Alaska Fisheries Science Center of the National Marine Fisheries Service

2012 Agency Report to the Technical Subcommittee of the Canada-US Groundfish Committee

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2010

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 groundfish. All Divisions work together closely 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, and Research Fishing Gear. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.

In 2011 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 major bottom trawl surveys of groundfish resources were conducted during the summer of 2011 by RACE Groundfish Assessment Program (GAP) scientists: the annual eastern Bering Sea shelf survey, the biennial eastern Bering Sea Continental Slope survey, and the biennial survey of the continental shelf of the Gulf of Alaska. In 2012 GAP scientists will again conduct the annual Bering Sea shelf survey, the Bering Sea Slope Survey, the Chukchi Survey and the biennial Aleutian Island survey of the continental shelf and upper continental slope resources.

RACE scientists of the Habitat Research Team (HRT) continue research on essential habitats of groundfish including identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, investigating activities with potentially adverse effects on EFH, such as bottom trawling, and benthic community ecology work to characterize groundfish habitat requirements and assess fishing gear disturbances.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock abundance during the summer in the Gulf of Alaska 2011. Research cruises investigating bycatch issues also continued.

For more information on overall RACE Division programs, contact Division Director Russ Nelson at (206)526-4170.

REFM DIVISION

The Alaska Fisheries Science Center's Resource Ecology and Fisheries Management (REFM) Division conducts research and data collection to support an ecosystem approach to management of Northeast Pacific and eastern Bering Sea fish and crab resources. More than twenty-five groundfish and crab stock assessments are developed annually and used by the North Pacific Fishery Management Council to set catch quotas. In addition, economic and ecosystem assessments are provided to the Council on an annual basis. Division scientists evaluate how fish stocks, ecosystem relationships and user groups might be affected by fishery management actions and climate. Research in the Arctic Ocean is an emerging activity. Specifically, REFM's activities are organized under the following Programs: Age and Growth, Economic and Social Sciences Research, Resource Ecology and Ecosystem Modeling, and Status of Stocks and Multispecies Assessment. Scientists in REFM assist in preparation of stock assessment documents for groundfish 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 in regional groundfish management teams.

For more information on overall REFM Division programs, contact Division Director Pat Livingston at (206)526-4172 or Pat.Livingston@noaa.gov.

AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL's Marine Ecology and Stock Assessment Program (MESA) is the primary group at ABL involved with groundfish activities. Major focus of the MESA Program is on research and assessment of sablefish, rockfish, and sharks in Alaska and with the study of fishing effects on the benthic habitat. Presently, the program is staffed by 17 scientists, including 16 permanent employees and 1 term employee. ABL's Ecosystem Monitoring and Assessment Program (EMA) has also been conducting groundfish-related research for the past few years.

In 2011 field research, ABL's MESA Program, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish 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) a sablefish maturity study conducted jointly with the AFSC RACE Division; 3) tagging studies of spiny dogfish in the Gulf of Alaska; 4) recompression experiments on rougheye rockfish; 5) a large-scale, epipelagic trawl survey of the eastern Bering Sea shelf conducted by ABL's EMA Program that provides annual data on abundance of age-0 walleye pollock; and 6) an upper trophic level fisheries oceanography survey of the Gulf of Alaska.

Ongoing analytic activities in 2011 involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of nine detailed status of stocks documents for Alaska groundfish: Alaska sablefish and Gulf of Alaska Pacific ocean perch, northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "Other Rockfish", thornyheads, and sharks. Other analytic activities in 2011 included analysis of sablefish archival tag data and an updated analysis of conventional sablefish tag data.

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

2011 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP

The thirtieth in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 4 August 2011 aboard the AFSC chartered fishing vessels *Arcturus* 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 2011 were 3.11 million metric tons (t) for walleye pollock, 911 thousand t for Pacific cod, 2.40 million t for yellowfin sole, 1.98 million t for rock sole, 26.2 thousand t for Greenland turbot, and 187 thousand t for Pacific halibut. There were slight increases in estimated total biomass compared to 2010 levels for Pacific cod, yellowfin sole, and Greenland turbot and slight decreases for walleye pollock, rock sole, and Pacific halibut.

For the first time since 2005, the average survey bottom water temperature for 2011 (2.33°C) was above the long-term survey mean (1982 to 2010), but only slightly (2.30°C); however, the average surface temperature in 2011 (5.07°C), remained well below the 29-year mean (6.55°C).

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

2011 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska– RACE GAP

The twelfth in a series of comprehensive bottom trawl surveys of groundfish resources in the Gulf of Alaska (GOA) region was conducted from May 18 through August 15, 2011 with actual trawling occurring from May 22nd to August 14th. This regional survey began in 1984 and was conducted triennially until 1999 and was then conducted biennially thereafter. The standard GOA survey area, established in 1999, begins at the U.S.-Canada border at Dixon Entrance (54° 30' N latitude) in the south and extends north and west along the shelf and slope to the Islands of the Four Mountains at the base of the Aleutian Islands (170° W longitude). Sampling depths range from approximately 15 to 1,000 m during a typical survey. Commercially and ecologically valuable species of flatfish, roundfish, rockfish, and invertebrates inhabit the area. In many areas rocky bottom conditions provide abundant substrate for many species of bottom-oriented including bryozoans, hydroids, sponges and corals, and these invertebrate communities, in turn, provide essential habitat for juveniles and adults of many groundfish species. 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 systematics, etc) and improving survey methodology.

Survey fishing was conducted aboard two chartered commercial trawlers, the F/V *Ocean Explorer* and the F/V *Sea Storm*, during the 85 day period. The survey design is a stratified-random sampling scheme based 59 strata of area, depth terrain (shelf, slope, gully) and applied to a grid of 5x5 km^2 cells. These cells are the sampling frame of possible trawl stations. Stations are 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. Some 812 were originally planned. 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 612 of the planned 812 stations or at nearby alternate sites, ranging in depth from 14 to 688 m. Because of late funding, a third vessel capable of deeper tows was not available for contract, so upper portions of the slope from 700 to 1000 m were not sampled and not as many stations were accomplished as planned. However, the two contracting vessels were accommodating and extended their contract time to make up for some of loss of sampling power. Just over 375.3 mt fish of fish and 6.7 mt of invertebrates were captured during the survey, and the catch consisted of 178 fish taxa and 471 invertebrate taxa. Not surprisingly, arrowtooth flounder was the most abundant species found in the survey, followed by Pacific ocean perch, walleye pollock, Pacific cod, and giant grenadier as dominant species by weight.

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

Summer 2011 Acoustic-trawl Survey of the Gulf of Alaska—RACE MACE

The MACE Program conducted a summer 2011 acoustic-trawl (AT) survey aboard the NOAA ship *Oscar Dyson,* targeting walleye pollock (*Theragra chalcogramma*) along the Gulf of Alaska (GOA) shelf. The survey, initially intended to cover the GOA from the Islands of Four Mountains eastward to Yakutat, was cut short by 16 days due to ship-related mechanical and personnel issues and so reached only as far east as Chiniak Trough. This summer survey curtailment followed cancellation of the winter acoustic-trawl survey efforts in the GOA and Bogoslof Island region due to vessel maintenance delays coupled with budget constraints.
The summer GOA shelf survey included smaller-scale surveys in several bays and around islands including Morzhovoi Bay, Sanak Trough, Pavlof Bay, the Shumagin Islands area (comprising Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Mitrofania Island, Nakchamik Island, Shelikof Strait, Chiniak Trough, Barnabas Trough, and Alitak Bay. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and near-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. Additional survey sampling included conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts to characterize the physical oceanographic environment. A number of specialized sampling devices were used during the survey, including light level sensors, a lowered echosounding system to measure target strength, and a trawl-mounted, stereo camera ("Cam-Trawl") designed to aid in determining species identification and size of animals encountered at different depths. A Simrad ME70 multibeam sonar was used to develop a trawlability index along with accompanying drop video camera deployments to groundtruth bottom classification.

The GOA shelf survey was conducted between 14 June and 12 August and consisted of 36 north-south transects spaced 20 nautical miles (nmi) apart covering the shelf and shelf break. Morzhovoi Bay, Pavlof Bay, and Sanak Trough were surveyed between 22 and 25 June along transects spaced 2 nmi apart. The Shumagin Islands were surveyed on 7-8 July along transects spaced 2.5 nmi apart in West Nagai Strait and Unga Strait, 2.0 nmi apart east of Renshaw Point, and 1.0 nmi apart in Popof Strait. Mitrofania Island was surveyed 9-10 July along transects spaced 3.5 nmi apart. Nakchamik Island was surveyed 11-12 July along transects spaced 3.0 nmi apart. Shelikof Strait was surveyed from 16 to 21 July along transects spaced 10 nmi apart (except the 3 northernmost transects, which were 20 nmi apart). Chiniak and Barnabas Troughs

were surveyed between 7 and 12 Aug along transects spaced 6.0 nmi apart. Alitak Bay was surveyed 10-11 August 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 walleye pollock aggregations along the GOA shelf were detected southeast of the Islands of Four Mountains, between Mitrofania and Nakchamik Islands, and near the mouth of Barnabas Trough. Based on catch data from 11 AWT and 10 PNE hauls, most of the walleye pollock captured ranged from 31 to 73 cm with a mode of 45 cm FL. The walleye pollock biomass estimate for the GOA shelf was approximately 45% of the total walleye pollock biomass observed for the entire survey.

Backscatter in Morzhovoi Bay attributed to walleye pollock was diffuse and fairly evenly scattered along the 46 nmi of survey transects. Most of the walleye pollock captured in 1 AWT and 1 PNE haul ranged from 57 to 73 cm with small numbers of fish ranging from 14 to 55 cm. The majority of acoustic backscatter attributed to walleye pollock in Pavlof Bay was observed on transects surveyed in the mouth of the bay. Most of the walleye pollock captured in the one AWT haul conducted in Pavlof Bay ranged from 27 to 46 cm FL. No significant acoustic backscatter was measured along the 83 nmi of transects in Sanak Trough, and no trawl hauls were conducted. In the Shumagin Islands, the densest walleye pollock aggregations were located in the northern part of West Nagai Strait, western Unga Strait, and the outer transects off Renshaw Point. Walleye pollock ranged in length from 31 to 67 cm FL, with the majority of the fish in the 36-40 cm range, from two AWT hauls, one in Unga strait and one off of Renshaw point. The majority of acoustic backscatter attributed to walleye pollock near Mitrofania Island was to the west and south of the island and fish captured in the one AWT haul near the island ranging from 32-64 cm with a mode of 46 cm. Backscatter attributed to walleye pollock near Nakchamik Island was evenly dispersed across the 47 nmi of surveyed transects. Walleye pollock captured in the one AWT haul near Nakchamik Island generally ranged from 26 to 42 cm with a mode of 37 cm and a few larger fish ranging up to 60 cm FL. The biomass in the aforementioned areas – i.e. Morzhovoi Bay to Nakchamik Island – accounted for approximately 4% of the GOA survey total.

In the Shelikof Strait area, the highest walleye pollock densities were observed in the southern half of the strait along the central to eastern side from Cape Ikalik, on western Kodiak Island, to Chirikof Island. Lengths of age-2 and older fish from 8 AWT and 1 PNE hauls ranged from 23 to 66 cm FL, with age-1 fish in the 14 to 19 cm range. Most age-1 walleye pollock were generally located at 150-200 m depths in rather dense aggregations approximately 50 m above the seafloor. The Shelikof Strait biomass accounted for approximately 35% of the survey total, of which 72% of the walleye pollock numbers were determined to be age-1 fish.

Chiniak and Barnabas Troughs contained large adult walleye pollock aggregations, with densities generally increasing from near Kodiak Island towards the outer troughs near the shelf break. Walleye pollock caught in three AWT hauls in Chiniak Trough ranged from 31 to 69 cm with modes at 36 and 53 cm FL. Walleye pollock caught in the two AWT hauls in Barnabas Trough ranged in length from 41 to 64 cm with a mode at 48 cm FL. Biomass in these two areas accounted for approximately 9% (Chiniak) and 8% (Barnabas) of the entire GOA summer survey biomass estimate. The densest pollock aggregations in Alitak Bay occurred in the inner part of Deadman Bay. Walleye pollock ranged in length from 28 to 61 cm with modes at 32 cm, 40 cm, and 47 cm FL in the one AWT haul conducted near the head of Deadman Bay and two PNE hauls conducted farther out in the open water off the mouth of Alitak Bay. A large group of whales feeding in the outer bay area prevented adequate sampling of the backscatter. This was not considered to be a major concern because the biomass in Alitak Bay represented < 1% of the GOA total. For more information, contact MACE Program Manager, Chris Wilson, (206) 526-6435.

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

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

Gulf of Alaska Project: Fisheries Oceanographic Surveys - ABL

The Gulf of Alaska Project in 2011 conducted the first Upper Trophic Level (UTL) fisheries oceanographic survey as part of the North Pacific Research Board's (NPRB) Gulf of Alaska Integrated Ecosystem Research Program (GOA Project) which focuses on comparing and contrasting ecological function in the southeast and central regions of the Gulf of Alaska (GOA). This 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, which 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. The LTL focuses on physical and biological oceanographic properties, zooplankton, and ichthyoplankton. 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.

Four fisheries oceanographic surveys were conducted off southeast Alaska and Kodiak Island during summer and fall by the F/V *Northwest Explorer*, a chartered commercial trawler. Fish samples were collected using a midwater rope trawl (Cantrawl model 400). During the survey, the trawl was either 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. A "live box" was attached to the codend of the survey trawl at predetermined grid stations to collect live age-0 rockfish in the southeast GOA region. Once the "live box" was retrieved, live *Sebastes* specimens were immediately transferred to an aerated live well on deck and transported to ABL for feeding and growth rate studies.

Acoustic data were collected by a Simrad ES-60 echosounder and a hull-mounted 38 kHz splitbeam transducer. Acoustic transects, orthogonal to shore, were run between all rope trawling stations. To verify constituent species observed in the acoustic record, opportunistic trawls targeted midwater aggregations that the surface trawl would not sample. As the survey progressed, the acoustic echogram was monitored in real time for unusual or interesting aggregations along transects. 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. Neuston tows were also made at the surface with a Sameoto sampler.

We intend to again sample the eastern and central regions of the GOA during summer 2012, although fall sampling will not occur. In 2013, when field work for this project terminates, we are planning both summer and fall surveys. For more information, contact Jamal Moss at (907)-789-6609 or jamal.moss@noaa.gov

2. Research

Combining bottom trawl and acoustic data to model acoustic dead zone correction and bottom trawl efficiency parameters for semi-pelagic species-RACE GAP

Abundances of semi-pelagic fishes are often estimated using acoustic-trawl or bottom trawl surveys, both of which sample a limited fraction of the water column. Acoustic instruments are effective at sampling the water column, but have a near-bottom acoustic dead zone (ADZ), in which fish near the seafloor cannot be detected. Bottom trawl surveys cannot account for fish that are located above effective fishing height (EFH) of the trawl. We present a modeling method that combines acoustic and bottom trawl abundance measurements and habitat data (e.g. grain size, temperature, depth, light levels) to derive ADZ correction and bottom trawl efficiency parameters. Bottom trawl and acoustic measurements of walleye pollock (*Theragra chalcogramma*) abundance and available habitat data from the eastern Bering Sea (EBS) are used to illustrate this method. Our results show that predictions of fish abundance in the ADZ can be improved by incorporating bottom habitat features such as depth and sediment particle size, as well as pelagic habitat features such as water temperature, light level, and current velocity. We also obtain predictions for trawl efficiency parameters such as EFH, density-dependent trawl efficiency, and proportionality coefficients for trawl and acoustic data by modeling bottom trawl catches as a function of acoustic measurements and the environmentally dependent ADZ correction. We conclude that the detectability of acoustic trawl surveys and the catchability of bottom trawl surveys are spatially and temporarily variable. Our modeling method can be applied to other semi-pelagic species to obtain estimates of ADZ and bottom trawl efficiency parameters. The ADZ correction derived from the model can then be used to assess detectability of acoustic trawl survey data in relation to habitat and environmental factors, and bottom trawl survey catchability can be assessed using estimated trawl efficiency parameters. Contact Stan.Kotwicki@noaa.gov

Detecting Temporal Trends and Environmentally Driven Changes in the Spatial Distribution of Groundfishes and Crabs on the Eastern Bering Sea Shelf-RACE GAP
This study uses a 30-year time series of standardized bottom trawl survey data (1982-2011) from the eastern Bering Sea shelf to model between-year responses of global and local spatial distribution indices for various bottom fishes and crabs against between-year differences in the areal extent of the cold pool, fluctuations in population abundance, and the time lag between surveys. The two density-independent factors, the areal extent of cold pool and the survey time lag, together had a greater effect on the distributions for both spatial scales than did the density-dependent factor population abundance. Spatial distributions were affected by fluctuations in the extent and structure of the cold pool, generally showing a decreasing similarity in spatial patterns with an increasing difference in the size of the cold pool. The model iteratively selected among temperature levels within the cold pool at 0°, 1°, and 2°C for the temperature with the best fit. The area of the cold pool contained within the 1° isotherm most frequently affected spatial patterns of distribution on local and global scales. Temporal shifts in populations varied considerably among species and directional vectors for some species were greater in magnitude to the east or west than to the north. Results clearly show that the size of the cold pool partly drives the short-term interannual variability in patterns of spatial distribution on the eastern Bering Sea shelf, and that despite inclusion of data from the extended cold period lasting from 2006 to2010, there is a continuing broad scale community-wide temporal northward shift. Based on our results, density-dependent or density-independent factors, other than a long-term warming trend, in the eastern Bering Sea are causing the observed northward temporal shifts in distribution. Contact Stan.Kotwicki@noaa.gov and Bob.Lauth@noaa.gov

The Alaska Coral and Sponge Initiative (AKCSI): a NOAA Deep Sea Coral Research and Technology Program regional fieldwork initiative in Alaska--RACE GAP
Beginning in FY2012 the NOAA Deep Sea Coral Research and Technology Program (DSCRTP) will be sponsoring 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. In anticipation of the upcoming fieldwork, a workshop was held Anchorage, Alaska in September 2010 to identify research priorities for the region. These priorities were largely derived from ongoing research needs and objectives identified by the DSCRTP, the North Pacific Fishery Management Council and Essential Fish Habitat-Environmental Impact Statement (EFH-EIS) process. The research priorities included:

- Determine the distribution, abundance and diversity of sponge and deep-sea coral in

Alaska (and their distribution relative to fishing activity)
- Compile and interpret habitat and substrate maps for the Alaska region
- Determine deep-sea coral and sponge associations with Fishery Management Plan species (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems 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 in Alaska from disturbance or mortality
- Establish a long-term monitoring program to determine the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

Another outgrowth of this workshop was the formation of a planning team to guide the FY2012-2014 field research activities for the Alaska region. Through on-going planning team discussions culminating in an August 2011 meeting, a series of specific research objectives and corresponding research projects were identified. These projects were translated into field projects that will begin in the summer of 2012. The field research will be led by a planning team from NMFS – Alaska Fisheries Science Center, NMFS – Alaska Regional Office, NOS – National Centers for Coastal Ocean Science, OAR – Office of Exploration and Research, and the University of Alaska, Fairbanks. The objectives for the projects are to:

- Identify and map areas of high abundance of Primnoa corals in the Gulf of Alaska using existing data, augmented by new multibeam mapping and ROV transects
- Determine the distribution and areas of high abundance and diversity of deep-sea corals and sponges in the Gulf of Alaska and Aleutian Islands through modeling and through field sampling using underwater cameras
- Estimate the recovery rates and sustainable impact rate for Primnoa corals in the Gulf of Alaska through a landscape ecology approach
- Determine the productivity increases in terms of fish abundance and condition in areas with and without deep-sea coral and sponge presence by measuring density, growth and reproductive potential
- Estimate the effects of commercial long-line and pot fishing on deep-sea coral and sponge communities in the Gulf of Alaska with an underwater camera system
- Estimate the connectivity of populations of Primnoa in the Gulf of Alaska, British Columbia and the west coast of the U.S. through genetic studies
- Initiate collection of long term data sets of oxygen and pH from summer bottom trawl surveys
- Set up long-term monitoring of nearshore and unique populations of deep-sea coral and sponge in southeast Alaska fjords
- Improve the taxonomy of deep-sea corals and sponges through special collections of unidentified specimens
- Collect data and specimens for paleoclimatological studies
- Compile a geologically based substrate map for the Gulf of Alaska and Aleutian Islands;

Most of these projects will be carried out in each of the three years of the DSCRTP funding and will result in completed research products and recommendations in early 2015. Throughout the Alaska Coral and Sponge Initiative we will attempt to communicate results to relevant management agencies in a timely manner, so that new information can be incorporated into management as it becomes available. In addition, preliminary research results will be timely and can be directly incorporated into the review and revisions of the EFH-EIS for commercial fisheries in Alaska. This EFH-EIS review is scheduled to begin in FY2014. At the conclusion of this three-year field effort we plan to advance knowledge of deep-sea coral and sponge ecology in Alaska so that management of these resources can be based on the most up-to date scientific information on understanding human and climate impacts. Among other products, we expect to produce are distribution maps for select deep-sea coral and sponge producing regions of Alaska, detailed descriptions of growth patterns for select deep-sea coral species in the Gulf of Alaska, and descriptions of how deep-sea coral and sponge communities influence production of select fish and invertebrate species found in these habitats. For more information, contact Chris Rooper (chris.rooper@noaa.gov)

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. At least one subsequent site visit is planned for 2013 to allow additional tile collections and to capture long-term effects of disturbance.

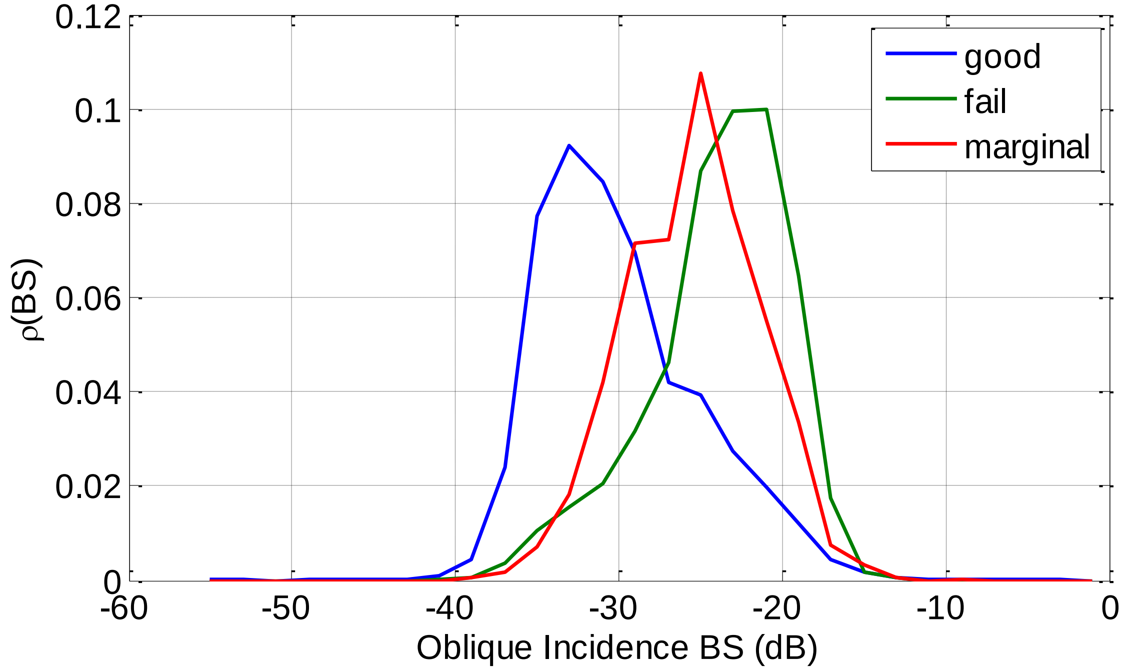
For more information, contact Patrick Malecha at (907) 789-6415 or pat.malecha@noaa.gov.

Mapping Untrawlable Habitats in the Gulf of Alaska-RACE GAP

Rockfish are difficult to assess using standard bottom trawl surveys due to their propensity to aggregate in rocky high relief (untrawlable) areas. The amount of untrawlable seafloor within the Gulf of Alaska bottom trawl survey area is unknown and has a negative impact on the accuracy of trawl survey biomass estimates for rockfish. The purpose of this study was to find methods to map trawlability of the seafloor using acoustics. The research was carried out in the summer of 2011, with scientists from the UNH-Center for Coastal and Ocean Mapping and AFSC participating aboard the GOA-wide biennial acoustic-trawl survey aboard the NOAA ship *Oscar Dyson*. This multi-day cruise covered a wide area from the Islands of Four Mountains in the Aleutian Islands (169°59'0"W 52°43'11"N) to East Kodiak Island (151°5'25"W 57°20'46"N). Simrad ME70 multibeam echosounder data were collected during the entire survey to map the seafloor.

In addition to ME70 data collected along the entire survey trackline, several fine-scale mapping surveys were conducted over localized areas where previously collected seafloor information (with cameras or submersibles) existed to provide groundtruthing observations. A total of 37 of these previously sampled camera locations were targeted. Fine-scale ME70 surveys also targeted localized areas having no ground truth seafloor data, but which were suspected of being untrawlable based on historical information from AFSC bottom trawl surveys. Single or stereo camera deployments were conducted at these stations to groundtruth the ME70 data.

In addition, to estimate the amount of trawlable and untrawlable seafloor within the survey area, the oblique (45 degrees) incidence seafloor backscatter data from the ME70 was matched with the spatial location of previously conducted AFSC bottom trawl survey tows from 1996-2011. Backscatter values were extracted for the area that the net contacted the seafloor, taking into account the length of the wire out from the ship, and the width of the net. Tows had been previously classified as good, failed, or marginally successful by the AFSC based on the level of gear damage sustained from contact with the seafloor. The ME70 mapping data from the ship trackline and fine-scale surveys corresponded with the location of 351 tows, including 325 good tows, 12 marginally successful tows, and 14 failed tows. Preliminary analysis shows separation in the distribution of backscatter values and seafloor types that correspond to the tow performance categories (Figure 1).



This work is continuing and diversifying to better understand how trawlable habitats are located during surveys and how these results can be applied to improving station selection during surveys.

For more information, contact Chris Rooper (chris.rooper@noaa.gov) and Michael Martin (Michael.martin@noaa.gov).

Bathymetric Analysis of the Gulf of Alaska and Aleutian Islands-RACE GAP
Several projects ongoing projects are aimed at improving the understanding of seafloor habitats in the Gulf of Alaska and Aleutian Islands by assembling multi-beam data sets and extracting observations of bathymetry and seafloor substrates from "smooth sheets" generated by original NOAA hydrographic and charting surveys that contain much more depth and sediment information than the resulting navigation charts. These improved datasets have immediate application to the GOA-IERRP study of the central and eastern GOA and to prediction of deepwater coral and sponge habitats in the upcoming Alaska Coral and Sponge Initiative (see above). The analysis has already identified details of relic glacial moraines, earthquake faults, slumps, and other features which have a significant impact on seafloor currents and bottom trawlability

Other GIS techniques have been applied to smooth sheet data and resulted in groundfish habitat descriptors including: shore measures such as length of mainland and island shore, and proximity of any location to land; water measures such as surface area and volume of any depth interval, tidal prism, and vertical cross-sections; seafloor measures such as areal exposure at low tide, bathymetry and bathymetric derivatives such as slope, rugosity, and aspect; sediment measures such as gravel, sand and mud on a 0 to 100% scale; and the areal extent of kelp patches and rocky outcrops. Additionally freshwater input from rivers and streams draining watersheds depicted on USGS topographic sheets and orthographic aerial or satellite imagery can be used to estimate areas of low and high salinity. For more information contact Mark Zimmermann (mark.zimmermann@noaa.gov).

RACE Recruitment Processes

The Recruitment Processes Program's 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.

Late Spring Larval Fish Abundance in the Gulf of Alaska- RACE Recruitment Processes
Late spring larval fish abundance data continue to be annually accumulated. The species abundance indices have been calculated from the designated study area for all available recent years extending the time-series from 1981 through 2009. Synchronicity among species interannual patterns in abundance has been investigated (Doyle and Mier, in review). Time-series of physical variables comprising monthly mean values for January through May, 1981-2009, are being updated and developed in conjunction with scientists from the EcoFOCI research program at NOAA's Pacific Marine Environmental Laboratory. With extension of the data time-series, links between species abundance and the physical variables will be re-examined (as in Doyle et al., 2009) for consistency or variability, and for evaluation of synchronous responses among species.

References: Doyle, M.J., Picquelle, S.J., Mier, K.L., Spillane, M., and Bond, N. 2009. Larval fish abundance and environmental forcing in the Gulf of Alaska, 1981-2003. Prog. Oceanogr. 80:163-187.

Doyle, M.J. and Mier, K.L. In prep. Synchronous responses among Gulf of Alaska fish species to environmental forcing during early ontogeny.

Early Life history and Ecological Gradients-RACE Recruitment Processes
A second project seeks to identify major early life history and ecological gradients among GOA fish species has been carried out by performing Principal Component Analysis ordination on a data matrix of species by early life history and ecological traits (numerically expressed). In addition, species have been assigned to groups based on their association with end-points of these gradients and associated ecological risk and resilience characteristics have been discerned. This research has yielded a conceptual framework for evaluating the exposure and response of fish species to the pelagic environment during early life. The working hypothesis 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.

Reference: Doyle, M.J. and Mier, K.L. A new conceptual framework for evaluating early life history aspects of recruitment dynamics among marine fish species. For submission to Canadian Journal of Fisheries and Aquatic Sciences. In prep.

GOA IERP Historical Ichthyoplankton Retrospective
A third effort continues the synthesis of historical GOA ichthyoplankton data as part of the Retrospective component of the NPRB-sponsored GOA IERP. Spatial, seasonal, and interannual patterns of variation in abundance of the ontogenetic stages of the five key species (Pacific cod, walleye pollock, sablefish, Pacific Ocean perch, and arrowtooth flounder) are being integrated into the development of individual pelagic exposure profiles for these species. 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. These comprehensive early life history reviews of the five key species are being developed into a single large manuscript for submission to the NOAA professional paper NMFS series.

Reference: Doyle, M.J. In prep. Pelagic early life history exposure patterns of selected commercially important fish species in the Gulf of Alaska. In prep.

Larval Fish Community Composition in the Southeastern Bering Sea
Oceanographic conditions in the southeastern Bering Sea are affected by large-scale climatic drivers (e.g. Pacific Decadal Oscillation, Aleutian Low Pressure System). This project examines shifts in larval fish community composition in the southeastern Bering Sea in response to environmental variability across both warm and cold periods. Larvae were sampled in spring (May) during 5 cruises between 2002 and 2008 using oblique 60 cm bongo tows. Non-metric multidimensional scaling (NMDS) approaches quantify variability and reduce multi-species abundance data to major modes of species composition. Generalized additive models (GAMs) characterize spatial and temporal differences in assemblage structure as a function of environmental covariates. A strong cross-shelf gradient delineating slope and shelf assemblages, the influence of water masses from the Gulf of Alaska on species composition, and the importance of nearshore areas for larval fish were identified. Species assemblages differed between warm and cold periods, and larval abundances were generally greater in warm years. High abundances of walleye pollock in warm years contributed most to differences in Unimak Pass, outer domain, and shelf areas (geographic areas defined based on bathymetry). *Sebastes* spp. contributed to differences over the slope with increased abundances in cold years. Community-level patterns in larval fish composition may reflect species specific responses to climate change and that early life stages may be primary indicators of environmental change. See Siddon et al. 2011.

Strong Participation in and Leadership of IERP activities
The Program remains a strong contributor to the IERP activities in Alaska. Scientists from the Program contributed 4 manuscripts to the first Bering Sea special issue to be published in *Deep-*

Sea Research II in early 2012 and another 3 manuscripts were submitted for peer review in the second special issue. Several scientists are either Principal Investigators (Janet Duffy-Anderson) or collaborators (J. Napp) on new NSF-supported BEST synthesis grants. J. Napp continues to serve on the Science Advisory Board for the Bering Sea Project.

Special Issue #1

Bachelor, N., Ciannelli, L., Bailey, K.M. and Bartolino, V. Do walleye pollock exhibit flexibility in where or when they spawn based on variability in water temperature? *Deep Sea Research II*, in press.
Smart, T., Duffy-Anderson, J.T., Horne, J., Farley, E., Wilson, C., and Napp, J. Influence of environment on walleye pollock eggs, larvae, and juveniles in the Southeastern Bering Sea. *Deep Sea Res. II*, in press.
Stabeno, P.J., Farley, E., Kachel, N., Moore, S., Mordy, C., Napp, J.M., Overland, J.E., Pinchuk, A.I., and Sigler, M. A comparison of the physics, of the northern and southern shelves of the eastern Bering Sea and some implications to the ecosystem. *Deep-Sea Research II*, in press.
Stabeno, P.J., Moore, S., Napp, J.M., Sigler, M., and Zerbini, A. Comparison of warm and cold years on the southeastern Bering Sea shelf. *Deep-Sea Research II*, in press.

Special Issue #2

Decker, M.B., Ciannelli, L., Lauth, R., Brodeur, R., Bond, N., Ladd, C., Napp, J., Yamaguchi, A., Ressler, P., Cieciel, K., and Hunt, Jr., G. Insights into the eastern Bering Sea through a jellyfish lens: Recent trends & tests of predictive models. Deep-Sea Res., II, submitted.
Heintz, R. Siddon, E., Farley, E., and Napp, J. Climate related changes in the nutritional condition of young-of-the-year pollock (*Theragra chalcogramma*) from the eastern Bering Sea. Deep-Sea Res., II, submitted.
Smart, T., Duffy-Anderson, J. and Siddon, E. Vertical distributions of the early life stages of walleye pollock in the eastern Bering Sea. Deep-Sea Res., II, submitted.

Recruitment Processes Program scientists are also active in the Gulf of Alaska IERP serving on the Lower Trophic Level, Modeling, and Retrospective components of the program. We completed our first field year during which larval fish samples were collected in both the eastern and western Gulf of Alaska in May, June and July. Preliminary results for the five target species (walleye pollock, Pacific cod, sablefish, Pacific Ocean perch and arrowtooth flounder) were presented at the 2012 PI meeting in Juneau.

De Forest, L. G., Matarese, A.C., Napp, J.M. and Doyle, M.B. Preliminary observations of fish eggs and larvae collected during GOA-IERP cruises in 2010 and 2011. In prep.

Increasing Our Knowledge of the Chukchi Sea Ecosystem
-Ichthyoplankton samples from the second RUSALCA cruise (Russian – American Long-Term Census of the Arctic) are undergoing analysis and we are preparing for a third cruise in summer 2012. In summer 2010 and 2011, a NOAA/BOEM (Bureau of Ocean Energy Management)-supported cruise to the Chukchi was conducted with colleagues from PMEL and NMML. We occupied hydrographic transect lines off Cape Lizburne, Point Hope, Cape Lay, Icy Cape,

Wainwright, and Barrow Canyon including the international Distributed Biological Observatory lines. In addition to plankton tows, we deployed biophysical moorings that examined temporal variability in plankton in the area off Icy Cape, Alaska near oil/gas lease sites. The biophysical moorings were inside clusters of moorings with passive acoustic recorders to detect marine mammal vocalizations. In 2012 we will re-occupy transect stations and engage in a new survey (Arctic Eis) which surveys both the water column (CTD, plankton tows, acoustics, surface and midwater trawls) and the bottom (bottom trawls). Fish trawls will be taken at stations spaced 30 nm apart and CTDs and plankton tow stations are 15 nm apart by latitude and 30 nm apart by longitude.

Scientific Exchange

In November 2014, 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 in Seattle, WA. This Symposium is organized every 3 years and provides an international platform for flatfish scientists and managers to meet, share their research, and discuss management applications. Past topics addressed by the meeting have included population-level connectivity, latitudinal variation, critical habitat, recruitment dynamics, stock structure, bycatch impacts, and climate change implications. A theme for the 9th Symposium will be the role of flatfishes in the trophic landscape, a critical concept that has far-reaching implications for global large marine ecosystems. The host organizers are looking to partner with other organizations in the Pacific Northwest and Canada to host an exceptional meeting. Anyone interested in serving on the local organizing committee and/or sponsoring the meeting please contact Janet Duffy-Anderson (NOAA) at Janet.Duffy-Anderson@noaa.gov or Tim Loher (IPHC) at Tim@iphc.int.

RACE Habitat Research Team (HRT)

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 the ecological consequences of fishing gear disturbances. Research in 2011 was primarily focused on evaluating acoustic backscatter and infaunal prey as predictors of groundfish distributions in the eastern Bering Sea (EBS). An analysis of short-term bottom trawl effects was also completed.
For additional information, see *http://www.afsc.noaa.gov/RACE/groundfish/hrt/default.php* or contact Dr. Bob McConnaughey, bob.mcconnaughey@noaa.gov, 206-526-4150.

Habitat Modeling

A variety of methods have been used to define the habitats of marine species. Some rely on purely geophysical characterizations but these are overly simplistic and may ignore significant factors, such as temperature, that affect species distributions. Similarly, standardized habitat-classification schemes are too restrictive in that they do not adequately account for the continuous nature of environmental variability or the associated continuous biological responses. The RACE Habitat Research Team 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), they 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.

Our current research (the "FISHPAC" project) is investigating whether quantitative information about seafloor characteristics can be used to improve existing habitat models for EBS species. Preliminary work[1] demonstrated that surficial sediments affect the distribution and abundance of groundfish, however direct sampling with grabs or cores is impractical over large areas. Subsequent pilot studies[2,3] showed that acoustic systems were suitable for broad-scale seafloor surveys and that processed acoustic data can be used to improve the numerical habitat models. At this point in our process, a rigorous experiment is needed to identify the most cost-effective system for acquiring the synoptic seafloor data to improve the existing models.

A field experiment will be conducted in 2012 to determine the (statistical) benefits and (operational) costs of five different acoustic systems, based on comparisons of backscatter acquired along strong gradients of groundfish abundance. The five systems include two hull-mounted hydrographic-quality multibeam echosounders, a towed high-resolution side scan sonar and the prototype Klein 7180 long-range side scan sonar system (LRSSS; which also incorporates an independent 38 kHz single-beam echosounder). The LRSSS is a prototype system that was purpose-built for our 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. The LRSSS towfish also measures basic water-quality properties (chlorophyll-a, concentrations of dissolved organic matter and turbidity), which are being investigated for use in the next generation of EBS habitat models.

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[1] 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.
[2] 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.
[3] Yeung, C. and R.A. McConnaughey. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES J. Mar. Sci. 65: 242–254.

The Effects of Fishing

Research to understand and quantify the effects of bottom trawls has occurred throughout the world in a variety of benthic marine habitats. Most of these studies have used methods based on one of two experimental approaches. Short-term (acute) effects are studied by comparing conditions in experimental corridors before and after a single pass or repeated passes of the gear. Occasionally, the recovery process is examined by resampling at a later date; these studies incorporate untrawled control corridors into the sampling program in order to account for natural variability during the study period (a before–after, control–impact, or BACI, experimental design). This approach provides insights about the process of trawl disturbance and is the basis for most knowledge about trawling effects. Longer-term (chronic) effects are studied by comparing conditions in heavily fished and lightly fished or unfished areas and, as such, measure the cumulative effects of fishing. These experiments are relatively uncommon because high-quality historical fishing-effort data are frequently unavailable, and their designs are often flawed because the (unfished) "control" areas have previously been fished or they are fundamentally different than the corresponding experimental units. Although generalizations about the effects of fishing are possible, site-specific responses are likely and local studies are advisable because of variation in the composition of the benthos and differences in the intensity, severity and frequency of both natural and anthropogenic disturbances.

The RACE HRT has been investigating potential adverse effects of bottom trawls at soft-bottom sites in the Bristol Bay region of the eastern Bering Sea (EBS; the "TRAWLEX" project). These sites are relatively shallow (44-57 m), have sandy substrates, show a high level of natural disturbance, and support a rich invertebrate assemblage. Both chronic and short-term effects on the benthos have been studied. This research addresses Congressional mandates to investigate potential adverse impacts of fishing gear on essential fish habitats.

The well-documented development of commercial trawl fisheries in the EBS since 1954 presented a unique opportunity to investigate the chronic effects of bottom trawling on soft-bottom benthos.[4,5] Using detailed accounts of closures and fishing activity, it was possible to reconstruct historical effort and identify untrawled (UT) areas immediately adjacent to areas that had been heavily trawled (HT) over many years. For most of the benthic invertebrate species examined, it was determined that biomass and mean body size were reduced as a result of heavy trawling, suggesting a general population decline. In a few cases, greater overall biomass accompanied the observed body-size reduction, suggesting a proliferation of relatively small individuals in the HT area. The only exception to the pattern of smaller individuals in the HT area was red king crab. In this case, mean body size was greater in the HT area, due to substantially fewer small crabs in the HT area than in the UT area. Since biomass in the HT area

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[4] McConnaughey, R.A., K. Mier and C.B. Dew. 2000. An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea. ICES J. Mar. Sci. 57: 1377-1388.

[5] McConnaughey, R.A., S.E. Syrjala and C.B. Dew. 2005. Effects of chronic bottom trawling on the size structure of soft-bottom benthic invertebrates. Pages 425-437 in P. W. Barnes and J. P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

was lower than that in the UT area, the red king crab response to chronic bottom trawling was fewer individuals of greater mean size. Overall, these effects on body size were relatively small when compared with natural variability in a large, adjacent area closed to commercial trawling. From a community perspective, the HT benthos was less diverse, was dominated by the purple-orange seastar (*Asterias amurensis*), had less emergent epifauna and less biogenic substrate (shell) resulting in reduced structural complexity, and was more patchy overall.

Another study investigated short-term effects of bottom trawling and recovery using a BACI experimental design. This work occurred inside the same closure area used for the chronic effects study. Six pairs of experimental and control trawl corridors (statistical blocks) were established adjacent to one another in a previously untrawled area. Each corridor was 19.4 km long, based on the average length of commercial bottom-trawl hauls in the area and was 100 m wide to contain all components of the commercial gear. Potential impacts were investigated with biological and geological sampling before and after four passes with a commercial bottom trawl (Nor'eastern Trawl System Inc. 91/140 two-seam Aleutian combination otter trawl with a 0.36 m footrope diameter). Invertebrates that live on the seafloor (epifauna) were sampled with 15 min tows at a speed of 3 kts, using a standard AFSC 83/112 bottom trawl that was modified to improve capture and retention of small organisms. At each of these locations, the invertebrates that live in the seafloor (infauna) and the physical-chemical properties of the surficial sediments were characterized with two pairs of grab samples collected prior to trawling for epifauna. Changes in seafloor morphology were assessed with side scan sonar surveys that were conducted prior to any sampling or commercial trawling disturbance and again after the commercial-trawl disturbance.

Catch-per-Unit Effort (CPUE) data were analyzed for 24 taxonomic groups (ranging from species to order) before and after trawling. In addition to the BACI design, covariates (depth, water temperature, and various sediment measurements) were included in the analyses to minimize effects of random variations in the habitat. Ultimately, there was no evidence that the covariates were associated with changes in the CPUEs due to any commercial trawling effects. "Statistically significant" effects of commercial trawling were found in three of the 24 taxonomic groups. But given the level of the test that was used in the analysis ($\alpha \leq 0.10$), one would expect to find 2.4 significant results due to nothing more that random variation in the data. Hence we concluded that the CPUEs of epifauna were not substantially affected by the level of commercial trawling used in this experiment. The study area was revisited during the following summer and the after-treatment sampling protocol was repeated to assess whether any long-term (one year) effects on CPUE could be observed. Again, only minimal effects were observed and could not be differentiated from random variation. The effects of trawling observed in the side scan imagery also were negligible, probably due to the naturally disturbed condition of the seabed. However, some degree of physical disturbance did occur based on distinctive patterns in the post-trawl imagery that were not present in the imagery acquired prior to the commercial trawling. Details of the analyses and results of this study are currently being written up for publication.
In 2011, the HRT also developed plans for a bottom-trawl-impact study in the Northern Bering Sea Research Area, a previously unfished area that may have potential for future fisheries development under a climate change scenario. This effort involved multiple workshops to gather input from native communities and interested scientists as well as preliminary experimental design work. The project is on hold pending further action by the North Pacific Fishery

Management Council.

Benthic Invertebrate Ecology

The RACE HRT is studying the life history and ecology of benthic invertebrates in the eastern Bering Sea (EBS) in order to better understand their role as habitat for commercially important species and to improve interpretation of population- and community-level changes due to fishing gear disturbances. The community of clams, crabs, sponges, corals, snails, marine worms, and similar organisms constitutes a living component of habitat. As a group, benthic invertebrates function as predators, prey, competitors, and provide shelter for other species. They are also useful indicators of the health and integrity of the ecosystem, and are known to be an important factor affecting the distribution of managed species. Unfortunately, relatively little is known about their life histories and ecologies let alone the complex linkages and dependencies that exist at the community and ecosystem levels.

A major benthic ecology study was completed in 2011 and provided insights on the relationships between flatfish habitats, diets, and prey availability. Flatfish stomachs and benthic grab samples were collected at 31 RACE bottom-trawl survey stations across the shelf. The two data sets were analyzed for correspondence between stomach contents and infauna assemblages across habitat types.

Yellowfin sole, northern rock sole, and Alaska plaice are three common flatfish that co-occur on the southeastern Bering Sea (EBS) shelf in depths usually not exceeding 100 m. Their small mouths are adept at preying on infauna, especially polychaete worms. The average diet of Alaska plaice consists of almost 60% polychaetes by weight. For yellowfin sole, which has the most varied diet of the three, polychaetes still comprise over a quarter of their diet by weight. Polychaetes and clams were the most dominant groups, each comprising 35-60% by weight of each infauna sample. They were also the only prey groups that frequently averaged over 50% of stomach content weight. Sediment grain size was the most important factor in determining the type of infauna assemblage in the habitat. Grain size becomes smaller, i.e. sediment becomes muddier, the further from shore (or deeper the water). Clams dominated the infauna biomass on the sandy inner shelf (0-50 m depth) (Fig. 2). The “muddy sand” of the middle shelf (50-100 m) had the highest infauna biomass, which was dominated by deposit-feeding polychaetes.
Prey availability strongly influenced diet choices. Stomach contents of all three flatfish generally reflected the infauna assemblage of the habitat where they were collected. Alaska plaice clearly adapted to prey availability – they ate mostly clams on the inner shelf, although their primary prey are polychaetes. All flatfish switched to eating more polychaetes on the middle shelf - even yellowfin sole, whose primary prey are amphipods and clams.

Polychaetes may not be obligatory prey for these flatfish, but they could very well be the choice prey - considering that polychaetes are overall the most dominant infauna group in the EBS, and generally have a higher organic nutrient content than the other major groups: clams, amphipods, and brittlestars. Under this hypothesis, the biomass or abundance of polychaetes could indicate the quality of the habitat for flatfish in terms of prey availability. Alaska plaice, northern rock sole, and yellowfin sole obviously all eat polychaetes. Their actual proportional intake of polychaetes may be a result of interspecific competition, which may be reduced somewhat by slightly-offset spatial distributions during periods with unusually cold bottom-water temperatures.

In general, the available information on ecologically important marine invertebrates is sparse and frequently exists in unpublished reports. To address this need, the HRT is assembling the existing information for individual EBS species and summarizing it in a standard format that includes topics such as growth and development, sexual maturity, reproductive cycles, feeding and diet, mortality rates and causes, distribution and abundance, and anthropogenic interactions. The first in a series of reports was produced in 2011 (in cooperation with the Kodiak Shellfish Lab) and focused on the four major species of snails in the genus *Neptunea* (Smith et al. 2011). These snails are a major component of the benthic invertebrate community on the EBS continental shelf and our research has demonstrated they are sensitive to bottom trawling. This synopsis summarizes studies of local populations as well as somewhat more extensive findings for *Neptunea* species in other geographic regions. Geographic distribution and abundance of the four species on the EBS shelf are represented with maps based on RACE bottom-trawl survey data for selected years from 1983 to 2010. Work is underway on a synopsis for the purple orange sea star (*Asterias amurensis*), an extremely abundant species in inshore areas that is also affected by bottom trawling.

Miscellaneous Projects

In August 2011, the RACE HRT supported the Naval Undersea Warfare Center with a navigable area hydrographic survey on the free-flowing Hanford Reach of the Columbia River in Washington State. This 8-day survey conducted on the research vessel Kvichak Surveyor was designed and conducted to address specific concerns of the Puget Sound Naval Shipyard and additionally served to deliver accurate hydrographic-quality survey data for updating the NOAA nautical charts for the area. The work demonstrated HRT expertise in mobilizing vessels of opportunity for conducting high quality ellipsoid-referenced hydrographic surveys and for delivering International Hydrographic Organization-compliant bathymetric data products. The project further illustrated the utility and benefit of an existing Interagency Agreement between the AFSC and the U.S. Navy.

Finally, two electronic databases are maintained to support the design and interpretation of RACE HRT experiments. One of these includes peer-reviewed papers and reports concerned with Mobile Fishing Gear Effects (http://access.afsc.noaa.gov/mfge/search.htm). Similarly, a database is maintained for literature on the life histories and ecology of important benthic invertebrates. New references are continually added to the databases.

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. During 2011, AFSC personnel analyzed the stomach contents of a wide variety of species from the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska regions. The contents of 8,351 stomach samples from 28 species were analyzed from the Bering Sea, 3,799 stomach samples from 38 species were analyzed from the Aleutian Islands, and 8,630 stomach samples from 26 species were analyzed from the Gulf of Alaska. Detailed analysis, with high taxonomic resolution of prey types and enumeration of all prey items, was performed on several flatfish species for an essential fish habitat (EFH) project and on walleye pollock for the Bering Sea Integrated Ecosystem Research Program (BSIERP) project. Both of these projects incorporate independent information on the available prey community. Euphausiid prey from the BSIERP project were measured for length frequency comparisons to net-caught euphausiids. Support of seasonal energy flow modeling in Alaska's marine ecosystems was also provided through stable isotope analysis of tissue samples. Over 62,000 records were added to AFSC's Groundfish Food Habits Database in 2011.

Collection of additional stomach samples was accomplished through resource survey and Fishery Observer sampling. AFSC's summer bottom trawl surveys of the eastern Bering Sea and the Gulf of Alaska, and the hydroacoustic survey of the Gulf of Alaska provided about 10,000 samples from about 40 fish species. These samples were supplemented by the collection of about 1,300 stomach samples from Alaskan fishing grounds by Fishery Observers.
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.

Three of the largest species of *Myoxocephalus* sculpins are widely distributed across the continental shelf of the eastern Bering Sea: plain sculpin (*M. jaok*), great sculpin (*M. polyacanthocephalus*), and warty sculpin (*M. verrucosus*). Stomach samples from all three species were collected during AFSC bottom trawl surveys during 2000 and 2006-2008. We divided each species into size categories and calculated the diet overlap among all species-size pairs using both the number and weight composition of the stomach contents (Table 1). The highest diet overlap generally occurred between size categories within each species (in bold face in the table), especially for plain sculpin and great sculpin. The warty sculpin had a high degree of diet overlap with the great sculpin, especially in the 46-55 cm and 36-45 cm size-categories. The plain sculpin had low diet overlap with both warty and great sculpin. The patterns in diet overlap are generally consistent with the geographic distributions of each species and the prey available to them. The plain sculpin is caught primarily on the inner shelf and has a diet of shrimp, mysids, and other small crustaceans that decrease in importance with increasing body size while flatfishes and other fishes increase in importance with increasing body size. The great sculpin is caught primarily on the middle shelf and consumes *Chionoecetes* crabs at all sizes examined, while eelpouts and smaller fishes decrease in importance with increasing body size and gadids, flatfishes, and scavenged offal increase in importance with increasing body size. The warty sculpin also inhabits the middle shelf but is most abundant in northern areas frequently influenced by the "cold pool." The warty sculpin diet includes less fish than the other two species, with lyre crabs, other crabs, shrimp, and other small crustaceans decreasing in importance with increasing sculpin body size and *Chionoecetes* crabs increasing in importance with increasing body size. Most of the *Chionoecetes* crabs consumed by warty and great sculpins are snow crabs (*C. opilio*), and the size of the snow crab consumed generally increases with the size of the sculpin predator, with great sculpin preying on slightly larger snow crabs relative to their body size than the warty sculpin (Fig. 1).

Table 1. Diet overlap indices among size categories (FL in cm) of three species of *Myoxocephalus* sculpins (great, plain, and warty). Indices above the diagonal were calculated using the numeric composition of the diet and indices below the diagonal were calculated using the gravimetric composition of the diet. Bold indices highlight comparisons within a species.

Species FL (cm)	Great 26-35	Great 36-45	Great 46-55	Great 56+	Plain <26	Plain 26-35	Plain 36-45	Plain 46-55	Plain 56+	Warty 26-35	Warty 36-45	Warty 46-55
Great 26-35		63.91	55.05	49.43	25.77	26.34	35.79	41.56	6.89	47.78	60.05	48.95
Great 36-45	56.33		83.33	75.01	14.49	17.87	24.89	37.54	19.06	30.90	51.59	67.60
Great 46-55	49.51	77.64		83.23	10.57	11.60	17.86	30.52	15.45	23.84	48.42	71.92
Great 56+	47.72	69.32	74.46		8.91	14.53	21.46	29.14	12.90	15.23	38.61	66.10
Plain <26	21.76	13.43	10.38	26.27		71.69	54.32	29.75	3.29	37.90	37.03	16.44
Plain 26-35	22.72	14.16	10.47	26.31	55.04		80.83	42.69	14.80	40.47	35.24	16.47
Plain 36-45	27.71	25.40	20.24	36.16	41.68	84.95		54.36	21.77	48.85	44.12	21.41
Plain 46-55	25.51	28.17	24.63	33.61	25.93	68.48	72.74		49.25	41.10	47.45	34.32
Plain 56+	5.05	11.47	4.93	18.75	17.24	58.62	61.63	57.54		12.31	24.17	9.90
Warty 26-35	28.78	24.79	21.30	12.84	21.96	19.29	22.17	21.11	3.50		64.05	33.03
Warty 36-45	47.90	67.22	64.23	53.21	7.43	8.06	12.84	23.30	3.50	51.53		55.12
Warty	35.60	65.09	60.74	49.75	0.95	1.63	6.00	20.76	2.06	19.77	67.32	

46-55

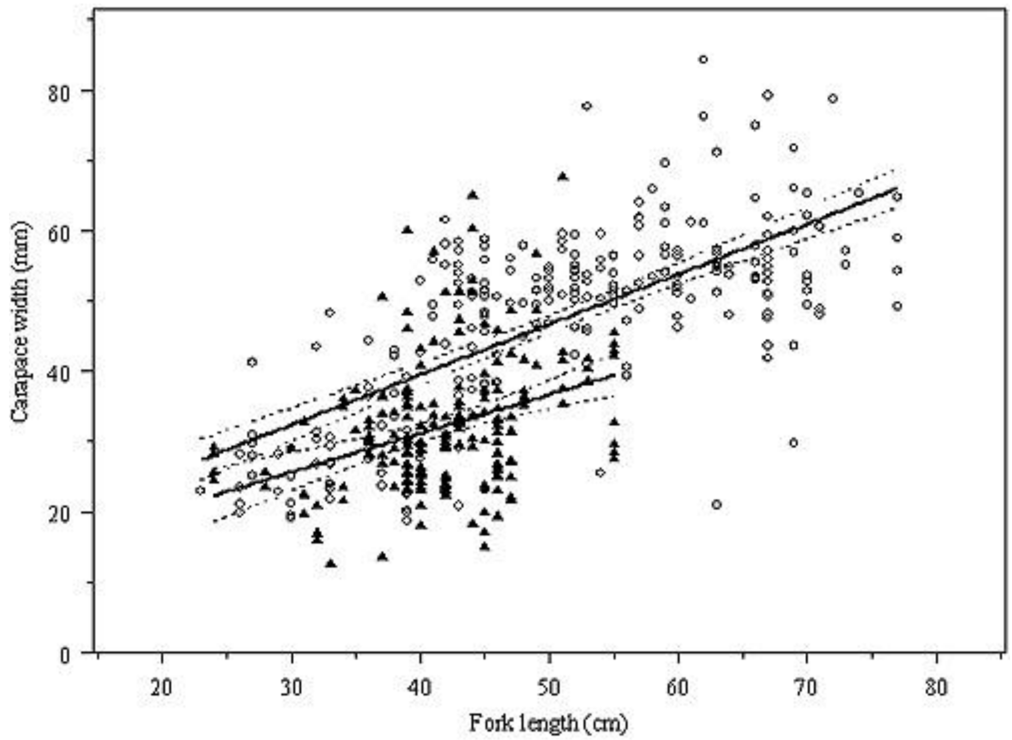

Figure 1. The sizes (carapace width, mm) of *C. opilio* consumed by sizes (fork length, cm) of great sculpin (circles) and warty sculpin (triangles) in the eastern Bering Sea. The regressions with 95% confidence intervals for each sculpin species are shown.

The arrowtooth flounder (*Atheresthes stomias*) is an ecologically important predator in the eastern Bering Sea and the Gulf of Alaska. The gravimetric diet composition (% weight) is presented here for different size-categories of arrowtooth flounder from 2007–10 summer surveys in the eastern Bering Sea, and from 2007 and 2009 surveys in the Gulf of Alaska (Fig. 2). The tendency for arrowtooth flounder to become more piscivorous with increasing size is consistent among years in both regions. Euphausiids and shrimp generally decrease as a percentage of the weight of the stomach contents, with increasing size of arrowtooth flounder. In the eastern Bering Sea, walleye pollock is the dominant fish prey, and the identifiable fishes in the miscellaneous fish category typically shift from stichaeids to zoarcids to pleuronectoids with increasing size of arrowtooth flounder. In the Gulf of Alaska, osmerid and clupeid prey is consistently important, and the identifiable fishes in the miscellaneous fish category are more variable, but stichaeids and pleuronectoids are prevalent. Instances of cannibalism, although fairly rare in arrowtooth flounder, were more frequent in the Gulf of Alaska than in the eastern Bering Sea. Unexpectedly, the low percentage of euphausiid prey in 2009 in the eastern Bering Sea coincides with the peak of euphausiid abundance found by AFSC hydroacoustic surveys from 2004 through 2010.

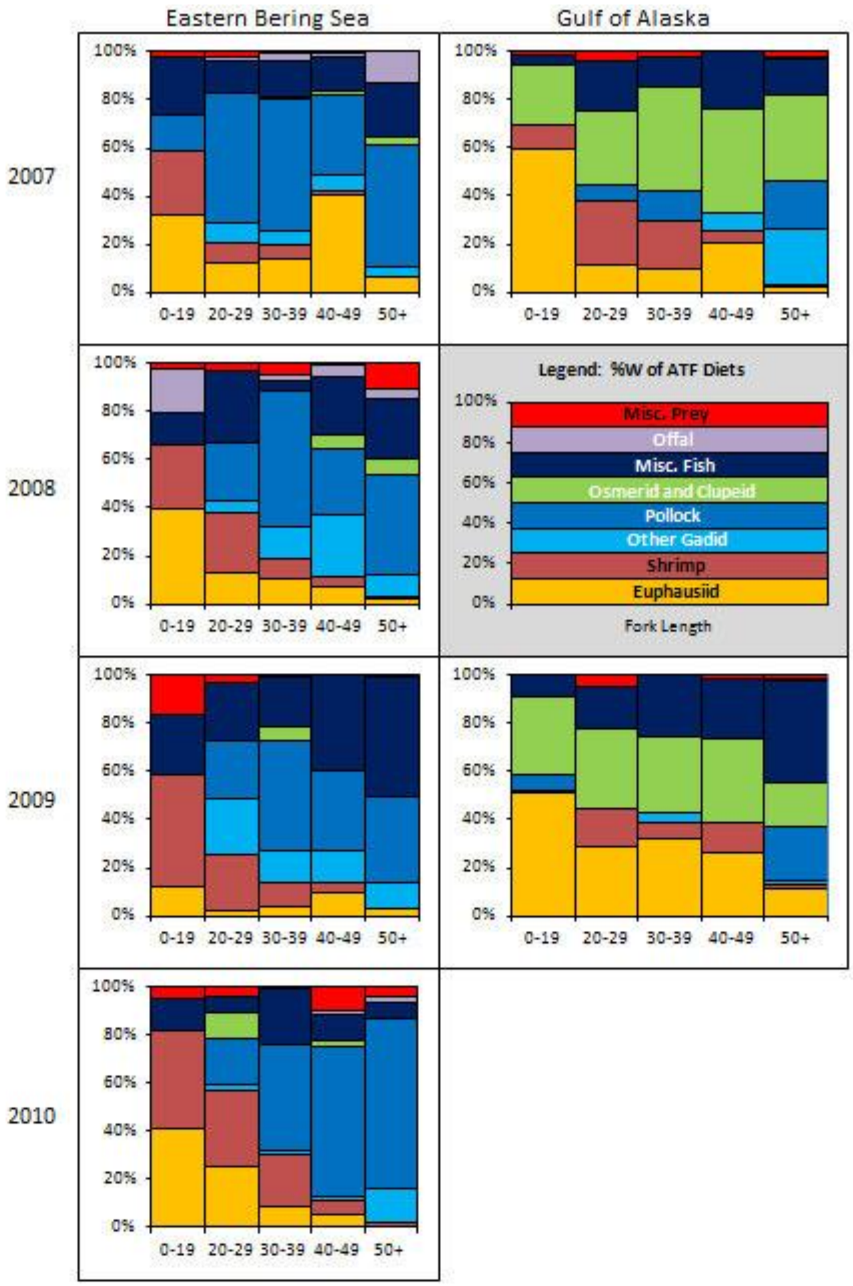

Figure 2. Summer diet composition, by weight (%W), of arrowtooth flounder from recent years in the eastern Bering Sea and Gulf of Alaska.

The Arctic cod (*Boreogadus saida*) is an ecologically important inhabitant in Arctic waters that extends its distribution southward into the eastern Bering Sea during colder years. The Arctic cod, known to be a predator of a variety of zooplankton and a prominent prey for many birds, marine mammals, and other fishes, is a nodal species in the Arctic marine foodweb. Arctic cod are caught during the AFSC groundfish and crab surveys in the eastern Bering Sea, especially during colder summers. These 253 Arctic cod ranged in length from 6 to 26 cm fork length (FL), with the large majority of the stomach samples obtained from fish between 10 and 18 cm FL.

The diet of these Arctic cod consisted mostly of small crustaceans in all the size categories examined, but chaetognaths tended to decrease in importance with increasing size of Arctic cod while fishes (Teleostei) and slightly larger crustaceans (Decapoda; shrimp and crabs) were consumed primarily by Arctic cod over 15 cm (Fig. 3). A consistent, more general trend with increasing size was the gradual decrease in pelagic prey (chaetognaths, copepods, euphausiids, and hyperiid amphipods) and the gradual increase in more benthically oriented prey (gammarid amphipods, mysids, cumaceans, and decapod crustaceans). When analyzed, the stomach samples collected in 2010 may provide some geographically interesting results, as the majority of them were collected in the northern Bering Sea between Saint Matthew Island and the Bering Strait.

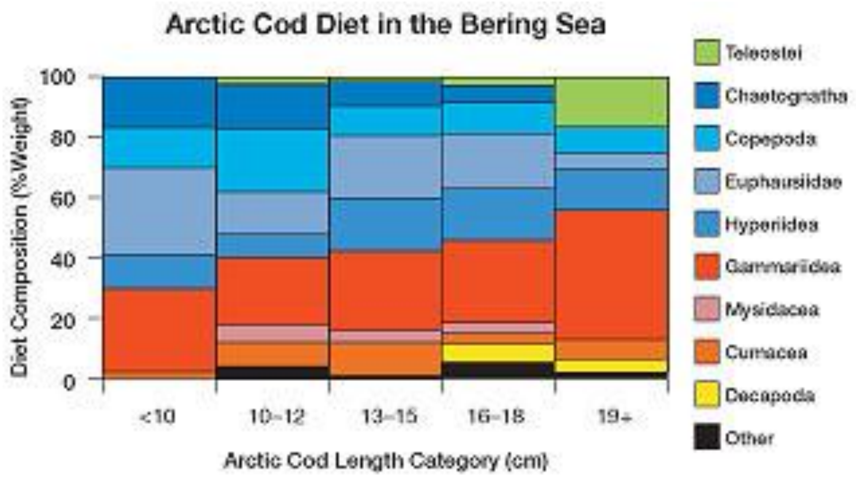

Figure 3. Summer diet composition of 6- to 26-cm FL Arctic cod in the eastern Bering Sea.

This year, food habits data were used as the basis for calculating predation-based estimates of octopus natural mortality to define the allowable biological catch (ABC) and overfishing limit (OFL) for the Bering Sea/Aleutian Island octopus stock (2,590 t and 3,450 t, respectively). The method combined groundfish ration, diet, and biomass estimates from 25 years of surveys to calculate both these estimates, their confidence limits, and range of interannual variation. In discussion of this new methodology, questions were raised about the size distribution of the consumed octopus. To answer these questions, AFSC staff will be estimating the size of octopus prey from the size of octopus beaks found in the stomach contents of groundfish.

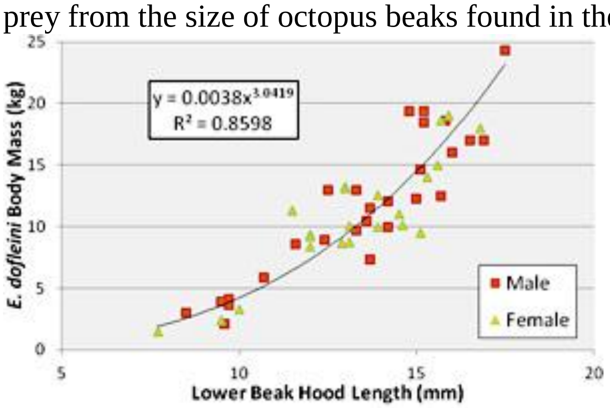

Figure 4. The relationship between beak-size and body-mass for *Enteroctopus*

dofleini. Although each sex is distinguished in the plot, the regression is independent of sex because this can rarely be determined from the remains in the predator stomachs.

A reference set of beaks, stylets, and statoliths from octopus of known size was collected as part of North Pacific Research Board (NPRB) Project 906, Field Studies in Support of Stock Assessment for the Giant Pacific Octopus *Enteroctopus dofleini* . Several standard measurements from both the upper and lower halves of these beaks were taken to assess the relationship of beak size to the known body mass of *E. dofleini* specimens and to assess the ease and consistency of taking the measurements. We found, for our purposes, hood length (for both upper and lower beak) has advantages over several other beak measurements: endpoints are clearly defined so consistent measurements among analysts is possible, and these endpoints are relatively easy to access when the beak remains encased in the buccal muscle mass, so handling-time is minimized during stomach content analysis. Based on preliminary data (Fig. 4), a power function of hood length to predict body mass produces an R^2 of 0.86 for the lower beak and 0.85 for the upper beak.

Seabird – Fishery Interaction Research

The AFSC is again producing annual estimates of seabird bycatch from the Alaskan groundfish fisheries monitored through the North Pacific Fishery Observer Program. Provisional estimates for 2007–2010 are posted on the AFSC seabird web page. These estimates are of great interest to many scientists, managers, and stakeholders. This year's estimates represent the third methodology employed since the start of our seabird bycatch monitoring in 1993 (Fig. 6). The first method was carried out by the U.S. Fish and Wildlife Service (USFWS) Migratory Bird Management Division in Anchorage, Alaska, following through on templates for collaboration done in the Dall's Porpoise and High Seas Driftnet Programs of the 1980s and early '90s. The intent was to produce estimates of overall seabird mortality based on these data each year. However, given the complexity and scope of the data and the need of the USFWS to address Endangered Species Act issues at the time, this methodology proved unfeasible for the USFWS.

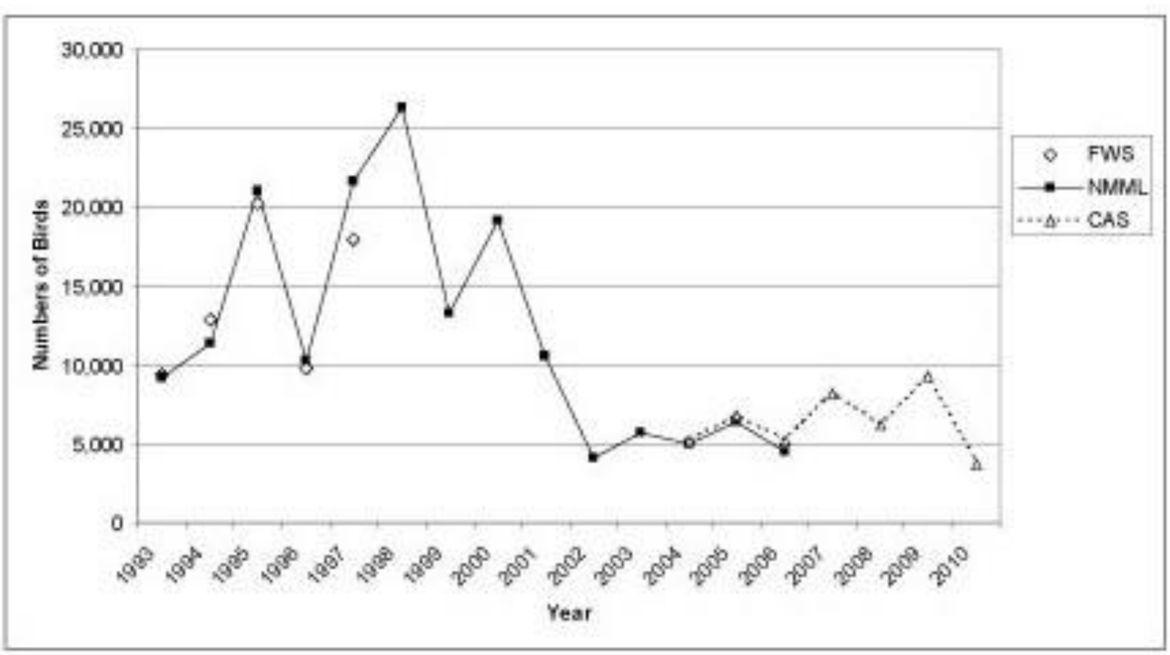

Figure 6. Total seabird bycatch in the Alaskan demersal longline groundfish fishery as estimated by three overlapping methods during the period 1993 through 2010. FWS = U.S. Fish and Wildlife Service; NMML = Alaska Fisheries Science Center National Marine Mammal Lab; CAS = Catch Accounting System.

The AFSC then agreed to dedicate resources, with annual funding support from the Protected Resources Division of the NMFS Alaska Regional Office, to develop procedures to estimate annual seabird bycatch. Marine mammal take estimation was being completed by an analyst from the AFSC National Marine Mammal Laboratory (NMML). Because seabirds had similar estimation challenges (seabird bycatch is a relatively rare event) similar estimation procedures could be used. Estimates were produced for all years (1993 onward) through 2006 (Fig. 6) and made available on the AFSC website and through the Ecosystem Chapter of the annual Stock Assessment and Fisheries Evaluation Reports prepared for the North Pacific Fishery Management Council (available at http://www.fakr.noaa.gov/npfmc/).

With retirement of the NMML analyst in 2007 and a new data platform launched in 2008, established procedures could no longer be used. Producing these annual estimates had also used resources that were now needed for other seabird projects. A workshop was held to address rare-event bycatch estimation in 2009 (reported in the April–May–June 2009 AFSC Quarterly Report). This workshop evaluated the stated needs of various end-users for these data. One result of the workshop was that the AFSC worked with the Sustainable Fisheries Division of the Alaska Regional Office, and the Catch Accounting System now produces seabird point-count estimates in a production mode that does not require as much staff resources as previous methods. The AFSC will use the results to again produce annual estimates of seabird bycatch in Alaskan fisheries.

In 2011 an incidental take of an endangered short-tailed albatross (*Phoebastria albatrus*) was recorded. A groundfish fishery observer reported to their in-season advisor that they had recovered a short-tailed albatross while monitoring gear retrieval on a Bering Sea freezer longline vessel fishing for Pacific cod. The AFSC immediately reported this take to the U.S. Fish and Wildlife Service and also informed interested parties in NOAA, the fishing industry, and environmental non-government organizations. Based on information supplied by AFSC staff, the Alaska Regional Office issued a Fisheries Information Bulletin on 31 October 2011, describing this most recent take. The take occurred on 25 October 2011 at lat. 56°35'N, long. 172°52'W. This is an area over the Bering Sea shelf break, directly west of the Pribilof Islands. The bird had a leg band placed on it by Japanese scientists during their standard research activities at the colony on Torishima Island. The bird was less than 2 years old. The current Biological Opinion for short-tailed albatross provides for the incidental take of four birds in a 2-year period. A new 2-year period began on 16 September 2011, making this the first take in the current period. The vessel was using paired streamer lines and had not observed any short-tailed albatross in the area prior to the take event. See the full information bulletin for additional details and a map of where short-tailed albatross takes have occurred: www.fakr.noaa.gov/index/infobulletins/bulletin.asp?BulletinID=7771.

Multi-species and Ecosystem Modeling:

Figure 7. Map of the model area in the eastern Chukchi Sea. The area is bounded by the U.S.-Russian convention line to the west, Bering Strait to the South, Pt. Barrow to the east, and both the EEZ and 70-m isobath to the north. Near shore the model is bounded by the 20-m isobath.

AFSC researchers completed the development of a preliminary mass-balance food web model for the continental shelf of the eastern Chukchi Sea (Fig. 7). The model provides a snapshot of community structure averaged over an annual time scale and describes key structural and functional components of the eastern Chukchi Sea food web. The majority of biomass in this ecosystem was concentrated in benthic invertebrates (Fig. 8) and accordingly most of the mass flow above trophic level 2.0 was through this group. Mass flows to higher trophic levels through pelagic groups like zooplankton were an order of magnitude less. Arctic cod, *Boreogadus saida*, were the principal fish prey connecting production between lower and upper trophic levels. Seabirds and marine mammals collectively consumed about 75% of total arctic cod production. To gain a broader perspective on the structure and function of the eastern Chukchi Sea, comparisons were drawn with the nearby subarctic eastern Bering Sea, using a set of system metrics derived from a common modeling framework. The total biomass density (t km^2) of the eastern Chukchi Sea was nearly equal the eastern Bering Sea but had less than half the total production (t km^2/yr). In practical terms, this fundamental difference between the eastern Chukchi Sea and eastern Bering Sea implies that the Chukchi may not be as resilient to fishing or other mortality agents such as a wide-spread oil spill.

This food web model provides a novel description of the trophic structure and functioning of the eastern Chukchi Sea. In the future it can be used to evaluate trophic changes that might accompany climate change and provides a means of assessing the ecosystem-wide impacts of the removal of fish species by a fishery.

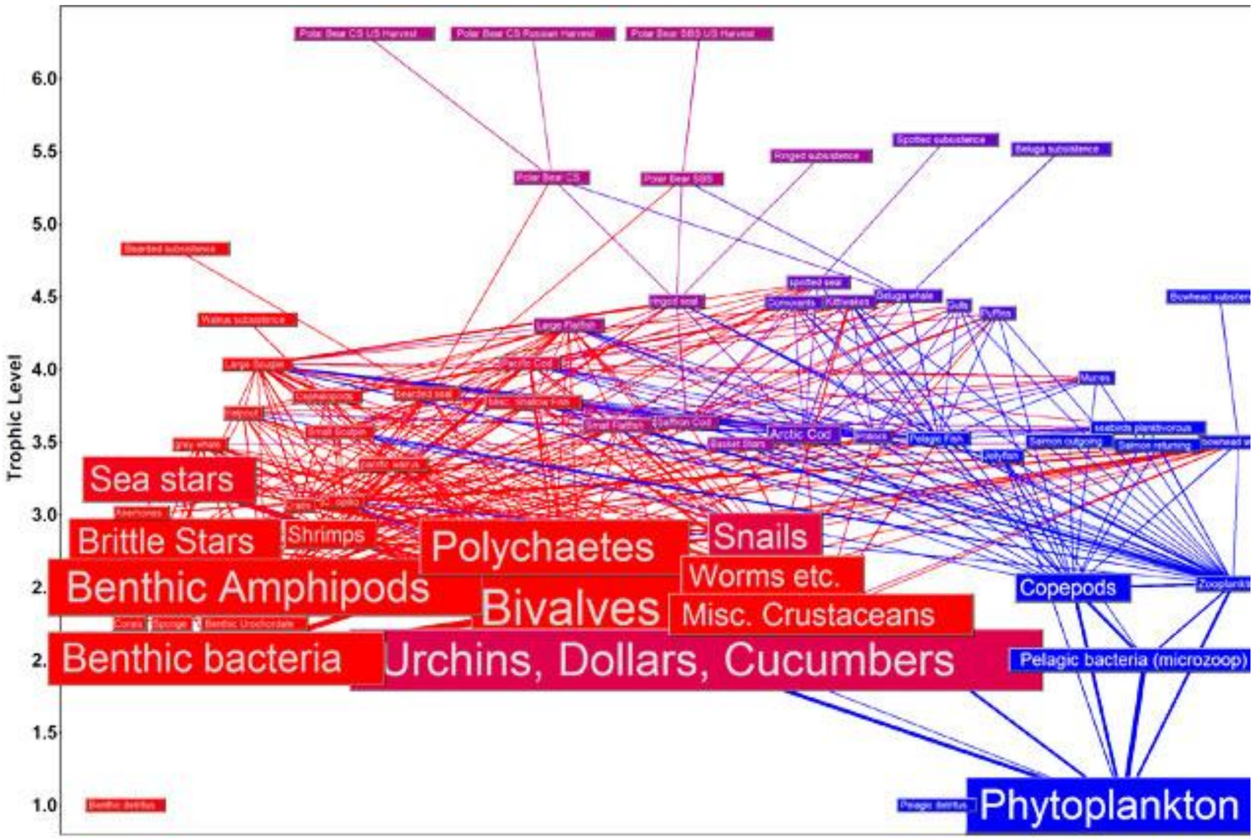

Figure 8. Food web diagram of the eastern Chukchi Sea. The boxes are arranged vertically by trophic level and box size is proportional to biomass density. Red colored boxes are associated with the benthic trophic pathway and blue denotes the pelagic pathway.

Preliminary simulations from the Forage Euphausiid Abundance in Space and Time (FEAST) model of the eastern Bering Sea were produced. FEAST is a high resolution model that uses a Regional Oceanography Model System as platform and has two-way feedback with a Nutrient-Phytoplankton-Zooplankton-Benthos module. FEAST is part of the Bering Sea Integrated Ecosystem Research Program (BSIERP), a partnership between the North Pacific Research Board and NSF, funding 35 linked projects on the Bering Sea. Fish movement is modeled seasonal movement of pollock as a function of prey density and temperature (measured as growth). Both hindcasts and forecasts of FEAST were run; in the forecast version, FEAST will be used as the real world model for management strategy evaluations.

The final meeting of the GLOBEC Pan-regional Synthesis project “End-to-end energy budgets in US-GLOBEC regions” was hosted at the AFSC, Seattle. This 3-year collaboration synthesized data and built ecosystem models to compare the characteristics of four regions studied by GLOBEC: the Gulf of Alaska, Georges Bank, the Northern California Current, and the Southern Ocean. During this project, a new ecosystem model was built for the Southern Ocean, existing models were improved for the Northern California Current and Georges Bank, and a model of the Central Gulf of Alaska was developed based on the existing full Gulf of Alaska ecosystem model. Simple models were derived to address physical drivers and bottom-up forcing in each ecosystem, and more complex models were maintained for implementing dynamic scenarios. At the meeting, the Central Gulf of Alaska model was finalized with all data updates and five dynamic scenarios were presented to collaborators. The scenarios were standardized across all ecosystems and included whale restoration (with and without fishing), no fishing, doubling jellyfish and halving jellyfish, and observing the ecosystem response to each. Model code and software developed at the AFSC will be used for similar dynamic runs incorporating uncertainty using the Southern Ocean and Northern California Current models.

Other widely collaborative, ecosystem modeling efforts, directed toward comparisons among modeled marine ecosystems around the world, have continued. Using data from more than 11 temperate marine ecosystems, production trends and fisheries and food-web models for species from various ecosystems were evaluated resulting in possible universal patterns and emergent trends being identified. Contrasting levels of species aggregation and ecosystems drivers were also evaluated. Preliminary management-relevant metrics and ecosystem attributes were developed, presented and compared across methods and ecosystems at numerous workshops, meetings, and conferences.

Ecosystem Considerations

The Ecosystem Considerations report is produced annually for the North Pacific Fishery Management Council (NPFMC) as part of the Stock Assessment and Fishery Evaluation (SAFE) report. The goal of the Ecosystem Considerations report is to provide an overview of marine ecosystems in Alaska through ecosystem assessments and tracking time series of ecosystem indicators. The ecosystems currently under consideration are the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska.

This year the report includes both new and updated sections. The section describing ecosystem and management indicators includes updates to 44 individual contributions and presents 7 new contributions. These include: 1) Phytoplankton biomass and size structure during late summer to early fall in the eastern Bering Sea; 2) Gulf of Alaska chlorophyll a concentration off the Alexander archipelago; 3) Long-term zooplankton trends in Icy Strait, Southeast Alaska; 4) Forecasting pink salmon harvest in Southeast Alaska; 5) Biodiversity (evenness) of the groundfish and invertebrate community for the eastern Bering sea slope; 6) A multivariate seabird index for the eastern Bering Sea; and 7) Indicators of Alaska-wide community regime shifts.

A new structure and key indicators were developed for the ecosystem assessment for the Aleutian Islands ecosystem. Significant variability in the island chain ecosystem warranted structuring the Aleutian Islands ecosystem assessment by three ecoregions: western, central, and eastern. The three Aleutian Islands ecoregions used in this assessment are defined from west to east as follows. The Western Aleutian Islands ecoregion spans 170° to 177°E. These are the same boundaries as the North Pacific Fishery Council fishery management unit 543. The Central Aleutian Islands ecoregion spans 177°E to 170°W. This area encompasses the North Pacific Fishery Council fishery management units 542 and 541. The Eastern Aleutian Islands ecoregion spans 170°W to False Pass at 164°W. Key indicators reflect the physical environment to top predators and humans, as well as both the nearshore and offshore zones. These key indicators should be updatable on a regular basis. The following indicators were selected for the Aleutian Island ecosystem assessment: 1) the Winter North Pacific Index; 2) reproductive anomalies of least auklet and crested auklets; 3) proportions of hexagrammids, gadids, and Ammodytes in tufted puffin chick diets; 4) apex predator and pelagic forager fish biomass indices; 5) sea otter counts; 6) Steller sea lion non pup counts; 7) the percent of shelf <500 m trawled; and 8) school enrollment.

A Hot Topics subsection was designed to present a succinct overview of potential concerns for fishery management, and has been extended this year to include the Gulf of Alaska and the Aleutian Islands ecosystems. The topics for the eastern Bering Sea include endangered short-tailed albatross bycatch that occurred during fall in the Pacific cod longline fishery and recent increases in jellyfish seen in both summer and fall scientific surveys. For the Gulf of Alaska, the topics include the recent increased prevalence of "mushy" halibut syndrome and the controversial finding of infectious salmon anemia. For the Aleutian Islands, the topics include a discussion of fishery changes in the western and central ecoregions in 2011 and the release of the new Aleutian Islands risk assessment, which evaluates shipping traffic and oil spill trends.

Findings from the Ecosystem Considerations report were presented to the NPFMC joint plan teams in September and November and to the Science and Statistical Committee in December. To see the chapter in its entirety, see the AFSC website at http://access.afsc.noaa.gov/reem/ecoweb.

Outreach Activities

AFSC scientists and visual information specialists created activities about current AFSC research as part of the Pacific Science Center's (PSC) Science Communication Fellowship Program. The program helps bring scientists and public audiences together to promote the understanding and appreciation of current scientific research. These activities were presented by AFSC scientists during the 2011 Polar Science Weekend (Fig. 9). Polar Science Weekend, now in its sixth year, is an annual event presented jointly by the PSC and the University of Washington's Applied Physics Laboratory, funded by the National Aeronautics and Space Administration. Funding from the NPRB also supported some of the AFSC activities. The "Polar Detectives" activity challenged visitors to solve "the case of the missing ice," and complete a puzzle of the Arctic, then, adding seals and other marine mammals to the picture, they learned why ice is important to these animals. Next, participants tossed seals into a mini-Arctic, complete with ice floes, and found out what happens as the global temperature rises and the amount of ice decreases. In the "How Old Is a Fish?" activity, visitors searched for otoliths in the head of a stuffed fish and

Fig. 9. AFSC biologist explains the purpose of analyzing fish stomach contents during the Pacific Science Center's Polar Science Weekend.

discovered how fish are aged. "This group has no kids!" said one girl as she looked at the age composition of one population of fish, learning why it's important to determine the age of fish. At "Stinky Slimy Stomachs," young scientists took fish from a basket, measured the length and then discovered what it ate, learning that fish of different sizes may eat different prey. "Eeeuw, that's gross...can I touch it?" was often heard as children poked at semi-digested prey from fish stomachs that were on display. "Bering Sea Food Webs" complemented the food habits activity by allowing visitors to construct food webs that illustrated how productivity, prey-competition and predator-prey relationships cascade through an ecosystem.

C. By Species

1. Pacific Cod

a. Research

Juvenile Pacific Cod Movement, Habitat, and Overwintering Study-RACE Kodiak Lab
In 2011, researchers from the Kodiak Laboratory continued work on 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 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, a laboratory study was completed that examined the effects of intra-peritoneal tag implantation on juvenile cod and the results indicated this is a valid technique. In the fall of 2011, 8 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 juvenile cod winter migratory behavior was highly variable among the tagged individuals. Some individuals briefly transited the acoustic gate during late September/ early October while others resided in the vicinity of the gate throughout the winter months. Upcoming work in 2012 will focus on acquiring additional habitat use data through the fall months and further documenting the winter migratory behavior patterns of juvenile cod. 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.

Age-0 Pacific Cod Pilot Tagging Study-RACE Kodiak Lab
In September, 2011, 40 age-0 Pacific cod, *Gadus macrocephalus,* were tagged with a variety of marker tag types to assess the feasibility of developing a large-scale tagging study. The objectives of this pilot study were to utilize a variety of tag types to examine retention rates, ease of application, and visible fish trauma caused by the tag. Tag types that were utilized were Visible Implant Elastomers (Northwest Marine Technology), t-bar and streamer (Floy, Hallprint), and fingerling (Floy). The fish were maintained at the Kodiak Laboratory sea water

facility and evaluated after 30 and 120 days. For smaller, early season fish (captured in July) Visible Implant Elastomers appear to have the most promise but care will need to be utilized in both location of implantation and color choice. For larger, later season fish t-bar tags may provide the best compromise between ease of tagging and retention rates. These tags were retained well but were particularly injurious to smaller fish. This study will continue in the upcoming year with additional testing of t-bar and Visible Implant Elastomer tags. For further information please contact Christina Conrath (907) 481-1732.

Diel vertical migration of Pacific cod in Alaska-RACE GAP
Two analyses of depth, both derived from depth-recording archival tags attached to individual Pacific cod, are being used to describe how vertical movement varies between day and night in two different areas of Alaska: off Kodiak Island in the Gulf of Alaska and near Unimak Island in the eastern Bering Sea. A total of 286 adult Pacific cod (49 – 85 cm FL), externally tagged with depth and temperature archival tags (Lotek LTD 1100) were recovered from among 653 individuals released between November 2001 and May 2002. The analysis being done includes comparisons of vertical movement between day and night, during consecutive 24-hr periods, and site-specific and seasonal components to vertical movement. Contact Dan.Nichol@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.

References: Cunningham, K.M., Canino, M.F., Spies, I.B., Hauser, L. 2009. Genetic isolation by distance and localized fjord population structure in Pacific cod (*Gadus macrocephalus*): limited effective dispersal in the northeastern Pacific Ocean. *Canadian* Journal of Fisheries and Aquatic Sciences, **66**, 153–166.

Canino M.F., Spies, I.B., Cunningham, K.M., Hauser, L. and Grant, W.S. 2010. Multiple ice-age refugia in Pacific cod, *Gadus macrocephalus*. *Molecular Ecology* 19:4339-4351.

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.

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS

Considerable effort to respond to the public and the Council comments on the Pacific cod assessment continued in 2011. There was a CIE review and two rounds of model proposals, trials, and reviews by the Plan Teams and SSC (May/June and September/October). Survey data indicate that after all-time lows from 2006 through 2008, the 2011 Bering Sea survey biomass was 4% higher than the 2010 estimate, which was more than double the 2009 estimate. The 2006 and 2008 year classes appear to be strong, and stock abundance is expected to continue to increase in the near future.

The accuracy of age readings for this stock has been a continuing concern, mainly because the mean size at age from age readings does not match the first three clear modes of cod length frequencies in the Bering Sea trawl survey. Other issues have been the natural mortality rate, the trawl survey catchability coefficient, the modeling of commercial selectivity (variable or not, asymptotic or not, fishery by fishery) and the modeling of growth (constant, cohort-specific, year-specific). In 2011 five candidate models (1, 2b, 3, 3b, and 4) were considered for the 2012 OFL/ABC specifications. Model 1 was the 2010 preferred model, whose main features were:
(i) Natural mortality $M = 0.34$ fixed externally.
(ii) Commercial length compositions fitted, not commercial CPUE. Length-specific commercial selectivities, estimated in blocks of years, some forced to be asymptotic.
(iii) Trawl survey age composition and CPUE fitted. Age-specific trawl survey selectivity with annually varying left limb. Trawl survey catchability fixed at 0.77, which in the 2009 assessment had resulted in the average product of catchability and selectivity of 60-80 cm fish being 0.47, the value estimated from a small set of data from archival tag recoveries.
(iv) A single schedule for mean length at age estimated internally for all years. Standard deviation of length at age a linear function of mean length at age, estimated externally.
(v) Assumed age reading bias of +0.4 y at all ages.
(vi) Length composition data not used where age composition data were available.

The other models were as follows:

- Model 2b was the same as Model 1 except that the pre-1982 trawl survey data were left out and the author made a number of small but helpful housekeeping changes to the model configuration.
- Model 3 was the same as Model 2b except that aging error parameters were estimated internally.
- Model 3b was the same as Model 3 except that the standard deviation of length at age was estimated internally, the mean length-at-age data were left out of the likelihood, and all length frequency data were used.

- Model 4 was the same as Model 3b except that all age composition data were left out of the fit (to avoid the whole issue of aging error).

All of the models produced similar fits to the survey abundance data and similar estimates of historical recruitment and present abundance. All models predicted mean length at age of younger fish in good agreement with the modes in the trawl survey length frequencies. Model 3b fitted the survey age data best in most years. The author adopted a set of criteria for choosing a preferred model, including among others (i) that the age data should be used if possible, (ii) that aging error should be estimated internally if possible, and (iii) that the standard deviation of length at age should be estimated internally. By these criteria Model 3b was the clear choice.

$B_{40\%}$ for this stock is estimated to be 355,000 t and projected spawning biomass in 2012 according to Model 3b is 410,000 t, so this stock is assigned to Tier 3a. While there remains some concern about the fixed value of trawl survey catchability used in the assessment, neither the author nor the Team saw any compelling reason to recommend OFL or ABC values lower than prescribed by the standard control rule. Recent catches have been well below OFL. The 2006 and 2008 year classes appear to be strong, and stock abundance is expected to increase in the near term. BSAI Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA

The 2011 NMFS bottom trawl survey estimate of 348 million fish is a 33 percent decrease in abundance over the 2009 survey estimate, which was a 199% increase from the 2007 estimate. All survey and commercial data series for CPUE, catch at age, and catch at length were updated.

The 2011 GOA Pacific cod assessment evaluated four assessment models. Model 1 is identical to the model accepted by the 2010 GOA Plan Team. Model 3 (a Model 2 was developed, but applied only to the BSAI Pacific cod) included internal estimation of aging bias, a parameter in the length-at-age equation that was increased to correspond to the age of age 1 fish at the time of the survey, and the variability in length-at-age was re-estimated external to the model. Relative to Model 3, Model 3b estimates the variability in length at age internally, includes all size composition records, excludes the fit to the mean size at age, fixes the selectivity and catchability in the 27-plus trawl survey to be constant over time, and uses a normal prior distribution for the catchability deviations in the sub-27 cm survey. Relative to Model 3b, Model 4 does not estimate the ageing bias internally, the age composition data were excluded, and the pre-1977 mean recruitment was constrained to be less than the post-1976 mean recruitment.

The author proposed 6 model evaluation criteria. Because no model met all criteria, the criteria were prioritized with the highest four criteria being: 1) use of (and fit to) the age composition data; 2) internal estimation of aging error bias; 3) correspondence between the model-estimated mean size-at-age and the empirical survey mean-size-at-age and first few modes of the average survey size composition; and 4) correspondence of the product of survey catchability and survey selectivity (for the 61-80 cm size range) from the model and the value of 0.92 estimated by Nichol et al. (2007). The author recommended Model 3 because of the good fit to the age composition data, and correspondence to the age 1 and 3 survey size composition modes and the

Nichol et al. (2007) estimate of the product of survey catchability and selectivity.

The Plan Team agreed with the authors that Model 3 is the preferred model. Model 1 can interpret age 1 fish as the sum of age 0 and age 1 fish, which can bias recruitment estimates. This issue is addressed in the other models by specifying age 0 data in the age composition and mean size at age input files. Internal estimation of ageing bias is considered an improvement from the 2010 model, and is not included in Model 4. Model 3b estimates the product of catchability and selectivity for 61-80 cm fish at 0.67, substantially below the value of 0.92 obtained by Nichol et al. (2007). In the absence of other data indicating the catchability of the stock, the Plan Team agreed that matching the Nichol et al. (2007) estimate was a useful criterion. Finally, the retrospective patterns indicate that inclusion of additional data tends to decrease estimates of abundance, which further supports models with a higher level of survey catchability.

Recent catches have been well below OFL. The stock was not subjected to overfishing in 2010, and is not determined to be overfished in 2011. Estimated age-0 recruitment has been relatively strong since 2005, and stock abundance is expected to increase in the near term.

$B_{40\%}$ for this stock is estimated to be 104,000 t and projected spawning biomass in 2012 according to Model 3 is 121,000 t, so this stock is assigned to 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 0.53 and 0.44.
At present, the ABC of Pacific cod is apportioned among regulatory areas based on the three most recent trawl surveys. The apportionments based on the average area-specific biomass estimates from the 2007-2011 surveys are 32% in the Western GOA, 65% in the Central GOA, and 3% in the Eastern GOA. An alternative that is used in the Bering Sea - Aleutian Islands based on a Kalman filter approach would result in apportionments of 35% in the Western GOA, 61% in the Central GOA, and 4% in the Eastern GOA. For further information, contact Dr. Grant Thompson at (541) 737-9318.

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 (*Theragra chalcogramma*) and juvenile Pacific salmon (*Oncorhynchus spp.*) has been conducted annually by Auke Bay Laboratories Ecosystem Monitoring and Assessment Program researchers in 2000–2011, with surveys planned for 2012 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, and ABL's Habitat Assessment and Marine Chemistry (HAMC) Program to examine recruitment processes of walleye pollock. Larval 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 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 (Wyllie-Echeverria 1995). 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 by the North Pacific Fishery Management Council to help reduce the uncertainty in stock assessments for EBS walleye pollock.

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 2006-2011. 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. Currently, age-0 pollock appear to 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.

Walleye Pollock in the Bering Sea- RACE Recruitment Processes

Water temperatures in the southeastern Bering Sea influence the density of walleye pollock *Theragra chalcogramma* early life stages, potentially influencing spatial distributions and the phenology of reproduction and development. Walleye pollock egg and yolk-sac larval spatial distributions are unaffected by temperature, suggesting that spawning locations are stable. Preflexion larvae, late larvae, and juveniles shift onto the shelf under warm conditions, similar to spatial shifts observed in distributions of sub-adults and adults. Temporal distributions were used to address the hypothesis that timing of the density peak at each stage is delayed under cold conditions. Differences in the timing of density peaks supported the hypothesis that the timing of spawning, hatching, larval development, and juvenile transition are temperature-dependent. The current analysis represents the best support available for the importance of temperature to walleye pollock in determining early life stage development and population trends in EBS. Data indicate that future changes in water temperatures could influence the early life stages of an ecologically dominant member of the EBS community by changing phenology and habitat use in the first several months of life.

Reference: Smart, T., Duffy-Anderson, J.T., Horne, J. In press. Alternating climate states influence walleye pollock life stages in the southeastern Bering Sea. *Mar. Ecol. Prog. Ser.*

Walleye Pollock Growth in the Gulf of Alaska- RACE Recruitment Processes

We quantified the growing season of yearling walleye pollock (*Theragra chalcogramma*) and related it to annual cycles of water temperature and day length. The study was restricted to members of the 2000 year class and thereby controlled for interannual variability. Fifty percent of juveniles exhibited an annulus on 16 March 2001 (± 11 days 95% confidence interval). No regional difference was detected in the timing of annulus formation or in post-annulus growth trajectories. A model, derived from growth trajectories, estimated that the growing season lasted 204 days (22 March to 13 October 2001) and that growth rate peaked at 0.59 mm day−1 on 2 July 2001. Growth rate increased with day length and water temperature during spring and decreased in late summer possibly due to thermal stress. Secondarily, we explored the utility of otolith size at the first annulus as a natural tag to identify nursery area, but this potential was curtailed by overlap in length among regions. Our results indicate that the first annulus can be used to advance our understanding of climate forcing on marine fish growth by providing fine temporal resolution of the growing season. See Wilson, et al. (2011b).

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

A survey of amplified fragment length polymorphism (AFLP) was conducted o assess the extent of selective mortality during early larval stages. Comparing a cold year (1995) and a warm year (1993) we investigated changes in allele frequencies at 361 loci from two temporal samples collected from a single cohort in the EBS. Levels of genetic differentiation were relatively high, especially in 1995. Permutation tests indicated 24 loci with differentiation higher than expected by chance in 1993, and 125 loci in 1995. The study demonstrated the value of using genetic markers potentially influenced by natural selection (as opposed to neutral genetic markers) for identifying the extent of spatial and temporal variation in natural populations.

Reference: Hauser, L., Bailey, K.M., Canino, M.F., Jimenez-Hidalgo, I. 2009. Adaptation to a changing world: molecular evidence for selective mortality in walleye pollock. North Pacific Research Board Final Report 610.

Walleye Pollock Feeding Ecology- RACE Recruitment Processes

We examined stomach contents of juvenile walleye pollock (*Theragra chalcogramma*) to explain previously observed seasonal and regional variation in body condition. Mean stomach content weight (SCW, 0.72% somatic body weight) decreased with fish body length except from winter to summer 2001. Euphausiids composed 61% of SCW and were the main determinant of seasonal change in the diets of fish in the Kodiak and Semidi regions. Before and during winter, SCW and the euphausiid dietary component were highest in the Kodiak region. Bioenergetics modeling indicated a relatively high growth rate for Kodiak juveniles during winter (0.33 mm standard length/d). After winter, Shumagin juveniles had relatively high SCW and, unlike the Kodiak and Semidi juveniles, exhibited no reduction in the euphausiid dietary component. These patterns explain previous seasonal and regional differences in body condition. We hypothesize that high-quality feeding locations (and perhaps nursery areas) shift seasonally in response to the availability of euphausiids. See Wilson et al. (2011a).

b. Stock Assessment

GULF OF ALASKA

The 2011 NMFS bottom trawl survey biomass estimate was very close to the 2009 estimate (<1% increase). The ADF&G crab/groundfish survey biomass estimate declined 19% from the 2010 biomass estimate, but is 32% above the mean for 2006-2008. The estimated abundance of mature fish in 2012 is projected to be 11% higher than in 2011, and is projected to increase gradually over the next five years. The model estimate of spawning biomass in 2012 is 227,723 t, which is 33.6% of unfished spawning biomass. The $B_{40\%}$ estimate is 271,000 t. This represents a 2% decrease from the 2010 assessment, and is due to the small reduction in average recruitment

The age-structured model developed using AD Model Builder and used for GOA W/C/WYK pollock assessments in 1999-2010 is unchanged. This year's pollock assessment features the following new data: (1) 2010 total catch and catch at age from the fishery, (2) 2011 biomass and length composition from the NMFS bottom trawl survey, and (3) 2011 biomass and length composition from the ADF&G crab/groundfish trawl survey. Recent estimates from both surveys are fit adequately by the model, and there are no large residuals to the fit to recent age data. The fit of Shelikof Strait acoustic survey age composition shows large residuals at age 2 and age 3 in 2006-2009 due to inconsistencies between the initial estimates of abundance and subsequent information about the magnitude of these year classes. The acoustic surveys were cancelled in winter of 2011 so less information was available to assess stock trends and status. Model fits are similar to previous assessments and general trends in survey time series 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 survey time series in the last three years (2009-2011) appear consistent in showing increases, but the magnitudes of the change vary between survey biomass estimates.

The Plan Team concurred with the author's recommendation to use the standard model projection and the more conservative adjusted $F_{40\%}$ harvest rate. There are some elements of risk-aversion in this recommendation, such as fixing trawl catchability at 1.0. Until an ABC framework is in place that deals explicitly with scientific uncertainty, the author suggests (and the Team agreed) that this approach is reasonable. Because model estimated 2012 female spawning biomass is below $B_{40\%}$, the W/C/WYK Gulf of Alaska pollock are in Tier 3b. The Plan Team accepted the author's recommendation to reduce F_{ABC} from the maximum permissible using the "constant buffer" approach (first accepted in the 2001 GOA pollock assessment). The projected 2012 age-3+ biomass estimate is 863,840 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 all years. Therefore, the ABC for 2012 based on this precautionary model configuration and adjusted harvest control rule is 108,440 t ($F_{ABC} = 0.14$) for GOA waters west of 140°W longitude, an increase of 22% from the 2011 ABC. **The ABC is 105,670 for 2012** (reduced by 2,770 t to account for the Prince William Sound GHL). The 2012 OFL under Tier 3b is 143,720 t (F_{OFL}= 0.19). In 2013, the recommended ABC and OFL are 114,560 t (reduced by Prince William Sound GHL) and 155,400 t, respectively.

Southeast Alaska pollock (East Yakutat and Southeastern areas) are in Tier 5 and the ABC and OFL recommendations are based on natural mortality (0.30) and the biomass from the 2011 NMFS bottom trawl survey. The biomass from the 2011 NMFS bottom trawl survey increased to 47,885 t. The result is a **2012 ABC of 10,774 t**, and a **2012 OFL of 14,366 t**. Recommendations for 2013 are the same as 2012. For more information contact Dr. Martin Dorn 526-6548.

EASTERN BERING SEA

Estimates of age 3+ biomass from the 2011 assessment were higher than those from the 2010 assessment for every year from 1988-2008, but lower for every year since then. For example, the estimates/projections of 2011 and 2012 age 3+ biomass in this year's assessment are 19 percent and 26 percent lower than the respective projections in last year's assessment. Spawning biomass in 2008 was at the lowest level since 1980, but has increased by 43 percent since then, with further increases projected for the next few years. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent and projected increases are fueled by strong recruitments from the 2006 and 2008 year classes. Spawning biomass is projected to be 17 percent and 26 percent above B_{MSY} in 2012 and 2013, respectively.

New data in this year's assessment include the following:
- 2011 NMFS summer bottom trawl survey abundance-at-age estimates
- 2010 age composition estimates were updated using acoustic-trawl survey age data (in last year's assessment, an age-length key from the 2010 bottom trawl survey was used)
- Observer data for age and average weight-at-age from the 2010 fishery
- Total catch as reported by NMFS Alaska Regional office were updated through 2011
- The acoustic index from the bottom trawl survey vessels was updated from 2006-2011

The only change in the assessment model was the use of the acoustic index from the bottom trawl survey vessels, which was reviewed last year by the Plan Team and SSC but not used in last year's assessment.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates of B_{MSY} and the probability density function for F_{MSY}. The Plan Team concurs with the assessment authors' conclusion that the Tier 1 reference points continue to be reliably estimated. The updated estimate of B_{MSY} from the present assessment is 2.03 million t. Projected spawning biomass for 2012 is 2.39 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 0.533, down 5 percent from last year's value of 0.564. The harvest ratio of 0.533 is multiplied by the geometric mean of the projected fishable biomass for 2012 (4.13 million t) to obtain the maximum permissible ABC for 2012, which is 2.20 million t, up 2 percent and down 3 percent from the maximum permissible ABCs for 2011 and 2012 projected in last year's assessment.

The authors recommend setting the ABCs for 2012 and 2013 below their respective maximum permissible levels; specifically, at values corresponding to the average harvest rate over the most recent five complete years (0.30), with the strength of the 2008 year class set equal to the long-term average. Projected harvesting under this scenario results in ABCs for 2012 and 2013 equal to 1.09 million t and 1.14 million t, respectively. Much debate occurred at the December meeting of the NPFMC over the value of the 2012 pollock ABC. The Council decided to use an ABC of 1.2 million metric tons for the 2012 fishing season. Arguments for a lesser ABC centered on the large hole in the age structure created by poor recruitments from the 2002-2005 year classes, which was expected to result in half of the 2011 catch coming from a single (2006) year class. As of this year, the 2008 year class has been observed by multiple surveys over three years and its above-average strength has been substantially confirmed, one result of which is that the 2012 catch is projected to be much less dependent upon a single year class. The authors listed 14 reasons in support of their recommendation to set ABC well below the maximum permissible level, and seemed to have made a compelling case which led to the difficult decision this year regarding the harvest recommendation.

The OFL harvest ratio under Tier 1a is 0.60, 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 2012 sets the OFL for 2012, which is 2.47 million t. The current projection for OFL in 2013 given a 2012 catch equal to the Plan Team's recommended ABC is 2.84 million t.

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

ALEUTIAN ISLANDS

This year's assessment estimates that spawning biomass reached a minimum level of about $B_{28\%}$ in 1999, increased steadily through 2006 to a level around $B_{37\%}$, and then decreased to about $B_{30\%}$ at present. The increase in spawning biomass since 1999 has resulted more from a large decrease in harvest than from good recruitment, as there have been no above-average year classes spawned since 1989. Spawning biomass for 2012 is projected to be 70,900 t.

The new data in the model consists of updated catch information from 1978 through 2011, and inclusion of the 1980, 1983, and 1986 Aleutian Islands bottom trawl surveys. In addition, a generalized additive model was applied to estimate weight-at-age data for years where those data were missing. This year's model estimate of natural mortality was 0.19, down from 0.20 in previous years.

The SSC has determined that this stock qualifies for management under Tier 3. The reference model estimates $B_{40\%}$ at a value of 93,600 t, placing the AI pollock stock in sub-tier "b" of Tier 3. Under Tier 3b, with $F_{40\%}$=0.37, the maximum permissible ABC is 32,500 t for 2012. The Plan Team recommends setting 2012 ABC at this level. Following the Tier 3b formula with $F_{35\%}$=0.47, OFL for 2012 is 39,600 t. Given a 2012 catch of 19,000 t, the maximum permissible ABC would be 29,300 for 2013 and the projected OFL would be 35,900 t. If the 2012 catch is only 1,540 t (i.e., equal to the five year average), the 2013 maximum permissible ABC would be 35,200 t and the 2013 OFL would be 42,900 t. The Plan Team recommended setting 2013 ABC and OFL at the latter levels.

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

Bogoslof District

The 2009 Bogoslof pollock acoustic-trawl survey resulted in the lowest estimate of biomass (110,000 t) in the region since the survey began in 1988. There was no survey in 2010 or 2011. Survey biomass estimates since 2000 have all been lower than estimates prior to 2000, ranging from a low of 110,000 t in 2009 to a high of 301,000 t in 2000. The SSC has determined that this stock qualifies for management under Tier 5. Traditionally, the ABC for this stock has been set using a formula similar to the Tier 3 formula, but substituting a reference biomass level of 2 million t for $B_{40\%}$.

This year the authors' presented three new strategies for setting ABC and OFL. The Plan Team concurred with the authors' recommendation to revert to a more standard Tier 5 approach, using the most recent survey to provide the estimate of current biomass. The maximum permissible ABC value for 2012 would be 16,500 t (assuming M = 0.2 and F_{ABC} = 0.75 x M = 0.15): ABC = B_{2009} x M x 0.75 = 110,000 x 0.2 x 0.75 = 16,500 t. The projected ABC for 2013 is the same. Following the Tier 5 formula with M=0.20, OFL for 2012 is 22,000 t. The OFL for 2013 is the same.

The walleye pollock stock in the Bogoslof district is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5. For further information contact Dr. James Ianelli, (206) 526-6510

3. Shelf Rockfish

Stock Assessment-Gulf of Alaska

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). Formerly, dusky rockfish were included in the pelagic shelf rockfish assemblage in the Gulf of Alaska which was comprised of three species: dusky rockfish, yellowtail rockfish (*S. flavidus*), and widow rockfish (*S. entomelas*). This assemblage was one of three management groups for *Sebastes* in the Gulf which were implemented in 1988 by the North Pacific Fishery Management Council (NPFMC). Until 1998, black rockfish (*S. melanops*) and blue rockfish (*S. mystinus*) were also included in the assemblage. In 1998, a NPFMC Gulf of Alaska Fishery Management Plan amendment removed these two species from the federal management plan and transferred their jurisdiction to the state of Alaska. In 2010, dark rockfish (*S. ciliatus*) was also removed from Federal management (including the associated contribution to OFLs and ABCs under the respective assemblages in both regions) and full management authority was turned over to the State. Partial justification for this is that dark rockfish share an inshore reef or kelp environment with black rockfish and the two species are often caught together, suggesting that darks should be managed with black rockfish and other inshore species rather than within the pelagic shelf assemblage.

In 2012, dusky rockfish were assessed for the first time as a stand-alone species; widow and yellowtail rockfish are now included in the Other Rockfish stock assessment. This change in management is partially justified because dusky rockfish has a large biomass in the GOA and supports a valuable directed fishery, especially in the central GOA. In contrast, yellowtail and widow rockfish have a relatively low abundance in the GOA, are only taken commercially in very small amounts as bycatch, and do not commonly co-occur with dusky rockfish.

Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the AFSC biennial trawl surveys in this region. In 2011, a full assessment was produced for dusky rockfish. An age-structured model is implemented and three model configurations were considered that incorporate recently published maturity data for dusky rockfish and that examine alternative estimation methods for fishery and survey selectivities. All three models incorporated updated catch, fishery, and survey data. The model selected to provide stock assessment advice included an intermediate maturity curve with parameters estimated conditionally in the assessment model and fitted to combined female dusky rockfish maturity data used in previous assessments and new maturity data. This methodology allows uncertainty in maturity to be incorporated into uncertainty in assessment model estimates.

For the 2012 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 5,118 mt. This ABC is 10% more than last year's ABC of 4,663 t. The increase in ABC is attributable to both changes in age at maturity estimates and to a 15% increase in the trawl survey biomass estimate from 2009 to 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 injuries from rapid, internal air expansion when caught. 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. Rockfish that have been studied previously in barotrauma research have not been deep-water dwelling. Rougheye rockfish (*S. aleutianus*) are a federally managed species in Alaska, and most of the catch occurs at depths from ~600-1200 ft. In 2011, ABL scientists sampled rougheye rockfish in inside waters of southeast Alaska at depths from 500 to 800 feet. All fish exhibited external signs of barotrauma including exophthalmia ("popeye"), an everted esophagus, and ocular emphysema (air bubble under the cornea). We tagged 47 fish and released these at depths of 200-250 ft, and 21 others were recompressed in portable pressure tanks and slowly brought back to surface pressure over the course of 48 hours. Of these 21, 13 survived and are currently held at the ABL facility in Juneau for long term monitoring. After re-pressurization, fish no longer had exophthalmia or an everted esophagus. In many cases ocular emphysema also disappeared. This result is noteworthy because it is the deepest known successful capture and recompression of any rockfish species, which suggests there is potential to conduct scientific tagging studies to track movements and behavior of deepwater rockfish species.

In 2012 we hope to further our research by increasing the number of tagged fish at-large, make the first attempt to recapture fish tagged in 2011, and increase the number of fish brought back to the ABL for long-term observation. In the future we also hope to tag a portion of fish with sonic tags so that movement can be tracked with receivers. In 2011 we found that survival may be inversely related to fish size; small fish had a greater chance at survival after recompression. To investigate this relationship further, more samples are needed to develop potential survival estimates for fish that are tagged and released in the natural environment.

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

Growth Potential and Links to Recruitment for Pacific ocean perch (*Sebastes alutus*) Nursery Habitats of the Gulf of Alaska--RACE GAP

Researchers in the RACE Groundfish Assessment Program have been investigating links between juvenile Pacific ocean perch (POP, *Sebastes alutus*) and their essential habitats since 2003. These studies have indicated that juvenile POP are found in specific types of nursery habitat, typically rocky habitats on the outer continental shelf within a narrow depth range of 85-200 m. Nursery areas for juvenile fishes are often important for determining recruitment in marine populations by providing habitats that can maximize growth and thereby minimize mortality. In the most recent study, Pacific ocean perch and their nursery areas were examined to look for links between growth potential and recruitment using both field collected and modeled data. Juvenile POP were captured from nursery areas in 2004 and 2008, and estimated growth rates ranged from -0.19 $g*d^{-1}$ to 0.60 $g*d^{-1}$ based on differences in size between June and August. Predicted growth rates from a bioenergetics model ranged from 0.05 $g*d^{-1}$ to 0.49 $g*d^{-1}$ and were not significantly different than observed growth rates. Substrate preferences and the distribution of their preferred habitats were utilized to predict the extent of juvenile POP nursery habitat in the Gulf of Alaska. Based on densities of fish observed on underwater video transects and the spatial extent of nursery areas, we predicted 278 and 290 million juvenile POP were produced in 2004 and 2008, similar to the magnitude of recruitment predicted from the stock assessment. Growth potential for juvenile POP was reconstructed using the bioenergetics model, spring zooplankton bloom timing and duration and bottom water temperature for 1982 to 2008. When a single outlying recruitment year in 1986 was removed, growth potential experienced by juvenile POP in nursery areas was significantly correlated to the recruitment time-series from the stock assessment, explaining ~30% of the variability. This research highlights the potential to predict recruitment using habitat-based methods and provides a potential mechanism for explaining some of the POP recruitment variability observed for this population. For further information contact Chris Rooper (Chris Rooper@noaa.gov).

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 Kodiak Lab

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: Pacific ocean perch, *Sebastes alutus*, 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 results for Pacific ocean perch and preliminary results for rougheye rockfish are presented below. During the upcoming year blackspotted, shortraker, and northern rockfish maturity studies will be completed. In addition, samples will be collected to enable researchers to examine the inter-annual variability in reproductive parameters of Pacific ocean perch.
For further information please contact Christina Conrath (907) 481-1732.

Rougheye Rockfish Maturity in GOA-RACE Kodiak Lab

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 one of these species, *S. aleutianus,* within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Preliminary results from this study indicate age and length at 50% maturity for this species are 26.3 years and 48.8 cm FL. These values are older and larger than values of 19 years and 43.9 cm FL currently being utilized in the stock assessment of the GOA rougheye rockfish complex. It is unknown whether these larger and older values are a result of a more geographically appropriate sampling plan or the exclusion of *S. melanostictus* from the analyses. These updated values for age and length at maturity have important implications for stock assessment and are likely to result in more conservative catch limits for this species in the GOA. For further information please contact Christina Conrath (907) 481-1732.

Pacific Ocean Perch Maturity in the Gulf of Alaska-RACE Kodiak Lab

Despite the ecological and economic importance of rockfish fisheries in Alaska waters little information is available concerning the reproductive biology of the majority of federally managed rockfish species in the Gulf of Alaska. This study re-examines the reproductive biology of Pacific ocean perch, *Sebastes alutus*, within the Gulf of Alaska utilizing histological techniques to microscopically examine ovarian tissue. Pacific ocean perch samples were obtained throughout the year during National Marine Fisheries Service and Alaska Department of Fish and Game scientific surveys, from the Fisheries Monitoring and Analysis Division, and from scientific charters. Pacific ocean perch ovaries began to ripen during the month of August with yolk increasing until February. Embryos appeared within the ovaries during February and continued to grow and develop until May when parturition occurred. Results from this study indicate the length at 50% maturity is 33.4 cm FL and age at 50% maturity is 8.5 years. Both of these values are smaller than those currently utilized in the stock assessment of Gulf of Alaska Pacific ocean perch. Results from this study will improve the stock assessment of this species by providing more accurate reproductive parameter estimates and reducing the uncertainty in length and age at maturity estimates. For further information please contact Christina Conrath (907) 481-1732.

Rockfish Maturity in the Aleutian Islands-REFM/REEM

The focus of a reproductive study was to obtain updated maturity information from females for five rockfishes occurring in the Aleutian Islands region: Pacific ocean perch (POP; *Sebastes alutus*); northern rockfish (*S. polyspinis*); blackspotted rockfish (*S. melanostictus*); rougheye rockfish (*S. aleutianus*); and shortraker rockfish (*S. borealis*). Estimates of maturity, in particular the proportion of a population mature by age, are an important metric of fish populations and play a critical role in the formulation of fishing reference points and harvest specifications. Age-structured stock assessment models for rockfishes in the Bering Sea-Aleutian Islands (BSAI) management region rely upon maturity data from the Gulf of Alaska (GOA) due to the lack of data in the BSAI. Misspecification of fishing mortality rates would occur if differences existed between the productivity of a species occurring in different regions, and species-specific maturity information will be required for more refined assessment methodologies.

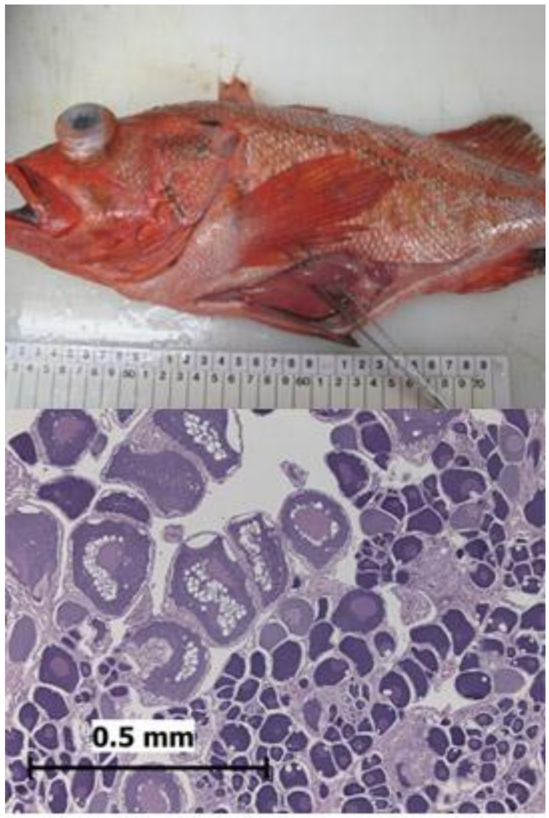

Figure 5. Macroscopic (a) and histological (b) view of an ovary from a large-sized blackspotted rockfish collected in April 2010. There was no evidence of vitellogenesis in the histological view.

Due to a lack of smaller-sized specimens caught and sampling during periods of reproductive inactivity, maturity estimates for blackspotted, rougheye, and shortraker rockfish could not be obtained. Throughout the sampling periods, blackspotted rockfish within our desired size range exhibited macroscopic and histological characteristics as immature, although many of the larger fish may have been resting or reproductively inactive mature fish (Fig. 5). This was also observed for rougheye and shortraker rockfish.

For these species, the seasonal reproductive cycle may be more compressed into the late fall to spring period, and further sampling throughout the year should be conducted to evaluate this hypothesis. Assessment models and harvest recommendations, however, will be improved by obtaining region-specific maturity information from the Bering Sea-Aleutian Islands area for Pacific ocean perch and northern rockfish and periodically updating the maturity information to monitor any temporal trends.

Habitat Use and Productivity of Commercially Important Rockfish Species in the Gulf of Alaska-RACE Kodiak

Habitat use and productivity of commercially important rockfish species in the Gulf of Alaska 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. We propose to 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. 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. This research will commence during 2012 and will continue through 2014. For further information contact Christina Conrath, (907) 481-1732

b. Stock Assessment

Pacific Ocean Perch (POP)

BERING SEA AND ALEUTIAN ISLANDS

Pacific ocean perch (POP) assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. A straightforward update of the assessment was presented in an executive summary because the Aleutian Islands survey was not conducted this year. Catch data were updated and the projection model was run using results from the starting point of the 2010 assessment model. The apportionment was updated and changed slightly. The POP stock has had an increasing trend in survey biomass estimates since 2002 resulting from strong recruitment estimates of the 1994-2000 cohorts.

Age 3+ biomass for 2012 is down slightly from the 2011 level projected a year ago. Spawning biomass is projected to be 221,000 t in 2012 and decline slightly to 214,000 t in 2013.
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 158,000 t, 0.061, and 0.074 respectively. Spawning biomass for 2012 (221,000 t) is projected to exceed $B_{40\%}$ (158,000 t), thereby placing POP in sub-tier “a” of Tier 3. The 2012 and 2013 catches associated with the $F_{40\%}$ level of 0.061 are 29,400 t and 28,300 t, respectively. In 2010, the Plan Team recommended an adjusted ABC approach until the next Aleutian Islands survey, which would keep the recommendation steady at 24,700 t for 2012, followed by an increase to 28,300 t in 2013. The Plan Team continues to endorse this approach. The 2012 and

2013 OFLs are 35,000 t and 33,700 t.

ABCs were set regionally based on the proportions in combined survey biomass as follows (values are for 2012): BS = 5,710 t, Eastern Aleutians (Area 541) = 5,620 t, Central Aleutians (Area 542) = 4,990 t, and Western Aleutians (Area 543) = 8,380 t. The recommended OFL is not regionally apportioned. Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA

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 even years (such as 2010's assessment for the 2011 fishery) when there is only new catch information, we run only the projection model with updated catch data for single-species, age-structured assessments. In odd years (like 2011), we run a full assessment with all new survey and fishery data accumulated since the last full assessment. In 2011, a full stock assessment was produced. The 2011 Gulf of Alaska trawl survey biomass estimate was the highest since 2005. For the 2012 fishery, we recommended the maximum allowable ABC of 16,918 t which was stable from last year's ABC of 16,997 t. The stock is not overfished, nor is it approaching overfishing status. For more information contact Dana Hanselman at (907) 789-6626 or dana.hanselman@noaa.gov.

Northern Rockfish

BERING SEA AND ALEUTIAN ISLANDS

Northern rockfish assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. A straightforward update of the assessment was presented in an executive summary this year because the Aleutian Islands survey was not conducted in 2011. Catch data were updated and the projection model was run using results from the starting point of the 2010 assessment model.

Age 3+ biomass has been on an upward trend since 2002 and catches are below allowed values. Spawning biomass has been increasing slowly and almost continuously 1977. Female spawning biomass is projected to be 72,200 t in 2012. The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$ (50,600 t), $F_{40\%}$ (0.058), and $F_{35\%}$ (0.071). Because the female spawning biomass of 72,200 t is greater than $B_{40\%}$, sub-tier "a" is applicable, with maximum permissible $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Under Tier 3a, the maximum permissible ABC for 2012 is 8,610 t, which is the recommendation for the 2012 ABC. Under Tier 3a, the 2012 OFL is 10,500 t for the Bering Sea/Aleutian Islands combined. The Plan Team continues to recommend setting a combined BSAI OFL and ABC. Because the catch has routinely been lower than the ABC, the 2011 catch was estimated at a value of 3,450 t to make projections to 2012. The recommended 2013 ABC and OFL are 8,490 t and 10,400 t, 2respectively. Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA

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. A new method was introduced in the 2011 full assessment to blend multiple sources of maturity data. A new maturity study was recently published that differed substantially from the previous maturity study. Because of these differences, the data from these two studies were fit simultaneously inside the model, allowing the uncertainty in the maturity curve to be propagated through the assessment. An additional analysis examined the optimal binning of age composition data and adjusted the maximum age fit in the model accordingly. The result was a recommended ABC for 2012 of 5,509 t; this ABC was 13% higher than the 2011 ABC of 4,857 t. 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, ABL, at (907) 789-6060 or pete.hulson@noaa.gov.

Shortraker Rockfish

BERING SEA AND ALEUTIAN ISLANDS-REFM Contribution
Shortraker rockfish assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. A straightforward update of the assessment was presented in an executive summary because the Aleutian Islands survey was not conducted in 2011. Catch data were updated.

Estimated shortraker rockfish biomass is 17,500 t, which is identical to the 2010 assessment biomass estimate. Overall, total biomass has trended slowly downward from 28,900 t in 1980. The SSC has previously determined that reliable estimates only of biomass and natural mortality exist for shortraker rockfish, qualifying the species for management under Tier 5. The Tier 5 biomass estimate is based on a surplus production model. Because neither the time series of survey biomass estimates nor the proxy values for F_{ABC} and F_{OFL} have changed since 2010, the OFL values for 2012 and 2013 in this update are the same as last year's values for 2011 and 2012. F_{ABC} was set at the maximum permissible level under Tier 5, which is 75 percent of M. The accepted value of M for this stock is 0.03 for shortraker rockfish, resulting in a $maxF_{ABC}$ value of 0.023. The biomass estimate for 2012 is 17,500 t for shortraker rockfish, leading to 2012 and 2013 BSAI OFLs of 524 t and ABCs of 393 t.
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 ALAKSA-ABL Contribution

Shortraker rockfish has been its own separate management category in the Gulf of Alaska (GOA) since 2005. Previously, it had been grouped with rougheye rockfish in the "shortraker/rougheye" management category. 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. Because these surveys occur in odd years, one was conducted in 2011, and therefore a full assessment for shortraker rockfish was completed in fall 2011. 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 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 2007, 2009, and 2011 surveys) is used to determine current exploitable biomass. This results in an exploitable biomass of 48,626 mt for shortraker rockfish. 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 1,081 mt for the GOA in 2012. This is an increase of 18% compared to the 2010 and 2011 ABCs of 914 mt. The increase is due to the relatively large biomass for shortraker rockfish found in the 2011 trawl survey that now goes into the calculation of current exploitable biomass. Gulfwide catch of shortraker rockfish was 457 mt in 2010, and estimated catch in 2011 was 522 mt. Shortraker rockfish is not considered overfished in the GOA, nor is it approaching overfishing status. For more information contact Dave Clausen at (907) 789-6049 or dave.clausen@noaa.gov.

Blackspotted/rougheye Rockfish Complex

BERING SEA AND ALEUTIAN ISLANDS-REFM Contribution

Black spotted and rougheye rockfish assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. A straightforward update of the assessment was presented in an executive summary because the Aleutian Islands survey was not conducted in 2011. Catch data were updated and the projection model was run using results from the 2010 assessment model.

Total biomass for 2012 was estimated at a value of 24,900 t, up slightly from the value for 2011 projected in last year's assessment. Female spawning biomass in the AI is projected to increase by about 5 percent per year through 2013.

This stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$. Because the female spawning biomass of 6,070 t is greater than $B_{40\%}$, (4,739 t), $F_{40\%} = F_{ABC} = 0.034$ and $F_{35\%} = F_{OFL} = 0.041$. Under Tier 3a, the maximum permissible ABC is 475 t, which is the authors' and Plan Team's recommendation for the 2012 ABC. Under Tier 3a, the 2012 OFL is 576 t for the Bering Sea/Aleutian Islands combined. The apportionment of 2012 ABC to subareas is 244 t for the Western and Central Aleutian Islands and 231 t for the Eastern Aleutian Islands and Eastern Bering Sea. Since the catch has routinely been lower than the ABC, the catch for 2011 was estimated by using an expansion for the last three months of the year based on the last three years' catch history in order to make projections to 2012.

The blackspotted and rougheye rockfish complex is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA-ABL Contribution

Rougheye (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) have been assessed as a stock complex since the formal verification of the two species (Orr and Hawkins 2008). Since 2005, Gulf of Alaska (GOA) rockfish have been assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. We use a separable age-structured model as the primary assessment tool for Gulf of Alaska rougheye and blackspotted rockfish (RE/BS complex). The model consists of an assessment, which uses survey and fishery data to generate a historical time series of population estimates, and a projection which uses results from the assessment model to predict future population estimates and recommended harvest levels. In off-cycle even years (such as the 2010 assessment for the 2011 fishery) we present an executive summary to recommend harvest levels for the next (odd) year. In on-cycle odd years (like 2011), we run a full assessment with all new survey and fishery data accumulated since the last full assessment. For this on-cycle year, we updated the 2009 assessment model estimates with new data collected since the last full assessment. The data sets used in this assessment include total catch biomass, fishery age and size compositions, trawl and longline survey biomass estimates, trawl survey age compositions, and longline survey size compositions.

We produced a full stock assessment for 2011 and there were no changes in assessment methodology since the last full assessment model in 2009. Parameter estimates were very similar to the 2009 estimates, with very similar trawl survey catchability, slightly higher longline survey catchability, and lower mean recruitment. Population biomass remains steady with a decrease in the 2011 trawl survey estimate and increases in the 2010 and 2011 longline survey relative population weight estimates. For the 2012 fishery, we recommend the maximum allowable ABC of 1,223 t from the updated model. This ABC is a 7% decrease from last year's ABC of 1,312 t. Recent recruitments are steady and near the median of the recruitment time series. This is evident in the ages for both fishery and survey with more young fish over time. The stock is not overfished, nor is it approaching overfishing status.

Additionally, we include brief summaries of rougheye and blackspotted rockfish speciation, the stock structure template, and current research in the "Evidence of Stock Structure" section of the 2011 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 Contribution
Other rockfish assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. A straightforward update of the assessment was presented in an executive summary because the Aleutian Islands survey was not conducted in 2011. Catch data were updated. Trends in spawning biomass for the species of this complex are unknown. Stock biomass, as measured by trawl surveys of the Aleutian Islands and the EBS slope are assumed

the same as the 2010 assessment.

F_{ABC} was set at the maximum allowable under Tier 5 ($F_{ABC} = 0.75M$). Multiplying these rates by the best biomass estimates of shortspine thornyhead and other rockfish species in the “other rockfish” complex yields 2012 and 2013 ABCs of 710 t in the EBS and 570 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. OFL was set for the entire BSAI area, which under Tier 5 is calculated by multiplying the best estimates of total biomass for the area by the separate natural mortality values and adding the results, which yields an OFL of 1,700 t for 2012 and 2013.

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 under Tier 5. For further information, contact Paul Spencer at (206) 526-4248.

GULF OF ALASKA-ABL Contribution

“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 category is comprised of the 15 rockfish species that were previously in the “Other Slope Rockfish” category together with yellowtail and widow rockfish. The latter two species were formerly in the “Pelagic Slope Rockfish” category along with dusky rockfish, but dusky rockfish is now managed as a stand-alone species and the Pelagic Slope group has been dissolved. 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. Because these surveys occur in odd years, one was conducted in 2011, and therefore a full assessment for “Other Rockfish” was completed in fall 2011. 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 2007, 2009, and 2011 surveys) is used to determine current exploitable biomass. This results in a current exploitable biomass of 85,774 mt 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 4,045 mt for 2012. This is an increase of 8% compared to the 2010 and 2011 ABCs of 3,749 mt for “Other Slope Rockfish”. The increase is mostly due to the addition of yellowtail rockfish to the group in 2012 and the large biomass of silvergray rockfish in the 2011 trawl survey. Gulfwide catch of “Other Slope Rockfish” was 942 mt in 2010, and estimated catch in 2011 was 849 mt. “Other Rockfish” is not considered overfished in the Gulf of Alaska, nor is it approaching overfishing status.

Two notable results were seen for “Other Rockfish” in the 2011 GOA trawl survey. First, compared to the 2009 survey, the biomass for silvergray rockfish increased ten-fold to over 100,000 mt. This is by far the largest biomass ever recorded for silvergray rockfish in the GOA, and is also the largest single biomass for any species of "Other Rockfish" in all the GOA trawl surveys. Second, for the third consecutive trawl survey, the biomass of harlequin rockfish was quite low at only ~4,000 mt. This could be a conservation concern because harlequin rockfish have comprised the majority of the commercial catch since 2003. For more information contact Dave Clausen at (907) 789-6049 or dave.clausen@noaa.gov.

5. Thornyheads

Stock Assessment

GULF OF ALASKA

New assessment information for Gulf of Alaska (GOA) thornyheads in 2011 included updated biomass and length compositions from the 2011 NMFS trawl survey, total catch weight for 2009, 2010, and estimates for 2011, and length compositions from the 2009 and 2010 longline fisheries. Additionally, Relative Population Numbers (RPN's) and weight and size composition from the AFSC 2010 and 2011 longline surveys were included.

Thornyheads continue to be a "tier 5" species according to the North Pacific Fishery Management Council's definitions of the overfishing level (OFL), and their assessment is based on biomass estimates from the NMFS GOA bottom trawl survey. The thornyhead assessment is on a biennial schedule to coincide with the timing of the NMFS trawl survey data. The 2011 NMFS GOA bottom trawl survey covered depths shallower than 700 m (11% of the estimated biomass in 2009 trawl survey occurred in the 701-1000 m stratum). With this in mind, a 20% decrease occurred relative to the 2009 survey estimate. When considering only depths <700 m, the decline between survey estimates is 9%.

Based on area-specific mean percentages of biomass in the 701-1000 m stratum relative to the other depth strata from the 2005, 2007, and 2009 surveys, the 2011 survey biomass estimate was inflated 17% from an observed estimate of 63,180 t to an adjusted estimate of 73,990 t. This adjusted biomass was a 9% decrease from the 2009 estimate with the largest area-specific decrease occurring in the Western Gulf (65% decrease). The 2012 ABC recommendation for the GOA from the current assessment (where F_{ABC} =0.0225) is 1,665 t and the OFL (F_{OFL} =0.03) is 2,220 t. Catch levels remain below the TAC and below levels where overfishing would be a concern. For further information contact James Murphy at (907) 789-6027 or james.t.murphy@noaa.gov.

6. Sablefish

a. Research

2011 Sablefish Longline Survey - ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2011. 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 2011, the thirty-third 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 25 – August 28, 2011 by the chartered fishing vessel *Ocean Prowler*. Sixteen kilometers of groundline were set each day, containing 7,200 hooks baited with squid.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), shortspine thornyhead (*Sebastolobus alascanus*), and arrowtooth flounder (*Atheresthes stomias*). A total of 98,592 sablefish were caught in 2011, representing a substantial increase over the 2010 survey sablefish catch. Sablefish, shortspine thornyhead, Greenland turbot (*Reinhardtius hippoglossoides*), spiny dogfish (*Squalus suckleyi*) and lingcod (*Ophiodon elongatus*), were tagged and released during the survey. Length-weight data and otoliths were collected from 2,532 sablefish. Killer whales *(Orcinus orca)* took fish from the longline at seven stations in the Bering Sea region, five stations in the western Gulf of Alaska, and one station in the central Gulf of Alaska. This represents a slight increase in killer whale interactions in the Western Gulf compared to 2010 but a decrease in the Bering Sea. Sperm whales *(Physeter macrocephalus)* were often present during haul back and were observed depredating on the longline at nine stations in the East Yakutat/Southeast region, four stations in the West Yakutat region, and one station in the central Gulf of Alaska. These numbers represent an increase in sperm whale interactions over the previous year but are below the highest number of interactions seen in 2008.

Several special projects were conducted during the 2011 longline survey. Lingcod and spiny dogfish were tagged with archival temperature/depth tags in the West Yakutat and central Gulf of Alaska regions. Forty-five satellite pop-up tags were deployed on spiny dogfish throughout the Gulf of Alaska. Information from these tags will be used to investigate the movement patterns of spiny dogfish within and out of the Gulf of Alaska. 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. Finally, opportunistic photo identification of both sperm and killer whales were collected for use in whale identification projects. For more information, contact Chris Lunsford at (907) 789-6008 or chris.lunsford@noaa.gov.

Sablefish Tag Program - ABL

The ABL MESA Program in 2011 continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database. Total sablefish tag recoveries for the year were around 653. Eighteen percent of the recovered tags in 2011 were at liberty for over 14 years, and about 10 percent of the total 2011 recoveries were recovered over 1,000 nautical miles (great circle distance) from their release location. The tag at liberty the longest was for approximately 34 years, and the greatest distance traveled of a 2011 recovered sablefish tag was 1,731 nautical miles. Eight sablefish tagged with archival tags were recovered in 2011. 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, and spiny dogfish are also maintained in the Sablefish Tag Database. Fourteen thornyheads, three archival turbot tags, and three archival lingcod tags were recovered in 2011. These are the first lingcod recoveries since the start of lingcod tagging in 2007.

Releases in 2011 totaled 5,183 adult sablefish (including six with archival tags and five with pop-up satellite tags), 948 juvenile sablefish (including 125 with archival tags), 910 shortspine thornyheads, 45 spiny dogfish with pop-up satellite tags, 32 lingcod with archival tags, and 68 Greenland turbot (including 29 with archival tags). 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 2011. A total of 823 juvenile sablefish (age 1+) were tagged with spaghetti tags and released during a cruise to St. John Baptist Bay near Sitka between July 12th-16th. During the cruise, 125 juvenile sablefish were implanted with electronic archival tags. Approximately 100 rod hours were recorded to catch the fish that were tagged during the cruise. Total catch-per-unit-effort (CPUE) equaled 7.83 sablefish per rod hour fished. This was the highest CPUE since 1994, and 3.6 times greater than 2010. This relatively small bay is the only known location in Alaska where juvenile sablefish have been consistently found on an annual basis.

The electronic archival tags will provide information on juvenile sablefish behavior and habitat during their transition from near shore rearing areas to the age at which they are intercepted by the fishery. Since 2003, a total of 852 electronic archival tags have been released in juvenile sablefish in St. John Baptist Bay. These tags record the temperature and depth experienced by the fish and are designed for recovery in the commercial fishery when the fish are age 2+ or greater. We have recovered seven archival tags and expect more as these young fish continue to enter the fishery. The St. John Baptist Bay juvenile sablefish tagging cruise will be conducted again in 2012 from July 12th-16th. For more information, contact Dana Hanselman at (907) 789-6626 or dana.hanselman@noaa.gov.

Sablefish Maturity Study – RACE and ABL

A collaborative cruise between the Alaska Fisheries Science Center's ABL and RACE Divisions took place in December, 2011 to better define the age and size at maturity and fecundity of sablefish, *Anoplopoma fimbria*, in Alaska. Previous estimates of maturity are known to be outdated and biased as the estimates were made nearly 25 years ago when sablefish grew more slowly, and also were based on macroscopic maturity classification methods that used fish collected during the summer months when maturity is difficult to assess. The present study's maturity estimates will be a significant improvement because it is the first to collect specimens during the pre-spawning period. This is considered the optimal time to unambiguously distinguish immature from mature females. During this period all females that would mature and spawn over the next annual spawning cycle would be expected to be clearly identifiable as mature. Histology will be used to for classification of ovarian maturity and oocyte development.

Jim Stark (RACE) and Katy Echave (ABL) completed the ten-day charter on the continental slope and shelf near Kodiak Island. During the study, they dissected ovaries from 398 female sablefish ranging in size from 37 to 88 cm fork length, and otoliths were collected for aging. Since the cruise, tissue samples have been prepared for microscopic determinations of ovarian development. In addition, fecundity has been measured from 47 maturing specimens. From these data, Jim Stark will work to develop new age and length at maturity curves for use in the sablefish stock assessment and Cara Rodgveller (ABL) will examine fecundity as it relates to age and size.

In addition to sampling female sablefish, Echave placed satellite tags on five large sablefish to monitor their movements during the spawning season. There is little knowledge of sablefish distribution during the winter spawning season and these tags will collect information on location via magnetic field measurements, depth, temperature, salinity, and acceleration. Four of the five tags have successfully released on their respective programmed dates in mid-January and early February with known pop-up locations. The two fish that were initially captured, tagged, and released nearshore north of Portlock Bank remained within one kilometer of their tagging location on the shelf. The two fish that were initially captured offshore but released nearshore traveled approximately 75 km (great circle distance) back to the slope within 10 km of their initial capture location. Future work will look at the daily tracking calculated by magnetic field measurements once the raw data is fully acquired. For more information, contact Jim Stark,RACE, at (206) 526-4155 jim.stark@noaa.gov or Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov.

Sablefish Archival Tagging Study - ABL

During the 1998, 2000 , 2001, and 2002 AFSC longline survey, 600 sablefish were implanted and released with electronic archival tags that recorded depth and temperature. These archival tags provide direct insight into the vertical movements and occupied thermal habitat of a fish. 127 of these tags have been recovered and reported from commercial fishing operations in Alaskan and Canadian waters. Analysis of these data began in earnest in 2011, 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. Sablefish exhibited a wide range of patterns in vertical movements and occurred mostly between 200 m – 800 m depth, though many fish often would spend shorter periods at depths >1000 m. Variability in vertical movement patterns were likely a function of individual variability and location of the fish (though horizontal locations were not recorded by the archival tags). Most fish regularly exhibited diel movement patterns and moved to deeper waters during the winter months, a pattern possibly related to spawning behavior. Sablefish typically occurred in waters between 3°-7° C with most occurring between 4°-6° C. Fish released along the slope of the eastern Bering Sea typically occurred in colder waters than those released along the slope of southeast Alaska. These results are preliminary and further analyses are ongoing. For more information, contact James T. Murphy (907) 789-6027 or at james.t.murphy@noaa.gov.

Age and Sex-Structured Sablefish Movement Model - ABL
Sablefish have been tagged annually during longline surveys in the Gulf of Alaska, Aleutian Islands, and the slope of the eastern Bering Sea shelf since the late 1970s. Almost all tagged sablefish are captured by longline and trawl fisheries with a small number captured by research surveys. Most recoveries occur in Alaskan waters with some occurring in British Columbia and a few along the West Coast of the United States.
In 1991, ABL scientists Jon Heifetz and Jeff Fujioka published a sablefish movement model utilizing tagging data from 1979-1987. Heifetz and Fujioka analyzed sablefish movement based on size-at-release. This study by Heifetz and Fujioka has been extended in 2011 by adding sex and age-structure to the model and incorporating tagging data through 2009. At time of tagging, the sex and age of the sablefish is not known but can be assigned by utilizing sex-specific length and age data collected during the surveys. Most sablefish recoveries are reported back to ABL without any sex data; however, only those recoveries with sex information were utilized in the current study. Preliminary results indicate moderate to substantial difference in movement patterns between ages. Younger sablefish tend to move towards or remain in western areas of the Gulf of Alaska, while older sablefish tend to move towards or remain in eastern areas. Whether sex-specific differences in movements occur is uncertain and requires further analysis. These findings are similar to the length-based results of Heifetz and Fujioka but can be readily utilized into future spatial age-structured assessment models.

For more information, contact James T. Murphy at (907) 789-6027 or james.t.murphy@noaa.gov.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

A full sablefish stock assessment was produced for the 2012 fishery. We added relative abundance and length data from the 2011 AFSC longline survey, relative abundance and length data from the 2010 longline and trawl fisheries, age data from the 2010 longline survey and 2010 longline fishery, biomass and length data from the 2011 GOA bottom trawl survey, updated 2010 catch, and estimated 2011 catch to the assessment model.

The fishery abundance index was down 9% from 2009 to 2010 (the 2011 data are not available yet). The longline survey abundance index increased 3% from 2010 to 2011, following a 10% increase in 2010. Spawning biomass is projected to be lower from 2013 to 2016, and then stabilize. Sablefish are currently below biomass targets. We recommended the maximum permissible yield for 2012 from an adjusted $F_{40\%}$ strategy is 17,240 t. The maximum permissible yield for 2012 is a 7% increase from the 2011 ABC of 16,040 t. This increase is supported by a substantial increase in the AFSC longline survey index in the past two years that offset both the prior year's decrease in the fishery abundance index and a low GOA bottom trawl survey biomass estimate. There was also a slight increase in estimates of incoming recruitment year classes. Spawning biomass is projected to decline through 2013, and then is expected to increase assuming average recruitment is achieved. Because of the lack of recent strong year classes, the maximum permissible ABC is projected to stabilize at 17,019 t in 2013 and 16,769 in 2014.

Projected 2012 spawning biomass is 37% of unfished spawning biomass. Spawning biomass has increased from a low of 30% of unfished biomass in 2002 to 37% projected for 2012. The 1997 year class has been an important contributor to the population but has been reduced and should comprise 10% of the 2012 spawning biomass. The 2000 year class appears to be larger than the 1997 year class, and is now 95% mature and should comprise 23% of the spawning biomass in 2012. The 2008 year class is beginning to show signs of strength. For more information, contact Dana Hanselman at (907) 789-6626 or dana.hanselman@noaa.gov

7. Yellowfin sole

Stock Assessment - Bering Sea

This year's EBS bottom trawl survey resulted in a biomass estimate of 2.40 million t, compared to last year's survey biomass of 2.37 million t (an increase of 1 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 5 of the past 20 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 should contribute to the reservoir of female spawners in the near future. The 2011 catch of 151,000 t represents the largest flatfish fishery in the U.S. 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:
• 2010 fishery and survey age compositions
• 2011 trawl survey biomass point estimate and standard error
• estimates of the discarded and retained portions of the 2010 catch
• estimate of total catch through the end of 2011.

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 2012 is 566,000 t. Based on the most recent time series of estimated female spawning biomass, the projected 2012 female spawning biomass estimate continues the generally monotonic decline in model estimates of spawning biomass exhibited since 1994. Above average recruitment from the 1995 and 1999 year-classes is expected to maintain the abundance of yellowfin sole at a level at or above $B_{40\%}$ for the next several years. Projections suggest a stable female spawning biomass in the near future if the fishing mortality rate continues at the same level as the average of the past 5 years.

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 341,000 t. Corresponding to the approach used in recent years, the 1978- 2005 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 0.10. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.11. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2012 biomass estimate produces the author- and Plan Team-recommended 2012 ABC of 203,000 t, and the corresponding product using the OFL harvest ratio produces the 2012 OFL of 222,000 t. For 2013, the corresponding quantities are 207,000 t and 226,000 t, respectively.

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

Northern Rock Sole Nursery Areas in the EBS-RACE Recruitment Processes
Age-0 nursery areas were located along the north side of the Alaska Peninsula as part of a multi-species juvenile flatfish beam trawl survey conducted by the AFSC in September 2008 and 2010. A large area of the EBS between Cape Newenham and Nunivak Island served as a nursery area in 2003 (a warm year survey conducted by B. Norcross), but not in 2008 or 2010 (cold years). Mean length was higher in warm, nearshore areas than in cold, offshore areas, suggesting temperature dependent growth and/or shoreward movement after settlement.

Reference: Cooper, D.W., Duffy Anderson, J.T., Norcross, B., Holladay, B., Stabeno, P. Northern rock sole (*Lepidopsetta polyxystra*) juvenile nursery areas in the eastern Bering Sea in relation to hydrography and thermal regimes. In prep.

The Influence of Polychaete Tube Habitat on the Prey Availability, Feeding Habits, and Condition of Juvenile Rock Sole. – RACE Kodiak Lab in Collaboration with the Newport Fish Behavioral Ecology Program:
The final analyses for this project were completed in 2011. Briefly, the abundance of juvenile flatfish (most notably northern rock sole) is highly correlated with abundance of ampharetid polychaete *Pseudosabellides sibirica* worm tubes in coastal nurseries around Kodiak Island, AK. In some years, concentrated aggregations of *P. sibirica* can form a dense lawn covering large sections of the seafloor in the bays around Kodiak. Juvenile northern rock sole *Lepidopsetta polyxystra*, aggregate along the edge of this habitat where tube density is low to moderate and patchy. We conducted a series of integrated field and laboratory studies to examine the ecological processes controlling this fish-habitat relationship. For this study, we specifically tested the following hypotheses: 1) areas of worm tube habitat will contain both a higher density and greater diversity of benthic fauna versus adjacent areas with bare, sandy substrate, 2) the diet composition and feeding activity of age-0 rock sole residing in worm tube habitat will differ from those fish residing in adjacent waters devoid of worm tubes, and 3) the condition of age-0 rock sole residing in worm tube habitat will be higher compared to rock sole found in adjacent areas without worm tubes. The results indicate the density of benthic fauna (potential prey) was

significantly higher in the worm tube habitat in comparison to adjacent areas devoid of worms. In addition, the diet composition of rock sole residing in the worm habitat was significantly different than fish residing in adjacent areas, with bare substrate. It was clear, that rock sole residing in the worm habitat were feeding primarily on the worms themselves. Rock sole residing in the worm tube habitat were not in better condition than fish residing in adjacent areas of bare substrate. After settlement in July, rock sole residing in bare substrate habitat had higher condition values than sole residing in the worm habitat. By the end of their first growing season in September, there were no discernible differences in rock sole condition between the habitats. This may indicate greater movement of rock sole between habitats over the course of the summer or this may highlight the predation refuge value of the worm tube habitat for juvenile rock sole, especially during July when the rock sole are potentially more vulnerable to predation due to their small size. Overall, it is clear that worm tube habitat positively influenced the density of benthic fauna in the nurseries. In addition, the worm tube habitat altered the foraging behavior of juvenile rock sole and the worms themselves were an important food source at deeper depths. However, it is not apparent if these factors created enhanced foraging opportunities for juvenile rock sole, as displayed through higher condition values in the worm tube habitat. The results suggest that when present, the presence of worm tube habitat could have implications for nursery productivity by influencing the prey availability and food habits of juvenile flatfish. This manuscript will be published in FY 2012. For further information please contact Brian Knoth (907) 481-1731.

Contrasting Maturation and Growth of Northern Rock Sole in the Eastern Bering Sea and Gulf of Alaska for the Purpose of Stock Management-RACE GAP

The primary purpose of this study was to provide commercial fishery managers with the age- and length-at-maturity information about northern rock sole *Lepidopsetta polyxystra* needed for them to set a sustainable overfishing limit and evaluate the precision of the two predictors of maturity. The estimated length at which 50% of eastern Bering Sea female northern rock sole matured (L_{50}) was 309 mm, which was significantly smaller than that for Gulf of Alaska females. We determined that the differences in L_{50} between populations were probably the result of differences in the rate of female growth. Growth was significantly faster in the Gulf of Alaska than in the eastern Bering Sea during 1996 and 1999. However, by 2007 the growth rates were similar between these areas. The variability in growth was correlated with seawater temperature. There were also differences in the age at which 50% of the females matured (A_{50}) between the populations in the eastern Bering Sea (9 years) and the Gulf of Alaska (7 years). In contrast, within the eastern Bering Sea, females maintained a similar A_{50} over several years, which indicates that age is the most reliable predictor of maturity for northern rock sole. A manuscript was completed and submitted for publication. Contact Jim Stark (jim.stark@noaa.gov) for more information.

b. Stock Assessment

The northern rock sole stock is currently at a high and increasing level due to strong recruitment from the 2001, 2002 and 2003 year classes which are now contributing to the mature population biomass. The 2011 bottom trawl survey resulted in a biomass estimate of just under 2 million t, 4% lower than the 2010 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 twice the B_{MSY} level.

New information for the 2011 analysis include:
- 2010 fishery age composition;
- 2010 survey age composition
- 2011 trawl survey biomass point estimate and standard error
- updated fishery catch and discards for 2010
- fishery catch and discards projected through the end of 2011.

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 stock assessment model resulted in a 2012 age-2+ biomass estimate of 1,857,000 t. This was an increase in the biomass estimate compared to the 2011 estimate of 1,765,000 t obtained in the 2011 assessment. The rock sole stock is expected to remain stable or increase because of good recruitment from the 2000- 2005 year classes.

The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning biomass for 2012 is projected to be at 238 percent of B_{MSY}, placing northern rock sole in sub-tier "a" of Tier 1. In some past years, one difficulty with applying the Tier 1 formulae to rock sole was that the harmonic and arithmetic means of the F_{MSY} distribution were extremely close, resulting in little buffer between recommendations of ABC and OFL. This closeness resulted from estimates of F_{MSY} that were highly certain. The use of time-varying fishery selectivity, first instituted in the 2010 assessment, increased the buffer between ABC and OFL from a little over 1 percent in 2009 to 9 percent in 2012.

The Tier 1 2012 ABC harvest recommendation is 208,000 t ($F_{ABC} = 0.13$) and the 2012 OFL is 231,000 t ($F_{OFL} = 0.15$). The 2013 ABC and OFL values are 196,000 t and 217,000 t, respectively.

Northern rock sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition. The exploitation rate is about 0.03.

9. Flathead Sole

a. Research

Contrasting the Maturation, Growth, Spatial Distribution and Vulnerability to Environmental Warming of *Hippoglossoides robustus* (Bering flounder) with *H. elassodon*

(flathead sole) in the Eastern Bering Sea
Two similar appearing congeners, *Hippoglossoides robustus* (Bering flounder) and *H. elassodon* (flathead sole), inhabit the Bering Sea and are harvested together during the commercial fishery. In order to establish more precise overfishing limits, the annual spawning biomass must be estimated. Spawning biomass is modeled using the best estimate of the age and length at which 50% of the stock is expected to reach maturity (A_{50}, L_{50}). The major objective of this study was to establish the first maturity estimates for Bering flounder. Females matured at a similar age for Bering flounder (A_{50}, 9 years) and flathead sole (A_{50}, 10 years). However, the body length at which females matured was significantly smaller for Bering flounder (L_{50}, 238 mm) compared to flathead sole (L_{50}, 320 mm). The difference in the length-at-maturity was probably caused by growth differences, which significantly differed between species. The distribution and spawning locations of both species in the eastern Bering Sea survey area was related to the prevailing seawater temperatures and Bering flounder occurred in significantly colder water than flathead sole. The association between cold and the distribution of Bering flounder suggests that this species may be particularly vulnerable to periods of extended sea warming. See Stark (2011a) or contact Jim Stark for further information (jim.stark@noaa.gov).

b. Stock Assessment

BERING SEA

Data on the flathead sole stock showed improved conditions compared to 2010. Bottom trawl survey estimates of total biomass for 2011 were 18% higher than for 2010. The 2007 year class is estimated to be above average, but it follows 3 years of poor recruitment. As a consequence, ABC for 2012 is only slightly (0.2%) higher than last year.

New data in this year’s assessment include the following:
- updated 2010 fishery catch and preliminary 2011 fishery catch
- updated 2010 fishery size compositions and preliminary 2011 fishery size compositions
- estimated survey biomass and standard error from the 2011 EBS trawl survey
- size compositions from the 2011 EBS trawl survey
- age compositions from the 2010 EBS trawl survey
- mean bottom temperature from the 2011 EBS trawl survey

The preferred model is identical to that selected in last year’s assessment.

The assessment model indicates that spawning biomass has declined continuously from a high of 328,000 t in 1997 to a minimum of 243,000 t in 2009, increasing slightly 247,000 t in 2011. The projected 2012 and 2013 values are 250,000 t and 244,000 t, respectively. The 2001-2003 year classes are estimated to be above the 1994-2008 average, but recruitments from 1994-2008 on average have been much lower than recruitments from 1974-1989.

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 $B_{40\%}$=133,000 t, $F_{40\%}$=0.28, and $F_{35\%}$=0.34. Because the projected spawning biomass for 2012 (250,000 t) is above $B_{40\%}$, flathead sole is in sub-tier “a” of Tier 3. The ABCs for 2012 and 2013 were set at the maximum permissible values under Tier 3a, which are 70,400 t and

69,200 t, respectively. The 2012 and 2013 OFLs under Tier 3a are 84,500 t and 83,100 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALAKSA

Flathead sole survey biomass increased from 225,377 t in 2009 to 235,639 t in 2011. Catch levels for this stock remain well-below the TAC and below levels where overfishing would be a concern. Stock assessment model estimates of projected female spawning biomass is estimated at 104,301 t for 2012, which is less than the projected 2010 model estimate for 2012 (115,427 t).

The assessment was updated as follows:
1. The fishery catch and length compositions for 2010 and 2011 (through Sept. 24, 2011) were incorporated in the model.
2. The 2009 fishery catch and length compositions were updated.
3. Age compositions from the 2001 and 2009 groundfish surveys were added to the model.
4. The 2011 GOA groundfish survey biomass estimate and length composition data were added to the model.

Flathead sole are determined to be in Tier 3a based on the age-structured model. The preferred model gives a 2012 ABC using $F_{40\%}$ (0.450) of 47,407 t. This ABC is 1,726 t lower than the 2011 ABC. The 2012 OFL using $F_{35\%}$ (0.593) is 59,380 t. The Plan Team noted the model's starting point is 1984 and encouraged the author to investigate starting the model in 1977 since catches from 1977-1984 are presented in the assessment. In addition, the Team recommended the author work to incorporate an ageing error matrix for flathead sole and to configure the model to accept fishery ages and evaluate the available sample sizes.

The stock is not overfished nor approaching an overfished condition. For further information, contact Jack Turnock (206) 526-6549, Teresa A'Mar (206) 526-4068 or William Stockhausen (206) 526-4241

10. Alaska Plaice

Stock Assessment

The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2011 survey biomass was 520,000 t, a at about the same level as the past three years and largely consistent with estimates from resource assessment surveys conducted since 1985. Of interest in 2010 is that 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 1975-2011.
New data for 2011 included:
the updated 2011 survey catch
• fishery catch through 15 October 2011

• 2011 trawl survey biomass estimate and standard error
• 2011 length composition of survey catch
• 2010 survey age composition

Female spawning biomass decreased from 1985 to 1998, and has been relatively stable since then with a small increase in the past three years. Total biomass peaked in 1984, then decreased through 2001, and has increased steadily since. The increase in total biomass is expected to continue. The shelf survey biomass has been fairly steady since the mid-1980s.

No changes were made in the stock assessment model recommended by the assessment authors. However, the authors presented an alternative model in which the survey catchability coefficient (Q) was increased from 1.0 (the value used in last year's assessment and the authors' preferred model in this year's assessment) back to 1.2 (the value used in previous assessments). The Plan Team and senior author agreed that the model with Q=1.2 more accurately reflected the catchability of the EBS bottom trawl survey relative to the biomass of Alaska plaice present in the standard survey area. The purpose of lowering Q to 1.0 was to compensate for the biomass of Alaska plaice found in the 2010 survey of the northern Bering Sea (NBS). However, the Plan Team concluded that it was premature to adjust the model to account for a one-time survey of the NBS, and instead accepted the alternative model with Q=1.2.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3a. The updated point estimates are $B_{40\%}$ = 151,000 t, $F_{40\%}$ = 0.15, and $F_{35\%}$ = 0.18. As a consequence of the reduced *M* used in the model, these are values are now in the range expected for flatfishes. Given that the projected 2012 spawning biomass of 260,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2012 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2012 ABC of 53,400 t and a 2013 ABC of 54,000 t. The OFL was determined from the Tier 3a formula, which gives a 2012 value of 64,600 t and a 2013 value of 65,000 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. Research

Greenland Halibut- RACE Recruitment Processes
Spawning in Greenland halibut (*Reinhardtius hippoglossoides*) occurs along the continental slope and in submarine canyons in the EBS. Eggs were found in Bering and Pribilof Canyons and over the adjacent slope during February and March, confirming that spawning occurs in these regions. Larvae were present over the slope, outer shelf and middle shelf in winter and spring, and settled juveniles were collected over the shelf in September. Oceanographic modeling approaches that simulate larval advection from spawning to nursery habitats indicate depth-discrete variations in transport pathways from submarine canyons to the adjacent shelf

contribute to interannual variability in transport trajectories. Overall, data highlight specific physical mechanisms of delivery that are modulated by large-scale atmospheric and oceanographic forcing, potentially varying the degree of slope-shelf connectivity for Greenland halibut and other slope-spawning species.

Reference: Duffy-Anderson, J.T., Blood, D.M., Cheng, W., Ciannelli, L., Matarese, A., Sohn, D., Stabeno, P., Vance, T., and Vestfals, C. Combining field observations and modeling approaches to examine Greenland halibut (*Reinhardtius hippoglossoides*) early life ecology in the southeastern Bering Sea. In review: *J. Sea Research*.

Greenland Halibut and Pacific Halibut- RACE Recruitment Processes
Greenland halibut (GH, *Reinhardtius hippoglossoides*) and Pacific halibut (PH, *Hippoglossus stenolepis*) are key commercial fish species in the EBS that share several critical life history attributes. Both species are thought to spawn eggs in batches offshore over the continental slope, deep in the water column during winter months, and have extended pelagic larval durations, moving to shallow, and nearshore areas on the EBS shelf to settle as juveniles. Despite similarities in their spawning times, locations and depths, GH and PH exhibit distinct differences in the distribution and abundance of their egg, larval, juvenile and adult stages, as well as their overall population dynamics. An examination of the affects of ocean currents on the transport of these two flatfish species during their early life history stages is being undertaken to explain these differences and understand how slope-shelf connectivity, and thus recruitment, may be influenced by changing environmental conditions. Ten years of data (1995-2004) from the Regional Ocean Modeling System (ROMS) ocean circulation model were examined for differences in along-shelf and cross-shelf transport. Strong seasonal and interannual variation in flow was observed, with along-shelf transport generally highest during fall and winter months, coinciding with spawning activity in both species. Preliminary analysis suggests that connectivity between spawning and settlement locations may be connected to the thermal regime of the EBS shelf, with slope-shelf connectivity being enhanced in ‘warm’ years and reduced in ‘cold’ years.

Reference: Vestfals, C.D., Ciannelli, L., Duffy-Anderson, J.T., Spitz, Y., and Dever, E.D. Influence of ocean circulation on Greenland halibut and Pacific halibut early life history in the eastern Bering Sea. 8th International Flatfish Symposium, Ijmuiden, The Netherlands. November 5-10, 2011.

A second project hypothesized that the settlement success in Pacific and Greenland halibut is related to variations in ocean circulation and atmospheric forcing during ontogeny. To test the hypothesis, we quantified inter-annual variability of settlement success for both species through their dispersal pathways. The dispersal pathways from spawning to settling locations were simulated using the Dispersal Model for Early Life Stages (DisMELS). Based on historical observations from the EBS groundfish surveys, we created a probability map using presence/absence data of newly settled juveniles of both species. We estimated successful settlers for each species by overlaying the probability map with path and end-point results from the dispersal simulations. Results indicate differences of successful settlement among years and between species, which are currently being examined in relation to ocean circulation and atmospheric forcing. The knowledge from this study could shed light on the difference in recruitment of these two species over time in the EBS.

Reference: Sohn, D., Ciannelli, L., Duffy-Anderson, J.T., Batchelder, H., Stockhausen, W., and Vestfals, C. Characterizing the interannual variability of settlement success in slope spawning flatfishes. In prep.

b. Stock Assessment

The projected 2012 female spawning biomass is 47,700 t. This is a slight (7 percent) decrease from the 2011 spawning biomass of 51,300 t. Spawning biomass is projected to decline further in 2013 to 41,400 t. While spawning biomass generally continues to decline, age 0 recruitment appears to have improved substantially in 2008, 2009, and particularly 2010. These year classes are all estimated to be stronger than any other year class spawned since 1989. Very high estimated biomass and numbers from the trawl survey are largely attributable to an increase in small (< 30 cm) fish.

This year's Greenland turbot assessment model included:
- updated 2010 and 2011 catch data
- 2011 EBS shelf survey biomass
- 2011 EBS shelf survey length composition estimates
- additional years of NMFS bottom-trawl shelf survey age data
- updated fishery catch-at-length data for longline and trawl gear from 2004-2011.

Refinements were made for estimating selectivities (additional parameters estimated), an alternative model was investigated in which male natural mortality was estimated (with female mortality fixed), and some adjustments were made to the length bin structure.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Greenland turbot therefore qualifies for management under Tier 3. Updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 21,600 t, 0.37, and 0.45, respectively. Projected spawning biomass for 2012 is 47,700 t. Relative to $B_{40\%}$, this places Greenland turbot in sub-tier "a" of Tier 3. The maximum permissible value of F_{ABC} under this Tier translates into a maximum permissible ABC of 9,660 t for 2012 and 8,030 t for 2013, and the OFLs for 2012 and 2013 under the Tier 3a formula are 11,700 t and 9,700 t, respectively. These are the authors' and Team's ABC and OFL recommendations. Greenland turbot is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

12. Arrowtooth Flounder

a. Research

Female Maturity, Reproductive Potential, Relative Distribution, and Growth compared Between Arrowtooth Flounder (*Atheresthes stomias*) and Kamchatka Flounder (*A. evermanni*) Indicating Concerns for Management-RACE GAP

Arrowtooth flounder (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*), major piscivorous predators in the eastern Bering Sea and Aleutian Islands, are morphologically similar. Consequently the two species have been managed together as a species complex using the length- and age-at-maturity derived from Gulf of Alaska arrowtooth flounder, which had been the only available maturity estimates. However, there could be serious management consequences if the two species matured at significantly different ages and fork lengths. Therefore, this study was conducted during 2007 and 2008 to determine if there were significant differences in maturation between the two species. Significant differences in size and age of female maturation and growth were found. The age and length of 50% maturity ($A_{50,}L_{50,}$ respectively) for arrowtooth flounder females is 7.6 years of age and 480 mm in body length. In comparison, $A_{50,}L_{50}$ of Kamchatka flounder females is 10.1 years of age and 550 mm, meaning that Kamchatka flounder has a significantly lower reproductive potential than arrowtooth flounder. The large difference in reproductive potential indicates that managing the two species together as a species complex using the reproductive characteristics of arrowtooth flounder, was not conservative for Kamchatka flounder. This study also determined that arrowtooth flounder maturation was consistent between the Gulf of Alaska and eastern Bering Sea populations. See Stark (2011b) or contact Jim Stark (Jim.Stark@noaa.gov).

b. Stock Assessment

BERING SEA

The annual Bering Sea shelf survey conducted in 2011, combined with the 2010 slope and Aleutian Islands surveys indicate that the arrowtooth flounder population continues at a high level. The stock is in an upward trend in all areas and the stock assessment model indicates that the resource has steadily increased from a low biomass in the late 1970s to a very high current biomass. Good recruitment from seven of the ten years from 1998-2007 combined with light exploitation should continue this trend.

Beginning in 2011, Kamchatka flounder were removed from the combined *Atheresthes* stock assessment and are assessed separately from arrowtooth flounder and receive an individual ABC and TAC.

New input data include:

- fishery catch through 12 September 2011
- estimate of retained and discarded portion of the 2010 catch
- 2011 shelf survey size composition and biomass point estimates and standard errors.

The 2011 stock assessment model resulted in a 2012 age 1+ biomass projection of 1,130,000 t. This is identical to the value projected in last year's assessment for 2012. There is a long-term trend of increasing arrowtooth flounder biomass in the EBS. If the harvest rate remains close to the recent average, this trend is expected to continue for the next couple of years due to the strong recruitment observed in the past decade. The current model includes the Aleutian Islands, Bering Sea slope and Bering Sea shelf. The biomass is modeled with 76 percent of the stock on the shelf, 14 percent in the Aleutian Islands and 10 percent on the Bering Sea slope. Examination of Bering Sea shelf survey biomass estimates indicate that some of the annual variability seemed to positively co-vary with bottom water temperature.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, arrowtooth flounder was assessed for management under Tier 3. The updated point estimates of

$B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 281,000 t, 0.22, and 0.27, respectively. Given that the projected 2012 spawning biomass of 818,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2012 were calculated under sub-tier "a" of Tier 3. The harvest level was set at F_{ABC} at the $F_{40\%}$ (0.22), which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2012 ABC of 150,000 t and a 2013 ABC of 152,000 t. The OFL fishing mortality rate under Tier 3a is $F_{35\%}$ (0.27), which translates to a 2012 OFL of 181,000 t and a 2013 OFL of 186,000 t.

Arrowtooth flounder is not overfished and is not approaching an overfished condition.

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Survey abundance estimates were low in the 1960's and 1970's, increasing from about 146,000 t in the early 1970's to about 2,822,830 t in 2003. Survey biomass declined to 1,899,778 t in 2005 and in 2009 declined to 1,772,029 t from the 2007 estimate of 1,939,055 t. The 2011 survey indicates the stock remains at a high level.

New data include updated 2009, 2010, and 2011 catch (through September 17, 2011). The 2011 survey biomass and length data were added to the model. Fishery length data for 2009 was updated and 2010 and 2011 were added to the model. Survey age data were added for 2007 and 2009. The same model configuration was used as in 2009, but the added constraint on the last three estimated recruitments was removed. The stock is not overfished nor approaching an overfished condition. Catch levels for this stock remain below the TAC level.

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. Since then the stock has stabilized. The age 3+ biomass estimates are slightly higher in the current assessment than the projected 2009 assessment estimates. Female spawning biomass in 2011 is estimated to be 1,238,210 t, a <1% decrease from the projected 2011 biomass from the 2009 assessment.

Arrowtooth flounder has been determined to fall under Tier 3a. The 2012 ABC using $F_{40\%}$=0.174 is 212,882 t, a slight decrease from the 2011 ABC of 213,150 t. The 2012 OFL using $F_{35\%}$=0.207 is 250,100 t. The 2013 ABC (212,033 t) and OFL (249,066 t) were estimated using the projection model and catch in 2012 estimated using the recent 5-year average (F=0.020).

The ABC set for arrowtooth flounder is equivalent to the maximum permissible ABC. Area apportionments of arrowtooth flounder ABCs for 2010 and 2011 are apportioned based on the fraction of the 2011 survey biomass in each area.

13. Other Flatfish

a. Research

Spawning and Nursery Areas in the EBS- RACE Recruitment Processes
This project modeled connectivity between spawning and nursery areas for northern rock sole in the EBS. Starting points for larvae were determined by historical ichthyoplankton data and were located to the north and south of Unimak Island, along the north side of the Alaska Peninsula, and north from Unimak Pass to the Pribilof Islands. The model indicates larvae are transported along the Alaska Peninsula by the Bering Coastal Current, or to the north towards the Pribilof Islands and farther north by baroclinic flow. The model also predicts that larvae from the Gulf of Alaska south of Unimak Island are transported into the Bering Sea through Unimak Pass. The model provided another line of evidence that northern rock sole settle and then move shoreward to nursery habitat in EBS.

Reference: Cooper, D.W, Duffy-Anderson, J.T., Stockhausen, W., Cheng, W. Modeled connectivity between northern rock sole (*Lepidopsetta polyxystra*) spawning and nursery areas in the eastern Bering Sea. In prep.

Early Juvenile Phase of Flatfishes in the Eastern Bering Sea- RACE Recruitment Processes
This project examines feeding success during the early juvenile phase of flatfishes, which may influence overall survival and have implications for the number of successful survivors to the fishery. To better understand factors influencing success, the feeding habits of two commonly occurring and commercially important flatfishes are being studied. Age-0 northern rock sole (*Lepidopsetta polyxystra*) and age-1 yellowfin sole (*Limanda aspera*) from the EBS are being examined for diet overlap, prey resource partitioning, and habitat preference. Juvenile northern rock sole and yellowfin sole spatially co-occur in shallow, nearshore waters in the EBS during fall. Collections were made during September 2008 and 2010 using a 3-m modified plumb-staff beam trawl. In both years the principal prey were gammarid amphipods and annelids for northern rock sole. In 2010 northern rock sole diets were more diverse and included bivalves and harpacticoid copepods. Northern rock sole diets were spatially structured in both 2008 and 2010. Diets of both species also appear to be age-structured, but structuring was not related to geography in yellowfin sole. In 2008 yellowfin sole diets were diverse and showed no spatial structuring; however, 2010 diets indicate limited spatial structuring within the inner shelf. We will be investigating further with additional statistical analysis on age structure, length of flatfish, and prey field.

Reference: Jump, C., Duffy-Anderson, J.T., Mier, K., and Cooper, D**.** Feeding ecology and niche separation of age-0 northern rock sole and age-1 yellowfin sole in the eastern Bering Sea. 8th International Flatfish Symposium, Ijmuiden, The Netherlands. November 5-10, 2011.

b. Stock Assessment

BERING SEA

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 2011. 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 2011 total catch and discard and 2011 trawl survey information. The 2011 EBS bottom trawl survey resulted in biomass estimates of 94,200 t, 18% lower than the 2010 estimate. The biomass of these species in the Aleutian Islands is 13,100 t from the 2010 survey.

Due to the amount of information available, “other flatfish” are classified as a Tier 5 species complex with natural mortality rates as described below. Projected harvesting at the 0.75 *M* level, gives a 2012 ABC of 12,700 t for the “other flatfish” species. The corresponding 2012 OFL is 17,100 t. It is not possible to determine whether the “other flatfish” complex is overfished or approaching an overfished condition because it is Tier 5 and not managed under Tiers 1-3.

Species-specific natural mortality rates are used to calculate ABC for the species in this complex, where they are available. Estimates of *M* for the GOA were used for Dover sole (0.085) and rex sole (0.17). All other species were assigned an M of 0.15. Starry flounder natural mortality estimates were examined (male M = 0.45, female M = 0.30), but are available only from the west coast stock assessment and may not be valid for Bering Sea starry flounder, so they are not being used at this time.

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The shallow water flatfish complex is made up of northern rock sole, southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole, Alaska plaice and other minor species. Stock status for shallow water flatfish is based on the NMFS bottom trawl survey (triennial from 1984 to 1999 and biennial from 1999 to 2011). Survey abundance estimates for the entire shallow-water complex were lower in 2011 compared to 2009; decreasing by 37,629 t. By species, southern rock sole has a generally increasing trend in abundance, although biomass decreased between 2009 and 2011. Northern rock sole has general increasing trend through 2007 and then has been decreasing since. The remainder of the species in the shallow water flatfish complex exhibit varying trends, although most species increased in abundance between 2009 and 2011 with the exception of sand sole and English sole.

There were no changes in the assessment methodology for Tier 5 (non-rock sole species) but a Tier 3 assessment methodology was adopted for northern and southern rock sole. This catch-at-age model was updated with fishery catch data, fishery catch-at-length data, NMFS bottom trawl survey age composition and size-at-age data from 1984, 1987, 1990, 2001, 2003, 2005, 2007, and 2009 and bottom trawl survey biomass and size compositions from the 2011 survey. For the remainder of the flatfish complex, the 2011 survey biomass was the only new input data. Relative the 2009 survey biomass (436, 590 t), total shallow water flatfish biomass decreased 9% in 2011.

The F_{ABC} and F_{OFL} values for southern rock sole were estimated as: $F_{40\%}$=0.16 and $F_{35\%}$ = 0.19, respectively. For northern rock sole the values are: $F_{40\%}$=0.18 and $F_{35\%}$ =0.214. Other flatfish ABCs were estimated with F_{ABC}=0.75 M and F_{OFL}=M. 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 50,683 t and OFL of 61,681 t for 2012. For 2013 the combined ABC of 46,483 t and the OFL is 56,781 t. The ABC and OFL for 2012 and 2013 shallow-water flatfish are lower than the 2010 and 2011 due to a decline in survey biomass. The ABC for the shallow water flatfish complex was set at the maximum permissible amount and was apportioned relative to the survey biomass estimated for each area.

The deep water flatfish complex is comprised of Dover sole, Greenland turbot, and deepsea sole. Catch and trawl survey biomass data for Dover sole, Greenland turbot and deepsea sole are updated to 2011. For Dover sole, an updated age-structured assessment model was presented.

The sex and age-structured model for Dover sole is similar to what was presented in 2009. The model fit the survey biomass relatively well, but underestimated large catches in the early 1990s. The model resulted in unrealistically high biomass values and was substantially different than the previous model estimates. The author and Team were concerned with this and concluded that further evaluation was needed and was inappropriate to apply for management recommendations. Some parameters converged at their bounds and the selectivity estimates seemed questionable. The Team agrees with the author's recommendation to move Dover sole into Tier 5 until the model can be more fully evaluated. The Plan Team requested a review of the revised model in September 2012.

Information is insufficient to determine stock status relative to overfished criteria for Tier 5 and 6 species such as Dover sole, Greenland turbot and deepsea sole. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

Dover Sole were previously in Tier 3a but due to the aforementioned concerns about the validity of the model the Plan Team recommended that it be moved to Tier 5. Both Greenland turbot and deepsea 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 2012 and 2013 ABC and OFLs. For the Dover sole Tier 5 assessment the 2012 and 2013 ABC using F_{ABC}=0.75*M = 0.064 results in 4,943 t. The 2012 and 2013 OFL using F_{OFL}=M = 0.085 results in 6,590 t. The combined ABC (5,126 t) and OFL (6,834 t) for the deep water flatfish complex are used for management of the deep water complex. The ABC is equivalent to the maximum permissible ABC.

Area apportionments of deep water flatfish (excluding Dover sole) are based on proportions of historical catch. Area apportionments of Dover sole are based on the fraction of the 2011 survey biomass in each area.

14. Dogfish and Other Sharks

a. Research

Spiny Dogfish Ecology and Migration - ABL
Scientists at the Auke Bay Laboratories are continuing an annual tagging program for spiny dogfish including both numerical Peterson disk tags and pop-off, electronic archival tags. Thirty-five pop-off and >300 numeric tags were deployed in Yakutat Bay in the summers of 2009 and 2010, and a further 45 pop-off tags were deployed during the annual AFSC longline survey in 2011. To date, all of the 2009 and 2010 pop-off tags have been "recovered" (i.e., the data is downloaded from them, but they are not physically recovered), as well as most of the 2011 tags (12 tags are still at liberty), and the remaining tag is programmed to pop-off and transmit its data in May 2012. Recovered data from the pop-off tags, which includes temperature, depth, and geographic location, are still being analyzed. 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. The project kicked off with a three day workshop on aging methods, which was also attended by age readers from WDFW and NWFSC. This project aims to compare the previous method of aging the dorsal fin spines with a new technique developed that uses the vertebrae. The groups that participated in the workshop will also participate in an inter-lab portion of the project comparing variability of the ages read (of each structure) between labs. Results of this project will be presented at the Center for Age Reading Excellence (CARE) meeting next April. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Salmon Shark Life History – Race Kodiak in collaboration with 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. To date, 19 female salmon sharks have been obtained at the Kodiak Laboratory during the fall months with additional specimens collected by researchers at the Alaska Department of Fish and Game and researchers at Auke Bay Laboratories. For further information please contact Christina Conrath (907) 481-1732.

Skate Nursery Sites as Habitat Areas of Particular Concern (HAPC)-RACE GAP

Six skate nursery sites in the eastern Bering Sea have been proposed to the North Pacific Management Council for designation as HAPC sites. The sites are important for the successful reproduction and well being of three skate species that dominate the eastern Bering Sea shelf and upper continental slope areas. Because of protracted embryo development time and the fragile nature of skate eggs, the sites are vulnerable to disturbances which may reduce hatching success. The HAPC proposal has been reviewed by all council committees and continues to be of consideration for adoption for future conservation measures. Contact Jerry Hoff, jerry.hoff@noaa.gov.

b. Stock Assessment

The shark bycatch assessment chapters from 2011 for the Bering Sea/Aleutian Islands (BSAI) and for Gulf of Alaska (GOA) were updated for 2012 and presented to the North Pacific Fishery Management Council's Groundfish Plan Teams in November 2011.

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 2003-2011 were updated from the NMFS Alaska Regional Office's Catch

Accounting System. The shark assessment for the BSAI was only an executive summary. Catch estimates from the Catch Accounting System were updated; total catch in the BSAI from 2010 was 53 mt and the estimated catch for the assessment in 2011 was 148 mt. The primary species caught in the BSAI is the Pacific sleeper shark.

In the GOA, spiny dogfish are the primary species caught and average bycatch of spiny dogfish from 1997–2007 (503 mt) represented 1% of the available spiny dogfish biomass from GOA bottom trawl surveys in 1996–2007 (average biomass of spiny dogfish in the surveys was 66,771 mt over the same years). Average bycatch of Pacific sleeper sharks from 1997–2007 (312 mt) represented less than 1% of the available Pacific sleeper shark biomass from GOA bottom trawl surveys 1996–2005 (average biomass of Pacific sleeper sharks was 37,821 mt). Average bycatch of salmon sharks from 1997–2007 (71 mt) was relatively small, and GOA bottom trawl survey biomass estimates for salmon sharks were unreliable because salmon sharks were only caught in four hauls from 1996–2007.

Catch in unobserved fisheries is a major concern for shark species, in particular the halibut IFQ fisheries. Methods for estimating bycatch in the halibut IFQ fishery have recently been developed by AFSC scientists, and these methods were examined and approved by the North Pacific Fishery Management Council's Scientific and Statistical Committee and were available for the 2012 assessments.

The "other species" assessment group was dissolved starting in 2011 and separate ABCs and OFLs are now being set for the shark complex in both the BSAI and GOA Fishery Management Plan areas. In the GOA, spiny dogfish are being considered a "Tier 5" assessment species for 2012 and all other sharks are still a "Tier 6" species. The GOA-wide ABC and overfishing level (OFL) for the entire complex is based on the sum of the ABC/OFLs for the individual species, which resulted in ABC=6,028 mt and OFL= 8,037 mt for 2012, compared to the 2011 ABC of 6,197 mt and OFL of 8,262 mt. In the BSAI, all shark species are still considered "Tier 6" with the ABC (1,020 mt) and OFL (1,360 mt) calculations from previous years. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

15. Other Species

Assessment of Grenadiers in Alaska - ABL

In 2011, a brief Executive Summary assessment was done for grenadiers in Alaska and incorporated as an appendix to the North Pacific Fishery Management Council's (NPFMC) annual Stock Assessment and Fishery Evaluation Report. The Executive Summary provided an update to the full assessment for grenadiers done in 2010 and presented new survey information and updated catches for 2011, but ABC recommendations remained the same as in the full assessment. Giant grenadier (*Albatrossia pectoralis*) is by far the most abundant grenadier in Alaska at depths <1,000 m, is the major bycatch species in directed fisheries for sablefish and Greenland turbot, and is the only grenadier species to warrant management concern in Alaska at present. Therefore, the assessments have been based on giant grenadier serving as a proxy for entire grenadier group. Current biomass estimates for giant grenadier are: eastern Bering Sea (EBS), 592,271 mt; Aleutian Islands (AI), 1,141,526 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, 34,648 mt; AI, 66,779 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.

The NPFMC for many years has categorized grenadiers as “not specified” (i.e. not included) in its Groundfish Management Plans. This means there are no regulations concerning grenadiers in Alaska, and fishermen have been free to catch as many as they want. Because of this “not specified” status, our recent assessments for grenadiers in Alaska and recommendations of OFLs and ABCs have not been official and are not binding. However, in response to NMFS guidelines developed to comply with the reauthorized version of the Magnuson-Stevens Fishery Conservation and Management Act, we have recommended that grenadiers be re-classified as “in the fishery” and be included in the Groundfish Management Plans, in which case an official assessment would be required. The NPFMC plans to discuss management options for grenadiers as an agenda item at its June 2012 meeting. For more information contact Dave Clausen at (907) 789-6049 or dave.clausen@noaa.gov.

D. Other Related Studies

Fisheries Resource Pathology Program – RACE

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 2011 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 Pacific cod, northern rock sole, Arctic cod, Bering founder, walleye pollock, Greenland turbot, and Pacific herring.
For further information, contact Dr. Frank Morado, (206) 526-6572.

Spectral Irradiance Logger –RACE

In 2010, we received funding to develop a ruggedized data-logging underwater spectroradiometer that could be deployed on bottom trawls and other sampling devices of opportunity. This would allow for the collection of spectrally-relevant light intensity data during surveys providing better information on the role of underwater light on fish distribution, behavior, and gear avoidance. Design and purchasing of major components of the Spectral Irradiance Logger (SIL) took place during 2010 and fabrication began in 2011. The SIL units are currently undergoing final programming and bench testing with the goal of deploying the units on the 2012 Aleutian Islands Bottom Trawl survey to assess the underwater ambient light environment near known Atka mackerel nesting sites. One component of this initial field test will be to refine the system for attaching the SIL to the headrope of trawl nets. Any researchers with questions or interest in the SIL, please feel free to contact Lyle Britt (email: lyle.britt@noaa.gov).

Systematics Program-RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2011. A partial revision of the fish family Caristiidae (manefishes and veilfins) was published (Stevenson and Kenaley, 2011), describing a new genus and three new species, as was a revision of the skate subgenus *Arctoraja*, describing a new species from the Aleutian Islands (Orr et al., 2011; Spies et al, 2011). Two additional new species of the snailfish genus *Careproctus* are currently in press (Orr), and a manuscript describing six additional new species of manefishes is in preparation (Stevenson). In addition to revisions and descriptions of new taxa, RACE systematists have collaborated with molecular biologists within and outside of the AFSC to document cryptic diversity in skates (Spies et al., 2011) and snailfishes (Kai et al., 2011a,b), and to identify an early-stage larval form of the deepwater sculpin *Zesticelus profundorum* (Matarese et al., 2011). A revision of the sandlance genus *Ammodytes* of the North Pacific, with a description of genetic diversity and the recognition of two species in the eastern North Pacific, is nearing completion (Orr et al). Additional projects documenting the genetic diversity of lumpsuckers (Cyclopteridae) across the North Pacific and Bering Sea (Kai and Stevenson), and testing the hypothesis of cryptic speciation in northern populations of the eelpout genus *Lycodes* (Stevenson) have recently been initiated. In addition to systematic publications and projects, RACE systematists have been involved in several works on the zoogeography of North Pacific fishes, including a northern range extension for the Aurora rockfish (Laman and Orr, 2011), a paper documenting latitudinal and temporal shifts in the Bering Sea ecosystem (Stevenson and Lauth, in press), and an ongoing collaborative effort with the University of Washington to document geographic range extensions for numerous species of North Pacific fishes (Maslenikov et al., in prep).

In addition to fish research, a number projects on invertebrate systematics are currently underway, including a comprehensive annotated checklist of the trawl-caught macroinvertebrates of Alaska, which will be completed this summer (Drumm). The preparation of this checklist has led to other projects, including a manuscript on the distribution of crustaceans new to U.S. or Alaskan waters (Drumm), and an ongoing collaboration with Japanese researchers on the shrimp genus *Argis* (Fujita et al, in press). The RACE systematics program continues to incorporate the taxonomic knowledge gained from these research endeavors into groundfish surveys and other AFSC research efforts by updating field identification materials, providing identification training for field staff, and performing quality assurance/quality control checks on field identifications through photograph and specimen vouchers.

Salmon Excluders-RACE MACE

AFSC Conservation Engineering (CE) scientists participated in tests and refinement of the salmon excluder designs in February and March 2011. CE scientists provided and operated underwater video and sonar equipment to directly observe gear, assuring effective tuning of devices. Chinook salmon escape rates were between 25 and 40%, while chum salmon escape rates remained in the 10 – 15% range. Pollock escape was insignificant at less than 1%. 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." BREP funding was also used for travel to a Fall 2011 workshop at the fishing gear testing facility in St. Johns, Newfoundland to develop new designs to improve escape rates for both salmon species. For further information contact Craig Rose (Craig.Rose@noaa.gov).

Development and Evaluation of Trawl Ground Gears that Produce Less Damage to Crabs in Soft Bottom Areas-RACE MACE

In June, CE scientists conducted two weeks of tests of alternative footrope designs for flatfish capture efficiency and crab bycatch rates aboard the catcher/processor *Cape Horn*. The vessel's twin trawling and catch handling systems allowed direct comparisons of catch rates on each tow. Preliminary results indicate that a conventional disk footrope had much lower crab bycatch rates than a comparable roller gear footrope (a result expected by fishermen), but very similar flatfish catch rates (an unexpected result). In a second test, we found that widening disk spacing, and hence reducing ground contact and potential for crab damage, had little effect on flatfish catch rates.

In August, the same footrope designs were used in tests to determine the mortality rate of crabs passing under each of these footropes. 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. Analysis of those results is not yet complete. During that cruise, we also conducted experiments to address concerns raised by fishermen regarding the experimental methods for estimating escape mortality rates of crabs. They were concerned that exposure to suspended sediment during recapture behind the footropes could be causing additional mortality. We developed a way to expose crabs to the sediment and recapture process, without having to also contact a footrope. This provides a better control condition for the mortality estimates, improving their scientific validity, as well as understanding and acceptance by affected fishermen. For further information contact Craig Rose (Craig.Rose@noaa.gov).

Mortality Rates for Crab Bycatch in Gulf of Alaska Trawls and Applicability of Sweep Modifications to Reduce Crab Morality-RACE MACE

CE scientists also evaluated Tanner crabs caught by commercial trawl vessels in the Gulf of Alaska to estimate crab bycatch mortality rates and applicability of mortality estimation methods from previous studies. A sample of the assessed crabs were held in both onboard and laboratory tanks to test how the RAMP relationship for bycatch crabs compared to the RAMP developed for escaping crabs after encountering trawls on the seafloor. In combination with similar observations for Tanner and snow crabs during the Bering Sea cruise on the *Cape Horn*, described above, this provided the observations and validation tests to generate estimates of trawl bycatch mortality rates. Preliminary analyses confirm how such mortalities are related to handling time aboard the capture vessel. We also worked with captains to assess the implementation of trawl sweep modifications to the Gulf fleet for reducing crab mortality on the seafloor. These improved estimates of crab bycatch mortality rates and information on applicability of sweep modifications will inform considerations of crab protection actions by the North Pacific Fisheries Management Council. For further information contact Craig Rose (Craig.Rose@noaa.gov).

APPENDIX I - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

Published January 2011 through December 2011 (AFSC authors in bold text)

BELGRANO, A., and **C. W. FOWLER** (editors). 2011. Ecosystem-based management for marine fisheries: an evolving perspective. Cambridge University Press. 384 p.

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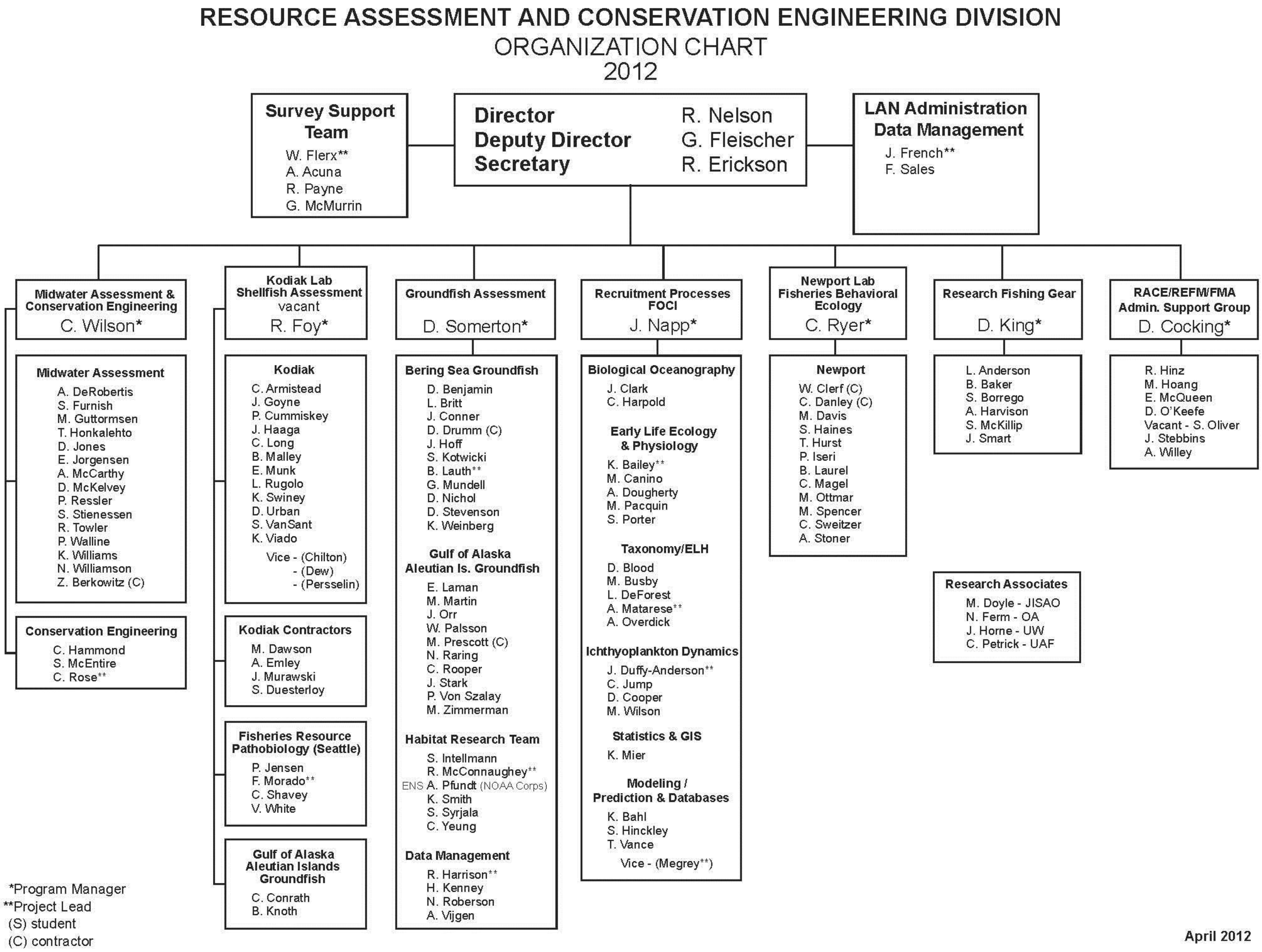
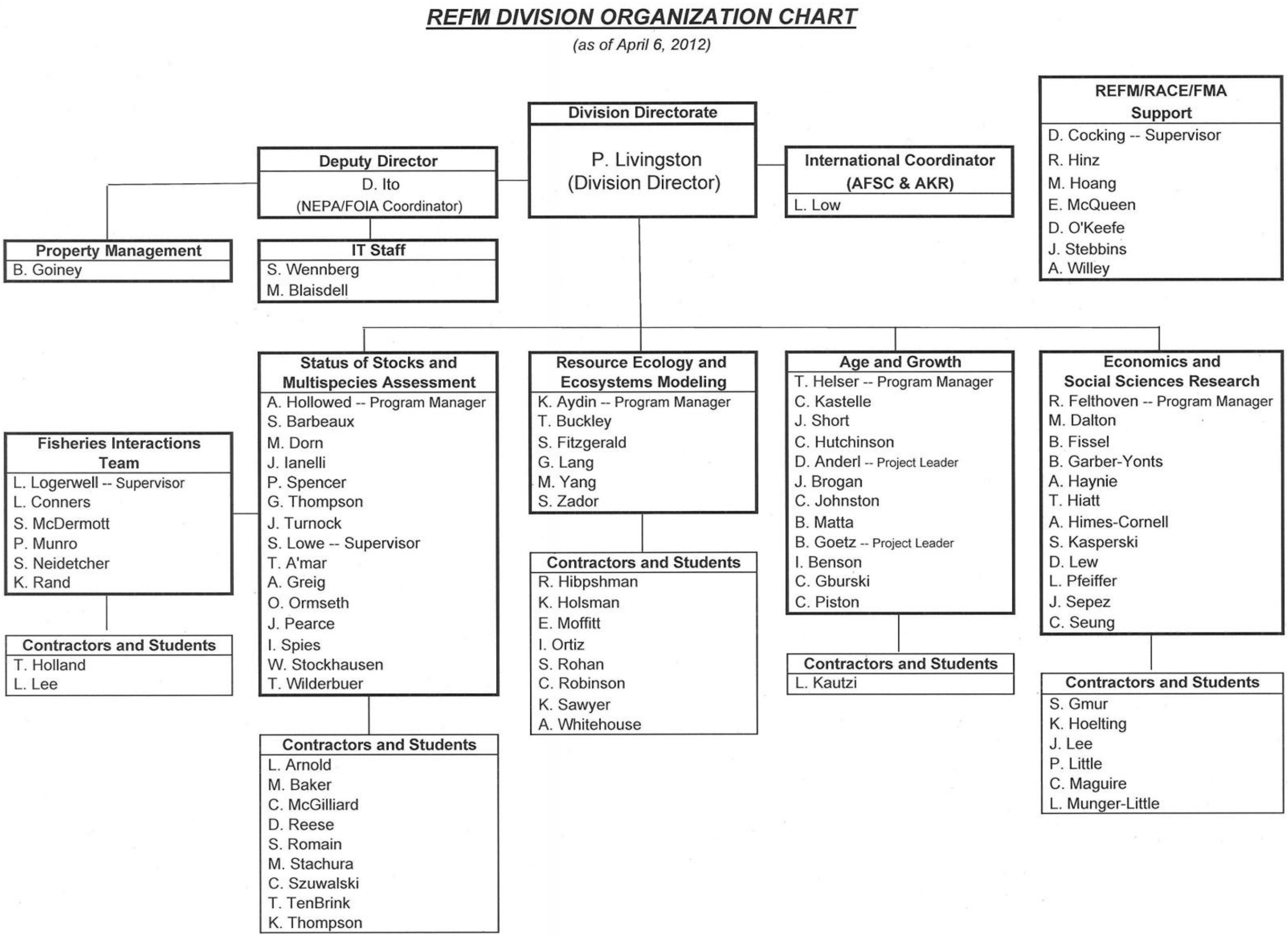
APPENDIX II. RACE ORGANIZATION CHART



APPENDIX III. REFM ORGANIZATION CHART



APPENDIX IV – AUKE BAY LABORATORY MARINE ECOLOGY AND STOCK ASSESSMENT (MESA) PROGRAM STAFF

Name	Duties
Phil Rigby	Program Manager
Dave Clausen	Rockfish, Grenadiers, Alaska Groundfish
Dave Csepp	Forage Fish, Hydroacoustics
Katy Echave	Sablefish Tag Database
Dana Hanselman	Sablefish, Rockfish, Stock Assessment
Pete Hulson	Rockfish and Shark Assessment
Jon Heifetz	Rockfish, Sablefish, Stock Assessment, Effects of Fishing
John Karinen	Gulf of Alaska Groundfish
Mitch Lorenz	Essential Fish Habitat
Chris Lunsford	Rockfish, Sablefish, Stock Assessment, Longline Survey
Pat Malecha	Groundfish Ecology, Effects of Fishing
James Murphy	Thornyhead Assessment, Modeling of Groundfish Tagging Data
Cara Rodgveller	Sablefish, Rockfish, Longline Survey, Grenadiers
Tom Rutecki	Sablefish, Webmaster, Outreach
Kalei Shotwell	Groundfish Habitat, Rockfish, Stock Assessment
Robert Stone	Seafloor Ecology, Effects of Fishing, Coral and Sponge Life History
Cindy Tribuzio	Sharks, Stock Assessment

Other ABL Staff Working on Groundfish-related Research

Scott Johnson	Essential Fish Habitat, Forage Fish
John Thedinga	Essential Fish Habitat, Forage Fish
Darcie Neff	Essential Fish Habitat, Forage Fish
Christine Kondzela	Rockfish Genetics
Sharon Hawkins	Forage Fish Genetics
Ed Farley	Epipelagic Trawl Survey in Bering Sea, Age-0 Walleye Pollock
Jamal Moss	Gulf of Alaska Fisheries Oceanography Project