samples were analyzed at sea during the Gulf of Alaska groundfish survey. This resulted in about 39,000 records added to AFSC's Groundfish Food Habits Database in 2013. Support of seasonal energy flow modeling in Alaska's marine ecosystems was also provided through preparation and stable isotopic analysis of about 1,200 muscle and liver tissue samples.

Collection of additional stomach samples was accomplished through resource survey and Fishery Observer sampling. Large and abundant predators were the focus of this year's stomach sample collection from the eastern Bering Sea bottom trawl surveys of the continental shelf. In total, 1,359 stomach samples were collected during the survey of the Gulf of Alaska, and 5,594 stomach samples were collected during the survey of the eastern Bering Sea shelf. These samples were supplemented by the collection of 2,374 stomach samples from Alaskan fishing grounds by Fishery Observers. Specimens were also collected from every species possible during scientific trawling operations in the eastern Chukchi Sea resulting in 970 specimens collected for stomach content analysis.

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

Seabird Bycatch Estimates for Alaskan Groundfish Fisheries, 1993-2012

Seabirds are caught as bycatch in Alaskan commercial Groundfish fisheries operating in federal waters of the U.S. Exclusive Economic Zone. Fisheries Observers record seabird bycatch from their sample and other sources while on board these demersal longline, pot, pelagic trawl, and non-pelagic trawl vessels. The AFSC produces annual estimates of total seabird bycatch from these fisheries each year. Estimates are based on two sources of information, (1) data provided by NMFS-certified Fishery Observers deployed to vessels and floating or shore side processing plants, and (2) industry reports of catch and production. The 2007 - 2012 seabird bycatch estimates presented here (Table 1) are produced from the NMFS Alaska Regional Office Catch Accounting System.

These estimates update those previously reported from 1993 to 2006. These numbers do not apply to gillnet, seine, troll, or halibut longline fisheries. Data collection on the Pacific halibut longline fishery began in 2013 and will be summarized in future documents. Figure 1 is provided to report seabird bycatch in the groundfish fisheries for 1993 through 2012, using results from two analytical methods employed. The AFSC produced estimates from 1993 through 2006 and the CAS from 2007 through 2012.

The 2012 numbers for the combined groundfish fisheries (Table 1) are 40% below the rolling 5-year average for 2007-2011 of 8,295. Albatross bycatch was reduced in 2012 by 27% compared to the previous 5 years, with the greatest decrease in Laysan (*Phoebastria immutabilis*) versus Black-footed (*P. nigripes*) Albatross (36% and 11% declines, respectively). Northern fulmar (*Fulmaris glacialis*) bycatch, down by 39% compared to the 5-year average and 52% from the year before, remained the highest proportion in the catch at 61%. Fulmar bycatch has ranged between 45 to 76% of the total seabird bycatch since 2007. Average annual mortality for fulmars since 2007 has been 4,586. However, when compared to estimates of total population size in Alaska of 1.4 million, this represents an annual 0.33% mortality due to fisheries. There is however some concern that the mortality could be colony-specific possibly leading to local depletions.

The demersal longline fishery in Alaska typically drives the overall estimated bycatch numbers and constitutes about 91% of seabird bycatch annually (but see comment regarding trawl estimates below). Bycatch in the longline fishery showed a marked decline beginning in 2002 (Figure 1) due to the deployment of streamer lines as bird deterrents. Since then, annual bycatch has remained below 10,000 birds, dropping as low as 3,704 in 2010. Numbers increased to 8,914 in 2011, the second highest in the streamer line era, but fell back to 4,544 in 2012. The increased numbers in 2011 were due to a doubling of the gull (*Larus* spp.) numbers (1,084 to 2,206) and a 3-fold increase in fulmars, from 1,782 to 5,848. These species group numbers have decreased in 2012 as well, to 885 and 3,016 respectively. There are many factors that may influence annual variation in bycatch rates, including seabird distribution, population trends, prey supply, and fisheries activities. Work has continued on developing new and refining existing mitigation gear.

Albatross bycatch varied annually. The greatest numbers of albatross were caught in 2008. In 2012, 57.0% of albatross bycatch occurred in the GOA (down from 87% in 2011). The GOA typically accounts for 10 to 20% of overall seabird bycatch. Only Laysan albatross were taken in the BSAI, and all Black-footed Albatross were taken in the GOA (along with about 14 Laysan). While the estimated bycatch of black-footed albatross underwent a 4-fold increase in bycatch (44 to 206) between 2010 and 2011, the 2012 numbers are about 11% under the long-term average of 153 birds per year. Although the black-footed albatross is not endangered (like its relative, the short-tailed albatross), it was considered for listing as threatened and is currently a Bird of Conservation Concern by the U.S. Fish & Wildlife Service. Of special interest is the endangered short-tailed albatross (*Phoebastria albatrus*). Since 2003, bycatch estimates were above zero only in 2010 and 2011, when 2 birds and 1 bird were incidentally hooked respectively, resulting in estimated takes of 15 and 5 birds. This incidental take occurred in the Bering Sea area. No observed takes occurred in 2012 (or 2013 either). The expected incidental take of 4 birds every two years, since the Biological Opinion was revised in 2003, totals to 20 observed takes while the realized observed take has been 3 birds.

The longline fleet has traditionally been responsible for about 91% of the overall seabird bycatch in Alaska, as determined from the data sources noted above. However, standard observer sampling methods on trawl vessels do not account for additional mortalities from net entanglements, cable strikes, and other sources. Thus, the trawl estimates are biased low. For example, the 2010 estimate of trawl-related seabird mortality is 823, while the additional observed mortalities (not included in this estimate and not expanded to the fleet) were 112. Observers now record the additional mortalities they see on trawl vessels and the AFSC Seabird Program is seeking funds to support an analyst to work on how these additional numbers can be folded into an overall estimate. The challenge to further reduce seabird bycatch is great given the rare nature of the event. For example, in an analysis of 35,270 longline sets from 2004 to 2007 the most predominant species, Northern fulmar, only occurred in 2.5% of all sets. Albatross, a focal species for conservation efforts, occurred in less than 0.1% of sets. However, given the vast size of the fishery, the total estimated bycatch can add up to hundreds of albatross or thousands of fulmars (Table 1).

Table 1. Total estimated seabird bycatch in Alaskan federal groundfish fisheries, all gear types and Fishery Management Plan areas combined, 2007 through 2012.

Species/ Species Group	Year					
	2007	2008	2009	2010	2011	2012
Unidentified Albatross	16	0	0	0	0	0
Short-tailed Albatross	0	0	0	15	5	0
Laysan Albatross	17	420	114	267	189	128
Black-footed Albatross	176	290	52	44	206	136
Northern Fulmar	4,581	3,426	7,921	2,357	6,214	3,016
Shearwater	3,602	1,214	622	647	199	510
Storm Petrel	1	44	0	0	0	0
Gull	1,309	1,472	1,296	1,141	2,208	885
Kittiwake	10	0	16	0	6	5
Murre	7	5	13	102	14	6
Puffin	0	0	0	5	0	0
Auklet	0	3	0	0	0	7
Other Alcid	0	0	105	0	0	0
Other Bird	0	0	136	0	0	0
Unidentified	509	40	166	18	259	284
Total	10,228	6,914	10,441	4,596	9,298	4,977

The AFSC remains committed to work with the fishing industry, Washington Sea Grant, and others to meet the challenges of further reducing seabird bycatch. Seabird mitigation gear used on longline vessels can substantially reduce bycatch. Individual vessel performance varies, and further reduction of overall fleet averages may depend on targeted improved performance for a handful of vessels within the fleet. Additional methods, such as integrated weight longline gear, have been researched and shown to be effective. Continued collaboration with the longline industry will be important. Albatross bycatch in the Gulf of Alaska is generally higher than in other regions. With observer program restructuring and the deployment plan recommended by NMFS and approved by the North Pacific Fisheries Management Council, we will have a better sense of albatross bycatch issues within GOA-fisheries.

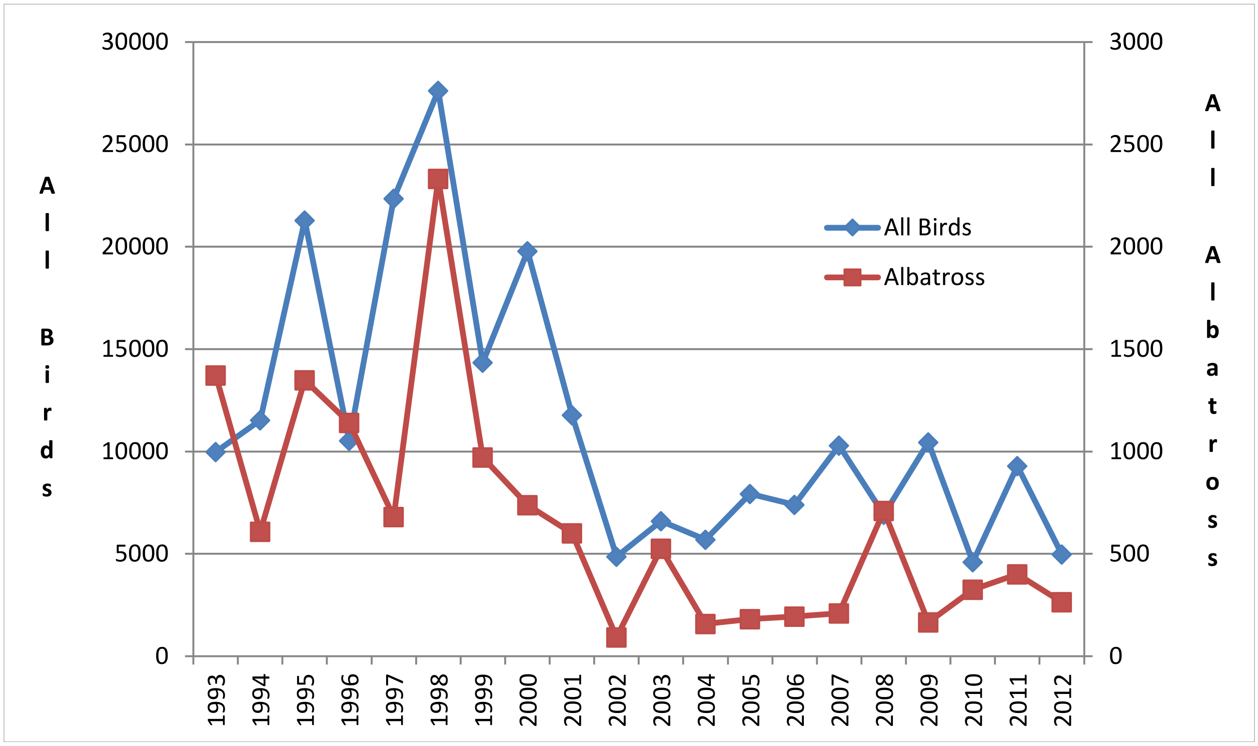

Figure 1. Seabird bycatch in Alaskan groundfish fisheries, all gear types combined, 1993 to 2012. Total estimated bird numbers are shown in the left-hand axis while estimated albatross numbers are shown in the right-hand axis.

Climate Impacts on Spawning Stock-recruitment Relationships from Multi- and Single-Species Stock Assessment Models

As part of a management strategy evaluation for the Bering Sea, the relationships between climate (i.e., water column temperature) and productivity (i.e., spring and fall zooplankton biomass) on spawning stock and recruitment relationships for three species of groundfish, walleye pollock, Pacific cod, and arrowtooth founder have been investigated. For this approach, recruitment estimates were first derived from a multi-species stock assessment models (MSM) fit to historical survey and fishery data. The model was run in multi-species mode, where each species is linked through a predation sub-model, as well as in single-species mode, where no predation interactions occur. This produced a time-series of spawning stock biomass and recruitment from the multi-species and single-species models. ROMS model estimates for mean water column temperature and spring and fall zooplankton biomass were then used as covariates on a Ricker stock recruitment curve, such that:

$$log(\hat{R}_{p,y}) = \log(\alpha_{R,p} \cdot SSB_{p,y-1}) - \beta_{R,p} \cdot SSB_{p,y-1} + \beta^{spr}_{Z,p} \cdot Z^{spr}_{y} - \beta^{fall}_{Z,p} \cdot \left(\delta^{fut}_{p,1,y} \big/ Z^{fall}_{y} \right) + \varepsilon$$

Where $\hat{R}_{p,y}$ is estimated recruitment in year *y* for species *p*, $SSB_{p,y-1}$ is the spawning stock biomass from the multi-species model, Z^{spr}_{y} and Z^{fall}_{y} are the total spring and fall zooplankton biomasses predicted from the ROMS/NPZ model for the Bering Sea, $\delta^{fut}_{p,1,y}$ is the ration of the youngest age class for each species, and

$\alpha_{R,p}$, $\beta_{R,p}$, $\beta_{Z,p}^{spr}$, $\beta_{Z,p}^{fall}$ are parameters of the recruitment function fit through maximum likelihood to recruitment from the multi-species model ($R_{p,y}$) such that $\varepsilon \sim N(0, \sigma^2)$ (Figure 3). Model estimates were compared via AIC and top models for each species were selected for use in projections of the multi-species model under future climate scenarios from ROMS/NPZ projections based on down-scaled IPCC climate model scenarios (Figure 4).

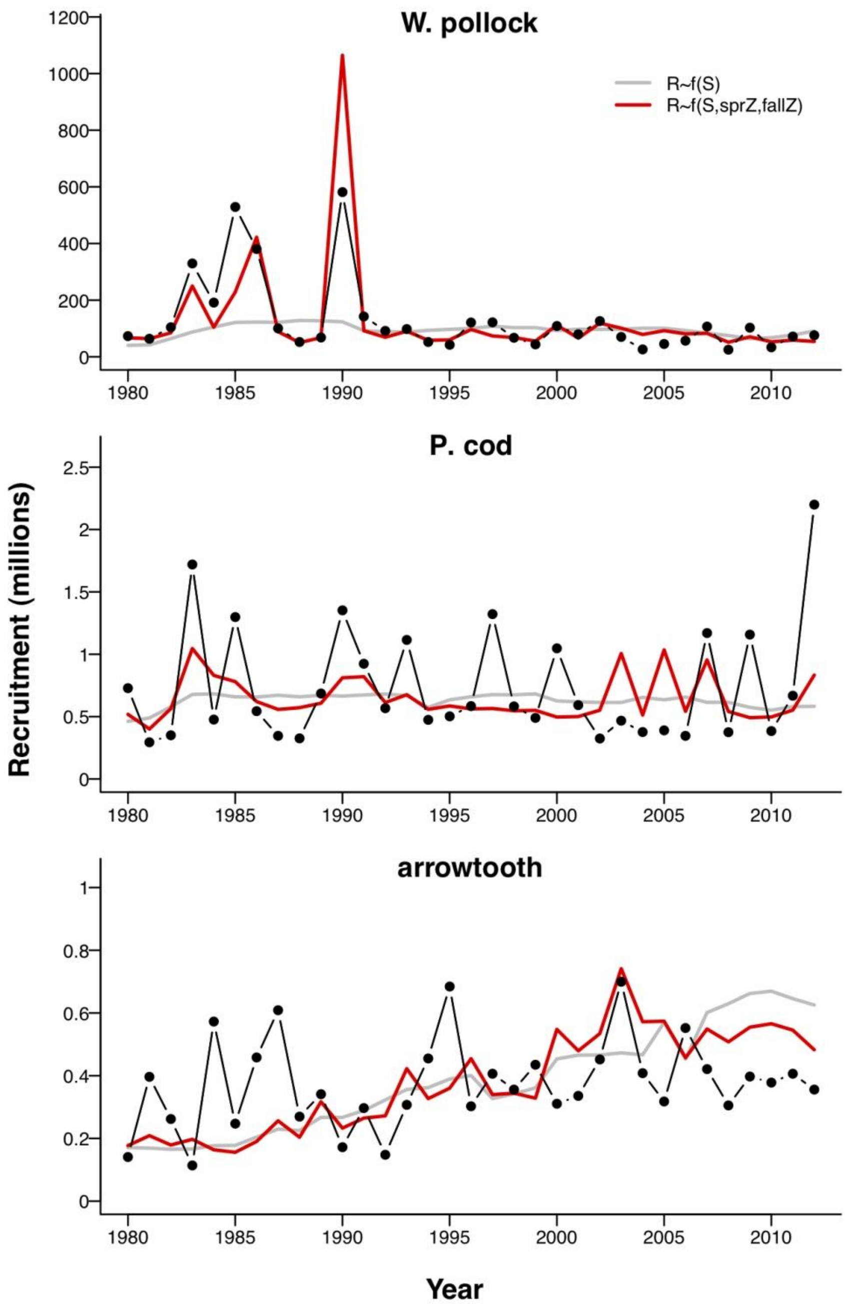

Figure 3. Recruitment estimates from the multi-species stock assessment model (black lines) and stock-recruitment regression model estimates for recruitment functions without zooplankton covariates (gray) and with zooplankton covariates (red).

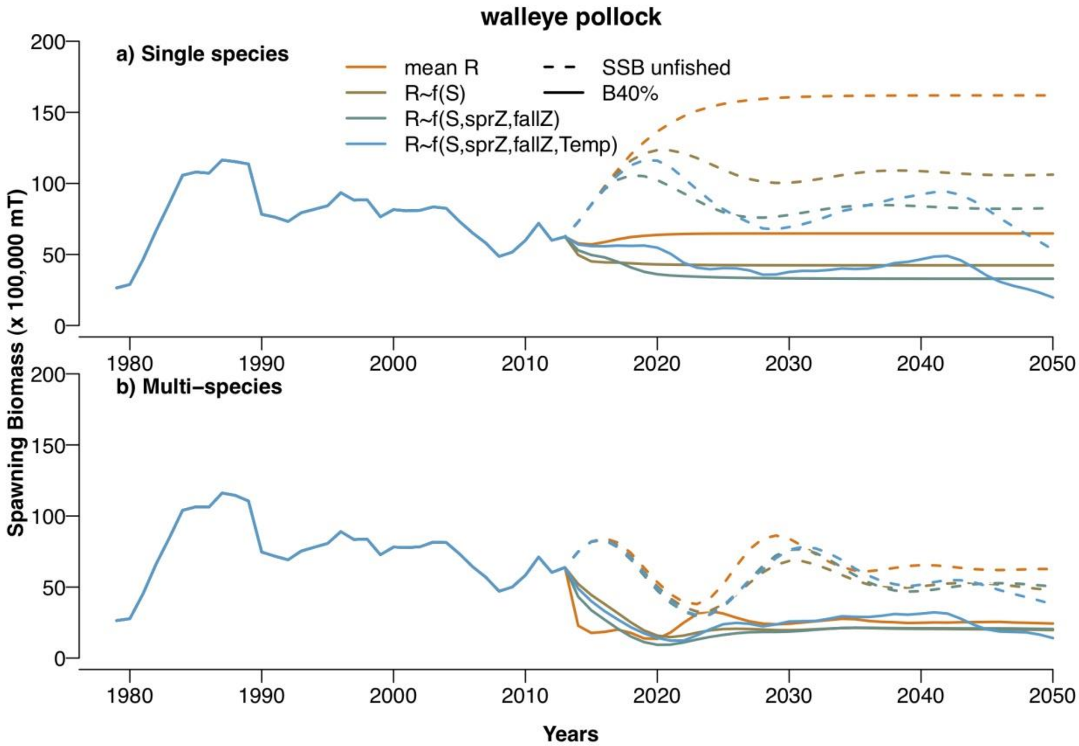

Figure 4. Projected spawning stock biomass for walleye pollock predicted from single (a) and multi-species (b) modes of MSM under various recruitment relationships and no harvest ("SSB unfished"; dashed line) or harvest that yields 40% of SSB on average during the last five years (2045-2050) of the projection (B40%; solid line).

Multispecies Management Strategy Evaluations

The North Pacific Fisheries Management Council (NPFMC) has stated that one of four priority objectives is to incorporate and monitor effects of climate change on Bering Sea and Aleutian Islands marine ecosystems and their dependent fisheries. Climate change is expected to impact marine ecosystems globally, with the largest changes anticipated for arctic and sub-arctic ecosystems. The 2 ^{o}C projected increase in mean summer sea surface temperature for Alaskan marine ecosystems may alter trophic demand, predator and prey distributions, and overall system productivity. REEM scientists are collaborating with REFM and PMEL scientists to use multi-species food-web and assessment models to link changes in the physical environment and food-web to recruitment and survival and help distinguish fishery impacts from large-scale climate pressures. Recently, model runs have been completed for the Bering Sea using a 10km^2 Regional Ocean Modeling System (ROMS) model coupled to a Nutrient-Phytoplankton-Zooplankton (NPZ) model to produce detailed hindcasts for the period 1970-2012 and forecasts using IPCC scenarios through 2040. These results drive a climate-driven Multispecies Statistical Model (MSM) for use in a management strategy evaluation of three groundfish species from the Bering Sea (walleye pollock, Pacific cod, arrowtooth flounder). First, ROMS model results modulate bioenergetics, food supply, growth, recruitment, and species overlap (i.e. functional responses and predation mortality) as fit in the MSM using hindcast-extracted time series. Then the MSM model is applied to downscaled IPCC climate projections via a ROMS and NPZ model projection of temperature, circulation, and zooplankton abundance. Results of model simulations have helped REEM scientists understand and predict how future climate driven changes to the system may impact predation and fishery harvest limits (Figure 5).

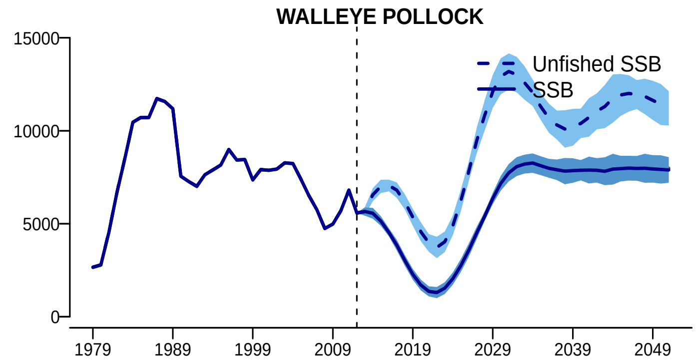

Figure 5. An example output from a multi-species stock assessment model that accounts for climate effects on future fished and unfished biomass estimates.

Alaska Integrated Ecosystem Assessments

The national IEA website team has recently completed an IEA website and it is now live at: www.noaa.gov/iea. The website serves as a portal for IEA research and highlights a number of recent advancements in regional IEAs (Figure 6). In addition, IEA scientists have recently completed a manuscript detailing the process for developing IEAs in a given region.

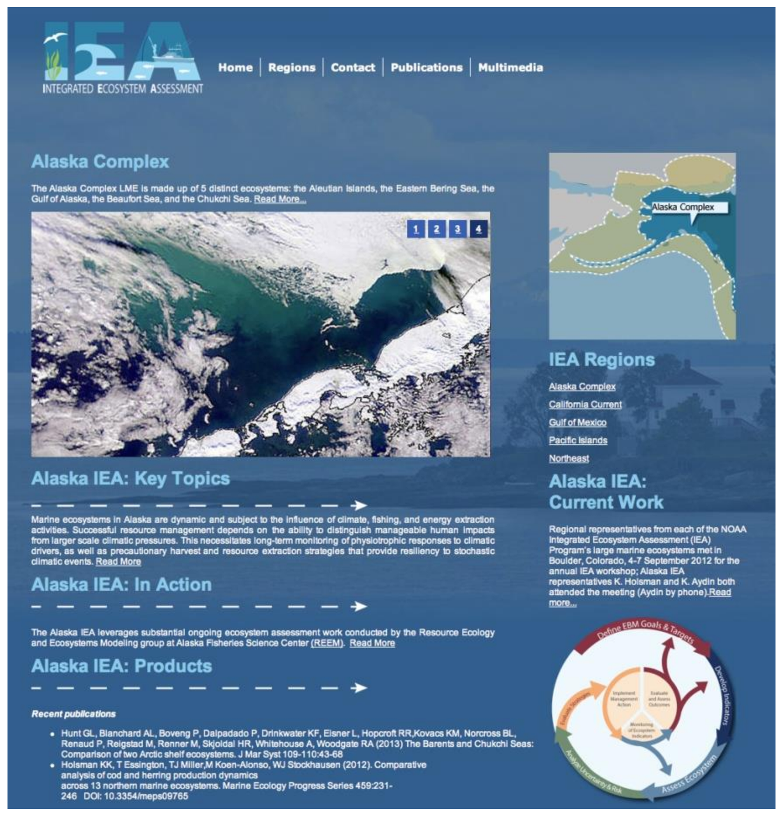

Figure 6. IEA home page summarizing processes and products.

Lastly, an integral component of the IEA process is to synthesize the response of ecosystem indicators to changes in natural and anthropogenic drivers (e.g., fishing and climate change) and develop ecosystem indicators and targets for conducting risk analyses. Ecosystem components identified as at risk are then targeted for intervention and evaluated for management actions through subsequent management strategy evaluations. AFSC and IEA scientists have recently leveraged efforts of an ongoing North Pacific Marine Science Organization (PICES) working group (WG-28) and FATE (Fisheries And The Environment) funded project to derive a composite index of ecosystem condition from combined risk scores for Alaskan marine habitats. The approach provides information on the relative risk of each habitat to combined climate and anthropogenic pressures (Figure 7; $Risk_h$) as well as an overall index of the present condition of the ecosystem that can be compared to a target Ecosystem Reference Point (ERP). The ERP and $Risk_h$ values can also be used to evaluate the probability of dropping below a specified ERP (and/or individual $Risk_h$) threshold under status quo or future climate conditions and management actions. The ERPs and included risk scores will be applied directly to the Alaska IEA and reported annually in the Ecosystem Assessment section

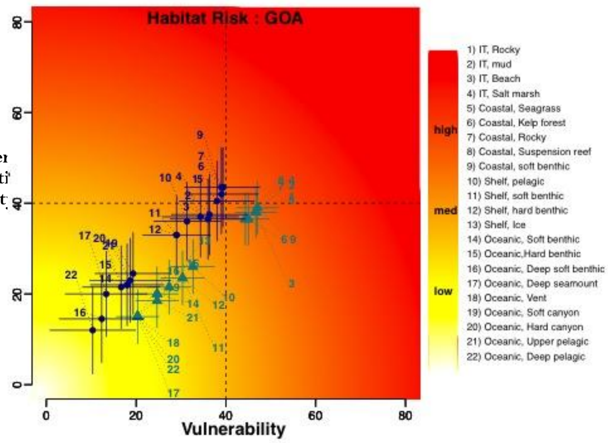

Figure 7. Habitat specific risk (cumulative for all pressures) for EBS and GOA ecosystems based on results of surveys from reviewers 1 and 2 (circles and triangles, respectively). Adapted from Samhouri and Levin (2012). Error bars represent uncertainty indices for each habitat (scored from 1 to 4; low to high).

of the regional stock assessment and fishery evaluation report. This report is reviewed annually by regional members of the North Pacific Fisheries Management Council.

Some promising groundwork towards an ecosystem risk assessment has recently been completed and new IEA and FATE support will help move this work towards a comprehensive synthesis for GOA and EBS marine ecosystems. Final $Risk_h$ and ERP values calculated and evaluated through this project will directly inform the Risk Assessment step of the Alaska IEA, and will serve as a framework for ecosystem risk analysis in regional IEAs that are in development elsewhere. Further, since the $Risk_h$ and ERP values can be improved through management actions as well as increased research and data quality (i.e., increase the certainty score), then this project can help identify both future management and research priorities.

Alaska Marine Ecosystem Considerations

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 eastern Bering Sea, the Aleutian Islands, the Gulf of Alaska, and the Alaskan Arctic. Consistent with ecosystem assessments of the eastern Bering Sea, Gulf of Alaska, and Aleutian Islands, the Arctic assessment includes a list of indicators that directly address ecosystem-level processes and attributes that can inform fishery management advice by communicating indicator history, current status, and possible future directions. Including the Alaskan Arctic to the Ecosystem Considerations report provides an overview of general ecosystem information that may form the basis for more comprehensive future Arctic assessments that would be useful for fishery managers making decisions on the authorization of new fisheries. The final report was presented to the Science and Statistical Committee and Council Advisory Board in December when the 2014 groundfish quotas were set. The report is now available online at the Ecosystem Considerations website at: http://access.afsc.noaa.gov/reem/ecoweb/index.cfm

Fishery Interaction Team (FIT), SSMA, REFM

The Fishery Interaction Team (FIT), a part of the Status of Stocks and Multispecies Assessment Program, in the REFM Division, conducts studies to determine whether commercial fishing operations are capable of impacting the foraging success of Steller sea lions either through disturbance of prey schools or through direct competition for a common prey. The present research focus is on the three major groundfish prey of sea lions: walleye pollock, Pacific cod and Atka mackerel.

FIT investigates the potential effects of commercial fishing on sea lion prey in two ways. First, by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones. FIT research examines the hypothesis that large-scale commercial fisheries compete with sea lion populations by reducing the availability of prey in relatively localized areas. Since 2000 FIT has been conducting field studies to examine the impact of fishing on sea lion prey fields in all three major Alaska regions: the Gulf of Alaska, Bering Sea and Aleutian Islands. The second way that FIT investigates the potential effects of commercial fishing on sea lion prey is by studying fish distribution, behavior and life history at spatial scales relevant to sea lion foraging (tens of nautical miles). This scale is much smaller than the spatial scales at which groundfish population dynamics are usually studied and at which stocks are assessed. This information is needed to construct a localized, spatially-explicit model of sea lion prey field dynamics that can be used to predict spatial and temporal shifts in the distribution and abundance of sea lion prey and potential effects of fishing on these prey fields.

In late winter-early spring 2012, FIT staff conducted an Atka mackerel tag recovery cruise in the Aleutian Islands. Tagging experiments are being used to estimate abundance and movement of Atka mackerel between areas open and closed to the Atka mackerel fishery. In 2013, staff estimated local abundance and movement probability inside and outside trawl exclusion zones with an integrated model that uses maximum likelihood to estimate all parameters simultaneously. These studies are needed to improve our understanding of whether trawl exclusion zones are effective at maintaining sufficient quantities of Atka mackerel prey for Steller sea lions foraging in the Aleutian Islands. In addition, data from multiple years of tagging will provide independent estimates of mortality rates that can be used to improve Atka mackerel stock assessment.

FIT staff also contribute to SSMA research objectives. In 2013, FIT staff began a two-year study of spatial and temporal variability of walleye pollock fecundity. Stock assessments for the Gulf of Alaska and Eastern Bering Sea would be markedly improved by the incorporation of contemporary fecundity estimates under current stock levels and climate regimes. During the first year of this project, archived ovary samples from NMFS research cruises were examined to determine which fecundity assessment methodology is appropriate, given the condition and preservation medium of the samples. Second year work will be an analysis of the demographic and environmental drivers of spatial and temporal variability observed in the fecundity estimates.

FIT also supports giant Pacific octopus stock assessments. In 2013 FIT staff initiated a field project to continue development and testing of habitat pot gear for directed octopus research. The AFSC wishes to develop this gear to facilitate life history, tagging, and other studies in support of the federal stock assessment for the octopus species group. The main objective is to determine the scope, effort, and costs that would be associated with a species-specific biomass index survey for octopus, using habitat pot gear. The project provided a loan of habitat pot gear from AFSC to two selected vessels in Kodiak, Alaska. These vessels fish the habitat pot gear on their own schedule and experiment with different configurations, soak times, and fishing methods. The participating vessels will provide AFSC and ADF&G researchers with detailed catch data and periodic access to the catch for life history specimens. This project represents a partnership between AFSC, ADF&G, and industry. Industry partners are interested in assessing the potential of octopus as a possible commercial species. AFSC and ADF&G need to develop field methodologies that will support future management decisions for octopus.

FIT research supports SSMA and AFSC priorities to advance ecosystem based fishery management, in particular in the Arctic. FIT participated in a multi-disciplinary survey of the Chukchi Sea in 2013. The Chukchi Sea is important for marine mammals, marine birds, numerous fish species, invertebrates and subsistence hunters of northern Alaska. Ecosystem studies in the Chukchi Sea have been limited in spatial and temporal coverage. For this reason, there is not enough information to characterize the status of the main tropic levels (fish and invertebrates) that support the majority of the top predators in the Chukchi Sea. The goals for this project (lead by the North Slope Borough, NSB) will be to collect data on: (1) water mass properties; 2) species composition, distribution and abundance of marine invertebrates 3) species composition, distribution and abundance of fish; and 4) fish diet. This information will be collected by providing research vessels as a platform of opportunity to various researchers, including staff from SSMA FIT. SSMA FIT staff, in collaboration with NSB and RACE surveyed the distribution and abundance and collected samples of demersal fish and benthic invertebrates.

Another key task of FIT staff is to provide analyses, advice and support to the Regional Office and the NPFMC in the preparation of Biological Opinions and Environmental Impact Statements. Libby Logerwell (FIT lead) is the Point of Contact, coordinating responses not only from FIT, but from other programs in REFM and RACE.

For more information on the FIT program, contact Libby Logerwell or access the following web link: http://www.afsc.noaa.gov/REFM/Stocks/fit/FIT.htm

C. By Species

1. Pacific Cod

a. Research

Juvenile Pacific Cod Seasonal Habitat Use and Movement Study - RACE GAP
In 2013, we finished the data collection for a project examining the seasonal habitat use and over wintering habits of juvenile Pacific cod, *Gadus macrocephalus*, within nearshore nursery areas of Kodiak Island, AK. Previous investigations have focused on the nursery requirements of age-0 and age-1+ juvenile Pacific cod, mainly during the summer. The current project is an extension of this prior work and focuses on examining the habitat use and movement patterns of older juvenile age classes (age 2+) still residing in the nursery areas. The project examines the hypotheses that older juvenile Pacific cod preferentially utilize bare substrate habitats and show strong site fidelity prior to the winter season and that juvenile cod winter migratory behavior will be variable among individuals. In 2010, we conducted a laboratory trial that examined the effects of intra-peritoneal tag implantation on juvenile Pacific cod and the results indicated this was a valid technique. In the fall of 2011 and 2012, 22 juvenile cod were captured in the field and fitted with acoustic transmitters. A combination of acoustic telemetry and a drop camera system was used to acquire habitat patch use of individual cod. In addition, a passive gate telemetry system was utilized to document the movement of individual cod transiting outside the nursery during the winter. Preliminary results suggest the habitat use of juvenile cod during the fall months was highly variable. Depth range of re-located tagged cod ranged from 11.5 to 86.5 ft. The bottom substrate varied from a bare sediment/shell mix in the deeper depths to a combination of the bare sediment/shell mix and kelp (*Agarum cribrosum* and *Laminaria* sp.) in the shallower depths. In 2011 and 2012, out-migrations commenced during late August to early September and typically occurred prior to the water column becoming isothermal. The early winter movements and residency patterns were highly variable among the tagged individuals. Some individuals briefly transited the acoustic gate during the fall and left the study area, while others resided in close proximity of the acoustic array near the mouth of the bay throughout the early winter months. Final analysis is ongoing and a manuscript will be completed in 2014. Results from this project will

contribute significant knowledge about essential fish habitat requirements of juvenile cod.

For further information please contact Brian Knoth (907) 481-1731.

Coastal Age-0 Pacific Cod Survey– Gulf of Alaska - RACE FBEP

The Fisheries Behavioral Ecology Program conducts research on the early life-history habitat requirements of commercially important Alaskan fish and crab species. Age-0 stages of Pacific cod are often restricted to surface waters or coastal nursery habitats where they are not available to the stock assessment trawl survey. As such, there are few direct measures of age-0 abundance data to fit stock-recruitment models and examine recruitment processes at this important early life stage. The Newport laboratory has been conducting an annual summer beach seine and camera survey of two coastal nurseries in Kodiak, AK across 16 sites since 2006. The survey samples are focused on age-0 and age-1 stages of juvenile Pacific cod, but also samples co-occurring juvenile walleye pollock and saffron cod. The Newport laboratory is examining this time-series and its efficacy of predicting year class strength locally (inshore) and more broadly (offshore) across the Gulf of Alaska. Models are also examining variance of sequential year class prediction as a function of habitat (e.g., structure, unstructured), spatial scale (within bay, across bay, regional), time of year (newly vs. late-settled fish) and environment (e.g., temperature, salinity). Mechanisms of such relationships will be examined using available seasonal and annual vital rate information for each species in each system

Vertical Availability of Pacific cod to Survey Bottom Trawls on the Eastern Bering Sea Shelf - RACE GAP

Pacific cod (*Gadus macrocephalus*) are an abundant and commercially valuable bottom fish in Alaska waters (REF). Bottom trawl (BT) surveys are the primary source of fishery independent data for informing stock assessment models about population trends of Pacific cod. Pacific cod occupy both demersal and pelagic habitats, so understanding their vertical availability to BT surveys is critical to the reliability of stock abundance estimates. Results from an archival tag study of Pacific cod suggested that BT survey abundance estimates were negatively biased because the tag data showed that 52.7% of cod resided above the functional height of the survey trawl headrope (2.5 m) making them unavailable to the survey BT gear. By increasing the functional headrope height to 7.0 m the total proportion of cod unavailable to the BT decreased to only 8.4%. Data from the archival tags were representative of the “average” Pacific cod living under natural and undisturbed conditions during daylight hours and did not record the behaviors of Pacific cod responding to external factors which may have affected their vertical distribution, such as presence of a trawl vessel or approaching trawl gear. Other limitations to the archival tag study were a low sample size (n=11) and narrow size range (60-81 cm) of Pacific cod.

There is good evidence that gadoids, in general, dive in response to vessels, trawls, or both. Acoustic echograms from a stationary buoy or from a second vessel in the path of an approaching trawler have shown diving responses for Pacific hake (*Merluccius productus*) and haddock (*Melanogrammus aeglefinus*). From the analysis of 20,000 individual acoustic targets collected by a free-floating buoy in the path of a BT vessel, it was concluded that a dive response in gadoids was triggered by the start-trawling event. In a detailed analysis of BT efficiency using a combination of trawl and acoustic data, it was estimated that walleye pollock (*Gadus chalcogrammus*) within 16 m of the seafloor were vertically herded into a survey trawl having a 2.5 m mean headrope height. The vertical availability of Pacific cod relative to bottom-trawling activity has not been studied and more detailed knowledge is needed in order to understand the precision and reliability of BT survey abundance estimates of Pacific cod used in stock assessment models.

To investigate vertical availability of Pacific cod to the BT, this study used a side-by-side BT experiment and analysis of acoustic data collected during the side-by-side experiment and from other BT surveys. The side-by-side experiment was used to test the null hypothesis that there was no difference in the vertical availability of Pacific cod between a low-opening (2.5 m) and a high-opening (7.0 m) BT. If results from the archival tag study are a typical representation of the vertical structure of Pacific cod from across the Bering Sea shelf, and if vertical availability of Pacific cod to the BT is unaffected by bottom-trawling activity (i.e., diving response), the expectation would be that the low-opening trawl would have approximately half the catch rate of Pacific cod compared to the high-opening trawl. Acoustic data from the experiment and from other historical BT survey tows were also analyzed to investigate whether the vertical structure of Pacific cod and their availability to the BT changed by area, during different times of day, or at different bottom depths. Abundance estimates from the acoustic analyses and the proportion of Pacific cod between the seafloor and 2.5 m and between 2.5 and 7.0 m were compared to corresponding BT abundance estimates to determine if vertical availability of Pacific cod to the BT varies during general survey operations conducted in different areas on the shelf and at different bottom depths. Possible mechanisms for non-varying vertical availability of Pacific cod to the BT survey are also discussed. For more information, contact Bob Lauth, e-mail: bob.lauth@noaa.gov

Examining Genetic Stock Structure of Pacific Cod in the NE Pacific - RACE Recruitment Processes

A study of microsatellite DNA variation across the geographic range of Pacific cod in North America found a clear genetic isolation-by-distance pattern for coastal populations. Notable exceptions to this pattern were from the Georgia Basin (Puget Sound and the Strait of Georgia). Further screening of mitochondrial DNA variation revealed that the Georgia Basin group represented a distinct evolutionary lineage. The distinctness of this group from the coastal group, and to some degree between Puget Sound and the Strait of Georgia, provides the first evidence for estuarine stocks in this species. This may be of particular relevance for conservation and management of the transboundary Strait of Georgia population, one of four stocks recognized for management in Canada. Contact Mike Canino (Mike.Canino@noaa.gov) for more information.

Genomic Evidence for Localized Adaptation in Salish Sea Pacific Cod - RACE Recruitment Processes

M. Canino and L. Hauser (University of Washington) have received funding for a two-year project to assess the potential for adaptive differentiation in Puget Sound compared with coastal Pacific cod, two groups that have already been differentiated using neutral genetic markers. We will rear Puget Sound and coastal larvae in common garden experiments to determine the effects of temperature on family-specific survivorship. Next-generation sequencing techniques will be used to determine and annotate specific genes associated with survivorship at different temperatures. Results should provide insight into localized adaptation of Salish Sea (Straits of Georgia and Juan de Fuca, Puget Sound) Pacific cod and the potential for adaptation in response to projected future climate change. Contact Mike Canino (mike.canino@noaa.gov) for more information.

Pacific cod Dispersal Patterns and Nursery Habitat Use in the Bering Sea - RACE FBEP
The Fisheries Behavioral Ecology program is collaborating with the RACE-Recruitment Processes Program, ABL-Ecosystem Monitoring and Assessment Program, and Oregon State University to examine the dispersal patterns of larval and juvenile Pacific cod and their use of coastal nursery habitats. In 2013, data analysis focused on the basin-wide distribution of age-0 Pacific cod, with future work examining spatial variation in diet and growth rates.

Dispersal patterns:
Pacific cod in the southeastern Bering Sea aggregate at discrete spawning locations but there is little information on patterns of larval dispersal and the relative contribution of specific spawning areas to nursery habitats. Otolith elemental variation can be used as a natural biomarker reflecting patterns of dispersal and mixing. Age-0 Pacific cod from two cohorts (2006 and 2008) were examined to address the following questions: (1) does size, age, and otolith chemistry vary among known capture locations; (2) can variation in elemental composition of the otolith cores (early larval signature) be used to infer the number of chemically distinct sources contributing to juvenile recruits in the Bering Sea; and (3) to what extent are juvenile collection locations represented by groups of fish with similar chemical histories throughout their early life history? Hierarchical cluster (HCA) and discriminant function analyses (DFA) were used to examine variation in otolith chemistry at discrete periods throughout the early life history. HCA identified five chemically distinct groups of larvae in the 2006 cohort and three groups in 2008; however, three sources accounted for 80-100% of the juveniles in each year. DFA of early larval signatures indicated that there were non-random spatial distributions of early larvae in both years, which may reflect interannual variation in regional oceanography. There was also a detectable and substantial level of coherence in chemical signatures within groups of fish throughout the early life history. The variation in elemental signatures throughout the early life history (hatch to capture) indicates that otolith chemical analysis could be an effective tool to further clarify larval sources and dispersal, identify juvenile nursery habitats, and estimate the contributions of juvenile nursery habitats to the adult population within the southeastern Bering Sea.

Pacific cod nursery habitats:
In four years of demersal beam trawling on the southeastern Bering Sea shelf at depths of 20 – 140 m, age-0 Pacific cod were most abundant along the Alaska Peninsula at depths to 50 m. In addition, one year of spatially intensive beam trawl sampling was conducted at depths of 5 – 30 m in a nearshore focal area along the central Alaska Peninsula. In this survey, age-0 cod were more abundant along the open coastline than they were in two coastal embayments, counter to patterns observed in the Gulf of Alaska. Demersal sampling of the shelf and nearshore focal area in 2012 was conducted synoptically with surveys of surface and subsurface waters over the continental shelf. As observed in earlier studies, age-0 cod were captured in pelagic waters over the middle and outer shelf, with maximum catches occurring over depths of 60-80 m. The similar size distributions of fish in coastal-demersal and shelf-surface habitats and the proximity of concentrations in the two habitat types suggests that habitat use in the Bering Sea occurs along a gradient from coastal to pelagic. While capture efficiencies may differ among trawl types, CPUE of age-0 cod in demersal waters along the Alaska Peninsula was 25 times that observed in the highest density pelagic-shelf habitats, demonstrating the importance of coastal nursery habitats in this population. Despite representing a much smaller habitat area, the cumulative contribution of coastal waters along the Alaska Peninsula appears to be markedly larger than those of offshore pelagic and demersal habitats.

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS - REFM

There was a major change in the Pacific cod assessment this year. Previously an analytical assessment was done for cod in the eastern Bering Sea (EBS), and the abundance estimate from that assessment was extrapolated to the Aleutian Islands (AI) region on the basis of survey estimates of relative abundance. This year, in anticipation of separate regional specifications of OFL and ABC by the SSC, separate assessments were done for the EBS and AI regions. The assessment author and the Team recommended a Tier 3 assessment for the EBS and a Tier 5 assessment for the Aleutians.

For the current assessment all survey and commercial data series on CPUE, catch at age, and catch at length were updated. Survey CPUE has been mostly steady since 2010, with modest decreases between 2012 and 2013 (numbers down 24%, biomass down 11%). As in the last several years, a number of alternative candidate models were considered at Team/SSC meetings in May/June and September/October, but owing to the government shutdown in October none was implemented, so there were no changes in assessment methods from 2012. The 2013 assessment is a rerun of last year's accepted model (Model 1, the same as the 2011 accepted model) with updated data files.

The stock assessment model estimates that the 2006, 2008, and 2010 year classes are strong, the stock is at a high level and spawning abundance is expected to increase in the near term. $B_{40\%}$ for this stock is estimated to be 318,000 t and projected spawning biomass in 2014 according to Model 1 is 361,000 t, therefore this stock is assigned to Tier 3a. The author recommended that ABCs for 2014 and 2015 be set at the maximum permissible levels under Tier 3a, which are 255,000 t and 272,000 t, respectively. The corresponding OFLs are 299,000 t and 319,000 t. EBS Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

For the Aleutian Islands, for many years there has been concern that a disproportionate share of the BSAI TAC was being taken from the Aleutians. The separate specification of EBS and AI OFL/ABC for the AI region is a response to that practice. Although separate assessments of the AI stock have been included in the last two SAFE reports (an approach based on Tier 5 in 2011 and multiple age-structured models in 2012), none have yet been accepted by the SSC. This year's assessment contains two models that would be consistent with management under Tier 3, and two others that would be consistent with management under Tier 5. All four models were requested by the Team and SSC. The AI assessment data consist of catch in weight and catch length frequencies from the commercial fishery, and CPUE and length frequencies from the AI trawl survey. The only age data are from the 2012 survey.

The survey time series from 1991-2012 shows a fairly consistent decline in Pacific cod biomass throughout the Aleutian Islands. The Team Plan Team concluded that neither of the age-structured models performed credibly. For the time being, the author and the Team recommend a Tier 5 approach which utilizes the random effects model. Assuming a natural mortality rate of 0.34 (as in the EBS assessment), this method estimates the 2014 and 2015 maximum permissible ABCs at 15,100 t. The corresponding OFLs for both years are 20,100 t. Work on a Tier 3 assessment is anticipated to continue.
This stock is not being subjected to overfishing. Assuming that the SSC concurs with the Team's recommendation to manage this stock under Tier 5, it is not possible to determine whether this assemblage is overfished or whether it is approaching an overfished condition.

GULF OF ALASKA

For the 2013 stock assessment the fishery data series was updated with catch for 2003-2013 (projected for 2013 expected totals) and updated 1997-2012 seasonal and gear-specific catch-at-length. The survey data series was updated with 2013 NMFS bottom trawl survey data for abundance and length composition. The 2013 trawl survey biomass estimate increased by 1% from the 2011 value. The 2013 GOA Pacific cod assessment author evaluated two models. Model 1 is identical to the final model configuration from 2012 that omitted all of the sub-27 survey data (abundances and size composition data for Pacific cod that are 27cm or less). Model 2 is identical to Model 1 but with age-0 recruits excluded from estimation for the 2010 and 2011 year classes (they are set to average levels). Model 1 only had the 2012 and 2013 year classes set to the average.

Model 2 was selected by the author as the preferred model primarily because the estimate of recruitment for the 2010 and 2011 year classes is highly uncertain and there is limited information in the data to estimate these year classes. The Plan Team accepted the author's recommendation to use Model 2 as the preferred model. The Team also noted that comparison of likelihood components indicated small differences in fits between the two model configurations, signifying that estimation of the two additional recruitment parameters in Model 1 is not justified.

Model results indicate that the estimated age-0 recruitment has been relatively strong since 2005, and stock abundance is expected to be stable and at a high level (well-above $B_{40\%}$) in the near term. $B_{40\%}$ for this stock is estimated to be 91,100 t and projected spawning biomass in 2013 according to Model 2 is 120,100 t, therefore this stock is determined to be in Tier 3a. Neither the author nor the Plan Team saw any compelling reason to recommend OFL or ABC values lower than prescribed by the standard control rule. The current values of $F_{35\%}$ and $F_{40\%}$ are 0.69 and 0.54. The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

In 2012 the ABC of Pacific cod was apportioned among regulatory areas based on trawl surveys using a Kalman filter approach. The SSC concurred with this method in December 2012. In this year's assessment the random-effects model was used (which is similar to the Kalman filter approach and adopted by the survey average working group). This method, using the updated trawl survey data, results in apportionments of 37% in the Western GOA, 60% in the Central GOA, and 3% in the Eastern GOA.

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

2. Walleye Pollock

a. Research

Seasonal Fish and Oceanographic Surveys to Link Fitness and Abundance of larval and Age-0 Walleye Pollock to Climate Change and Variability on Bering Sea Ecosystems - ABL

The eastern Bering Sea (EBS) shelf is a highly productive ecosystem, where atmospheric forcing, duration and extent of sea ice cover, and transport through ocean passes in the Aleutian Islands dominate the physical processes on the shelf. Inter-annual variability in these processes is believed to influence the distribution, feeding, growth, and recruitment of important fisheries stocks. Physical oceanographic features (e.g. sea surface temperature (SST), fronts, mixed layer depth) and lower trophic level dynamics (e.g. primary production, zooplankton prey availability) also are critical to understanding migration, distribution, and survival of forage fish. Research on the interaction between physical oceanography, plankton, and forage fish such as age-0 walleye pollock (*Gadus chalcogramma*) and juvenile Pacific salmon (*Oncorhynchus spp.*) has been conducted annually by Auke Bay Laboratories Ecosystem Monitoring and Assessment Program researchers in 2000–2012, with biennial surveys planned for 2014 and onward. These surveys are part of a joint effort with other AFSC/NOAA programs, including the Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), the RACE Division's Midwater Assessment and Conservation Engineering (MACE) Program, REEM program within REFM Division and ABL's Recruitment Energetics Coastal Assessment (RECA) Program to examine recruitment processes of walleye pollock. Larval and juvenile fish and oceanographic information are collected during spring followed by epipelagic trawl and midwater acoustic surveys during late summer/early fall (August-October). The surveys provide information to assess the abundance and condition of these fish during the larval to juvenile stages and at the end of their early marine growth period, prior to their first winter.

The few large-scale studies of walleye pollock in the Bering Sea have mainly focused on their distribution in relation to sea-ice conditions. In contrast, the seasonal time series on critical life stages of walleye pollock is presently the only shelf-wide data available to examine marine survival from spring to fall in the EBS. This time series provides integrated information on energy density, diet, abundance, and distribution in relation to changing ocean conditions. Such information coupled with an age-0 abundance index provides a unique opportunity to evaluate survival of juvenile walleye pollock relative to the reproductive output estimated from pollock stock assessments. For example, we have found a direct correlation ($r^2 = 0.73$) between the energy content of age-0 pollock (kJ/fish) and the number of age-1 recruits as predicted in the pollock stock assessment. These data are currently being considered for inclusion in the EBS pollock stock assessment to help understand climate and ecosystem variability on pollock recruitment in an effort reduce the uncertainty in recommended total allowable catch .

Our survey results have been used to document the rapidly changing marine conditions in the EBS during the past ten years and provide baselines and analogues for different climate regimes. The EBS SST's underwent large-scale warming from 2002-2005 followed by substantial cooling in 2006-2012. These shifts altered fisheries distributions and have the potential to affect the overall ecology of this region. Coincident with changes in the SST we have observed changes in the energy density (kJ/g) of age-0 pollock. For example, age-0 pollock energy density was low during 2002 to 2005, but significantly increased during 2006 to 2012. Recent data during the cool period suggests that age-0 pollock have maximized their energy content. The extent of winter sea ice and its rate of retreat influences spring bloom dynamics, secondary production, and the spatial extent of the cold-water pool during the summer. Because most fish growth occurs during the summer, the winter and spring climatic forcing along with summer atmospheric and oceanographic conditions will dramatically affect fish distribution and production. For more information, contact Ed Farley at (907) 789-6085 or ed.farley@noaa.gov.

Factors Affecting the Availability of Walleye Pollock to Acoustic and Bottom Trawl Survey Gear - RACE GAP

Abundances of semi-pelagic fishes are often estimated using acoustic or bottom trawl surveys, both of which sample only a fraction of the water column. Acoustic instruments are effective at sampling the majority of the water column, but they have an acoustic dead zone (ADZ), where fish near the seafloor are undetected. Bottom trawls are effective near the seafloor, but miss fish that are located above the effective fishing height (EFH) of the trawl. Quantification of the extent of omission between these gears is needed, particularly in cases where environmental factors play a role. We developed logistic regression models to predict the availability (q_a) of walleye pollock (*Gadus chalcogrammus*) to both acoustic and bottom trawl gears using factors shown to affect q_a (depth, light intensity, fish length) and introducing additional factors (tidal currents, surface and bottom temperature, sediment size). Results build on earlier studies and quantify the uncertainty associated with the estimation of the ADZ correction using Bayesian methods. Our findings indicate that on average, availability of walleye pollock to the bottom trawl is larger than to the acoustics. Availability to both gears depends mostly on bottom depth, light conditions, and fish size, and to a lesser extent on sediment size. Availability to the acoustic gear depends also on surface temperature. Variability in availability to both gears also depends on environmental factors.

For more information, contact Stan Kotwicki, e-mail: stan.kotwicki@noaa.gov

Walleye Pollock Ichthyoplankton Dynamics in the Bering Sea - RACE Recruitment Processes
The Eco-FOCI program conducts ongoing work to examine seasonal linkages between spring spawning areas, early summer distribution patterns, and late summer/early fall occurrences of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. We conduct annual surveys in spring to assess abundance of eggs and larvae of walleye pollock (*Theragra chalcogramma*) over the eastern Bering Sea shelf, and to describe larval fish assemblages after the late winter spawning season. Data are used to determine how physical and biological factors affect the transport, distribution, recruitment and survival of fish larvae. We have previously documented spatial shifts in the distribution of early life stages to the east (middle domain) under warmer-than-average conditions over the Bering Sea shelf.

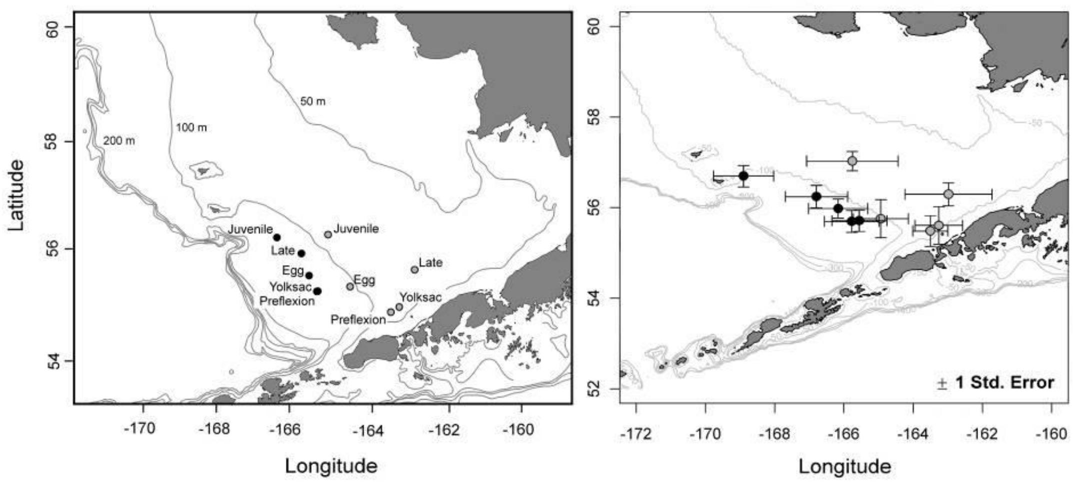

Figure 1. Early life stages of walleye pollock are distributed over the outer shelf during cold periods (filled circles) and over the middle shelf during warm years (open circles). Error bars denote 1 STD.

Most recently individual-based model of pollock early life stages was developed by coupling a hydrodynamic model (ROMS-NEP6) to a particle-tracking model with biology and behavior (TRACMASS). Simulation experiments were performed with the model to investigate the effect of wind on transport, ice presence on time of spawning, and water temperature on location of spawning. This modeling approach benefited from the ability to individually test mechanisms to quantitatively assess the impact of each on the distribution of pollock. Neither interannual variations in advection nor advances or delays in spawning time could adequately represent the observed differences in distribution between warm and cold years. Changes to spawning areas, particularly spatial contractions of spawning areas in cold years, resulted in modeled distributions that were most similar to observations (Figure 2). The location of spawning pollock in reference to cross-shelf circulation patterns is important in determining the distribution of eggs and larvae, warranting further study on the relationship between spawning adults and the physical environment.

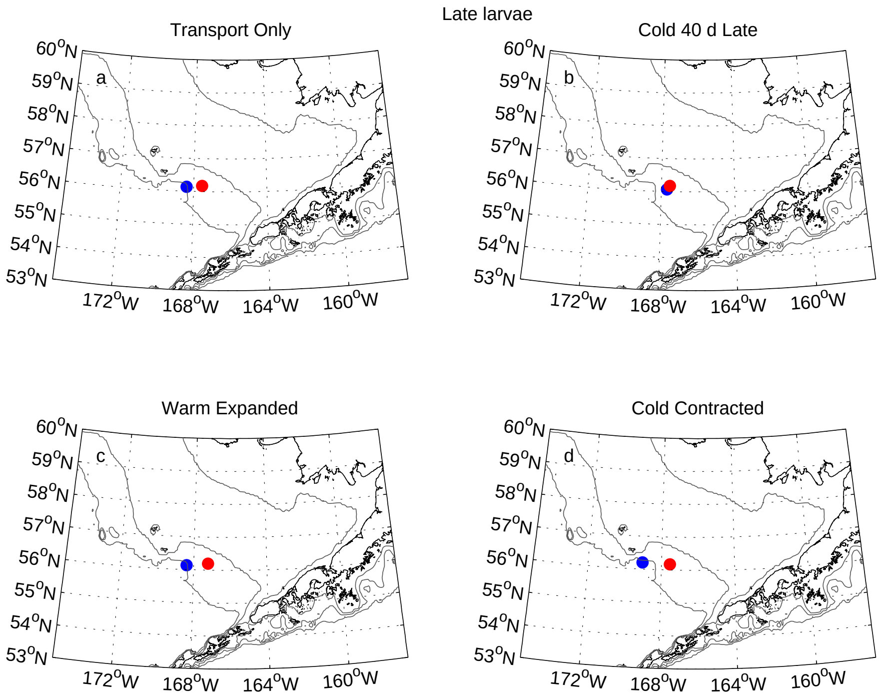

Figure 2. Modeled centers of gravity of pollock larvae (10-40 mm SL) in cold (blue) and warm (red) years for all model scenarios. Transport Only = interannual variations in advection, Cold 40 d Late = spawning delayed by 40 days under cold conditions, Warm Expanded = spawning distribution expanded eastward under warm conditions, Cold Contracted = spawning distribution contracted westward under cold conditions.

Work from seasonal surveys described above is also being utilized to examine variations in ichthyoplankton assemblages and relationships of larval fish communities with climate and oceanographic variables. Data show strong cross-shelf gradients delineating slope and shelf assemblages, an influence of water masses from the Gulf of Alaska on species composition, as well as differences in relative abundances between warm and cold periods. Understanding these variables can elucidate ecosystem-level responses to climate variability, and we are working toward understanding how community-level changes in ichthyoplankton composition reflect species-specific responses to climate change.

Walleye Pollock Age-0 Ecology in the Gulf of Alaska - RACE Recruitment Processes
Eco-FOCI conducts small-mesh midwater trawling cruises, mostly in alternate years, primarily to study the biology and ecology of small neritic forage fishes in the GOA. Due to their commercial importance, research focuses on juvenile walleye pollock. However, capelin and eulachon are studied because these species are poorly covered by groundfish assessments and because their importance in the GOA food web has been underscored by food web modeling.

Eco-FOCI research on these fishes focuses on the western GOA where walleye pollock are prevalent and during late summer and early autumn when age-0 fish are abundant. Our findings indicate that age-0 walleye pollock and capelin are broadly distributed across the shelf during late summer while older walleye pollock (age1+) and eulachon occur in association with elevated current velocity and krill population density. At this time of year, age-0 walleye pollock and capelin exhibit opposite cross-shelf gradients in body size: age-0 walleye pollock are largest near shore and capelin are largest offshore. Considerable overlap in food habits exists, with all species consuming copepods and krill, but capelin and age-0 walleye pollock respond differently to low krill availability. Eulachon are almost singularly dependent on krill, while walleye pollock are flexible zooplanktivores. For age-0 walleye pollock, the area off east Kodiak Island provides greater food-related benefits than the more heavily populated area downstream of Shelikof Strait due to higher krill abundance that is associated with greater oceanic influence (Figure 1).

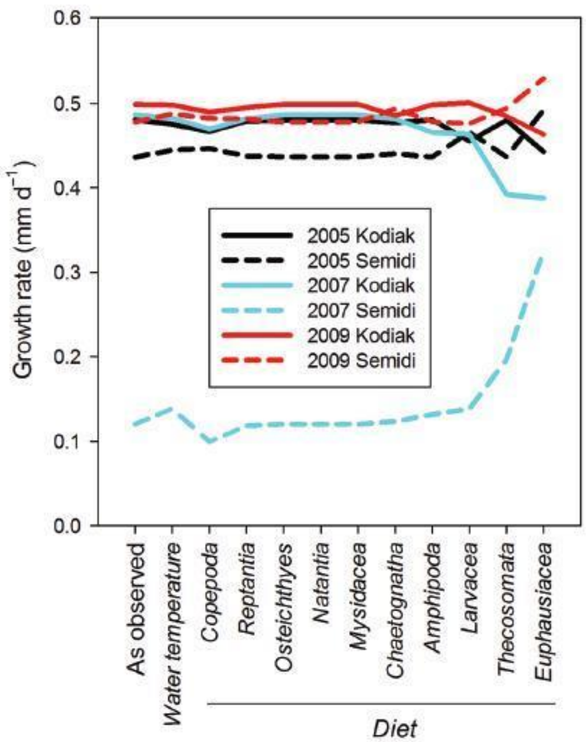

Figure 1. Bioenergetics model-based estimate of growth rate of a 70-mm SL age-0 walleye pollock with the observed weight-based diet at observed water temperatures. Lines show how growth rate estimates were affected when water temperature or the proportion of each dietary component was, in turn, equated between regions (Kodiak, Semidi).

We are investigating spatial and temporal variation in the size of prey consumed by these species to assess whether predator-prey size ratios govern energy flux through marine food webs (including commercially important fishes, protected marine mammals and seabirds). In the GOA, small neritic fishes support a predator-dominated coastal food web. Samples of "forage fishes" collected with small-mesh midwater trawls are dominated by juvenile walleye pollock (*Gadus chalcogrammus*), a gadid, and two smelts (Osmeridae): capelin *Mallotus villosus* and eulachon *Thaleichthys pacificus*. These fishes consume copepods, euphausiids, and other zooplankton depending on predator species and size, and they exhibit species-specific responses to meso-scale spatial and temporal variation in the zooplankton community that relates to bathymetry and hydrography. The availability of body-mass data from these studies should enable us to verify a previously published predator-prey mass relationship, but we will use a broader collection of GOA forage fishes; existing data will also enable us to examine the mass ratio among species over several years and meso-scale geographic regions for evidence that size ratios are resilient to geographic variation in habitat quality and yet sensitive to taxonomic change. Work on this project is being done in consultation with AFSC ecosystem modelers due to its relevance to the REEM Program's FEAST model.

Eco-FOCI has leveraged opportunities to collaborate with other programs that conduct studies that put our late-summer studies into a seasonal context to better understand the spatial-temporal interactions that determine year-class strength. Overwinter samples collected by other programs showed that the benefit to juvenile walleye pollock of rearing off Kodiak Island was restricted seasonally to late summer and only when fish are age-0 juveniles. For age-1 walleye pollock, otolith-based growth trajectories indicate that the growing season lasts almost 7 months with a 0.6 mm/day peak in growth during early July (Figure 2). Onset of the growing season corresponds with vernal lengthening of the photoperiod while autumnal slowing may reflect increased thermal stress.

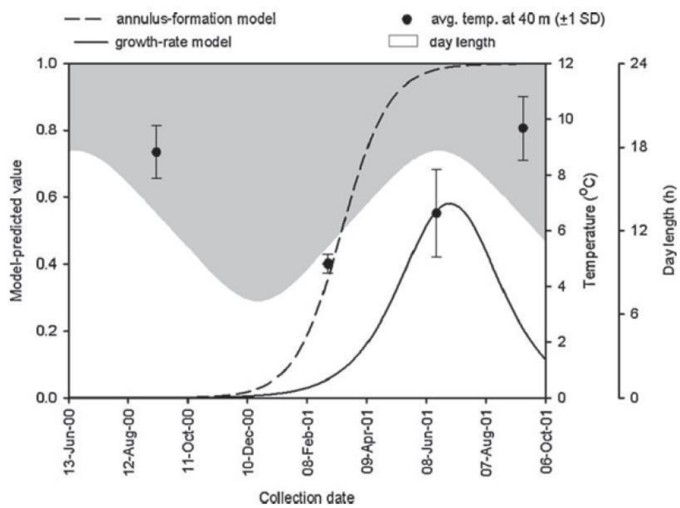

Figure 2. For age-0+ juvenile walleye pollock in the Gulf of Alaska, empirically derived models of first annulus formation and post-annulus growth rate are compared to time series of observed water temperature at 40-m depth and predicted day length.

We are investigating the use of otolith chemistry as a natural tag to identify GOA pollock nurseries, which are areas that contribute substantially to the adult population. This will provide geographic focus to subsequent research and management efforts to understand recruitment and protect essential nursery habitat. Preliminary results indicate that the chemical signature of age-0 juvenile walleye pollock otoliths differ between fish collected off Kodiak Island versus those from farther southwest in the Semidi Bank vicinity. It appears that the Kodiak fish have concentrations of strontium and barium isotopes in recently deposited otolith material that are relatively high and low, respectively. This work is being done in collaboration with experts in otolith elemental composition at Oregon State University and at the AFSC, REFM's Age and Growth Program.

The survey conducted by Eco-FOCI during August-October 2013 to survey neritic fish populations, zooplankton, and physical oceanography encompassed an unprecedented geographic extent in the

Gulf of Alaska from Unimak Pass to, but not including, Prince William Sound. Although the data and samples are currently being prepared for analysis and archival, preliminary results indicate that the 2013 year class of walleye pollock is likely to be large relative to those observed since 2000. This "early alert" has been included in presentations to the Plan Team on the Gulf of Alaska ecosystem status.

Recently, Eco-FOCI researchers have been tasked with examining the suitability of surface and midwater trawls to conduct assessment surveys of age-0 walleye pollock. Goals are threefold: to compare catch per unit effort of YOY among the gear types, to compare the size ranges of walleye pollock collected, and to compare the community assemblage of fishes collected across gear types. We have accomplished two activities. First, we conducted two paired-tow comparisons, each consisting of replicate tows, between the Cantrawl and the Stauffer (aka anchovy) trawl during the 2013 field season in Kalsin Bay, Kodiak Island, where the sea state was calm enough to safely change between the large Cantrawl doors and the small Stauffer-trawl doors. The catch and length data preliminarily indicate that size ranges of age-0 walleye pollock are similar between the two nets (50-80 mm SL), though greater numbers of the smallest sizes (<60 mm SL) were collected with the Stauffer trawl. Species catch compositions were similar, but absolute numbers collected and species biomass were greater using the Cantrawl. Second, we conducted a gear-trial experiment to investigate whether longer bridles compensate for overspreading of the Stauffer trawl when fished with over-size doors, which may be necessary for conducting paired-tow comparisons in the Bering Sea where the sea state will make door changes unsafe. Gear-trial results indicate that longer bridles mitigate overspreading, but their use resulted in a concerning large and rapid submergence of the trawl when initially deployed; interestingly, over-size doors only marginally decreased trawl mouth vertical opening and it is unknown if this was compensated for in terms of mouth area by increased horizontal spread. These activities were planned and executed in consultation with AFSC scientists in the EMA and MACE Programs.

Climate Induced Changes in Survival and Biogeographic Range Expansion - RACE FBEP

The Fisheries Behavioral Ecology Program examines physiological processes that may control fish and crab responses as oceans warm. The geographic range of fish is largely determined by their thermal preferenda i.e., the temperature at which physiological processes are optimal. These physiological processes include a suite of cellular activities (e.g., biochemical homeostasis, energy conversion efficiency, muscle performance, etc.) but are manifested collectively in terms of growth and condition of the animal. In the Bering Sea and Gulf of Alaska, walleye pollock (*Gadus chalcogrammus*) and Pacific cod (*Gadus macrocephalus*) represent two of the most important fisheries in terms of landings and value and there is growing interest in whether walleye pollock will expand their range northward as temperatures continue to increase or whether resident Arctic species (Arctic cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*)) will hold their 'thermal niche' in polar regions. The Newport laboratory is conducting a standardized series of laboratory experiments to quantify optimal thermal habitats for walleye pollock and other gadid populations in Alaska. Projected thermal habitats will be based on optimal growth and condition (energy storage) of juvenile gadids exposed to broad, temperature ranges in the laboratory (0 – 16ºC). Thus far, Arctic cod demonstrate a cold-water, stenothermic response in that there was relatively high growth at 0°C, limited growth beyond 5°C and negative impacts on condition, activity, growth and survival above 9°C. In contrast, juvenile walleye pollock and can grow 2 – 3 times faster than Arctic gadids across a relatively broad temperature range (i.e., 5 – 12°C), but cannot maintain growth at temperatures below 1°C.

Effects of Ocean Acidification on Walleye Pollock-RACE FBEP
The Fisheries Behavioral Ecology Program has been evaluating the impacts of ocean acidification on the early life history stages of these critical resource species. This includes three lines of research examining: a) the effects of OA on the growth of early life stages; and b) the effects of OA on behavioral responses of walleye pollock; and c) evaluation of the impact of OA on Alaskan communities.

Two papers present the results obtained in experiments with walleye pollock. Eggs, larvae, and juveniles of walleye pollock were reared at ambient and elevated CO_2 levels (to ~ 2100 µatm). In walleye pollock, there were no significant differences in hatch rates, larval or juvenile growth rates across multiple independent trials with each life stage. As observed in other species, hypercalcification of otoliths occurred in juvenile pollock held at high CO_2 levels. New experiments conducted with larval northern rock sole produced similar results, but suggest possible negative effects of OA in later larval stages as fish undergo metamorphosis. These results suggest a general resiliency of physiological capacity for growth in these species due to population acclimation or adaptation, while demonstrating the necessity of examining responses in multiple life stages.

Elevated CO_2 has been shown to disrupt sensory and behavioral responses in some tropical reef fish species, even when growth was not disrupted. In a separate experiment, we examined the behavioral responsiveness of juvenile walleye pollock, 58-97 mm, to prey scent cues under elevated CO_2. Baseline activity levels were not significantly different among CO_2 treatments, but fish reared at high CO_2 (> 800 µatm) were less likely to respond to injections of prey scent cues than fish reared at ambient CO_2 levels (~ 400 µatm). Future experiments are planned to examine the sensitivity of other behavioral responses in walleye pollock and provide species contrasts with Pacific cod. Such sensory and behavioral responses will be a significant determinant of how acidification affects the functioning of marine ecosystems.

The experimental information on the potential direct effects of OA on groundfishes and other animals harvested for commercial and subsistence purposes was incorporated into an evaluation of the vulnerability of Alaskan communities to Ocean Acidification. The project, led by researchers at NOAA's Pacific Marine Environmental Laboratory, used a variety of biological, economic, and social science data to evaluate the overall risk to each region of the state based on degree of the hazard, exposure to the hazard, and vulnerability to the hazard.

b. Stock Assessment

GULF OF ALASKA - REFM
The age-structured model developed using AD Model Builder and used for GOA W/C/WYK pollock assessment is very similar to the model used for the 2012 assessment. The model differences are primarily the three changes that were implemented based on recommendations of the July 2012 Center for Independent Experts (CIE) review: 1) removing two years of Biosonics acoustic survey time series (1992 and 1993) that were actually produced using the EK500 with the acoustic data analyzed at a higher noise threshold, 2) setting the CVs for the Biosonics acoustic survey estimates equal to the nominal value (0.2) of later acoustic surveys, and 3) removing the ADFG survey length data and increasing the input sample sizes for the ADFG survey age data. Further changes to the assessment should be anticipated as other CIE recommendations are incorporated in the assessment model in the future.

For comparison purposes, two alternative models were also presented: 1) a model with last year's configuration updated with recent fishery and survey data, and 2) a model with the new configuration with 2013 recruitment (2012 year class) set to the average value for yield projections. The Plan Team agreed with the authors that the new model configuration was preferred since it performed well and incorporated a number of improvements over the 2012 configuration. Given the multiple observations of high age 1 abundance, the Plan Team again agreed with the author that the 2013 estimate could be used directly and not replaced by an average.

This year's pollock assessment includes the following new data: 1) 2012 total catch and catch-at-age from the fishery, 2) 2013 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2013 biomass and length composition from the NMFS bottom trawl survey, 4) 2012 age composition and 2013 biomass from the ADFG crab/groundfish trawl survey. Model fits to fishery age composition data are reasonable.

The largest residuals tended to be at ages 1-2 for the Shelikof Strait acoustic survey and the NMFS bottom trawl survey due to inconsistencies between the initial estimates of abundance and subsequent information about year class size. Model fits to survey time series are similar to previous assessments, and general trends are fit reasonably well. The discrepancy between the NMFS trawl survey and the Shelikof Strait acoustic survey biomass estimates in the 1980s accounts for the poor model fit to both time series during those years. The model fit the rapid increase in the Shelikof Strait acoustic survey and the NMFS survey in 2013 poorly since an age-structured pollock population cannot increase as rapidly as is indicated by these surveys. In contrast, the model expectation is close to the ADFG survey in 2013. Although there is considerable variability in each survey time series, a fairly clear downward trend is evident to 2000, followed by a stable, though variable, trend to 2008. All surveys indicate a strong increase since 2008.

The 2013 Shelikof Strait acoustic survey biomass estimate is 2.7 times the biomass estimate for 2012, and is the largest biomass estimate from this survey since 1985.The 2013 NMFS bottom trawl survey biomass estimate is the highest in the time series, and is an increase of 43% from the 2011 estimate. In contrast, the ADFG crab/groundfish survey biomass estimate decreased by 40% from the 2012 estimate, but is close to the 2011 estimate. The estimated abundance of mature fish is projected to remain stable or to decrease gradually to 2015, and then to increase in subsequent years.

The model estimate of spawning biomass in 2014 is 308,541 t, which is 42.5% of unfished spawning biomass (based on average 1978-2012 one-year old recruitment). The B40% estimate is 290,000 t. This represents a 2% decrease from the 2012 assessment, which is a mostly a result of the decrease in mean recruitment. The Gulf of Alaska Pollock stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

The Plan Team concurred with the author's recommendation to use the new model projection and the more conservative adjusted F40% harvest rate. Because model estimated 2013 female spawning biomass is above $B_{40\%}$, the W/C/WYK Gulf of Alaska pollock stock is in Tier 3a. The Plan Team accepted the author's recommendation to reduce FABC from the maximum permissible using the "constant buffer" approach (first accepted in the 2001 GOA pollock assessment). The projected 2014 age-3+ biomass estimate is 972,750 t (for the W/C/WYK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock being below $B_{20\%}$ will be negligible in the next 5 years. An exempted fishing permit (EFP) has been granted to evaluate the effect of salmon excluder devices in the pollock fishery in 2013 and 2014. The assessment used a projection model that accounted for the EFP catches by including the actual EFP pollock catch in 2013, and the projected 2014 EFP catch at the start of year in 2014. Therefore, the 2014 ABC accounting for these adjustments is 166,514 t (F_{ABC}= 0.20) for GOA waters west of 140°W longitude. To account for the Prince William Sound GHL this is reduced by 2.5% (4,163 t) to a 2014 ABC of 162,351 t. The 2014 OFL is 211,998 t (F_{OFL}= 0.26). In 2015, the recommended ABC and OFL values are 181,184 t (reduced by 4,646 t to account for the Prince William Sound GHL) and 248,384 t, respectively.

The Southeast Alaska pollock component (East Yakutat and Southeast areas) is in Tier 5 and the ABC and OFL recommendations are based on natural mortality (0.30) and the estimated biomass in 2014 and 2015 from a random effects model fit to the 1990-2013 bottom trawl survey biomass estimates in Southeast Alaska. The result is a 2014 ABC of 12,625 t, and a 2014 OFL of 16,833 t. Recommendations for 2015 are the same as 2014. The Plan Team also recommended that revised winter acoustic survey numbers at age and biomass be evaluated to account for net selectivity and that the NMFS 2013 summer acoustic trawl survey be used. From 2012 Plan Team and SSC comments the authors should :1) estimate M to at least two significant digits, 2) consider using inter -annual smoothing for selectivity, 3) model the age 1 (and possibly age 2) age classes separately from the other age classes with their own variance structure, 4) explore spatial variations in female relative abundance. The Plan Team discussed the practice of including a year - class estimate for projections and excluding it from the reference point (B100%) calculations.

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

EASTERN BERING SEA - REFM

Walleye Pollock spawning biomass in 2008 was at the lowest level since 1980, but has increased by 71 percent since then, with a 2% decrease projected for next year. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent and projected increases are fueled by slightly above average recruitment from the 2006 year class and very strong recruitment from the 2008 year class along with reductions in average fishing mortality (ages 3-8) from 2009-2012. Spawning biomass is projected to be 23 percent and 16 percent above *BMSY* in 2014 and 2015, respectively.

New data in the 2013 assessment included the following: 2013 summer bottom trawl survey abundance at age; 2012 and 2013 abundance estimates from the “acoustic vessels of opportunity” index; updated 2012 summer acoustic-trawl survey abundance at age (data using an age-length key from that survey replaced those in last year’s assessment that were based on an age-length key from the bottom trawl survey); updated catch at age and average weight at age from the 2012 fishery; and updated total catch, including preliminary value for 2013. There were no changes in the authors’ recommended assessment model.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates of *BMSY* and the probability density function for *FMSY*. The updated estimate of *BMSY* from the present assessment is 2.122 million t, similar to last year’s estimate of 2.114 million t. Projected spawning biomass for 2014 is 2.606 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 0.469, down 4 percent from last year’s value of 0.491. The harvest ratio of 0.469 is multiplied by the geometric mean of the projected fishable biomass for 2014 (5.391 million t) to obtain the maximum permissible ABC for 2014, which is 2.528 million t, up 10 percent and down 3 percent from the maximum permissible ABCs for 2013 and 2014 projected in last year's assessment.

However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. They list five reasons for doing so in the SAFE chapter. Beginning with the 2010 assessment, the Team and SSC have based ABC recommendations on the most recent 5-year average fishing mortality rate. This year, the authors' base their 2014 and 2015 ABC recommendations on the same strategy, giving values of 1.369 million t and 1.258 million t, respectively. The Plan Team concurred with these recommendations, noting that this assessment is very much in line with projections made last year and noting also that the October government shutdown limited opportunities for analysis of alternative harvest strategies.

The OFL harvest ratio under Tier 1a is 0.518, 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 2014 determines the OFL for 2014, which is 2.795 million t. The current projection for OFL in 2015 given a 2014 catch equal to the Team's recommended ABC is 2.693 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 - REFM

This year's assessment estimates that spawning biomass reached a minimum level of about *B23%* in 1999 and then has generally increased, with a projected value of *B33%* for 2014. 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 2014 is projected to be 79,029 t.

The new data in the model consist of updated catch information. There were no changes in the assessment methodology. The SSC has determined that this stock qualifies for management under Tier 3. The Team concurred and supported continued use of last year's model for evaluating stock status and recommending ABC. The model estimates *B40%* at a value of 96,006 t, placing the AI pollock stock in sub-tier "b" of Tier 3. The model estimates the values of *F35%* as 0.41 and *F40%* as 0.33. Under Tier 3b, with the adjusted value of *F40%*=0.26, the maximum permissible ABC is 35,048 t for 2014. The Team recommended setting 2014 ABC at this level. Following the Tier 3b formula with the adjusted value of *F35%*=0.33, OFL for 2014 is 42,811 t. Given a 2014 catch of 19,000 t, the maximum permissible ABC would be 32,950 for 2015 and the projected OFL would be 40,290 t. If the 2014 catch is only 1,294 t (i.e., equal to the five year average for 2008-2012), the 2015 maximum permissible ABC would be 39,412 t and the 2015 OFL would be 47,713 t. The Team recommended setting 2015 ABC and OFL at the latter 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 DISTRICT - REFM

There was no Bogoslof pollock acoustic-trawl survey in 2013. The 2012 Bogoslof pollock acoustic-trawl survey resulted in the lowest estimate of biomass (67,100 t) in the region since the survey began in 1988.

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 SSC has determined that this stock qualifies for management under Tier 5. The maximum permissible ABC value for 2014 would be 10,059 t (assuming $M = 0.2$ and $FABC = 0.75 \times M = 0.15$): ABC = $B2012 \times M \times 0.75 = 67{,}063 \times 0.2 \times 0.75 = 10{,}059$ t. The projected ABC for 2015 is the same. Following the Tier 5 formula with M=0.20, OFL for 2014 is 13,413 t. The OFL for 2015 is the same.

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

3. Dusky Rockfish

a. Stock Assessment

GULF OF ALASKA - ABL

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 2013, a full assessment document with updated assessment and projection model results were presented. However, due to the 2013 government shutdown, no new alternative model configurations different from the previous assessment were explored or presented for dusky rockfish.

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.

For the 2014 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 5,486 t. This ABC is a 17% increase from the 2012 ABC. This increase in ABC is attributable to a 19% increase in the trawl survey biomass estimate in 2013 from 2011. 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.

4. Slope Rockfish

a. Research

Recompression Experiments on Rougheye Rockfish with Barotrauma - ABL

Because rockfish (*Sebastes* spp.) are physoclystic, i.e. their gas bladders are closed off from the gut, they often suffer internal barotrauma injuries from rapid air expansion in their tissues when brought up from depth. There is some evidence that recompression may greatly increase the survival of barotrauma-injured rockfish. However, survival can be species specific therefore it is important to gauge the impacts on each species of interest.

From 2011-2013, we tagged and released 184 blackspotted rockfish fish at ~150-225 m and 60 others were recompressed in portable pressure tanks and slowly brought back to surface pressure. All fish exhibited some signs of barotrauma including exophthalmia ("pop-eye") (89%), everted esophagus (95%), subcutaneous emphysema (gas bubbles under the skin) (57%), and ocular emphysema (air bubble under the cornea) (83%). After re-pressurization in the tanks, the great majority of fish no longer had any external signs of barotrauma (Figure 1). In 2011, 50% of fish survived long term in the lab, 60% in 2012, and 78% in 2013. This increase in survival was likely related to experience with tanks and a longer decompression schedule in 2013. In 2013 a cage equipped with video capability was used to release fish at 75 m (Figure 2). Fish were all oriented downward when released and were capable of swimming. In March, 2014 a fish was recaptured in the Pacific halibut fishery 59 km away from the release location a year and a half later.

During the winter of 2013 and the winter of 2014 fish were sacrificed and their swim bladders were examined for ruptures. Approximately 50% had a rupture that had healed and we did not see signs of a rupture in the remaining specimen.

Figure 1. A blackspotted rockfish right after capture (top) and 1.5 months after capture (bottom).

Figure 2. Release cage used to video fish behavior during descent and release.

Predicting the Abundance and Distribution of Pacific Ocean Perch in the Aleutian Islands - RACE GAP

Work was continued examining which habitat characteristics best predict the abundance of POP in the Aleutian Islands. POP have been observed living in association with a variety of epibenthic invertebrates during juvenile and adult life stages, and adult POP have been observed schooling over sea whip forests, and juvenile abundance has been correlated to total sponge and coral biomass. We used generalized additive models (GAMs) to predict juvenile and adult *S. alutus* distribution and conditional abundance in Aleutian Islands bottom trawl surveys from both the occurrence of biogenic structures (i.e., sponges, corals, and bryozoans) and selected environmental parameters (e.g., depth, temperature, local slope, and tidal velocity). For our analyses we separated sponges into distinct morphological groups using gross shapes like vase, fan, or ball.

Based on the six surveys conducted between 1997 and 2010, GAMs explained 25-28% of the observed deviance in juvenile and adult distribution and 40-44% of the deviance in conditional abundance. The GAMs predicted increased probability of encountering *S. alutus* as well as increasing abundance over the study period consistent with the increasing biomass trend observed for *S. alutus* in the Aleutian Islands since 1997; the greatest predicted increases were in the major Aleutian passes. Our results indicate that the probability of encountering both adult and juvenile *S. alutus* increased in the presence of fan and ball shaped sponges over moderate slopes within life-stage-specific depth ranges and decreased in the presence of strong currents. Longitude and depth had the greatest explanatory power in the GAMs, but combinations of epibenthic invertebrates, sponge morpho-groups, local slope, and tidal current also contributed significantly to predictions of *S. alutus* distribution and conditional abundance. Among other findings, this research suggests that some types of upright sponges and epibenthic invertebrates likely support higher abundances of *S. alutus* juveniles and adults, possibly indicating that these structures provide a form of refuge for this species. For further information contact Ned Laman (Ned.Laman@noaa.gov).

Rockfish Reproductive Studies - RACE GAP
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 at least the 2015 reproductive season.

Rougheye and blackspotted rockfish
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. 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.

*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.

b. Stock Assessment

Pacific Ocean Perch (POP)

BERING SEA AND ALEUTIAN ISLANDS - REFM
Pacific ocean perch (POP) assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. Since the Aleutian Islands were not surveyed in 2013, an “update” is produced by revising the recent catch data and re-running the projection model using the results from the previous full assessment as a starting point. Therefore, this update does not represent any change to the 2012 assessment methodology or input data, but does include updated catch estimates for 2013-2015. The 2012 assessment was a full assessment because the Aleutian Islands survey was conducted in 2012.

The survey biomass estimates in the Aleutian Islands and the Bering Sea Slope both were high in 2012. The updated 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 257,878 t in 2014 and to decline to 243,400 t in 2015, but still well above the target female spawning biomass levels.

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 183,774 t, 0.063, and 0.076 respectively. Spawning biomass for 2014 (257,878 t) is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier "a" of Tier 3. The 2014 and 2015 catches associated with the $F_{40\%}$ level of 0.063 are 33,122 t and 31,641 t, respectively, and are the authors' and Team's recommended ABCs. The 2014 and 2015 OFLs are 39,585 t and 37,817 t.

The ABCs are apportioned regionally based on the proportions in combined survey biomass as follows (values are for 2014): BS = 7,684 t, Eastern Aleutians (Area 541) = 9,246 t, Central Aleutians (Area 542) = 6,594 t, and Western Aleutians (Area 543) = 9,598 t. The recommended OFL for 2014 and 2015 is not regionally apportioned. Pacific ocean perch in the Bering Sea/Aleutian Islands is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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 2013's assessment for the 2014 fishery) there is new trawl survey data available. In these years, we conduct a full stock assessment update. The new data included were 2013 survey biomass estimates, 2011 survey age compositions, 2012 fishery age compositions, a final catch estimate for 2012 and a new catch estimate for 2013. For the 2014 fishery, we recommended the maximum permissible ABC of 19,309 t from the updated model. This ABC was an 18% increase from the 2013 ABC of 16,412 t. This increase was attributed to a 67% increase in the survey biomass estimate from the previous survey and resulted in a 20% higher ABC than the 2014 ABC projected last year. Overfishing was not occurring, the stock was not overfished, and it was not approaching an overfished condition.

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

Northern Rockfish

BERING SEA AND ALEUTIAN ISLANDS - REFM
Northern rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For BSAI rockfish in alternate (odd) years an executive summary is presented to recommend harvest levels for the next two years. Please refer to last year's full stock assessment report for further information regarding the assessment model. For the 2013 assessment the projection model is run with updated catches. New data in the 2013 assessment included updated 2012 catch, and estimated 2013 and 2014 catches.

Northern rockfish age 3+ biomass has been on an upward trend since 2002. Spawning biomass has been increasing slowly and almost continuously since 1977. Female spawning biomass is projected to be 84,237 t in 2014. The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for *B40%* (59,167 t), *F40%* (0.063), and *F35%* (0.079). Because the female spawning biomass of 84,237 t is greater than *B40%*, sub-tier "a" is applicable, with maximum permissible *FABC* = *F40%* and *FOFL* = *F35%*. Under Tier 3a, the maximum permissible ABC for 2014 is 9,761 t, which is the recommendation for the 2014 ABC. Under Tier 3a, the 2014 OFL is 12,077 t for the Bering Sea/Aleutian Islands combined. The Team continues to recommend setting a combined BSAI OFL and ABC. The Team recommendation for 2015 ABC is 9,652 t and the 2015 OFL is 11,943 t. Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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. Updated catch data is the only data available in even years, while in odd years a full assessment is run that includes both updated survey and catch data since the last full assessment. In 2013 a full assessment was performed with new survey and catch data implemented into the stock assessment model to determine ABC. The result was a recommended ABC for 2014 of 5,324 t; this ABC was 4% larger than the 2013 ABC of 5,132 t. The increase in ABC can be attributed to an increase in the trawl survey biomass estimate; however, GOA northern rockfish are characterized by highly uncertainty trawl survey biomass estimates across the time series of the bottom trawl survey. While the 2013 survey biomass estimate increased, it had a coefficient of variation (CV) of 60%, thus, the stock assessment model did not respond to this survey biomass estimate strongly. The GOA northern rockfish stock is not subjected to overfishing, is not currently overfished, and is not approaching a condition of overfishing.

For more information, contact Pete Hulson at pete.hulson@noaa.gov.

Shortraker Rockfish

BERING SEA AND ALEUTIAN ISLANDS - REFM
The 2013 stock assessment was presented in executive summary format, as a scheduled "off-year" assessment. The biomass estimate is based on the survey data through 2012 with no changes in the assessment methodology. Estimated shortraker rockfish biomass is 16,447 t and has trended slowly downward since 1980. The SSC has previously determined that there are only reliable estimates of biomass and natural mortality for the shortraker rockfish stock, qualifying the species for management under Tier 5. The Tier 5 biomass estimate is based on a surplus production model. Last year, the Team recommended setting *FABC* 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 *maxFABC* value of 0.0225. The ABC is 370 t for 2014 and 2015 and the OFL is 493 t for 2014 and 2015, identical to the respective values for 2013.

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.

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 2013, the biomass estimate was updated with 2013 survey data. Estimated shortraker rockfish biomass is 58,797 t, which is an increase of 22% from the 2011 estimate. This increase is due to the high biomass in the 2013 survey, specifically in the eastern Gulf of Alaska. 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, in which the assessment is mostly based on averaging the exploitable biomass from the three most recent trawl surveys (presently the 2009, 2011, and 2013) to determine the recommended ABC. Estimated shortraker biomass is 58,797 mt, which is an increase of 22% from the 2011 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 1,323 t for the 2014 fishery. Gulfwide catch of shortraker rockfish was 765 t in 2012 and estimated at 682 t in 2013. 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 - REFM

The 2013 stock assessment was presented in executive summary format, as a scheduled “off-year” assessment. New data included updated catch for 2012 and for 2013 through October 19, 2013. The projection model for the Tier 3 component of the assessment was re-run using the results from last year’s full assessment as a starting point. Also, an alternative estimate of current biomass (using a random effects model) was provided for the Tier 5 component of the assessment. Total biomass for the AI component of the stock in 2014 is projected to be 29,087 t. Female spawning biomass in the AI is increasing. Application of the random effects model reduces the estimated projected biomass of the EBS-SBS slope area to 1,389 t from 1,774 t.

For the Aleutian Islands, this stock qualifies for management under Tier 3 due to the availability of reliable estimates for *B40%*, *F40%* (=0.035), and *F35%* (=0.043). Because the projected female spawning biomass for 2014 of 7,328 t is less than *B40%*, (10,502 t), the adjusted *F40%* values for 2014 and 2015 are 0.024 and 0.026, respectively, and the corresponding adjusted *F35%* values are 0.029 and 0.031. Under the Tier 3b formula, the maximum permissible ABC is 416 t, which is the 2013 assessment recommendation for the 2014 ABC. Under Tier 3b, the 2014 OFL is 505 t for the Bering Sea/Aleutian Islands combined. The apportionment of 2014 ABC to subareas is 239 t for the Western and Central Aleutian Islands and 177 t for the Eastern Aleutian Islands and Eastern Bering Sea. The recommendation for 2015 overall ABC is 478 t and the 2015 OFL is 580 t. The blackspotted and rougheye rockfish complex is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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. For Gulf of Alaska rockfish in odd years we usually conduct a full stock assessment update. However, due to the 2013 government shutdown, we presented an executive summary, similar to an off-cycle year, to recommend harvest levels for the next two years. There was a large amount of new and updated data available for this stock complex (not just the most recent year) and there was not sufficient time for performing model evaluation and sensitivity analyses of this information. Additionally, for this update year, we did not re-run the assessment model, but do update the projection model with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points. For the 2014 fishery, we recommend the maximum allowable ABC of 1,244 t from the updated projection model. This ABC is slightly more than last year's ABC of 1,232 t and slightly less than last year's projected 2014 ABC of 1,254 t. The stock is not overfished, nor is it approaching overfishing status.

A full stock assessment document with updated assessment and projection model results will be presented in next year's Stock Assessment and Fishery Evaluation (SAFE) report.

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

Other Rockfish Complex

BERING SEA AND ALEUTIAN ISLANDS - REFM

This chapter was presented in executive summary format, as a scheduled "off-year" assessment. A small change in the average survey biomass occurred because of the inclusion of some unidentified rockfish, which were inadvertently omitted from last year's assessment. New data in the 2013 assessment included updated catches for 2012 and 2013 and there were no changes in the assessment methodology. Trends in spawning biomass are unknown. The 2012 assessment reported that biomass of other rockfish in the EBS slope survey was at an all-time high in 2012, while biomass in the AI was down relative to 2010, but still higher than pre-2002 levels.

The Plan Team agreed with the approach recommended by the author of setting *FABC* at the maximum allowable under Tier 5 (*FABC* = 0.75*M*). Multiplying these rates by the best biomass estimates of shortspine thornyhead and other rockfish species in the "other rockfish" complex yields 2014 and 2015 ABCs of 690 t in the EBS and 473 t in the AI. The assessment uses a three survey weighted average to estimate biomass in similar fashion to the methodology used in the Gulf of Alaska rockfish assessments. The Plan Team recommended that OFL be set for the entire BSAI area, calculated under Tier 5 by multiplying the best estimates of total biomass for the area by the separate natural mortality values and adding the results. This calculation gives an OFL of 1,550 t for 2014 and 2015. The "other rockfish" complex is 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 using Tier 5 methodology.

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

GULF OF ALASKA - ABL

"Other Rockfish" in the Gulf of Alaska (GOA) is a new management category that was implemented by the North Pacific Fishery Management Council (NPFMC) in 2012. The total complex 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". The Pelagic Shelf rockfish category has since been dissolved and dusky rockfish are now managed as a stand-alone species. 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. While the trawl survey was conducted in 2013, a full assessment was not conducted due to the government shutdown. An expanded executive summary assessment was presented in 2013 which included updated survey biomass. The next full assessment will be completed in the fall of 2015.

All species in the group have always been classified into "tier 5" or "tier 4" (only sharpchin rockfish is "tier 4") in the NPFMC definitions for ABC and overfishing level, in which the assessment is mostly based on biomass estimates from trawl surveys, instead of modeling. As in previous assessments since 1994, an average of the Gulf-wide biomass from the three most recent trawl surveys (presently the 2009, 2011, and 2013 surveys) is used to determine current exploitable biomass. This results in a current exploitable biomass of 83,383 t for "Other Rockfish". Applying either an $F_{ABC} \leq F_{40\%}$ rate for sharpchin rockfish or an $F_{ABC} \leq 0.75M$ (M is the natural mortality rate) for the other species to the exploitable biomass for "Other Rockfish" results in a recommended ABC in the GOA of 4,079 t for 2014. This is an increase of 1% compared to the 2013 ABC of 4,045 t for Other rockfish. While the overall survey biomass was similar to the previous survey (85,774 t in 2011), the composition of the species included changed. The Demersal shelf rockfish species had not previously been included in the biomass calculations. With the inclusion of the new species, the large decline in biomass observed for silvergray rockfish did not impact the overall exploitable biomass substantially. Gulfwide catch of Other rockfish was 1,039 t in 2012, and estimated catch in 2013 was 760 t. Other rockfish is not considered overfished in the Gulf of Alaska, nor is it approaching overfishing status. However, in 2013, the apportioned ABC for the Central GOA was exceeded and the catch consisted of mostly harlequin rockfish, which is the most abundant of the Other rockfish species in that region, however the biomass is low.

Two notable results were seen for Other rockfish in the 2013 GOA trawl survey. First, compared to the 2011 survey, the biomass estimate for silvergray rockfish decreased by 81% from 100,049 t to 19,239. Second, the survey biomass of harlequin rockfish remained relatively low at only 7,485 t, but is an approximately 2 fold increase over the previous survey. Total estimated catch of harlequin rockfish for 2013 was 357 t, exceeding the estimated species specific ABC by 32% and OFL by 10% (ABC = 241 and OFL = 321). This could be a conservation concern because harlequin rockfish have comprised the majority of the commercial catch since 2003. However because harlequin rockfish are managed as part of complex with the ABC and OFL set for the complex as a whole, overfishing was not declared for harlequins rockfish. For more information contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Thornyheads

GULF OF ALAKSA - ABL

Gulf of Alaska thornyheads (*Sebastolobus* species) are assessed as a stock complex under Tier 5 criteria using the assessment methodology introduced in 2003. We use the exploitable biomass from the most recent trawl survey to determine the recommended ABC for thornyheads. This complex is assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska thornyheads, in odd years we usually conduct a full stock assessment update. However, due to the 2013 government shutdown, we present an executive summary with updated survey biomass estimates to recommended harvest levels for the next two years. New data added for this assessment are biomass estimates from the 2013 trawl survey for shortspine thornyheads. The 2013 biomass estimate of 69,878 t is an 11% increase from the 2011 estimate and similar to the 2009 estimate for the 1-700 m strata. As with the 2011 survey, the 700-1000 m stratum was not sampled; therefore, the 2013 biomass estimate was also inflated to account for the lack of sampling in the deep strata. We used the same methods described in the 2011 assessment where area-specific mean percentages of biomass in the 701-1000 m stratum relative to the other depth strata for the Western, Central, and Eastern GOA from the 2005, 2007, and 2009 trawl surveys were calculated and the 2013 area-specific biomass estimates were increased by these percentages. The modification results in a total estimated biomass of 81,816 t, which is a 17% increase in the observed biomass estimate of 2013.

For the 2014 fishery, we recommend the maximum allowable ABC of 1,841 t for thornyhead rockfish. Catch levels remain below the TAC and the stock was not being subjected to overfishing last year.

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

6. Sablefish

a. 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 2013. Total sablefish tag recoveries for the year were around 660. Twenty eight percent of the recovered tags in 2013 were at liberty for over 10 years. About 33 percent of the total 2013 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 36 percent within 100 – 500 nm, 17 percent within 500 – 1,000 nm, and 13 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 35 years, and the greatest distance traveled of a 2013 recovered sablefish tag was 1,945 nm. Five adult sablefish and two juvenile sablefish tagged with archival tags were recovered in 2013. 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. Nineteen thornyhead and one archival Greenland turbot tag were recovered in 2013.

Releases in 2013 totaled 2,589 adult sablefish, 602 juvenile sablefish, 1,125 shortspine thornyheads, and 50 rougheye rockfish. Electronic archival tags were implanted in 36 Greenland turbot and 101 juvenile sablefish. Pop-up satellite tags (PSAT) were implanted in 27 sablefish, 6 spiny dogfish, 4 lingcod, and 6 rougheye rockfish. The second year of extensive tagging of sablefish with pop-up satellite tags was conducted on the AFSC annual longline survey in 2013. Pop-off satellite tags were deployed on 27 sablefish throughout the Gulf of Alaska on the 2013 AFSC longline survey to study daily and large-scale movements. 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 2013. A total of 602 juvenile sablefish were caught, and 600 tagged and released in St John Baptist Bay near Sitka, AK over 5 days (July 8th – July 12th) with 124 rod hrs. A total of 106 archival tags were surgically implanted. Researchers from University of Alaska participated to continue an ecological study of the bay. Gastric lavages were conducted on 391 juvenile sablefish. The majority of these samples had recoverable stomach contents, which consisted primarily of small herring, jellyfish and assorted osmerids. Herring were omnipresent, and sea lions, seals, and humpback whales were frequenters of the bay. Spiny dogfish were more frequently caught in 2013, with a catch of 6 medium to large specimens. Total catch-per-unit-effort (CPUE) equaled 2.29 sablefish per rod hour fished. This was down significantly from 2011 (7.63) but higher than the 5-year average. Juvenile sablefish had a mean length of 33 cm fork length (95% CI, 29-36 cm), with one 46 cm fish (presumably a 2 year old). The St. John Baptist Bay juvenile sablefish tagging cruise will likely be conducted again in 2014 during a similar timeframe.

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

Sablefish Maturity Study – RACE GAP and ABL

RACE and ABL cooperatively completed a cruise to collect female sablefish maturity information in December 2011 off Kodiak Island, Alaska. A manuscript is currently being prepared for publication. Although samples were not taken randomly, smaller females were found on the shelf and older, larger fish on the slope. The minority of fish on the shelf were mature (10%); whereas, 90% of the samples taken on the slope were mature. Skip spawning fish were identified primarily on the shelf (19 of 22 skip spawning fish were on the shelf, total study sample size = 394). Skip spawning fish could be identified the combination of 1) small ovaries that were flaccid, 2) perinucleolar oocytes, 3) atretic perinucleolar oocytes, and 4) a thicker ovarian wall, measured from histological slides. Weight specific fecundity was not related to fish size or age, indicating that relative reproductive output stays constant, verifying the assumption made in the stock assessment that reproductive output is linearly related to female spawning biomass. Four satellite tags were deployed during the cruise and programmed to pop-off after a month to two months. The sablefish exhibited sight fidelity; 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.

The age at 50% maturity for the study data was 6.8; the age at 50% maturity of the combined annual maturity data from the longline survey in the central Gulf of Alaska was 7.0 years old. However, the model fit to the study data had a steeper slope and estimated that there were a greater proportion of mature fish at ages 6.5-12, and a lower proportion of mature fish at ages under age 5.7. This indicates that samples taken during the summer provide an overall lower estimate of the proportion of fish that are mature in the population than fish sampled in the winter just before spawning commences. Using the maturity curve from the winter study would result in an increase in the estimate of female spawning biomass in the sablefish population model used in the Alaska sablefish stock assessment. The quantity of the effect on spawning biomass will be examined in the future.

Juvenile Sablefish Ecology Study – ABL and UAF

Sablefish (*Anoplopoma fimbria*) are long-lived demersal fish inhabiting the waters of the North Pacific Ocean and the Bering Sea and among the most valuable commercial groundfish in Alaska. Juvenile sablefish are commonly found in nearshore bays; however, the characteristics that make this habitat preferable are not well understood. This joint study between ABL and UAF will investigate the diet composition of juvenile sablefish, quantify seasonal and ontogenetic shifts in diet, and assess their habitat use of nearshore bays.

To determine diet composition, samples were obtained over multiple seasons (July 2012, September 2012, May 2013, July 2013, and September 2013) from St. John Baptist Bay, Baranof Island, Alaska. In total 1140 juvenile sablefish were caught during daytime angling trips and their stomach contents sampled using gastric lavage. Food items identified include teleosts such as gadids, clupeids, pleuronectids, cottids and hexagrammids as well as invertebrates, primarily amphipods, euphausiids, polychaetes and larval crustaceans. Sablefish sampled in September (2012 and 2013) were feeding on salmon carcasses, organs and eggs. Preliminary multivariate analyses show there are differences in presence and abundance of prey items between July and September 2012 (Fig. 1 and Fig 2.).

Habitat use and movement patterns of juvenile sablefish will be elucidated through the analysis of acoustic telemetry data from St. John Baptist Bay collected from 2003-2004. Generalized linear models will be used to identify relationships between environmental factors and sablefish movement within the bay. Diet and habitat use information for the juvenile life stage will aid in identifying essential fish habitat (EFH) and may facilitate management and conservation of the species.

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

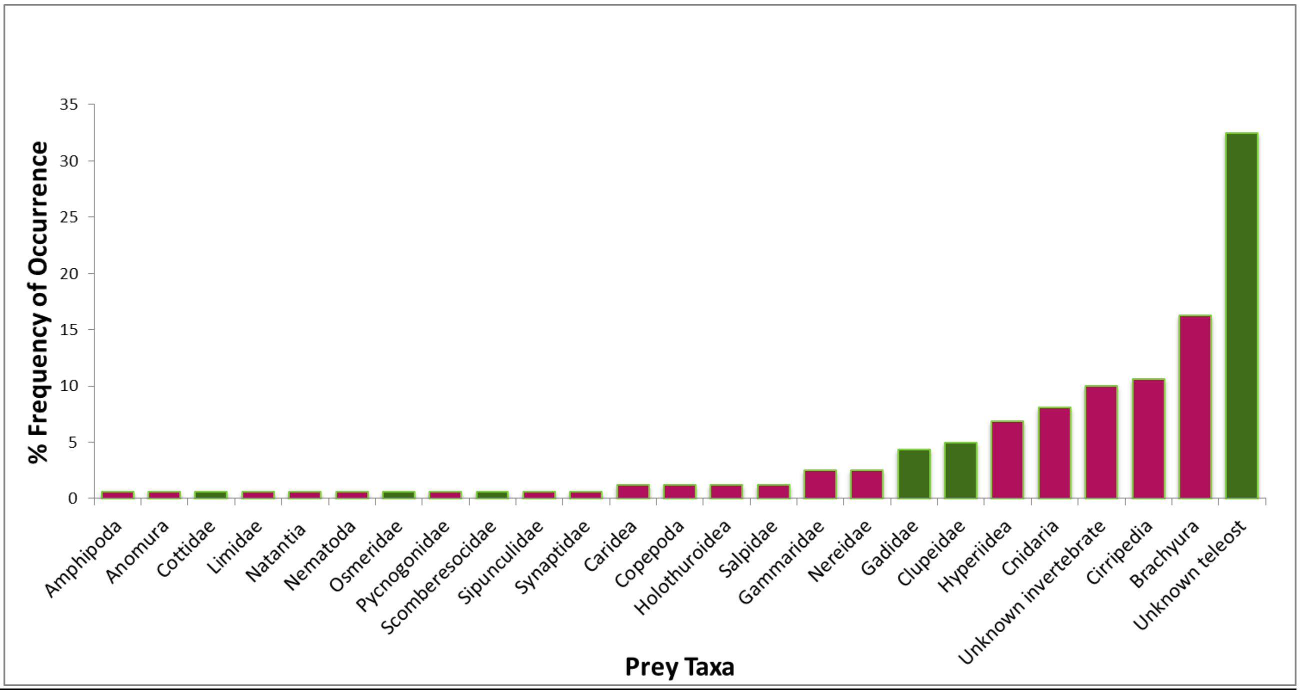

Figure 1. Frequency of occurrence of prey taxa in sablefish stomachs from July 2012 (N=142) with % occurrence shown on the y-axis and prey taxa shown on the x-axis. Magenta bars represent invertebrate prey and green bars represent teleost prey.

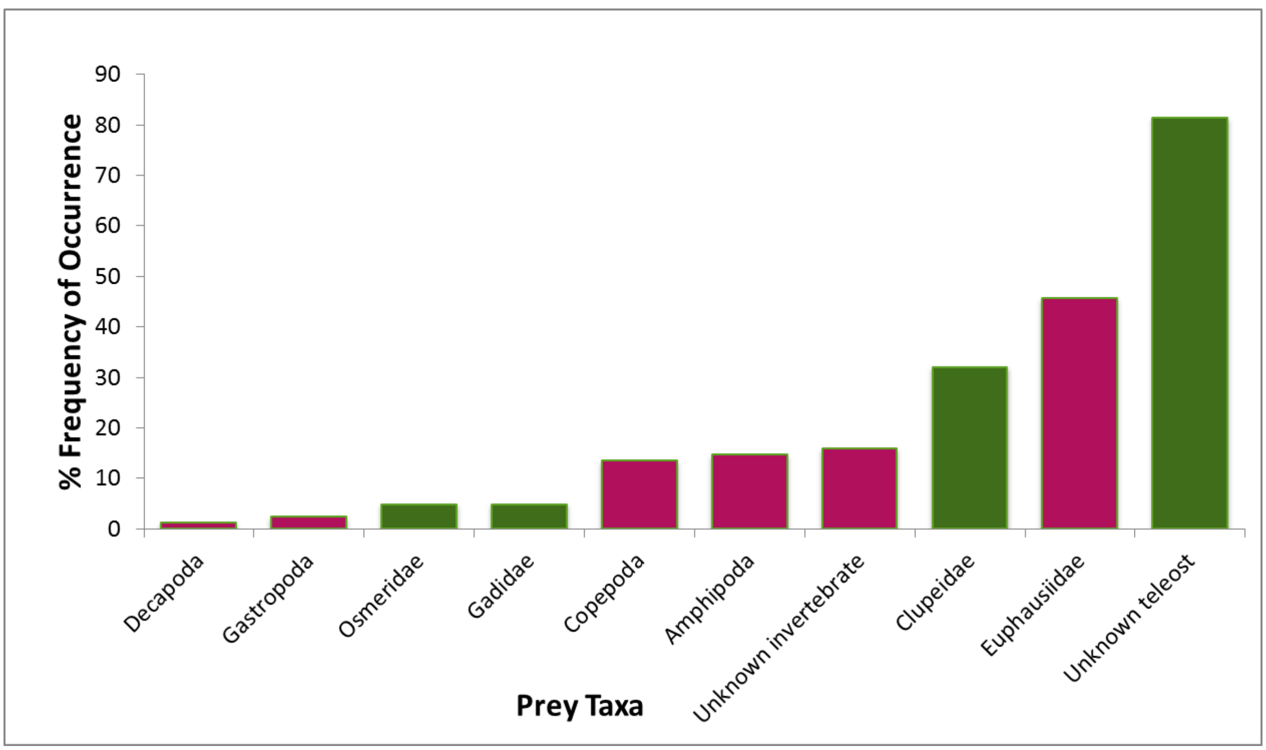

Figure 2. Frequency of occurrence of prey taxa in sablefish stomachs from September 2012 (N=85) with % occurrence shown on the y-axis and prey taxa shown on the x-axis. Magenta bars represent invertebrate prey and green bars represent teleost prey.

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, data analysis will resume in 2014. For more information, contact Mike Sigler mike.sigler@noaa.gov or Pete Hulson pete.hulson@noaa.gov.

Sablefish Satellite Tagging - ABL
The second year of extensive tagging of sablefish with pop-up satellite tags was conducted on the AFSC annual longline survey in 2013. Pop-off satellite tags were deployed on 27 sablefish throughout the Gulf of Alaska on the 2013 AFSC longline survey to study daily and large-scale movements. These tags were programmed to release from the fish 1 January 2014 and 1 February 2014, 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 2013 released tags join the 48 tags that were released throughout the Gulf of Alaska and Aleutian Islands on the 2012 longline survey, and 4 tags that were released during a sablefish winter maturity cruise in December 2011. With just two 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 December 2011 released tags, while on the fish for a short amount of time, were ideal for observing behavior during the spawning season. Two fish were captured, tagged, and released nearshore north of Portlock Bank on the shore side of Amatuli Trough at 58° 55' 12"N 150° 0' 35"W, and two fish were initially captured offshore on the Kodiak Slope at 57° 4' 47"N 151° 11' 59"W but were released nearshore at 57° 38' 24"N 151° 50' 59"W due to inclement weather. The tags were set to release from the fish during the spawning season; two released 35 days later on 2012 January 15 and two released 48 days later on 2012 February 1. The two fish that were initially captured, tagged, and released nearshore north of Portlock Bank on the shore side of Amatuli Trough at an approximate depth of 155 m remained within one kilometer of their tagging location on the shelf. Tagged specimens that were initially captured together offshore on the Kodiak Slope at an approximate depth of 400 m, but released that same day approximately 75 km (great circle distance) northwest on the shore side of Chiniak Gully, traveled back to the slope within 10 km of their initial capture location within 48 days. These results show that within the winter spawning season sablefish appear to have site fidelity. It is unknown whether this fidelity is consistent since very few fish were tagged over a small area relative to their spatial range and only females were tagged (an assumption based on the size of the fish). It is also unknown whether there is site fidelity from year to year. Even if there is no site fidelity from year to year, the behavior we saw may indicate that there are aggregations of spawning sablefish that the tagged fish moved back towards after being relocated. For more information, contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA - ABL
A full sablefish stock assessment was produced for the 2014 fishery. We added relative abundance and length data from the 2013 AFSC longline survey, relative abundance and length data from the 2012 longline and trawl fisheries, age data from the 2012 longline survey and 2012 longline fishery, abundance and length data from the 2013 Gulf of Alaska trawl survey, updated 2012 catch, and estimated 2013 catch to the assessment model.

The fishery abundance index decreased 3% from 2011 to 2012 (the 2013 data are not available yet). The longline survey abundance index decreased 5% from 2012 to 2013 following a 21% decrease from 2011 to 2012. The GOA trawl survey biomass index decreased 29% from the last trawl survey in 2011. Spawning biomass is projected to decrease from 2014 to 2018, 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 the maximum permissible yield for 2014 from an adjusted F40% strategy of 13,722 t. The maximum permissible ABC for 2014 is a 15% decrease from the 2013 ABC of 16,230 t. The 2012 assessment projected a 6% decrease. This larger decrease is supported by the lowest values of the time series for the domestic longline survey index in 2012 and 2013 that offset relatively high survey years in 2010 and 2011. The fishery abundance index was lower in 2012 than 2010 and 2011, and has been trending down since 2007. The GOA trawl survey biomass index decreased 29% from 2011. The 2012 IPHC sablefish index was not used in the model, but also declined 22% from 2011. In last year's assessment, the estimate of the 2008 year class was increasing based on patterns in the age and length compositions. However the estimate in this year's assessment is only just above average because the estimate is heavily influenced by the large recent overall decrease in the longline survey and trawl indices. Spawning biomass is projected to decline through 2018, and then is expected to increase, assuming average recruitment is achieved. The projection is toward decreasing ABCs with the maximum permissible ABC projected to decrease in 2015 to 12,400 t and 11,876 t in 2016.

Projected 2014 spawning biomass is 34% of unfished spawning biomass. Spawning biomass is higher than its low of 30% of unfished biomass in 2002 at 34% of unfished biomass projected for 2014, but is now trending downward. The 1997 year class has been an important contributor to the population but has been reduced and is predicted to comprise less than 8% of the 2014 spawning biomass. The 2000 year class is still the largest contributor, with 18% of the spawning biomass in 2014. The 2008 year class is slightly above average and will comprise 8% of spawning biomass in 2014 even though it is only 40% mature.

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

7. Yellowfin sole

a. Stock Assessment

BERING SEA - REFM
The 2013 EBS bottom trawl survey resulted in a biomass estimate of 2.28 million t, compared to the 2012 survey biomass of 1.95 million t (an increase of 14 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 (57% 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 6 of the past 22 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 is a contributor to the reservoir of female spawners. The 2013 catch of 165,000 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:
• 2012 fishery and survey age compositions
• 2013 trawl survey biomass point estimate and standard error
• estimates of the discarded and retained portions of the 2012 catch
• estimate of total catch through the end of 2013.

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.

The projected female spawning biomass estimate for 2014 is 581,100 t. Projected spawning biomass for 2014 through 2019 indicates an increasing trend and a slow decline thereafter. The upward trend in the population biomass is due to strong recruitment from the 2003 year class.

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock. Accordingly, yellowfin sole qualify for management under Tier 1. The estimate of B_{MSY} from the present assessment is 366,000 t. 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 0.113. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.123. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2014 biomass estimate produced 2014 ABC of 239,800 t recommended by the author and Team, and the corresponding product using the OFL harvest ratio produces the 2014 OFL of 259,700 t. For 2015, the corresponding quantities are 248,300 t and 268,900 t, respectively.

Yellowfin sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition. As in previous years, this assessment contains an ecosystem feature that represents catchability of the EBS shelf trawl survey as an exponential function of average annual bottom temperature.

8. Northern Rock Sole

a. Research

The Influence of Polychaete Tube Habitat on the Prey Availability, Feeding Habits, and Condition of Juvenile Rock Sole. – RACE GAP and Fish Behavioral Ecology Program
Ampharetid polychaete worm tubes (*Sabellides sibirica*) are prevalent, small-scale habitat features in flatfish nurseries around Kodiak, Alaska, USA. Juvenile (age-0) northern rock sole (*Lepidopsetta polyxystra*) are the predominant member of flatfish assemblage in the nurseries and they associate with worm tubes in summer months. However, the functional role of this small-scale habitat remains uncertain. In this study, we investigated whether worm tubes contribute to increased benthic infauna and result in associated changes in diet composition, size, and body condition of age-0 rock sole. We conducted benthos sampling and beam trawl surveys at a Kodiak flatfish nursery during the summers of 2008 and 2009. Results indicated the abundance, biomass, and number of benthic fauna (potential prey) increased with depth, most significantly in regions with sparse to moderate worm-tube density. Juvenile rock sole diets reflected the spatial availability of prey, including the ingestion of *S. sibirica*, which formed a significant component of the diet where available. However, despite increased feeding opportunities associated with worm tubes, rock sole body condition was only highest in these regions during August. In July, rock sole in the bare substrates had higher body condition compared to rock sole in worm-tube habitat, and in September, body condition was similar across the entire nursery region. These patterns require further investigation but may reflect ontogenetic changes in rock sole feeding constraints. Alternatively, spatial-temporal interactions in prey quality, predator interactions, or water temperatures within the nursery may be important components of habitat quality during this period. Collectively, these data suggest that worm-tube habitat serves an important trophic role in flatfish nurseries during discrete time periods, and should be considered alongside other mediating factors that affect food availability (e.g. temperature, predators, and prey quality). The manuscript for this project has been submitted to the journal Marine Ecology Progress Series for review.

For further information please contact Brian Knoth (907) 481-1731.

Age-0 yr northern rock sole habitat studies around Kodiak Alaska - RACE FBEP
The Fisheries Behavioral Ecology Program, located in Newport Oregon, in cooperation with staff members from the Kodiak Laboratory, conduct research and test hypotheses designed to better understand annual recruitment of juvenile northern rock sole to coastal nursery areas in the Gulf of Alaska around Kodiak using a combination of field and laboratory studies. Laboratory studies focus upon specific habitat features which promote settlement and survival in these species, while field research focuses the recruitment of juvenile northern rock sole and their distribution among habitats. In addition, the program continues an annual survey (10-years in 2013) of juvenile recruitment that may ultimately prove useful in understanding annual variability in habitat features that control nursery production, subsequent year-class strength, and eventual adult recruitment to the fishery. In 2013 a study was completed that documented inter-annual variability in the depth distribution of juvenile northern rock sole on their nursery grounds around Kodiak Island, Alaska. This study evaluated whether this variability was a response to inter-annual changes in the availability of habitat created by polychaete tubes; principally *Sabellides sibirica*. Worm tubes may constitute an alternative refuge and/or feeding habitat for juvenile flatfish. Accordingly, it was hypothesized that during years of low worm abundance, fish would concentrate in the shallows (< 10 m depth) where they would find refuge from predation, but would move to greater depths (> 15

m, where the worms occur) during years when the worms were abundant. Using data on worm abundance and fish density over 5 yr, this hypothesis was tested at 2 Kodiak nursery embayments. Whether worms were abundant in a given year or embayment had no influence on overall fish abundance, however, worm abundance did influence juvenile flatfish depth distributions. At one site, where worms tended to be scarce, fish were typically concentrated in shallow water. However, during the 1 year when worms were abundant, fish were concentrated in deeper water. At another site, where worms are more regularly found, fish tended to concentrate in deeper water, the exception being the one year when worms were nearly absent. Regression analysis for both sites and all years indicated that the percent of fish occupying shallow water (< 10m) decreased with increasing worm abundance. When worms were prevalent, fish were most commonly found on bottom with sparse to moderate worm cover, but avoided bottom where the worms were so dense as to form a 'turf'. These results demonstrate that the geographic and inter-annual variation in worm tube abundance has significant influence over the distribution of juvenile northern rock sole.

b. Stock Assessment

BERING SEA - REFM

The northern rock sole stock is currently at a high level due to strong recruitment from the 2001, 2002 and 2003 year classes which are now contributing to the mature population biomass. The 2013 bottom trawl survey resulted in a biomass estimate of 1.75 million t, 8% lower than the 2012 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 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 projected to increase in the near future due to the recently observed strong recruitment. It is currently estimated at over twice the B_{MSY} level.

New information for the 2013 analysis include:

- 2012 fishery age composition;
- 2012 survey age composition
- 2013 trawl survey biomass point estimate and standard error
- updated fishery discards through 2012
- fishery catch and discards projected through the end of 2013.

Northern rock sole are assessed on an annual basis in the Bering Sea/Aleutian Islands region to coincide with the annual Bering Sea multispecies groundfish trawl survey conducted each summer. Due to a temporary lack of appropriations, the Department of Commerce implemented an orderly shutdown from October 1 – October 16 2013. Although the trawl survey was completed again in 2013, the shutdown did not allow time to produce a full stock assessment for northern rock sole and many other species. Therefore an executive summary was presented to provide management recommendations for the 2014 fishing season.

Northern rock sole are managed as a Tier 1 stock using a statistical age-structured model as the primary assessment tool. Details of the model can be found at http://www.afsc.noaa.gov/REFM/docs/2012/BSAIrocksole.pdf. The assessment model is not re-run for this update but instead, projections made from the recommended 2012 assessment (time-varying temperature/catchability) model are presented. The model assumes a 2013 and 2014 catch of 65,000 t and provides estimates of 2014 and 2015 ABC, OFL and FSB without re-estimating the stock assessment model parameters and biological reference points.

The stock assessment model estimates a 2014 spawning biomass of 638,300 t. This was equal to the 2014 value projected in last year's assessment, due to the fact that there were no changes in the data. According to last year's assessment, spawning biomass is expected to increase due to strong 2000-2005 year classes, if fishing mortality rates remain at recent levels. The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning biomass for 2014 is projected to be well above B_{MSY}, placing northern rock sole in sub-tier "a" of Tier 1. The Tier 1 2014 ABC harvest recommendation is 203,800 t (F_{ABC} = 0.15) and the 2014 OFL is 228,700 t (F_{OFL} = 0.16). The 2015 ABC and OFL values are 190,100 t and 213,310 t, respectively.

This is a stable fishery that lightly exploits the stock because it is constrained by PSC limits and the BSAI optimum yield limit. Usually the fishery only takes a small portion of the northern rock sole ABC (the average catch/biomass ratio is about 4 percent). Northern rock sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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. An executive summary was presented which included updated 2012 catch and the partial 2013 catch as well as projections using the updated catches from the northern and southern rock sole assessment.

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. The rock sole assessment model will be updated and presented in 2014. Stock status for shallow-water flatfish is based on the NMFS bottom trawl survey (triennial from 1984 to 1999 and biennial from 1999 to 2013). Survey abundance estimates for the entire shallow-water complex were lower in 2013 compared to 2011; decreasing by 35,156 t. By species, southern rock sole has a generally increasing trend in abundance. Northern rock sole survey trend has been variable in recent years and increased between 2011 and 2013. The remainder of the species in the shallow-water flatfish complex have varying trends. Notable declines were observed in the trends for butter sole and yellowfin sole from 2011to 2013. Information is insufficient to determine stock status relative to overfished criteria for the complex. 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.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. An updated projection model for northern and southern rock sole was run this year; the remaining shallow water flatfish biomass estimates were from the 2013 survey. For the shallow water flatfish complex, ABC and OFL for southern and northern rock sole are combined with the ABC and OFL for the rest of the shallow water flatfish complex. This yields a combined ABC of 40,805 t and OFL of 50,007 t for 2014. For 2015, the combined ABC is 37,505 t and the OFL is 46,207 t.

9. Flathead Sole

a. Stock Assessment

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 2013 shelf trawl biomass estimate increased 29% from 2012. Areas of high abundance for both stocks are very similar 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 chapter was presented in executive summary format, as a scheduled “off-year” assessment. New information available to update the projection model for flathead sole consists of total catch for 2012 (11,386 t) and estimated catch for 2013 (17,246 t) and 2014 (assumed equal to 2013). The projected spawning stock biomass for 2014 is 239,985 t. Flathead sole are abundant and only lightly exploited. In last year’s assessment, spawning biomass was projected to decrease for the next several years.

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 $B_{40\%}$=128,286 t, $F_{40\%}$=0.285, and $F_{35\%}$=0.348. Because projected spawning biomass for 2014 (239,985 t) is above $B_{40\%}$, flathead sole is in sub-tier “a” of Tier 3. The authors and Team recommend setting ABCs for 2014 and 2015 at the maximum permissible values under Tier 3a, which are 66,293 t and 64,127 t, respectively. The 2014 and 2015 OFLs under Tier 3a are 79,633 t and 77,023 t, respectively.

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

GULF OF ALASKA - REFM

A full assessment with a new model was presented for the 2013 stock assessment and was configured as follows. Catch data for 1978-1983 and 2012-2013 were included in the model. 2012 and 2013 fishery length composition data were added and 1985-1988, 2000, and 2008 fishery length composition data were excluded from the model due to low sample size. The number of hauls was used as the effective sample size of fishery length-composition data. The 2013 survey biomass index and survey length composition data were added to the model. Conditional age-at-length data were used instead of marginal age composition data. 2011 age composition data (within each length bin) were added to the model. The “plus” group was increased to age 29.

The assessment was conducted using the Stock Synthesis modeling platform with the fishery and survey selectivity curves estimated using an age-based double -normal function without a descending limb instead of an age-based logistic function. A conditional age-at-length likelihood approach was used: expected age composition within each length bin was fit to age data conditioned on length in the likelihood function, rather than fitting the expected marginal age-composition to age data that weren’t conditioned on length. Growth parameters and an initial equilibrium fishing mortality rate were estimated within the model. Relative weights of composition data were adjusted using a data-weighting method that accounted for correlations in composition data. An ageing error matrix was incorporated into the model. Recruitment deviations prior to 1984 were estimated as “early-period” recruits separately from main- period recruitment deviations (1984-2008).The Plan Team endorsed the author’s recommended model.

The 2014 spawning biomass estimate (84,076 t) is above $B_{40\%}$ (35,532 t) and projected to be stable through 2015. The stock is not overfished nor approaching an overfished condition. Catch levels for this species remain below the TAC. Flathead sole are determined to be in Tier 3a. For 2014 the recommendation is to use the maximum permissible ABC of 41,231 t. The FOFL is set at $F_{35\%}$(0.61) and gives an OFL of 50,664 t.

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10. Alaska Plaice

a. Stock Assessment - REFM

The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2013 survey biomass was 505,600 t is a 13% decrease over 2012 and is largely consistent with estimates from resource assessment surveys conducted since 1985. The combined results of the 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 in 2010. The stock is expected to remain at a high 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 1975-2012.

This chapter was presented in executive summary format, as a scheduled "off-year" assessment for 2013. New input for the projection model included the final estimate of the 2012 catch and preliminary estimates of 2013 and 2014 catch. The model assessment methodology was unchanged (only the projection model was run). Female spawning biomass decreased from 1985 to 1998 and has been relatively stable since then. The shelf survey biomass has been fairly steady since the mid-1980s. There was exceptionally strong recruitment from the 2002 year class. There may also be a strong 2004 year class.

Reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock, therefore qualifying it for management under Tier 3a. Last year's estimates (which were not updated this year) are *B40%* = 152,000 t, *F40%* = 0.158, and *F35%* = 0.19. Given that the projected 2014 spawning biomass of 250,600 t exceeds *B40%*, the ABC and OFL recommendations for 2014 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the *F40%* level gives maximum permissible ABCs of 55,100 t and 54,700 t for 2014 and 2015, respectively. These ABC values were adopted for management in 2014. The OFLs were determined from the Tier 3a formula, which gives a 2014 value of 66,800 t and a 2015 value of 66,300 t.

Model projections indicate that this species is neither overfished nor approaching an overfished condition. There is not a targeted fishery for this species as there is presently no market. The total exploitation rate is quite low for Alaska plaice as it is caught principally in pursuit of yellowfin sole.

11. Greenland Halibut (Turbot)

a. Stock Assessment

This year's Greenland turbot assessment model included: updated 2013 catch data, 2013 EBS shelf survey biomass, 2013 ABL longline survey RPN, 2013 EBS shelf survey and ABL longline length composition estimates, 2010, 2011, 2012 shelf survey age data and updated fishery catch-at-length data for longline and trawl gear from 2013.

No new models were explored nor any refinements made to last year's model due to the government shutdown. The projected 2014 female spawning biomass is 22,010 t. This is a 17% decrease from the 2014 spawning biomass of 26,537 t projected in last year's assessment. Spawning biomass is projected to increase in 2015 to 27,624 t. While spawning biomass continues to decline as of 2013, large 2008 and 2009 year classes are still 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. A near doubling of abundance in the 2012 slope survey estimate (relative to 2010) is largely attributable to an increase in small (30-50 cm) fish.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock. Greenland turbot therefore qualifies for management under Tier 3. Updated point estimates of *B40%*, *F40%*, and *F35%* from the present assessment are 39,906 t, 0.22, and 0.27, respectively. The stock remains in Tier 3b. The maximum permissible value of *FABC* under this tier translates into a maximum permissible ABC of 2,124 t for 2014 and 3,173 t for 2015, and a OFL of 2,647 t for 2014 and 3,864 t for 2015. These are the authors' and Team's ABC and OFL recommendations. Greenland not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

12. Arrowtooth Flounder

a. Stock Assessment

BERING SEA - REFM
This chapter was presented in executive summary format, as a scheduled "off-year" assessment. New input data include: fishery size composition for 2010 and 2011, and updated 2012 catch and preliminary 2013 catch.

Because this 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 and provides estimates of 2014 and 2015 ABC and OFL without re-estimating the stock assessment model parameters and biological reference points. The projection model is based on the previous year's model, except that it incorporates a new maturity ogive, which was approved by the Team in September.

The 2012 stock assessment model (using a different maturity schedule) resulted in a 2014 age 1+ biomass projection of 1,021,060 t, compared to 1,023,440 t from this year's assessment. The corresponding values for 2014 spawning biomass are 638,377 t (last year's assessment) and 626,319 t (this year's assessment). This year's assessment projects a slight increase in female spawning biomass between 2014 and 2015. The stock is at a high and stable level.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock.

Arrowtooth flounder therefore qualifies for management under Tier 3. The point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from last year's assessment were 246,476 t, 0.17, and 0.21, respectively; from this year's assessment, they are 231,015 t, 0.156, and 0.186, respectively. The projected 2014 spawning biomass is far above $B_{40\%}$ in both last year's and this year's assessments, so ABC and OFL recommendations for 2014 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, which results in 2014 and 2015 ABCs of 106,599 t and 106,089 t, respectively, and 2014 and 2015 OFLs of 125,642 t and 125,025 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.

In contrast to the Gulf of Alaska, arrowtooth flounder is not at the top of the food chain on the EBS shelf. Arrowtooth flounder in the EBS is 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 these species in the EBS overall, these occasionally recorded events do not translate into considerable total mortality for the arrowtooth flounder population in the EBS ecosystem.

GULF OF ALASKA - REFM
Arrowtooth flounder are assessed on a biennial schedule to coincide with the timing of survey data. A full assessment was completed this year to update the stock status using the 2013 GOA survey information. The 2013 NMFS GOA trawl survey biomass and length data were added to the stock assessment model. Catch for 2011 was updated, and updated catch for 2012 and 2013 was added. Fishery length data was updated for 2011 and fishery length data from 2012 and 2013 was added to the model. No new age data were available. There were no changes in assessment methodology. Arrowtooth flounder are managed as a Tier 3 stock, using a statistical age-structured model as the primary assessment tool. An age-based model was used with the same configuration as the 2011 assessment.

The estimated age 3+ biomass from the model has increased by an order of magnitude since 1961 and peaked at about 2.2 million t in 2006. The age 3+ biomass estimates are slightly lower in the current assessment for the years since 2000 when compared to estimates from the 2011 assessment. Female spawning biomass in 2013 was estimated at 1,200,320 t, which is<1% less than the projected 2013 biomass of 1,278,530 t from the 2011 assessment. Age 3+ biomass is expected to decrease in 2015 .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.

Arrowtooth flounder has been determined to fall under Tier 3a.The 2014 ABC using $F_{40\%}$=0.172 is 195,358 t, a decrease from the 2013 ABC of 210,451 t.The 2014 OFL using $F_{35\%}$=0.204 is 229,248 t. The 2015 ABC (189,556 t) and OFL (222,160 t) were estimated using the projection model and with total catch in 2012 and the estimated catch for 2013 and 2014. Catch in 2013 and 2014 was estimated using the recent 5-year average (F=0.02). Area apportionments of arrowtooth flounder for 2014 and 2015 are based on the fraction of the 2013 survey biomass in each area.

13. Other Flatfish

a. Stock Assessment

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. For example, Starry flounder and rex sole comprised 90% of the “other flatfish” catch in 2013. Because of insufficient information about these species, no model analyses are possible and trawl survey estimates are used to determine stock biomass. The latest assessment incorporates 2013 total catch and discard and 2013 trawl survey information. The 2013 EBS bottom trawl survey resulted in biomass estimates of 89,995 t, 9% lower than the 2012 estimate. The biomass of these species in the Aleutian Islands is 15,700 t from the 2012 survey.

Because this complex is managed under Tier 5, no models are available from which to predict future trends. 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. Starry flounder continues to dominate the shelf survey biomass in the EBS and rex sole is the most abundant “other” flatfish in the Aleutian Islands. There is no consistent trend in the survey biomass of EBS butter sole over time. The 1982 butter sole estimate for the Eastern Bering Sea was 182 t compared to the 2013 estimate of 1,310 t, with values as high as 6,340 t in 1986 and as low as 37 t in 1983 (the median of the absolute value of the relative change from year to year is 59 percent). EBS starry flounder biomass increased from 7,780 t in 1982 to a high of 98,600 in 2007. This estimate has been decreasing since 2007 to 58,900 t in 2013. Conversely, EBS longhead dab decreased from a one-time high of 104,000 t in 1982 to 5,450 t in 2013. This estimate has fluctuated over time, though less dramatically from 1985 through the present. Longhead dab are found in inshore waters that are not normally sampled by the bottom trawl survey. 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.

GULF OF ALASKA - REFM

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) in the GOA SAFE document 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 *FABC* = 0.11), gives a 2014 ABC of 12,400 t for the “other flatfish” complex. The corresponding 2014 OFL (average *FOFL* = 0.15) is 16,700 t.
Before the implementation of Amendment 80, fishing for this complex was usually closed for trawl gear prior to attainment of TAC because of the bycatch of Pacific halibut, a prohibited species. With the implementation of Amendment 80, a higher TAC for “other” flatfish was assigned for 2007-2010, although it was subsequently decreased for 2011-2013.

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.

GULF OF ALASKA Deep-water flatfish - REFM

The deep water flatfish complex is comprised of Dover sole, Greenland turbot, and deep sea sole. The assessment included updated fisheries catch data for all three species through 2013. Dover sole are assessed with an a statistical stock assessment model whereas Greenland turbot and deep sea sole rely on survey biomass estimates alone. Dover sole fishery and survey length compositions, and survey age compositions were updated. The 2013 survey biomass estimate was included in the Dover sole model. The 1984, 1987, and 2001 length and age at length data were excluded from the Dover sole model due to survey biases in these years. The Stock Synthesis assessment platform was used to conduct the Dover sole assessment. A survey averaging random effects model was used to estimate survey biomass and variance in missing depth and area strata and these estimates were included in the survey biomass index. Male and female selectivity curves were estimated based on the survey biomass index and composition data from surveys that covered more than 500 m in depth. Separate sex-specific selectivity curves were estimated using only composition data from surveys that covered no more than 500 m in depth. A conditional age-at-length approach was used in the model and growth parameters were estimated internally. Fishery selectivity was changed to be length-based and double-normal, allowing for dome -shaped selectivity. An initial equilibrium fishing mortality rate was estimated. An ageing error matrix was incorporated into the model. Recruitment deviations prior to 1984 (1967–1983) were estimated separately from main-period recruitment deviations (1984–2008). Composition data sources were weighted using a method that accounted for intra-year correlations in residuals.

The Plan Team endorsed the use of the author's recommended model for setting catch limits. In addition to the author's recommended model, three alternate models were also presented. These encompassed treatment of early recruitment, and the exclusion of the 1984 and 1987 survey biomass estimates. The model estimate of spawning stock biomass in 2013 is 66,147 t, which is well above B35% (24,690 t). Thus the Dover sole stock is not overfished. Information is insufficient to determine stock status relative to overfished criteria for Tier 6 species. Catch levels for this complex remain well below the TAC and below levels where overfishing would be a concern. Last year ABCs and OFLs for Dover Sole were in Tier 5 last year (2012). This year (2013) the author and Plan Team recommend that Dover sole be moved to Tier 3a management. B40%for this stock is estimated to be 28,128 t and projected spawning biomass is 66,147 t. For the Dover sole Tier 3a assessment, the 2014 and 2015 ABC are 13,289 t and 13,120 t, respectively. The 2014 and 2015 OFL using Tier 3a results are15,915 t and 15,711 t, respectively. Both Greenland turbot and deep sea sole are in Tier 6. The Tier 6 calculation (based on average catch from 1978–1995) for the remaining species in the deep water flatfish complex ABC is 183 t and the OFL is 244 t. These values apply for 2014 and 2015 ABC and OFLs. The GOA Plan Team agrees with the authors' recommendation to use the combined ABC (13,473 t) and OFL 16,159t) for the deep water flatfish complex for 2014 and 2015. The ABC is equivalent to the maximum permissible ABC. Area apportionment Area apportionments of deep water flatfish are based on the relative abundance (biomass) of each species in the stock complex in each management area. Area apportionments of deep water flatfish (Dover sole and others) ABCs for 2014 and 2015 are based on the fraction of the 2013 survey biomass in each area for Dover sole and the estimate of 2013 catch by area for Greenland turbot and deep sea sole.

14. Sharks and Skates

a. Research

Salmon Shark Life History – RACE GAP, ABL, and the Alaska Department of Fish and Game

Sharks in Alaska waters are currently managed as a part of the 'Other Species' group by the North Pacific Fishery Management Council. Shark catches within the Gulf of Alaska (GOA) are dominated by three species, the spiny dogfish, *Squalus acanthias*, the Pacific sleeper shark, *Somniosus pacificus*, and the salmon shark, *Lamna ditropis*. While not the target of commercial fisheries, salmon sharks are captured by recreational fishers and as bycatch in several fisheries within the GOA. The stock assessment and management of this species is hindered by a lack of life history data to input into models. Parameters needed to support stock assessment include reproductive timing and periodicity, fecundity, and improved age and length at maturity estimates. The life history of this species is being examined by researchers at the Kodiak Laboratory. Salmon sharks captured incidentally in other fisheries are being collected and dissected to examine: length at maturity, fecundity, reproductive periodicity, and age and growth. Female salmon sharks were found to have a biennial reproductive period with a 9-10 month gestation, a resting period of over a year, and a fecundity of approximately four pups per litter. The manuscript for this project is in press.

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

Spiny Dogfish Ecology and Migration - ABL

Scientists at the Auke Bay Laboratories are continuing an annual tagging program for spiny dogfish using electronic archival tags. A total of 183 satellite pop-off tags have been deployed on spiny dogfish since 2009. Data has been successfully recovered from 147 tags, with some tags still at liberty. Three 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 are participating in a North Pacific Research Board funded project to investigate alternative aging methods for spiny dogfish. This project aims to compare the previous method of aging the dorsal fin spines with a new technique developed that uses the vertebrae. Challenges to this ageing project were discussed at the last CARE meeting: vague ageing criteria and sample collection location (within an animal). As a result, new ageing criteria were established for both spines and vertebrae and the structures are being re-examined. Progress and preliminary results for this project have been presented at the Alaska Marine Science Symposium, the American Elasmobranch Society, Western Groundfish Conference and the Northeast Pacific Shark Symposium. 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 was to investigate the population structure of sleeper sharks in Alaskan waters. Tissue samples were opportunistically collected from 141 sharks from 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. 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. 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.

b. Stock Assessment

Sharks - ABL

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) were moved to biennial cycles. The GOA assessment coincides with the biennial trawl survey in odd years and the BSAI assessment is in the even years. In 2013 an expanded executive summary assessment was presented for the GOA sharks instead of the full assessment due to the government shutdown. A full assessment for the BSAI sharks is planned for the fall of 2014 and in 2015 for the GOA sharks.

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 2003-2013 were updated from the NMFS Alaska Regional Office's Catch Accounting System. Total shark catch in 2013 was 1,019 t, up from 634 t in 2012. This is the highest since 2009, but was still below the maximum historical catch of 1,538 t in 2006 (over the years 2003 – 2012). Substantial changes to the observer program (referred to as "observer restructuring") likely affected the catch estimates for shark species. Smaller vessels are now subject to observer coverage, and this includes vessels fishing halibut IFQ, which were previously exempt from coverage. The increase in 2013 can be attributed mostly to an increase in the catch estimate of spiny dogfish in the Pacific halibut target fishery, which was 460 t, up ~300 t from the average catch from 2003 – 2012, but was still within the range of catches from this target group. Pacific sleeper shark catch in the halibut target group in 2013 (60 t) was significantly greater than the 2003 - 2012 average (7.4 t, SD = 18.3). An additional impact of observer restructuring 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 group in 2013 was 126 t and 52 t, respectively, whereas historically it has been small (<1 t for Pacific sleeper sharks and ~14 t average, SD = 23, for spiny dogfish). There was approximately 2 t of salmon shark and other shark 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 2013 would be 1,199 t, which is still below the recommended acceptable biological catch (ABC) for this complex.

Survey biomass was updated for the 2013 assessment. The trawl survey biomass estimates are only used for spiny dogfish. The 2013 survey biomass estimate (160,384 t, CV = 40%) is nearly four times greater than the 2011 biomass estimate of 41,093 t (CV = 22%); this variability is typical for spiny dogfish. The 3 – year average biomass from the trawl survey that is used in calculating the ABC and over fishing level (OFL) declined from 79,979 t (2007, 2009 and 2011 surveys) to 76,452 t (2009, 2011 and 2013 surveys) with the inclusion of the new survey data. The 2007 survey biomass estimate (161,965 t, CV = 35%) dropped out of the calculations, but because the 2013 estimate was nearly equal to the 2007 estimate, the average had only minimal change.

In the BSAI, estimates of shark catch from the Catch Accounting System from 2012 were 95 t and the estimated catch for the assessment in 2013 was 71 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 are calculated as a "Tier 5" species (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=5,989 t and OFL= 7,986 t for 2014. In the BSAI, all shark species are considered "Tier 6" with the 2014 ABC = 1,020 t and OFL = 1,360 t. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

15. Other Species

a. Research

Otolith Morphology and Microchemistry of Giant Grenadier – ABL (MESA and Genetics), REFM

Three very different shapes of otoliths have been observed in giant grenadier. A review of the literature and world-wide experts revealed that such variability in otolith shape is highly unusual for an individual fish species. Otolith morphology differences could be related to speciation or stock structure. Tagging studies are a traditional way to determine migration patterns and spatial stock structure for fish. However, these studies are not possible for giant grenadier because the fish do not survive the pressure difference when caught at depth and brought to the surface. Genetic and otolith microchemistry studies are an alternative means for determining stock structure and species determination, i.e. if giant grenadier are actually two or more species. In 2013, tissue and otoliths samples were collected on the AFSC longline survey in the eastern, central, and western Gulf of Alaska and the Bering Sea. Otoliths will be aged and measured for a quantitative comparison of otolith shape and for an examination of fish growth; microchemistry will be employed to examine movement and habitat use during the juvenile stages; microsatellites will be used to genetically determine if stock structure exists, and the genetic technique called the "bar code of life" will be used to examine speciation. For more information, contact Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

Octopus Life History – RACE GAP and REFM

Initial stock assessments of octopus within the Gulf of Alaska have revealed that there is little life history information available for this group. RACE biologists at the Kodiak Laboratory in collaboration with REFM biologists in Seattle initiated a life history study of giant Pacific octopus during 2009. This study co-occurred with gear studies to examine the feasibility of an octopus fishery. The giant Pacific octopus, *Enteroctopus dofleini*, is the largest and most abundant octopus species found on the continental shelf of Alaska and it dominates the commercial bycatch of octopus within the Gulf of Alaska. Giant Pacific octopus specimens were obtained from charter operations, Pacific cod pot fishermen, and from scientific surveys within the Gulf of Alaska in order to examine the reproductive biology of this species. Giant Pacific octopus were found to have a protracted reproductive cycle with peak spawning occurring in the winter to early spring months. In the Gulf of Alaska, this species matures between 10-20 kg with 50% maturity values of 13.7 kg (95% CI 12.5-15.5 kg) for females and 14.2 kg (95% CI = 12.6-15.9 kg) for males. Fecundity for this species was found to range from 41,600 to 239,000 with an average fecundity of 106,800 eggs/female. Fecundity was significantly and positively related to the weight of the female. These data are a necessary first step in examining the life history of octopus within this region in order to determine their vulnerability to overfishing and establish appropriate management strategies for this species group within the Gulf of Alaska. The manuscript for this project has been submitted and is in review.

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

Octopus Delayed Discard Mortality - RACE GAP

Octopus are caught incidentally in trawl, longline, and pot fisheries; however, the majority of the catch comes from Pacific cod pot fisheries. There is concern that the establishment of annual catch limits (ACLs) for this group may unnecessarily constrain this and other commercial fisheries. During 2011, in the Bering Sea/Aleutian Islands regions the total allowable catch (TAC) for octopus was reached in August 2011 and octopus retention was prohibited starting September 1, 2011. The overfishing limit (OFL) for octopus was reached October 21, 2011 and directed fishing for Pacific cod pot gear was closed for the remainder of the year. Due to the lack of reliable abundance estimates and life history information about octopus in the Gulf of Alaska it is appropriate that they be managed conservatively, however better scientific data will ensure the most appropriate values are used for discard mortality rates for this assemblage. Observer data have documented the short term mortality of octopus captured within these pot fisheries is very low. Data on delayed or long-term mortality of this species will enable scientists to develop a gear-specific discard mortality factor. During the 2014 “A” season for Pacific cod, twenty octopus were collected for long term mortality studies from commercial fishing vessels utilizing pot gear. To date these octopus have exhibited low mortality rates and these data support the development of a gear specific discard mortality factor. Additional octopus specimens will be collected during the fall fishery for Pacific cod in 2014 and the winter fishery in 2015.

Blue King Crab Modeling in the Bering Sea - RACE Recruitment Processes

Eco-FOCI personnel are involved in modeling of blue king crab (BKC) in the Bering Sea in a project funded by NOAA’s FATE program. We are adapting an existing individual-based model (IBM) of snow crab larval drift, for BKC. The snow crab IBM has been used to demonstrate connectivity patterns for snow crab across the eastern Bering Sea. BKCs are found in widely-separated populations in the Bering Sea, and stock structure is largely unknown. Population trends are very different between the Pribilof Islands regions and the St. Matthew region, however, there are no apparent barriers to adult dispersal between the regions. They are, however, infrequently taken in NMFS trawl surveys between those islands suggesting limited post-settlement dispersal as adults. General current structure in the region suggests that there may be a possible source-sink relationship of planktonic larvae released in the Pribilof Islands region that could settle in the St. Matthew region, but also potential retention in the area around the Pribilofs.

The objectives of the FATE project is to adapt a biophysical individual-based model (IBM) to determine connectivity between larval release and benthic settlement areas for eastern Bering Sea BKC populations. The study is examining the likelihood of exchange via larval drift among populations of BKC in different regions of the eastern Bering Sea, from near the Alaska Peninsula, the Pribilof Islands and St Matthew Island. Connectivity, or the lack of it, between these regions can shed light on populations structure of BKC in the Bering Sea.

The results of this study will directly inform the assessment and management of the Pribilof Islands and St. Matthew BKC stocks. Currently, stock boundaries are established based on geographical features and fishing practices without any information on stock overlap or connectivity. Information on larval drift and likely impacts of environmental conditions and habitat availability on settling locations may inform the management boundaries. This would affect the estimation of biomass, determination of removals, and subsequent definitions of stock status. An extreme yet possible outcome of the changes in boundary definitions might lead to the aggregation of the Pribilof Islands and St. Matthew stocks for overfishing determinations. This would obviously have dramatic impacts on the overfishing status of BKC in the eastern Bering Sea and have potentially lasting impacts on the Pribilof Islands ecosystem.

Contributed by S. Hinckley, e-mail: Sarah.Hinckley@noaa.gov

Distribution and Migration of Morphometrically Mature Male Snow Crab in the Eastern Bering Sea - RACE GAP

Tagging of adult male snow crab (*Chionoecetes opilio*) in the eastern Bering Sea, using pressure and temperature recording data storage tags, was conducted during 2010 and 2011 in an effort to determine the occurrence and extent of seasonal migrations. The research was designed to address the question of whether or not morphometrically mature males undergo a migration from offshore wintering areas northwest of the Pribilof Islands where the fishery occurs to more inshore areas where mature females reside. Fishery managers have recognized a spatial mismatch among larger commercial-sized (≥ 102 mm carapace width) snow crab males, which are found over the middle EBS shelf (< 100 m bottom depth) during annual summer bottom trawl surveys, but appear centered over the outer shelf (100 - 150 m bottom depth) during winter where the fishery occurs. Part of this mismatch occurs because, upon reaching morphometric maturity, adult males undergo an offshore migration during winter. Although this movement into deeper water during is firmly established, the timing and other particulars of a return migration (which might contribute to the mismatch), have not been demonstrated. Since mature females are thought to remain in the shallower areas throughout the year, the specifics of this return migration are also important because they are critical to understanding whether males continue to participate in breeding throughout their lives.

A total of 277 adult males were tagged and 33 were recovered by the fishery between 2011 and

2012. Analyses of the tag depth records indicated that most of these males underwent some limited inshore movements during spring, but that the timing and extent of these movements were highly variable among individuals. Comparisons of tag depth records with distributions of adult female snow crab during the two years in which tagged males were at liberty, indicated that inshore movements were likely made for the purpose of mating. However, the timing and extent of these migrations were such these males could only mate with females that had already released a brood in a prior years (multiparous), and not with those that were holding their first brood (primiparous).

For more information, contact Dan Nichol, e-mail: dan.nichol@noaa.gov

b. Assessment

Grenadiers - ABL

In February, 2014 the NPFMC moved grenadiers into the fishery management plans (FMPs) in Alaska. They were put into the FMPSs as "ecosystem components" and so landings are now required to be reported, but there are no OFL, ABC, and TACs. It is recommended that an "ecosystem component" be monitored for overfishing, but no definition of overfishing exists for this group. The only other "ecosystem component" is forage fish. An unofficial assessment has been conducted annually since 2006; ABL will continue to do a Stock Assessment and Fishery Evaluation Report (SAFE) as often as possible since there is no requirement to complete an assessment for an "ecosystem component".

Giant grenadier (*Albatrossia pectoralis*) are by far the most abundant grenadier in Alaska at depths <1,000 m. They are the major bycatch species in directed fisheries for sablefish and Greenland turbot. Assessments have been based on giant grenadier serving as a proxy for entire grenadier group. Besides being the most abundant grenadier, they also have the highest CPUE of all species caught during the trawl survey in depths >400 m.

In 2013, an unofficial executive summary SAFE was done for grenadiers in Alaska. ABC recommendations remained the same since there has not been a trawl survey that has sampled deep enough to be used in calculations of giant grenadier ABCs. Current biomass estimates for giant grenadier are: eastern Bering Sea (EBS), 553,557 mt; Aleutian Islands (AI), 598,727 mt; and Gulf of Alaska (GOA), 597,884 mt. Based on the NPFMC's "tier 5" definition for ABC, we applied an $F=M=0.078$ approach (M is the natural mortality rate) to these biomass estimates to compute overfishing levels (OFLs) for giant grenadier in each region, and then multiplied the OFLs by 0.75 to compute the following ABCs: EBS, 32,383 mt; AI, 35,026 mt, and GOA, 34,976 mt. When these values are compared with the estimated catches of giant grenadier, it appears giant grenadier are not being overfished at this time.

D. Other Related Studies

Fisheries Resource Pathology Program – RACE

During the 2013 survey season, the Fisheries Resource Pathobiology sub-task continued its monitoring effort of potentially important diseases of a number of species found in the Bering Sea shelf region. As part of an ongoing study, non-lethal hemolymph withdrawals were collected from *Chionoecetes opilio*, *Chionoecetes bairdi*, *Paralithodes camtschaticus*, and *Paralithodes platypus* to determine the prevalence and distribution of bitter crab syndrome caused by *Hematodinium sp*., a parasitic dinoflagellate.

As a disease program, we frequently get inquiries regarding the nature of encountered anomalies. It is our goal to develop a web-based reference site or information center. Therefore, we inspected numerous fish and shellfish for assorted visual anomalies during the 2013 EBS RACE survey. Abnormalities were photographed, excised, and placed in fixative for subsequent microscopic diagnosis and for genetic characterization of the respective etiological agent. Species analyzed included Alaska plaice, yellowfin sole, northern rock sole, Pacific cod, flathead sole, and walleye Pollock.

For further information, contact Dr. Frank Morado, (206) 526-6572.

Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2013. A taxonomic revision of the sandlance genus *Ammodytes* of the North Pacific was submitted (Orr et al., in review). Based on molecular and morphological data, the revision recognizes two species in the eastern North Pacific (*A. hexapterus* in the Bering Sea and north; *A. personatus* in the southern Bering Sea and farther south) and describes and names a new species from Japan. The second part of a revision of the fish family Caristiidae (manefishes and veilfins), describing five new species, was recently published (Stevenson and Kenaley, 2013), as well as a comprehensive osteological description of the prowfish, *Zaprora silenus* (Hilton and Stevenson, 2013). A taxonomic revision of snailfishes in the *Careproctus rastrinus* species complex (Orr et al.), and a project documenting the genetic diversity of lumpsuckers (Cyclopteridae) across the North Pacific and marginal seas (Kai and Stevenson) are in draft. A guide to cods and cod-like fishes (Gadiformes) is nearly complete (Hoff, Orr, and Stevenson) and a manuscript clarifying the taxonomy and distribution of sculpins of the genus *Malacocottus* (Stevenson) is in review. An additional study, testing the hypothesis of cryptic speciation in northern populations of the eelpout genus *Lycodes* (Stevenson) is underway. In addition to taxonomic revisions, descriptions of new taxa, and guides, RACE systematists have collaborated with molecular biologists within and outside of the AFSC to identify snailfish eggs in crabs (Orr, Stevenson, Somerton, and Spies) and examine population-level genetic diversity in the skate *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies), *Ammodytes* (Orr and Wildes), *Eumicrotremus* (Kai and Stevenson), and *Lycodes* (Stevenson and Paquin). 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 (Pietsch and Orr, in press) and notes on new records and range extension of other fishes (Kai et al., 2013; Maslenikov et al., 2013; Okamoto et al., in review; Paquin et al., in press).

With the support of NPRB and JISAO, an annotated checklist of the marine macroinvertebrates of Alaska comprising over 3500 species has been submitted (Drumm et al., in review). A new species of a tanaidaceiid crustacean was described (Drumm and Bamber, 2013). Two additional papers on new records of shrimps and crabs have been published or submitted (Fujita et al., 2012; Drumm et al., 2013; Drumm and Orr, in review). As a result of this checklist and following Stevenson and Hoff (2009), a processed report providing species-level confidence identification matrix for the Gulf of Alaska and Aleutian Islands is in press (Orr et al., in press) and another on species of the Bering Sea slope is nearly complete (Orr et al., in review).

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." This work was conducted both in the Bering Sea and the Gulf of Alaska Pollock trawl fisheries. There has been no substantial change in Chinook and Chum salmon escape rates. Pollock escape was insignificant at less than 1%. 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. This new camera system is expected to see wide use on Alaska fishing vessels. An additional model testing/development workshop at the flume tank in St. Johns, Newfoundland was conducted in Fall of 2013, including improvements to the new design and tests of new designs.

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 will begin exploring these possibilities with experiments to compare the seafloor effects of the different alternative footropes.

Development and Evaluation of Trawl Ground Gears that Produce Less Damage to Crabs in Soft Bottom Areas-– RACE CE
In May, CE scientists continued the work from 2012 and 2013 but incorporated feedback from the Bering Sea flatfish trawl fleet to test alternative bottom trawl footropes to reduce potential damage to crabs. CE scientists spent two and half weeks testing alternative footrope designs, including those provided by the flatfish trawl fleet, for crab mortality rates, flatfish capture efficiency, and crab bycatch rates aboard the F/V Great Pacific. Reflex scans were conducted on recaptured crabs and converted to mortality rates with a relationship between reflex loss and delayed mortality (RAMP) developed in prior years. We found that widening disk spacing, and hence reducing ground contact and potential for crab damage, had little effect on flatfish catch rates and improved crab mortality rates.

Provide underwater video systems to fishermen and other researchers to facilitate development of fishing gear improvements – RACE CE
We have continued to provide five 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. Delivery, training and maintenance have been managed by contractors in the ports of Dutch Harbor and Kodiak with established contacts with the fishing industry. 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 10 x 9 inches and is of nearly neutral buoyancy in water. Two test trips (Kodiak and West Coast) and production use aboard the salmon excluder experiment have proven these to be very easy to use, durable and flexible. Six new systems will be built for our use and potential replacement of the older loaner systems. However, this design may be so inexpensive and functional that enough vessels will acquire their own systems and the loaner concept will no longer be needed.

APPENDIX I - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS
Published January 2012 through December 2012 (AFSC authors in bold text)

BABIJ, E., P. NIEMEIER, B. HAYUM, **A. HIMES-CORNELL**, **A. HOLLOWED**, P. LITTLE, M. ORBACH, and E. PIDGEON.
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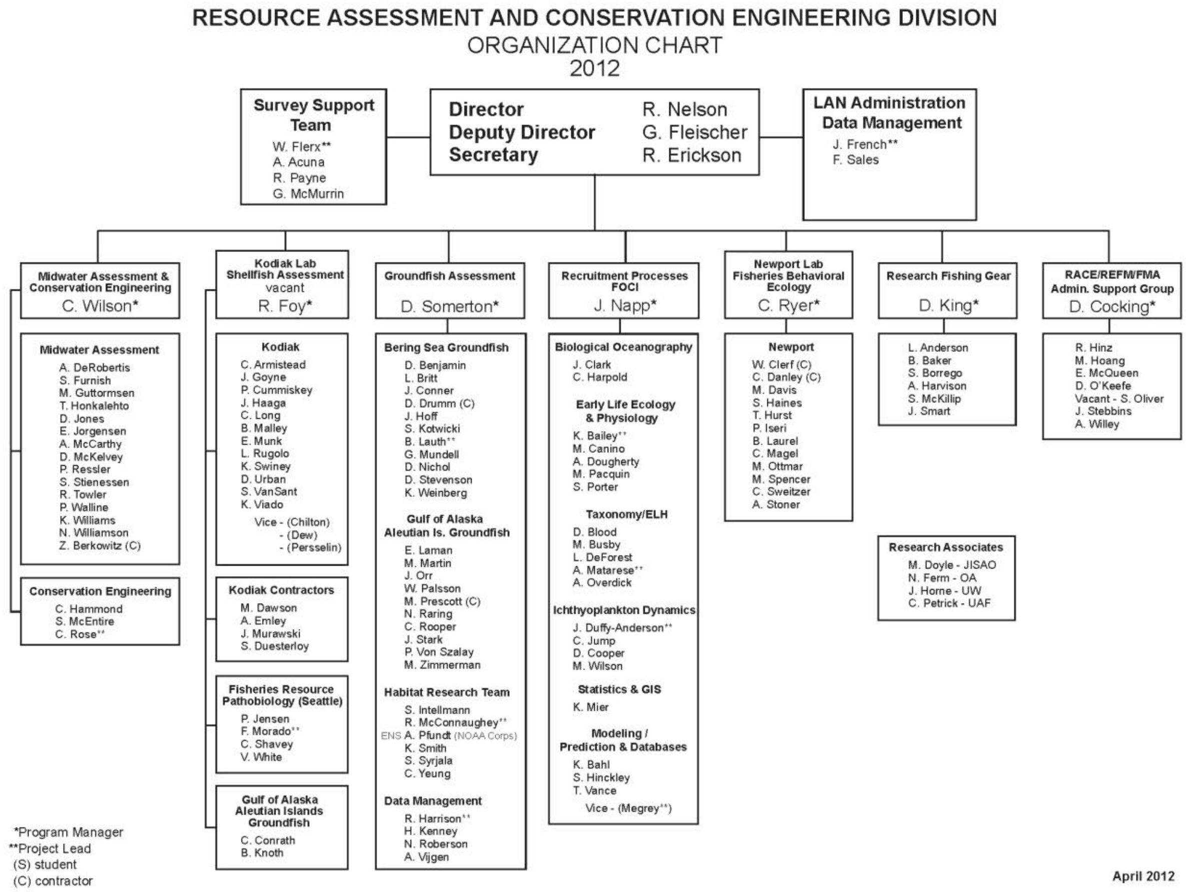
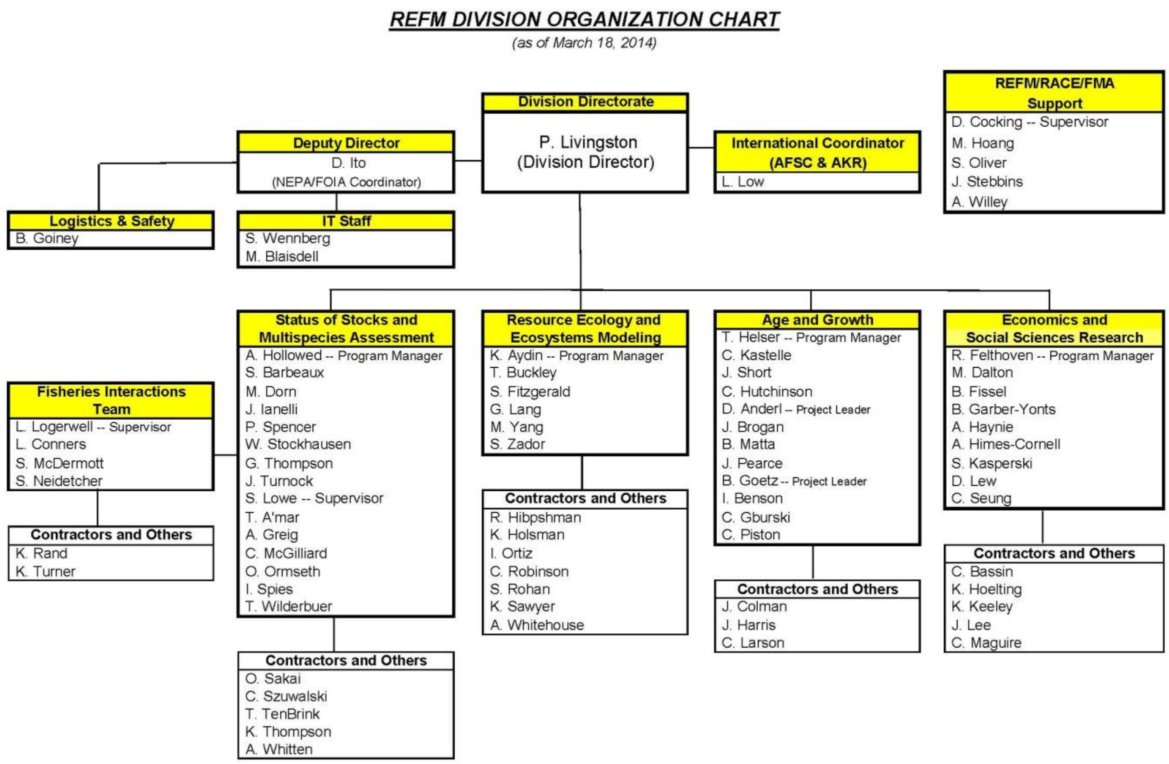
APPENDIX II. RACE ORGANIZATION CHART



APPENDIX III. REFM ORGANIZATION CHART



APPENDIX IV – AUKE BAY LABORATORY ORGANIZATIONAL CHART