Alaska Fisheries Science Center
of the
National Marine Fisheries Service

2010 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 2009

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, Midwater Assessment and Conservation Engineering, Recruitment Processes, Shellfish Assessment, and Research Fishing Gear. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.

In 2009 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 2009 by RACE Groundfish Assessment Program (GAP) scientists; the annual eastern Bering Sea shelf survey and the biennial survey of the continental shelf and slope in the Gulf of Alaska. In 2010 GAP scientists will again conduct the annual Bering Sea shelf survey and the biennial Aleutian Islands 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.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted winter echo integration-trawl (EIT) surveys of midwater pollock abundance in the Shumagin-Sanak area in February 2009 and around Chirikof-Shelikof Strait in March 2009. A summer survey of pollock on the eastern Bering Sea shelf was conducted in June and July 2009. 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 research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. Specifically, REFM's activities are organized under the following Programs: Age and Growth Studies, Socioeconomic Assessments, Resource Ecology and Ecosystem Management, and Status of Stocks and

Multispecies Assessment. Scientists at AFSC 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 Dr. Pat Livingston at (206)526-4173.

FMA DIVISION

The Fisheries Monitoring and Analysis (FMA) Division is responsible for placement of observers on vessels fishing for groundfish species in the U.S. EEZ of the northeastern Pacific Ocean and Bering Sea. Observers collect data, which provide the basis for in-season management of the groundfish fisheries by NMFS. This observer data also provides a means for evaluating and developing management strategies by NMFS and the regional management council, and are used in the stock assessment process. Observers play important roles in providing information that is critical to the U.S. fishing industry.

During 2009, the FMA Division trained and deployed 657 observers to 267 vessels and 19 shore plants in Alaska. These observers spent 35,677 days collecting data in 2009. The Division is responsible for defining the sampling duties and data collection methods used by observers, training of the observers prior to deployment, debriefing of observers upon their return, and editing and managing the resulting data. The catch data are provided to the Alaska Regional Office to assist in management decisions regarding the catches of groundfish and prohibited species. Data are also collected regarding the operations of the groundfish fishery.

The FMA Division's existing North Pacific Groundfish Observer Program (Observer Program), has been in place since 1990. It established coverage levels for most vessels and processors based on vessel length and amount of groundfish processed, respectively. Vessels and processors contract directly with NMFS-certified observer provider companies to procure observer services to meet coverage levels in Federal regulation. During the past several years, the North Pacific Fisheries Management Council (Council), NMFS, and the Council's Observer Advisory Committee have been working to develop a new system for observer funding and deployment in the Observer Program. The concept is often called 'observer restructuring.' In general, the program would be 'restructured' (the service delivery model would be changed) such that NMFS would contract directly with observer providers for observer coverage, supported by a broad-based user fee and/or direct Federal funding. Concerns with the existing program arise from the inability of NMFS to determine when and where observers should be deployed, inflexible coverage levels established in regulation, disproportionate cost issues among the various fishing fleets, and the difficulty to respond to evolving data and management needs in individual fisheries. The problem statement and alternatives developed by the Council are as follows:

Problem Statement:

The Observer Program is widely recognized as a successful and essential program for management of the North Pacific groundfish fisheries. However, the Observer Program faces a number of longstanding problems that result primarily from its current structure. The existing program design is driven by coverage levels based on vessel size that, for the most part, have been established in regulation since 1990 and do not include observer requirements for either the <60' groundfish sector or the commercial halibut sector. The quality and utility of observer data suffer because coverage levels and deployment patterns cannot be effectively tailored to respond to current and future management needs and circumstances of individual fisheries. In addition, the existing program does not allow fishery managers to control when and where observers are deployed. This results in potential sources of bias that could jeopardize the statistical reliability of catch and bycatch data. The current program is also one in which many smaller vessels face observer costs that are disproportionately high relative to their gross earnings. Furthermore, the complicated and rigid coverage rules have led to observer availability and coverage compliance problems. The current funding mechanism and program structure do not provide the flexibility to solve many of these problems, nor do they allow the program to effectively respond to evolving and dynamic fisheries management objectives.

Alternatives:

- Alternative 1. Status quo; continue the current service delivery model.
- Alternative 2. GOA-based restructuring alternative. Restructure the program in the GOA, including shoreside processors; and include all halibut and <60' vessels participating in groundfish fisheries in the GOA and BSAI. Vessels in the restructured program would pay an ex-vessel value based fee. Retain current service delivery model for vessels > 60' and shoreside processors in the BSAI.
- Alternative 3. Coverage-based restructuring alternative. Restructure the program for all fisheries and shoreside processors with coverage of less than 100 percent. Vessels in the restructured program would pay an exvessel value based fee. Leave vessels and processors with at least 100 percent coverage under the current service delivery model.
- Alternative 4. Comprehensive restructuring alternative with hybrid fee system. Restructure program for all groundfish and halibut fisheries off Alaska. Vessels and shoreside processors with 100 percent or greater coverage would pay a daily observer fee and vessels and shoreside processors with less than 100 percent coverage would pay an ex-vessel value based fee.
- Alternative 5. Comprehensive restructuring alternative that would assess the same ex-vessel value based fee on all vessels and shoreside processors in the groundfish and halibut fisheries in the GOA and BSAI.

The Council's work on restructuring the Observer Program is a high priority issue and a significant amount of FMA resources are being spent to enable Council decision making. An implementation plan for restructuring the Observer Program was presented to the Council in 2009. Work is now proceeding on an analysis of the alternatives to support Council decision making. The initial analysis will be presented to the Council at its June, 2010 meeting in Sitka.

On another priority issue, the FMA Division is working with the Alaska Region and the fishing industry, in the development of regulations and data collection protocols implementing the Council's action in 2009 which approved Amendment 91 to the groundfish fisheries management plan in the North Pacific. The Council's action recommended placing a hard cap on the number of Chinook salmon that can be caught as bycatch in the Bering Sea pollock fishery. This action will be implemented via Federal rule-making and NMFS is planning for implementation in January of 2011. The proposed rule can be found at: http://www.fakr.noaa.gov/prules/75fr14016.pdf

As drafted, the proposed rule envisions the salmon cap to be distributed to fishing sectors (groups of vessels), after which it will be further allocated by industry to individual fishing vessels with creative incentives to avoid salmon and mechanisms to transfer allocations. The FMA Division is challenged with developing approaches to account for salmon bycatch at the finer scale of individual vessels. Chinook salmon bycatch amounts that reach the established cap could be controversial because they will limit further pollock fishing. The rule also proposes that pollock vessels currently covered 30 percent of the time will shift to 100 percent observer coverage with the implementation of this action.

In 2009, the FMA Division's Observer Program continued to adapt to new observer coverage requirements implemented under Amendment 80 to the groundfish fisheries management plan in the North Pacific. This amendment allowed fishing cooperatives to form among the Bering Sea flatfish catcher-processors and required additional observers (an increase from one to two observers) on each vessel. Amendment 80 vessels have offered the FMA Division and the fishing industry a workable example of video monitoring. Videos are used in a surveillance capacity to monitor fish bins which cannot be directly seen by observers from where they sample. When the observer's line of sight is obstructed, the video cameras along with a live monitor screen at the observer station provide an electronic visual record saved on a computer hard drive which can later be used for enforcement purposes, if needed.

Also in 2009, the FMA Division made significant improvements in the details of data collection and electronic storage for information concerning seabird/fishing activity interactions and seabird species of interest sightings. Sightings information of six species of seabirds, including short-tailed albatross and red-legged kittiwake are now systematically collected by observers. Also, observers are collecting more detailed information about seabird interaction with fishing gear and vessel operations which often results in seabird mortality. This information is now collected by observers at sea using standardized methods and stored in an electronic format which has interactive capabilities with the larger observer sampling database.

For more information on overall FMA Division programs, contact Division Director Martin Loefflad at (206)526-4194 or Deputy Director Pattin Nelson at (206)526-4194.

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 and rockfish in Alaska and with the study of fishing effects on the benthic habitat. Presently, the program is staffed by 16 scientists, including 15 permanent employees and 1 term employee. One personnel change in early 2010 was the retirement of Nancy Maloney, who for many years had responsibility for ABL's Sablefish Tag Program. At present, this position has not been re-filled. Several employees in other ABL programs have also been involved with groundfish-related research in the past year.

In 2009 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 rockfish acoustic/trawl survey conducted jointly with the AFSC's REFM and RACE Divisions to investigate new survey designs for rockfish; 3) a tagging study of spiny dogfish near Yakutat, Alaska; 4) experiments during the NMFS longline survey to test methods for quantifying sperm whale depredation rates on the catch; 5) a study that used a manned submersible to examine the recovery of sponges and sea whips from effects of bottom trawling 13 years before; and 6) a large-scale, epipelagic trawl survey of the eastern Bering Sea shelf conducted by ABL's Ocean Carrying Capacity Prgram that provides data on abundance of age-0 walleye pollock..

Ongoing analytic activities in 2009 involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of eight detailed status of stocks documents for Alaska groundfish: Alaska sablefish; Gulf of Alaska Pacific ocean perch, northern rockfish, pelagic shelf rockfish, rougheye and blackspotted rockfish, shortraker rockfish and "other slope rockfish", and sharks, and Bering Sea/Aleutian Islands sharks. Also, a new longline survey database was nearly completed and a website created to provide the public with on-line access to survey catches and abundance indices.

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

B. Multispecies Studies

1. Research

Fisheries Behavioral Ecology Program - RACE

The Fisheries Behavioral Ecology Program based in Newport, Oregon conducts experimental research designed to understand the role that behavior plays in regulating distribution, abundance growth, and survival of fish species and their interactions with fishing methods and gear. The goal of the Program is to provide the critical information needed to improve survey techniques, to improve predictions of population abundance and survival, and to conserve populations of economically significant marine resource species and their habitats. Research conducted during 2009 continued under long-term research themes related to recruitment processes, basic studies in fish ecology relevant to the definition of growth, recruitment, and essential habitat.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

Age and Growth Program - REFM

[Section has not been updated for 2010]

For further information contact Dr. Thomas Helser (206) 526-4200.

Resource Ecology and Ecosystem Modeling - REFM

Multispecies, foodweb, and ecosystem modeling and research are ongoing. Documents, symposia and workshop presentations, and a detailed program overview are available on the 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. Emphasis is being placed on collecting stomachs during seasons and in regions where historic sampling has been less comprehensive, and on collecting tissue samples for stable isotope analysis that provides trophic information integrated over months of feeding. Emphasis is also being directed toward collection of stomachs with corresponding information about the zooplankton and benthic prey field. Collection of groundfish stomach samples is primarily through the RACE bottom trawl and echo-integration/trawl surveys. Additional samples that broaden our spatial and seasonal coverage are obtained through the Observer Program and through coordinated studies with other agencies. In 2009, REEM collected samples and data during bottom trawl and/or midwater surveys of the Gulf of Alaska (GOA) and eastern Bering Sea (EBS). Stomach samples were also collected during surveys by other agencies and by Observers during fishery operations. In total, 9,018 stomach and tissue samples were collected from the EBS and 7,423 were collected from the GOA regions. Laboratory analysis was conducted on 3,927 fish stomachs from the Bering Sea, 1,332 fish stomachs from the GOA, and 29 fish stomachs from the AI. At-sea analysis was conducted on 2,014 fish stomachs from the GOA. The REEM predator-prey database was updated with 15,229 records in 2008.

Predator/Prey Interactions and Fish Ecology

Accessibility and visualization of the predator-prey data through the web has cleared significant hurdles and is now more readily available. Complete database details 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/dietmap.php. 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.

A two-year project funded by the North Pacific Research Board, investigating the age, growth, maturity, reproductive biology, and diet of five sculpin species has been completed. These five species, *Myoxocephalus jaok* (plain sculpin), *M. polyacanthocephalus* (great sculpin), *M. verrucosus* (warty sculpin), *Hemilepidotus jordani* (yellow Irish lord) and *Hemitripterus bolini* (bigmouth sculpin) contribute approximately 95% of the sculpin biomass within the Bering Sea/Aleutian Islands (BSAI) region. Sculpin biomass estimates for the BSAI region have exceeded 200,000 mt. Although sculpins are most common along the eastern Bering Sea continental shelf, unique assemblages appear to be present within the shelf and slope areas of the eastern Bering Sea and the Aleutian Islands. Because of their abundance, sculpins are an ecologically important component in the eastern Bering Sea with some species feeding heavily on commercially caught Tanner and snow crabs and juveniles of walleye pollock.

Potential distributional shifts in overlap between arrowtooth flounder and walleye pollock in the Bering Sea were investigated. This work identified physical and biological habitat characteristics that are correlated with arrowtooth flounder biomass trends sampled at individual trawl stations, and found that small-scale regions within the eastern Bering Sea shelf have contributed unequally to the overall rapid increase in abundance of arrowtooth flounder. Hierarchical k-medoids clustering of arrowtooth catch-per-unit-effort revealed four distinct spatial groups showing stable, increasing, and variable trends. Catch rates in high-density areas near the shelf break have remained stable since the early 1990s while catch rates have increased to the northwest and east. Annual changes in range expansion and contraction are negatively correlated with the extent of the cold pool over the Bering Sea shelf. Age-1 and -2 pollock comprise the majority of arrowtooth diets in all areas, but higher rates of non-empty stomachs in the northwest region indicate that predatory impacts on pollock may be higher there. This analysis provides information about the potential for arrowtooth flounder to further increase their distribution and abundance in the Bering Sea and helps to predict future responses to climate and fisheries management actions.

Comparisons of zooplankton catch data and pollock diet data were initiated. Few zooplankton sampling stations have been identified, that include zooplankton community composition data, to compare to pollock diet composition data, within a reasonably narrow temporal and spatial window. Another source of zooplankton abundance information results from frequency differencing of hydroacoustic data through a MACE, BSIERP project. This technique provides estimates of euphausiid backscatter from Hydroacoustic Surveys back to 2004. During these years, prior to 2009, pollock stomachs were collected only from 14 trawl stations in the northern Bering Sea during the 2004 survey. Cursory examination of this data indicates no relationship between local euphausiid backscatter density nor local pollock density. Average stomach fullness as a percentage of individual pollock body weight appears to be related more to the variation in copepod consumption than euphausiid consumption as indicated by the average amount of each prey type eaten per fish (g-prey / fish). However, all evidence suggests the overall abundance of euphausiids in the Bering Sea in 2004 was extremely low. Stomach samples of walleye pollock were collected during the 2009 Hydroacoustic Survey so much more data will become available in 2010.

Seabird - Fishery Interaction Research

The Seabird Coordinated Studies group activities included updating important information. The seabird presentations for the Observer 3-week training and 4-day briefing sessions were upgraded. This was coordinated closely with the Observer Training Center in Anchorage. In addition, FMA database changes were implemented to capture what was “ad hoc” information on seabirds recorded by Observers. This encompasses bird mortalities from third wires or trawl warps, bird storms, sightings of short-tailed albatross, and other seabird events at sea that go beyond the normal sampling routine. In a separate project, the production of a NOAA Technical Memorandum that reports seabird bycatch from 1993 through 2006 was initiated.

On June 22, 2009, a working session was convened at the AFSC to provide guidance on estimating the bycatch of rare-event species such as seabirds and marine mammals. Participants included representatives from the UW, NWFSC, PIFSC, SWFSC, and NEFSC in addition to staff from the Alaska Regional Office and the AFSC. The day’s focus was to advise the AFSC on how to provide annual estimates of bird and mammal bycatch. Discussions were held noting mandated reporting requirements, strengths and weaknesses of the data, and general needs of a suite of end-users. Having an estimation procedure that is well documented and repeatable was noted as a priority. Generally, the AFSC plans to work with the Alaska Region’s Catch Accounting System to support the annual production of seabird bycatch estimates while also looking into longer-term comparative modeling exercises to evaluate the effectiveness of this ratio-estimator based approach.

The Alaska Fisheries Science Center also hosted the first strategic planning workshop for the NMFS National Seabird Program on September 9-11. The purpose of the workshop was to assess the current state of the program and to consider how the program can best address emerging issues related to seabird conservation, within U.S. waters and on the high seas. NMFS shares responsibility for the conservation of seabirds with the U.S. Fish and Wildlife Service through its role managing fisheries - one of the greatest known threats to seabird populations worldwide.

With funding from the National Cooperative Research Program and the Bycatch Reduction Engineering Program, we conducted a pilot study on seabird interactions with paravanes in August. A paravane is a device that trawl operators use to obtain signals from net monitoring equipment. The paravane receives acoustic signals as it is deployed at 5 or more fathoms deep via a boom alongside the vessel (Fig. REEMBird1). Because seabirds attend vessels to take advantage of fish discharge they may come into contact with this gear. This study is the first work in the North Pacific on seabird paravane interactions.

Project goals were to: (1) learn about the basic usage of paravane gear, (2) obtain baseline information on seabird interactions with the paravane gear, and (3) attempt to develop and deploy at least 3 different types of mitigation measures. Industry partners included the North Pacific Fisheries Foundation and Cascade Fishing, Inc., owners of the fishing trawler *Seafisher*. This study was needed due to a potential for interactions between paravanes and the endangered short-tailed albatross (*Phobastria albatrus*).

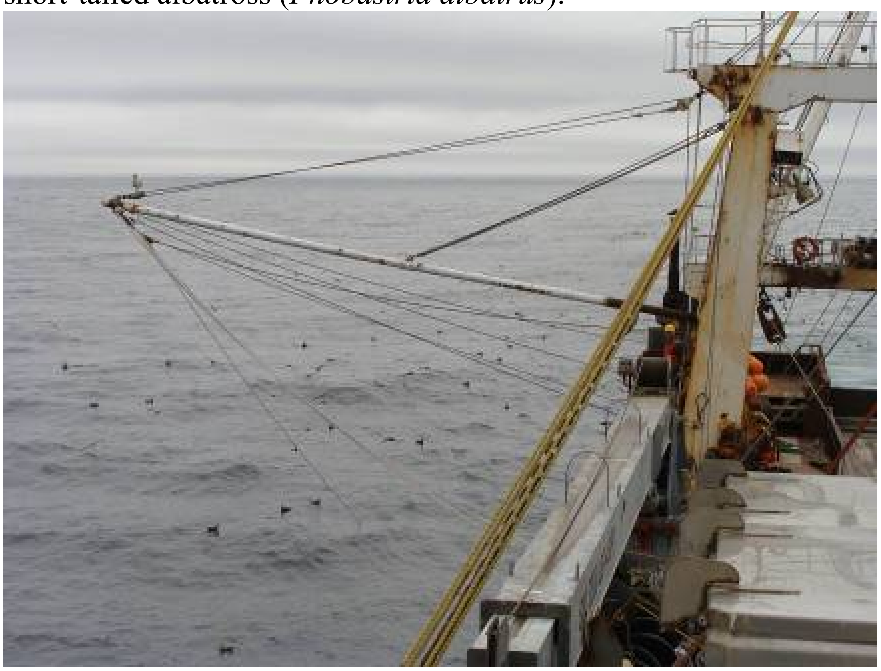

Figure REEMBird1: Field biologist Jeff Pesta conducting a seabird/paravane interaction session. The paravane cable runs down into the water from near the end of the boom (and back to the vessel under the boom). All other lines control the boom or are used to deploy and retrieve the block used to deploy the paravane. Very few interactions were recorded with these lines. Note the gull perched on the boom.

A biologist experienced with seabird mitigation was deployed to the trawler *Seafisher* for one trip, August 8 through 16. During this period we were able to achieve all the stated goals of the pilot project. There were 20 observation sessions of seabird/paravane interactions (without mitigation measures), which will provide baseline interaction rates for comparisons to rates while mitigation measures were deployed. The crew and biologist coordinated together to try 6 different types of mitigation measures (Fig. REEMBird 2). The biologist was able to conduct another 20 observation periods of these measures. There were no seabird mortalities or injuries associated with the paravane during this trip. Interaction rates varied from 0 to 138 per 15-minute observation session. Nearly all interactions were by Northern Fulmars (*Fulmaris glacialis*) and were of the paravane cable itself rather than the various lines supporting or controlling the paravane boom.

Figure REEMBird 2. Crew members working on one of their ideas for a seabird mitigation measure before deploying the paravane. Collaboration between officers, crew, and the field biologist resulted in 6 different measures being developed and deployed.

The AFSC Seabird Coordinated Studies Group, in partnership with fisheries observers, the Fisheries Monitoring and Analysis Division, and the non-profit group Oikonos, has for several years been involved with salvaging bycatch birds from Alaskan Groundfish fisheries, sending them to a necropsy lab, and then having the stomach contents analyzed for plastics (Fig. REEMBird 3) and food habits (Fig. REEMBird 4). Preliminary examination of 30 albatross (19 Laysan and 11 Black-footed) and 43 Northern fulmars has been accomplished to date. Much more natural prey has been found in the stomachs than was expected for bycaught birds. In addition, food items introduced by the fishery also appear to be readily identifiable. This will allow for important information to be gained on the natural feeding strategy of these birds in the region. The Bering Sea albatross samples will provide information from an oceanic region not previously represented. Most comprehensive North Pacific albatross diet studies, utilizing stomach samples, are based on samples collected during the breeding season from the Hawaiian Archipelago or from bycaught birds taken in the North Pacific Transition Zone. Examination of the northern fulmar samples also revealed more natural prey than anticipated. Northern fulmars make up the majority of bycaught birds in the Bering Sea region. The large sample size of birds returned by observers should ultimately allow for a detailed study of potential regional and seasonal variations in the natural diet of this species.

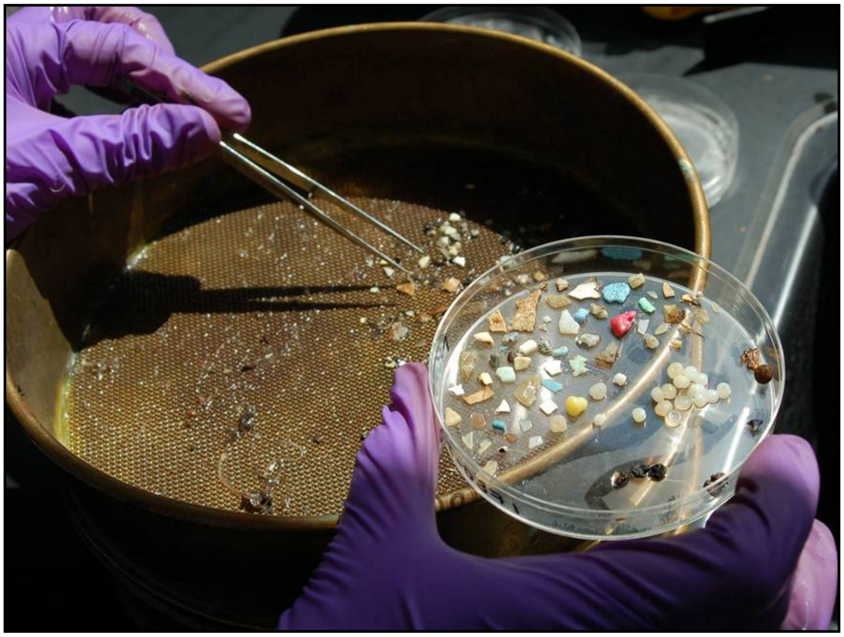

Figure REEMBird 3. Sorting out all of the plastic fragments ingested by a Northern Fulmar.

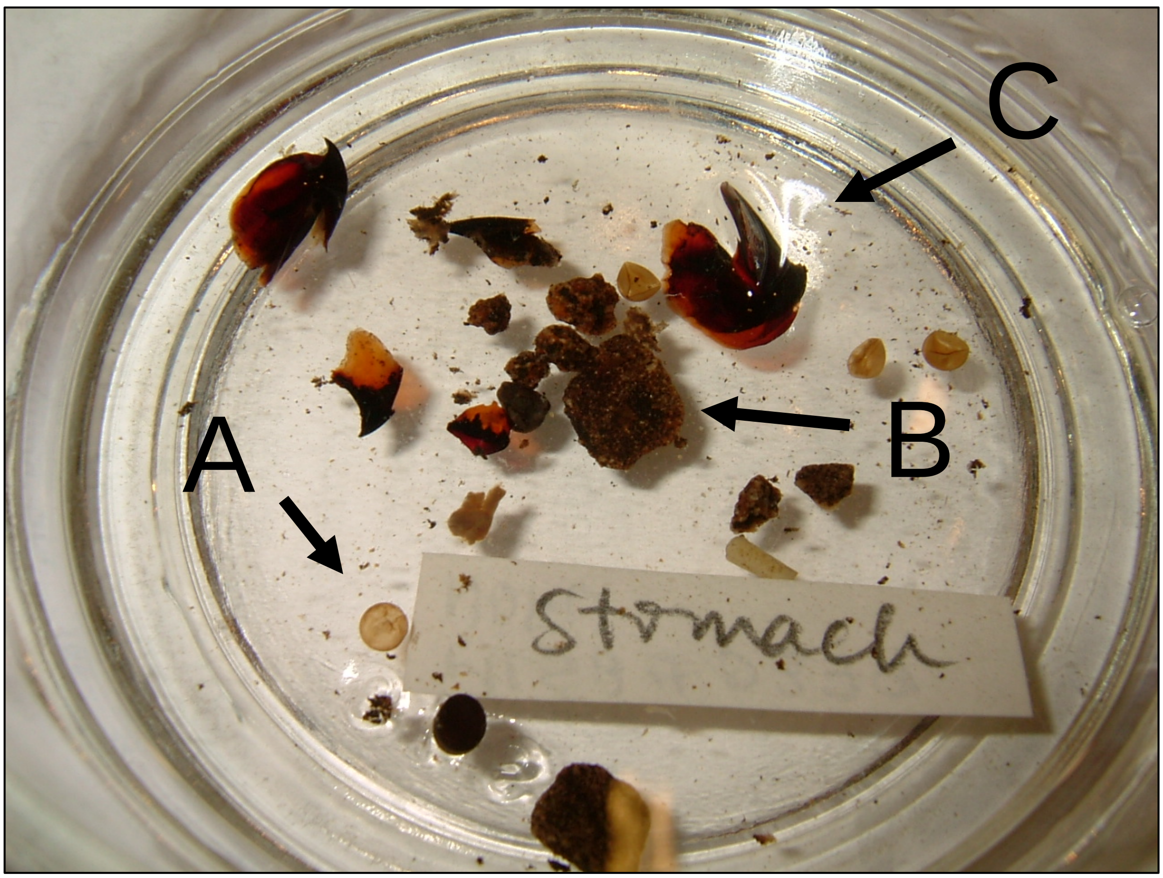

Figure REEMBird 4. Stomach contents from a Northern Fulmar (A) Plastic Fragments, (B) rocks, and (C) squid beaks.

Multispecies and Ecosystem Modeling

REEM modelers have attended weekly meetings with the Bering Sea Integrated Research Program (BSIERP) vertical modelers to continue development of the Forage and Euphausiid Abundance in Space and Time (FEAST) model. FEAST is a multispecies bioenergetics model for forage and predatory fish species linked to NPZ (Nutrient-Phytoplankton-Zooplakton) and ROMS (Regional Ocean Modeling System) models for the Northeast Pacific and Bering Sea at a 10km resolution. This 3D model of the Bering Sea will model the coupling between physics, plankton, forage fish, and predatory fish. FEAST models nine fish species (walleye pollock, Pacific cod, arrowtooth flounder, salmon, capelin, herring, eulachon, sandlance and myctophids) which have a two way interaction with the seven zooplankton groups in the NPZ model (small/large microzooplankton, small/large copepods, euphausiids, jellyfish, and benthic infauna). Additionally, temperature and advection from the ROMS model are used in the bioenergetics and movement components. The operating hypothesis in FEAST is that forage fish and macrozooplankton (e.g. euphausiids) are tightly coupled in a two-way interaction, and the dynamics of this interaction under different climate scenarios is a strong structuring element for the ecosystem as a whole. FEAST itself will ultimately be incorporated into economic and spatial fishery predictions, as well as into management strategy evaluations which are also part of BSIERP. Progress to date includes a fully coupled 1-dimensional version (depth over time) producing expected growth rates and consumption for fish lengths 10cm+ for 1999. The 3D version of FEAST is fully coupled and ready for initial preliminary runs which will focus on refining movement parameters. Milestones in early 2010 include one year runs for 1999 (a cold year) and 2004 (a warm year).

Several workshops and symposia were organized, convened and attended to coordinate the development of the FEAST model, to coordinate the integration of regional ecosystem models, and to promote the integration of ecosystem models with a variety of management interests. REEM modelers hosted a workshop of the North Pacific Research Board's BSIERP Vertical Integrated Modeling Project in Seattle, June 1-3 2009. Results of this FEAST development workshop were presented at the annual meeting of the Resource Modeling Association and at the third international Global Ecosystems (GLOBEC) meeting in late June. Results of the 1D model were presented and discussed during another workshop hosted by the BSIERP Fish Group in Seattle, August 11-13 2009. The workshop focused on preliminary results of the fish-related field projects, introduction to models and discussion of model outputs between modelers and field researchers. Updated results of the 1D and 3D models were presented and discussed again at the annual BSIERP PI meeting in mid-October. REEM personnel participated, on behalf of multiple project members from the AFSC, in a workshop meeting of the GLOBEC Pan-regional-synthesis program in Boulder, CO. The work focused on comparing ecosystem structure and function of the Gulf of Alaska, the Northern California Current, George's Bank, and the Antarctic Ocean. REEM personnel also attended and co-organized a symposium at the International Marine Conservation Congress, a meeting sponsored by the Society for Conservation Biology's Marine Section in Washington, D.C., 19-24 May 2009. The purpose of this international meeting was to bring conservation and fishery scientists, managers, policy-makers, and the public together to "put conservation science into practice" with respect to ecosystem-based management and global climate change, in particular to jointly address fishery and biodiversity conservation objectives. REEM personnel co-organized the symposium "Conservation in Working Seascapes: Bridging the Gap Between Fishery Management and Biodiversity Conservation." The symposium was very well attended and generated considerable discussion among the audience, the invited speakers, and the organizers.

A co-authored review/summary publication is currently in preparation as a result of this symposium.

The second NMFS National Ecosystem Modeling Workshop (NEMoW II) was held August 25-27, 2009 at the Chesapeake Bay Foundation's Merrill Center in Annapolis, MD. NEMoW II continued work started at the first NEMoW in Santa Cruz, CA in 2007 to develop a regular ecosystem modeling (EM) workshop analogous to the National Stock Assessment Workshops and National Economist Meetings. In this context, EM includes a wide range of biophysical, multispecies and ecosystem modeling methods. Where NEMoW classified major ecosystem model types and began a list of "best practices" for using the models, NEMoW II focused on sources of uncertainty in EM and how to provide management advice that appropriately expresses, but is not hampered by uncertainty. REEM personnel served on the steering committee and made a presentation reviewing the venues that each NMFS Science Center is using to present and review EM. REEM personnel also made a presentation reviewing single species and EM comparisons across NMFS Science Centers.

Data and information gaps for modeling were identified across NMFS Science Centers and prioritized to address major sources of EM uncertainty. Common types of uncertainty were identified as well as approaches for addressing that uncertainty. Establishing and refining our list of best practices to address EM uncertainty should be continually re-evaluated. This workshop provided a strong basis for identifying those best-practices. A key conclusion from the workshop was that we need to better engage our stakeholders in terms of communicating, interacting and discussing ecosystem model rationales, uses, applications, and benefits. The four preliminary major recommendations are suggestions to: 1) establish distinct EM review panels, 2) identify and note sources of EM uncertainty as a must for EM use, 3) bolster the value of strategic advice, and 4) bolster Ecosystem Modeling Capacity.

Ecosystem Considerations

The Ecosystems Considerations chapter in the Stock Assessment and Fisheries Evaluation is updated annually by REEM personnel to provide information on relevant ecosystem components to the North Pacific Fishery Management Council for consideration in management decisions. The chapter is composed of three parts, the first of which is an integrated ecosystem assessment, time series of ecosystem indicators that measure components of the ecosystem, and management indices that reflect the impact of humans on the marine ecosystem. The last two parts are composed of individual contributions from a broad range of scientists. Contributions were updated, and two new contributions were added. One provides measurements of the potential area disturbed by trawl fishing gear in the eastern Bering Sea from 1990-2008. This analysis showed that the maximum total area of seafloor potentially disturbed by trawls varied around 120,000 km^2 in the 1990s and decreased in the late 1990s to approximately 90,000 km^2. The area disturbed remained relatively stable in the 2000s with a slight increase in the 2007-2008. The second new contribution describes the spatial distribution of groundfish in the eastern Bering Sea from 1982-2008. The contributors demonstrated that both the latitudinal and depth distribution of the demersal community on the eastern Bering Sea shelf have shown clear directional trends over the last three decades, indicating significant distributional shifts to the north and into shallower waters. Although the average distribution shifted slightly south after the very warm years of 2004/05, there was little evidence that recent cold temperatures in 2006-2008 have led to a commensurate reversal of the long-term northward shifts. Highlights from the draft were presented to the joint North Pacific Fishery Management Council plan teams in mid-September.

This year, status and trends of eastern Bering Sea (EBS) and Gulf of Alaska (GOA) feeding guilds were analyzed by incorporating current stock assessment and survey results within the framework of existing food web models. EBS biomass trends were summed stock assessment model estimates or scaled survey data, where available, for each species within the guild. If neither time series were available, the species was assumed to have a constant biomass equal to the mid-1990s estimated levels. The GOA ecosystem model was forced by stock assessment model estimates where available for each species within the guild, and fit to survey time series, catch data, groundfish diet data, and the mid-1990's mass balance for all other species. Current EBS status (2004-2009) mean biomass, catch, and exploitation rates have been within +/- one standard deviation of 1977-2009 levels for all guilds except pelagic foragers (biomass below mean, exploitation rate above mean) and structural epifauna (biomass above mean). Apex predators and pelagic foragers had decreasing trends in biomass, catch, and exploitation rates, while benthic foragers had increasing catch and exploitation rate trends. The apex predator trends were driven largely by a decrease in Pacific cod biomass and catch. The pelagic foragers guild was dominated by walleye pollock (77% of guild biomass in 2009), whose decrease with general declines in other forage species has brought the biomass of this group to overall low levels. Exploitation rate was over one standard deviation above the mean from 2004-2007, however the decreased catches in 2008 and 2009 have decreased the pelagic foragers exploitation rate back towards its long-term mean. Increasing trends in benthic forager catch and exploitation rate reflect increased Allowable Biological Catches (ABCs) for flatfish species allowable under the 2 million metric ton OY cap with decreased pollock ABCs. Current GOA mean biomass was more than one standard deviation above 1977-2009 mean levels for apex predators and benthic foragers, and the biomass trend is increasing for benthic foragers. The apex predator guild was driven by the stock assessment-estimated high biomass of arrowtooth flounder, and to a lesser extent in Pacific halibut and Pacific cod, while the benthic forager guild was driven by a stock assessment-estimated increase in flathead sole and survey trends for increasing skates and flatfish. In contrast, pelagic foragers recent mean biomass is nearly one standard deviation below the long term mean, driven by the stock assessment estimated decline in pollock. Catch for pelagic foragers remains within one standard deviation of the long term mean, while exploitation rates have trended down. GOA shrimp are above long term mean biomass, due to a long term trend which agrees with trawl survey results.

For more information about REEM research, please contact Dr. Kerim Aydin at (206)526-4225.

Recruitment Processes – RACE Division

Scientists of the Recruitment Processes Program conduct a number of studies investigating distribution, abundance, and size structure of larval and juvenile groundfish in the Gulf of Alaska and Bering Sea. In the Bering Sea, species under investigation include northern rock sole and Greenland halibut; flatfishes, Pacific cod, walleye pollock and capelin are being studied in the Gulf of Alaska.

- We are completing our third field year for the Bering Sea Integrated Ecosystem Research Program (IERP) and analyzing data from Years 1 & 2 with colleagues from UAF. Results are helping to address specific questions about the target species (walleye pollock, cod, and arrowtooth flounder). J. Napp serves on the Science Advisory Board for BSIERP. We are also finishing a revised work plan for GOA lower trophic level investigations for the GoA IERP slated to start in 2011.

- Comparative analyses of marine ecosystems - Dr. Kevin Bailey co-organized an international workshop on predatory-prey interactions16-18 March 2010. The goal is to examine existing and new methods for scaling up from local observations, shifting processes as scale changes, and complexity and organizational structure in predator-prey interactions. (http://bioweb.coas.oregonstate.edu/~ciannellilab/cameo/). B. Megrey is a PI for two CAMEO projects, one to construct an end to end model (physics to dynamic fishing fleets) that will simulate low frequency oscillations in the population dynamics of small pelagic fish (anchovies and sardines). The modeling builds on an HPCC proposal to get access to NOAA high performance computing resources to construct and test the model. The other project is an international workshop to use surplus production models to compare and contrast nine different marine ecosystems.
- Chukchi Sea Ecosystem - Ichthyoplankton samples from the second RUSALCA cruise are undergoing analysis and we are preparing for an NOAA/MMS-supported cruise to the Chukchi this summer. In August we will work with PMEL and NMML to deploy biophysical moorings that will examine temporal variability in plankton in the area off Wainright, Alaska near oil/gas lease sites where we will also have passive acoustic devices to detect marine mammal vocalizations. Hydrography, nutrients and plankton samples will also be collected.

Bering Sea

Northern rock sole - 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 in September 2008. Mean length was higher in warm, nearshore areas than in cold, offshore areas, suggesting temperature dependent growth and/or shoreward movement with development. Nursery areas north of Unimak Island are significantly closer to shore and warmer than identified nursery areas to the north in the EBS. Reference: Cooper, D. W., Duffy-Anderson, J.T., Stockhausen, W., Stabeno, P., and Jump, C. Northern rock sole (*Lepidopsetta polyxystra*) connectivity between spawning and settling areas along the Alaska Peninsula in relation to currents and hydrography. American Fisheries Society Larval Fish Conference. Portland, OR, July 2009.

Greenland halibut - Early life stages were examined based on historical field data from the EBS and adjacent water along the eastern Aleutian Islands. Results indicate that pre-flexion larvae to newly-settled juveniles have a long pelagic duration and are subject to extended drift pathways. Hatching may occur in deep water, below 530 m, and larvae rise in the water column as they grow. Post-flexion larvae are mostly found around the Pribilof Islands over the middle shelf (50-100 m isobaths) in July, and settling occurs during late summer on the middle shelf near St. Matthew Island. However, given that age-1 individuals were primarily found on the outer shelf, it appears that they halibut actively move to deeper water with age (or size). Reference: Sohn, D., Ciannelli, L., Duffy-Anderson, J.T. In review. Distribution of Greenland halibut eggs, larvae, and juveniles over the Eastern Bering Sea shelf (1990-2007). *Fish. Oceanogr*.

Other Flatfishes - A study was conducted to investigate the early life ecology of Alaska plaice in the EBS. Patterns of abundance and distribution of eggs, larvae and pelagic juveniles over the southeastern Bering Sea shelf were examined to better understand factors controlling transport and recruitment. Eggs were present throughout the water column, though densities of preflexion stage larvae were concentrated at depths 10-20 m. Spawning occurs primarily east of Port Moller in April and May, and eggs and larvae appear to drift to the north and northeast. Connectivity between spawning areas and nursery habitats is likely influenced by wind forcing, so climate-mediated changes to dispersal trajectory or timing is expected to have impacts on recruitment in this species, though entrainment in consistent, directional currents may modify these effects. Reference: Duffy-Anderson, J.T., Doyle, M., Mier, K.L., Stabeno, P., and Wilderbuer, T. In press. Early life ecology of Alaska plaice (*Pleuronectes quadrituberculatus*) in the eastern Bering Sea: distribution, transport pathways, and effects of hydrography. *J. Sea Research.*

Walleye pollock - Retrospective collections were used to examine associations between the early life stages and their environment (Smart et al., in prep. a). Highest abundances of eggs and yolk sac larvae were found at low temperatures and relatively high turbulence levels, whereas pre-flexion and post-flexion larvae and juveniles are most abundant at times of warm temperatures and low wind-driven turbulence. These findings indicate the importance of changing temperature and storm regimes on the growth and survival over the southern Bering Sea shelf.

Another study identified changes in abundance, distribution, and phenology of early life stages under alternate warm and cold climate states (Smart et al., in prep. b). Warm conditions (small cold pool, high sea surface temperature, few storms) favor high abundances of late stages (advanced larvae and juveniles) over early stages (eggs and non-feeding larvae). We also found expansions and contractions of distribution over the shelf for several stages, depending on conditions, along with shifts in the time of occurrence or highest abundance. Changes in distribution and phenology can be attributed to delayed spawning, growth, and increased mortality of late stages under cold conditions relative to warm.

References: Smart, T.I., J.T. Duffy-Anderson, E. Farley, J. Horne (in prep. a). Environmental variability and the early life stages of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. Smart, T.I., J.T. Duffy-Anderson, C. Wilson, and E. Farley (in prep. b). Alternate climate states and the early life stages of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea.

Pacific cod - Surveys to determine the horizontal and vertical distribution of larvae over the EBS shelf were conducted throughout the spawning season in 2008-09 (partially funded by NPRB). Combined with retrospective data analysis, we identified general trends in distribution and dispersal. Based on egg and yolk sac larval distribution, spawning occurs along the Alaska Peninsula and Unimak Pass and near the Pribilof Islands. Larvae are found primarily in Unimak Pass, followed by the Pribilof Islands and the middle shelf domain. Preflexion and flexion larvae typically are found in the upper water column (< 20 m), suggesting high potential for wind-driven transport of larvae from spawning grounds. However, flexion and postflexion larvae have been collected only north of Unimak Island and the Pribilof Islands, suggesting strong retention of larvae near spawning grounds, which may also serve as nursery grounds. Reference: Vertical distribution of larval walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and *Atheresthes* spp. in the eastern Bering Sea. BEST-BSIERP Principal Investigators Meeting, October, 2009.

Gulf of Alaska

Walleye pollock and capelin - A project was undertaken to investigate the processes affecting the productivity of these important forage fishes in the GoA. Objectives were to investigate key physical processes by comparing the distribution of fish and prey with oceanographic properties, and to examine the potential for interspecific competition by comparing measures of foraging success. Results support the linkage between oceanography, prey, fish diet and fish distribution. Age-0 pollock were distributed in cool, high-salinity waters offshore of a mid-trough front, coincident with the distribution of the bulk of their preferred prey, euphausiids. In contrast to pollock, capelin were distributed throughout the trough, as was the distribution of their dominant prey, copepods. Although capelin and pollock had different distributional patterns and diets in 2005, in a previous year's survey they were both found inshore of the mid-trough front foraging on euphausiids, suggesting a potential for competition. Sympatric capelin often had reduced foraging success compared to allopatric capelin. Age-0 pollock were the superior competitor of the two species and that the exclusion of capelin from foraging on euphausiids can have negative consequences for growth and potentially survival. Reference: Logerwell, E., Duffy-Anderson, J.T. and Wilson, M.T. In press. The physical and biological processes resulting in habitat partitioning by two potential competitors, juvenile pollock and capelin, in the Gulf of Alaska. *Fish. Oceanogr.*

Capelin - We studied spatial and temporal patterns of vertical distributions of larvae and related observed patterns to biological and physical environmental parameters. Transport of yolksac larvae is likely heavily influenced by winds, and the importance of wind driven transport likely decreases with ontogenetic development. Vertical migration patterns varied on a small spatial scale, over time, and with published reports for other capelin stocks, which highlights the complexities of larval vertical migration behavior. Reference: Cooper, D.W., Duffy-Anderson, J.T., Lanksbury, J.A., Mier, K.L., and Stabeno, P. Vertical distribution of capelin larvae (*Mallotus villosus*) in the Gulf of Alaska: influence of ontogeny and abiotic factors. American Fisheries Society Larval Fish Conference. Kiel, Germany, August 2008.

Multi-species Approaches: Bering Sea and Gulf of Alaska

- One study focused on a 20+ year time-series of larval fish abundance in the northwest GoA. Links between species larval abundance and the physical environment were explored using Generalized Additive Modeling. Results demonstrate species-specific associations between larval abundance and environmental variables, and were reflective of similarities in life history characteristics. The study showed there is good potential for identifying levels of resilience or vulnerability of individual species early life history patterns to fluctuating oceanographic conditions. Reference: Doyle, M.J., S.J. Picquelle, K.L. Mier, M. Spillane and N.A. Bond (2009). Larval fish abundance and physical forcing in the Gulf of Alaska, 1981–2003. *Prog. Oceanogr., 80*, 163–187.
- A project examined the influence of shelf-edge mesoscale eddies on ichthyoplankton species composition and diversity. Evidence for larval fish entrainment in these eddies was examined using data from: a cruise in 2005 that sampled three eastern GoA mesoscale eddies, and sampling that compared shelf to slope ichthyoplankton assemblages in the northern GoA (2002 – 2004). Hierarchical cluster analysis of oceanographic data showed that stations grouped according to location within an eddy. Species hierarchical cluster analysis revealed a latitudinal turnover in species composition, and an abundant species group. Species richness was correlated with distance from eddy center and assemblages

within eddies were significantly different from surrounding basin and shelf waters. These results suggest that mesoscale eddies propagating along the continental shelf-break influence larval assemblages over the shelf and slope, which has implications for the timing and extent of distribution in the GoA. Reference: Atwood, E., Duffy-Anderson, J.T., Horne, J., and Ladd, C. In review. Influence of mesoscale eddies on ichthyoplankton assemblages in the Gulf of Alaska. *Fish. Oceanogr*.

- A project in progress examines shifts in ichthyoplankton community composition in the EBS in response to environmental variability. Non-metric multidimensional scaling is being used to quantify variability and reduce multi-species abundance data to major modes of species composition. These principle axes are used as the response variable for modeling differences in assemblage structure in space and time and as a function of environmental covariates. Using a generalized additive model, we will describe spatial patterns of variability, test for differences in assemblage structure over time, and identify covariates responsible for the largest fraction of variability in assemblage structure. We hypothesize that observed community level changes in ichthyoplankton composition over time reflect species-specific responses to climate change. Reference: Siddon, E., Duffy-Anderson, J.T., and Mueter, F. Community-level response of ichthyoplankton to environmental variability in the eastern Bering Sea. Western Groundfish Conference. April, 2010. Juneau, AK.

Examining Genetic Stock Structure in NE Pacific Groundfish

Walleye pollock - A survey of amplified fragment length polymorphism (AFLP) was conducted to 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.

Pacific cod - A study of microsatellite DNA variation across the geographic range of cod in North America found a clear genetic isolation-by-distance pattern for coastal populations. Notable exceptions to this pattern were cod 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 coastal cod, 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. 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., Grant, W.S. in review. Multiple ice-age refugia in Pacific cod, *Gadus macrocephalus*. Molecular Ecology.

For further information, contact Dr. Jeff Napp, (206) 526-4148.

2. Stock Assessment

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, provide technical support for the evaluation of potential impacts of proposed fishery management measures, and conduct fishery interaction studies with a focus on Steller sea lion prey species.

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, 6) development of the Arctic Fishery Management Plan, 7) non-target species fishery management, 8) development of the Northern Bering Sea Research Plan, and 8) various task members participated in numerous national and international committees and workshops on a variety of issues.

Highlighted accomplishments in the above areas include: 1) development of age-structured stock assessment models for Bering Sea/Aleutian Islands (BSAI) blackspotted and rougheye rockfish and BSAI Alaska skates, 2) development of an analytical framework to forecast the impact of climate change on fish and shellfish. This method was applied in a case study for BSAI northern rock sole, 3) development of stock projection software to conduct Management Strategy Evaluations for Gulf of Alaska walleye pollock, 4) development of a statistical model of factors influencing the timing and distribution of winter catch of walleye pollock in the eastern Bering Sea, and 5) designing and conducting a nearshore survey of fish habitat in Bristol Bay.

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 species of Steller 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.

3. Management

Economics and Social Science Research Program – REFM

Not yet updated for current year.

For further information or if you have questions about the Economic and Social Sciences Research Program please contact Dr. Ron Felthoven (206)-526-4114.

C. By species, by agency

1. Pacific Cod

a. Research

Juvenile Pacific Cod Nursery and Habitat Study – Kodiak Laboratory and FBE Newport

In 2008, researchers from the Kodiak Laboratory and the Fisheries Behavioral Ecology Program continued studies examining the habitat associations in juvenile Pacific cod in nursery areas around Kodiak Island. One aspect of these studies was to assess the diets of juvenile gadids in the nursery areas in order to quantify their degree of dietary overlap and the extent of cannibalism on younger conspecifics. Juvenile cod (age 1+ Pacific and saffron cod) were collected by hook and line and beach seining at two nursery sites around Kodiak Island, AK during the summer months in 2007 and 2008. To date, a total of 354 juvenile cod (n=260 saffron cod, 17.1-39.0 cm TL; n=94 Pacific cod, 17.4-36.0 cm TL) have been collected. Preliminary results revealed the gadids consumed primarily benthic invertebrates and displayed a high degree of dietary overlap in 2008 (driven mainly by the importance of mysids and amphipods in the diets). Other common prey items included annelids (polychaeta spp.), crangonid shrimps, hermit crabs (Paguridae spp.), and fish (Pacific sand lance, *Ammodytes hexapterus*, Stichaeidae spp., and Cottidae spp.). Pacific cod had a higher rate of piscivory than saffron cod (2007- Pacific cod 16%; saffron cod 3%; 2008- Pacific cod (27%); saffron cod (23%)) although there was no evidence of inter-cohort cannibalism found in 2007 and 2008. A high degree of dietary overlap suggests competition for food resources may occur if food supplies become limited within the nursery areas. However, the diets of the two cod species varied noticeably outside the importance of mysids and amphipods which suggest these species are able to exploit different niches which may reduce competition. Furthermore, differences in the relative importance of secondary prey items (i.e. fish and decapods- Pacific cod *versus* isopods-saffron cod) may reflect small scale differences in habitat use by the juvenile gadids within the nursery areas. Inter-cohort cannibalism does not appear to be a factor affecting cod survival in these areas. However, the abundance of age 0+ cod can fluctuate greatly on a yearly basis within the nursery areas and it is possible that cannibalism is density dependent and is an important function when densities are high. In 2009, an additional 65 juvenile cod samples were collected within and adjacent to the nursery areas. The third year of sampling will allow for the continued assessment of the temporal variations in the food habits of these species.

Juvenile Pacific Cod Movement, Habitat, And Overwintering Study - Kodiak Laboratory

In 2010, researchers from the Kodiak Laboratory will undertake a project examining the seasonal habitat use and over wintering habits of juvenile Pacific cod within nearshore nursery areas of Kodiak Island. Previous investigations conducted by Kodiak Laboratory and Fisheries Behavioral Ecology Program scientists have described the nursery requirements and habitat use of age-0 and age-1+ juvenile Pacific cod during the summer and early fall. The 2010 project is an extension of this work and will focus on examining the habitat use patterns of older juvenile age classes (age 2+) still residing in the nursery areas. The project will test the hypotheses that older juvenile Pacific cod will preferentially utilize bare substrate habitats, show strong site fidelity prior to the winter season, and that their winter migratory behavior will be variable among individuals. Acoustic telemetry and a drop camera system will be used to define the seasonal habitat use and monitor the overwintering habits of juvenile Pacific cod. Active telemetry will be conducted to acquire habitat patch use of individual cod during the summer and fall. Additionally, a continued passive gate telemetry system will be utilized to measure the movement of individual cod outside the nursery habitat into the winter. The combination of acoustic telemetry (both active and passive) and drop camera techniques will allow us to effectively determine the habitat use patterns of older age classes of juvenile Pacific cod. Results of this project will contribute significant knowledge about seasonal habitat use patterns by juvenile Pacific cod. This knowledge will allow us in the future to examine the interaction of older and younger juvenile Pacific cod as well as to understand how habitat use changes throughout the life cycle of this species. Ultimately it is hoped this project will assist researchers in obtaining a more comprehensive understanding of EFH for juvenile Pacific cod which is needed for effective management and conservation of this species.

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

Growth and Condition During Early Life History – RACE FBE Newport

In 2009, the FBEP conducted a series of studies to examine and best quantify growth and condition of Pacific cod during their early life history. The research focused on two separate developmental periods: 1) pelagic larvae (Days 0-30) and 2) settled juveniles (days 180-270). Larval studies were partially supported by NPRB-BSIERP funding and the Auke Bay Laboratory, and focused on critical periods (yolk absorption, flexion) using combined approaches of behavior, starvation trials and RNA/DNA analyses. The goals were to 1) determine whether critical periods exist in the first 30 days of development and 2) groundtruth techniques in the lab so they can be applied to field sampled larvae. Similar approaches were also used for juvenile studies with support from HEPR funding. Using both lab-reared and field-sampled fish, the FBEP groundtruthed modified Fulton's K approaches to determine the degree to which condition is driven by habitat (e.g., inshore vs offshore) or temporal patterns e.g., seasonal and annual variance. Ultimately, the goal will be to determine if patterns in growth and condition of age-0 juvenile cod can be linked with subsequent year class survival and adult recruitment.

In another project, analysis of data from experiments measuring growth rates of fish from three consecutive cohorts (2006-2008) across a range of temperatures indicated temporal instability in the thermal reaction norm for growth. The cold winter and spring of 2007 resulted in the recruitment to Kodiak Island nursery areas of a cohort which grew faster than the other cohorts at low temperatures (2-5°C) but had poor growth and survival at higher temperatures (>12°C). Analysis of vertebral count variation in archived samples of fish from the three cohorts revealed significant differences among the cohorts in mean vertebral counts. The higher mean vertebral counts observed in 2007 are consistent with the phenomenon known in fishes as "Jordan's Rule", or the common observation that low temperature exposure during the egg and early larval stages leads to the development of higher numbers of vertebrae (and sometimes other repeated structural elements, eg. fin rays). Although the mechanism responsible for the observed variation in growth patterns among cohorts could not be unequivocally identified, correlated variation in vertebral counts suggests that a persistent response to environmental history (epigenetic effect) is responsible.

Thermal Effects on Ecology – RACE FBE Newport

Previous experimental work on the effects of temperature on habitat use and behavior of juvenile Pacific cod were supplemented with measures of maximum swimming speeds as a function of temperature. As observed in other fishes, maximum swim speed increased with body size and temperature (2°-9°C). However, analysis of data on routine swim speeds in small groups differed markedly from similar observations made for juvenile walleye pollock. Whereas routine swim speeds in walleye pollock increased at low temperatures (Hurst 2007), swim speeds of Pacific cod decreased at low temperatures. In a separate experiment, we observed that juvenile cod used eelgrass habitat more frequently at high temperatures (9°) than low temperatures (2°) consistent with the observed movement from inshore waters in the fall. These observations on the effects of temperature on the behavior and habitat use are important to understanding the mechanistic links between environmental variability and community dynamics in marine systems.

In a separate experiment, we analyzed the effects of temperature and growth rate on elemental incorporation in to the otoliths of larval Pacific cod. Otolith concentrations of Li, Mg, Ca, Mn, Zn, Sr, and Ba were measured using laser ablation-inductively coupled plasma mass spectrometry. The effects of temperature, somatic growth rate, and otolith precipitation rate on otolith partition coefficients (D_{Me}) varied among elements. D_{Mg} showed no relationship with temperature whereas D_{Sr} and D_{Ba} decreased with increasing temperature. It is possible that, for larval Pacific cod, kinetic effects are more important in the incorporation of Sr and Ba whereas metabolic effects may play a larger role in the incorporation of Mg. There was no evidence for an effect of somatic growth rate or otolith precipitation rate on D_{Me} for any of the elements, which indicates that individual growth variation is unlikely to lead to misinterpretation of field-collected data. Understanding variable relationships among otolith elemental signatures, environmental conditions, and fish physiology can improve the accuracy of interpretations of field data, particularly in marine systems where spatial variation in element concentrations are typically lower than freshwater environments.

b. Stock Assessment

BERING SEA/ALEUTIANS

Relative to last year’s stock assessment, the following changes were made to the input data.

1) Catch data for 1991-2008 were updated, and preliminary catch data for 2009 were incorporated.
2) Commercial fishery size composition data for 2008 were updated, and preliminary size composition data from the 2009 commercial fisheries were incorporated.
3) Size composition data from the 2009 EBS shelf bottom trawl survey were incorporated.
4) The numeric abundance estimate from the 2009 EBS shelf bottom trawl survey was incorporated (the 2009 estimate of 717 million fish was up about 50% from the 2008 estimate).
5) Age composition data from the 2008 EBS shelf bottom trawl survey were incorporated into some of the models.
6) Age composition data from the 2008 January-May longline fishery were incorporated into some of the models.
7) Mean length at age data from the 1994-2008 EBS shelf bottom trawl surveys were incorporated into some of the models.
8) Mean length at age data from the 2008 January-May longline fishery were incorporated into some of the models.

9) The variances in the ageing error matrix were updated in all of the models that use age data, and possible biases in age data were corrected for in some of the models that use age data.
10) Seasonal catch per unit effort (CPUE) data for the trawl, longline, and pot fisheries from 2008 were updated, and preliminary catch rates for the trawl, longline, and pot fisheries from 2009 were incorporated.
11) The Pacific cod catch rate from the 2008 International Pacific Halibut Commission (IPHC) longline survey was incorporated.
12) Pacific cod size composition data from the 2009 IPHC longline survey were incorporated.

The assessment of the BSAI Pacific cod stock has gone through a series of changes in the last few years. A major change took place in 2005 when the model was migrated to the Stock Synthesis 2 program. Difficulties encountered in the 2006 assessment resulted in a thorough review of various assessment models in April 2007 during a public workshop. Many suggestions for changes and refinements of the analytical approaches were made. Refinements continued in the 2007, 2008, and 2009 assessment cycles based on suggestions from the plan teams, SSC, and the public.

The accuracy of age readings for this stock has been a continuing concern in this assessment. The chief symptom of the problem is the lack of agreement between the first few well-defined modes of the survey length compositions and the mean lengths at ages 1-2-3 based on age readings. At the September 2009 team meeting Tom Helser, NMFS Alaska Fisheries Science Center, presented some age reading data and analysis that, while not conclusive, suggested greater uncertainty about the age readings. The team minutes from September recommended attempting bias correction within the assessment as a short-term remedy. The minutes also recommended attempting to estimate a growth schedule for each cohort rather than a single schedule.

Three groups of models were presented at the November meeting. The first group (Models A1, A2, and A3) fitted the chosen 2008 model to different data sets. The features of these models, which had evolved over the course of the last two assessment cycles, are: fixed natural mortality rate M=0.34, double normal selectivity functions with freely estimated parameters except for some fisheries that are required to be asymptotic, selectivity parameters estimated for blocks of years where appropriate, trawl survey catchability estimated, mean and standard deviation of length at age estimated internally. Model A1 was fitted using all available age composition data, Model A2 using only length composition data, and Model A3 using all available age data except readings from the 2008 January-May longline fishery. These were the first readings of otoliths from the commercial fishery (all other age data are from the trawl survey), and they showed a highly anomalous abundance of one age group.

The second group of models (Model B1 and its variants) used all available age data and implemented several recommendations while maintaining almost all features of the base model A1. First, a bias term of 0.4 years at all ages was added to the internal ageing error matrix. This value was found in trials to improve the likelihood most. Second, cohort-specific growth was estimated. This required using external estimates of mean length at age estimated from the biased age readings, with the bias accounted for by the ageing error matrix. Third, the product of survey catchability and selectivity averaged over the 60-81 cm length range was required to equal 0.47, based on archival tag data on vertical distribution. This feature has the effect of pegging the abundance estimates to the trawl survey results, at least for this length group. Fourth, no selectivity deviations were estimated for the last two surveys, so those schedules used the expected values. Fifth, the standard deviation of length at age was estimated externally to avoid the somewhat perverse internal estimates located by the minimizer.

Model D1 was the same as Model B1 except that it does not estimate selectivity at maximum age or length as a parameter of the double normal selectivity; instead this value is determined by the right-side mean and variance parameters. In Model E1 this value is required to be the same for all fleets. In Model G1 no survey selectivity deviations are estimated, so a single survey selectivity is estimated and applied in all years. All of these variants were requested of the author by various reviewers.

The last group of models (Models B2, D2, E2 and G2) were fitted to length composition data only. In addition there was a length-based model named F2 proposed by members of the public in 2007, 2008, and 2009 that differed from Models A2 and B2 in a number of ways. It made trawl survey selectivity asymptotic and estimated natural mortality internally (M=0.48).

All of the models fitted the data adequately. The authors' recommended model was B1, chosen because it achieved the best fit among all the models that made use of the age data and implemented the recommended changes. A majority of the Plan team also preferred Model B1, and for the same reasons. A minority, concerned about the age data and skeptical of the bias correction applied in Model B1 (and even in Model B2 for the purpose of fitting mean length at age), favored Model A2.

The estimate of 2010 spawning biomass from Model B1 is 345,000 t, projected to rise to 370,000 t in 2011, while $B_{40\%}$ is 411,000 t. The 2009 catch was well below OFL. The stock is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

The 2008 year class, which has been observed only once, appears to be extremely large, although this estimate is accompanied by a large confidence interval. The 2006 year class, which appeared exceptionally strong in the 2007 survey, still appears to be above average. However, the 2006 year class follows a string of five consecutive sub-par year classes spawned from 2001-2005.

According to criteria set by the SSC, this stock qualifies for management under Tier 3, where reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for the stock. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 411,000 t, 0.29, and 0.35, respectively. Pacific cod specifically qualifies for management under sub-tier "b" of Tier 3 because the projected biomass for 2010 is below $B_{40\%}$. Fishing at the adjusted Tier 3b rate of 0.24 is projected to result in a 2010 catch of 174,000 t, which is the maximum permissible ABC under Amendment 56.

The Plan Team recommends setting the 2010 ABC at 174,000 t, which is the maximum permissible. ABC is projected to increase to 214,000 t in 2011. The corresponding OFL levels under Tier 3b (F_{OFL}=0.29) are 205,000 t and 251,000, respectively.

GULF OF ALASKA

Relative to the 2008 stock assessment, the following input values were updated for 2009.
1) Catch data for 1991-2008 were updated, and preliminary catch data for 2009 were incorporated.

2) Commercial fishery size composition data for 2008 were updated, and preliminary size composition data from the 2009 commercial fisheries were incorporated.
3) Age composition and mean-length-at-age data from the 2007 bottom trawl survey were incorporated into some models.
4) Age composition data from the 2008 January-May longline fishery were incorporated into some of the models.
5) Mean length at age data from the 2008 January-May longline fishery were incorporated into some of the models.
6) Size composition data from the 2009 bottom trawl survey were incorporated.
7) The numeric abundance estimate from the 2009 EBS bottom trawl survey was incorporated (the 2009 estimate of 574 million fish was up about 199% from the 2007 estimate).
8) The variances in the ageing error matrix were updated in all of the models that use age data, and possible biases in age data were corrected for in some of the models that use age data.
9) Seasonal catch per unit effort (CPUE) data for the trawl, longline, and pot fisheries from 2008 were updated, and preliminary catch rates for the trawl, longline, and pot fisheries from 2009 were incorporated.

Ten models were included in the GOA Pacific cod assessment which addresses many of the comments and requests from the Plan Teams, SSC, and the public. The models were divided into three groups. The first group contained four models, each of which used the analytical model accepted for GOA Pacific cod in 2008 but differed in the data applied to the model. Each of the four models in this group drastically down-weighted the age composition data, and in one case removed it entirely. A second group contained three models that included the age composition data and included features such as cohort-specific growth and attempted to correct for potential bias in age readings. A final group of models contained a set of three models which omitted age composition data but were otherwise identical to the models in the second group.

The authors' criteria for selecting the final model considered: 1) the inclusion of age composition data (which has been consistently been requested by the Plan Team and SSC); 2) the response to requests such as the correction of age reading bias and cohort-specific growth; and 3) the best statistical fit to the data. Based on these criteria, the model with the best statistical fit from the second group (model "B1") was chosen as the preferred model. This model included mean length at age values as input data to the model, and estimates the standard deviation of length at age for the maximum and minimum ages outside the model (the modeling software only allows a linear relationship between the maximum and minimum ages). The model provided several improvements to the 2008 model, notably in the improvement of the fit to the survey abundance.

The authors' procedure to correct for the perceived age reading bias was to use a constant bias (across ages) that gave the best model fit; thus, the age reading bias was estimated within the model. It was unclear that the age reading bias was truly constant across ages, or if this bias could have been reasonably estimated within the model. By simultaneously estimating this bias with all other model parameters, it may have been that the age bias matrix affected related parameters in complex ways. Thus, any improvement in model fit may result not simply from correcting an age reading bias, but also from other features of the model fit that are difficult to interpret. A more straightforward method of estimating age reading bias would be to obtain age readings of known age fish. The assessment would benefit from continued research on age validation and on age-determination errors and potential biases. All of the GOA models presented used age information in some manner, either in the age composition data or in the length at age data. Thus, although there may be concerns about the quality of the age readings, a model that is truly free of age readings is not presently available. The Plan Team was concerned about the ad-hoc procedure used to account for age reading bias but accepted it as a reasonable short-term measure until data becomes available to estimate the bias more reliably (i.e., outside the model).

Model B1 results produced an estimated 2010 spawning biomass of 117,600 t, or 40% of the unfished spawning biomass. The $B_{40\%}$ estimate was 116,600 t. The estimated stock biomass increased relative to the 2008 assessment, due in part to a large biomass estimate in the 2009 GOA trawl survey. Spawning biomass is projected to increase dramatically in subsequent years due to a number of young year classes in the population.

Pacific cod are not overfished nor are they approaching an overfished condition. Catches remain well below levels where overfishing would be a concern. The Plan Team accepted the author's preferred model and therefore recommended Tier 3 for this stock. The model estimate of 2010 spawning biomass exceeds $B_{40\%}$, thus Gulf of Alaska Pacific cod are in Tier 3a, which is a change from the 2008 assessment when Pacific cod were classified in Tier 3b. The projected 2010 age-0+ biomass estimate is 738,300 t. The probability of the stock being below $B_{20\%}$ was estimated to be less than 1% in 2010 and subsequent years. Using the author's recommendation to use the maximum permissible F value from Tier 3a, the ABC for 2010 is 79,100 t (F_{ABC} =0.49). The 2010 OFL under Tier 3a is 94,100 t (F_{OFL} = 0.60).

For further information, contact Dr. Grant Thompson at (541) 737-9318.

2. Nearshore Rockfish

a. Research

GULF OF ALASKA

Dark Rockfish Mortality Study – Kodiak Laboratory

Accurate natural mortality estimates derived from life history parameters of unexploited fish populations are difficult to obtain, especially for species from the genus *Sebastes*. The objective of this research was to provide growth and natural mortality estimates of an unexploited population of dark rockfish (*Sebastes ciliatus)* from the western Gulf of Alaska. Based on information obtained from Alaska Department of Fish and Game fish tickets and historical knowledge of the fishing effort in the study area, the dark rockfish population was unexploited at the time of the study. A total of 242 males and 553 females with sizes ranging from 160 to 490 mm FL were caught in August 2001 and July 2002 using commercial jig fishing gear. Maximum observed age was 75 years for males and 61 years for females. The von Bertalanffy growth parameter estimates were: L_∞ = 401 mm, k = 0.297, t_0 = 2.19 for males and L_∞ = 435 mm, k = 0.195, t_0 = 0.84 for females. The annual instantaneous rate of natural mortality rate (M) was estimated to be 0.062 for males and 0.073 for females.

For further information contact Elizabeth Chilton (907) 481-1725.

3. Shelf Rockfish

b. Research

GULF OF ALASKA

Dusky Rockfish Maturity Study – Kodiak Laboratory

Dusky rockfish (*Sebastes variabilis*) has recently been resurrected as a distinct species in the genus *Sebastes*. Reproductive biology and growth were examined for this redescribed species in the central Gulf of Alaska. Prior to this research study, estimates of the size and age at 50% maturity for this species were based on visual observations of gonad maturity taken from a limited sample collection. In order to improve these estimates for the stock assessment and fishery evaluation report, this study determined the maturity stage of female dusky rockfish at the histological level from samples collected over a two year period. Dusky rockfish age and length at 50% maturity are 9.2 years and 365 mm fork length, respectively, which are lower than previously reported. Fertilized ova and eyed embryos were observed in April while evidence of post-parturition was not observed until May. The gonadosomatic index decreased with the onset of post-parturition in May. Von Bertalanffy growth parameters of female dusky rockfish estimated from the maturity samples were L_∞=449 mm, k=0.219, and t_0=0.855 and significantly different than the growth parameters derived from Gulf of Alaska fishery-independent survey data of L_∞=480 mm, k=0.211, and t_0=1.106 (X^2=158.8, df =3, P<0.001).

For further information please contact Elizabeth Chilton (907) 481-1725.

Maternal Age Effects on Larval Viability - Southeast Alaska Rockfish

Rockfish larvae contain an oil globule during embryonic development and at parturition that contains energy for growth and metabolic needs during development and the critical stage when larvae are first learning to feed. The size of this oil globule has been shown to be related to growth and survival of some rockfish larvae based on collections off Oregon and California. The oil globule size, and therefore the survival rate, was also related to the age of the mother in black rockfish (Berkeley et al. 2004). If older rockfish mothers have more fit offspring than younger mothers, stock assessments should be modified to reflect this difference in recruitment. Quillback rockfish larvae were sampled in 2006-2008 in southeast Alaska for analyses of effects of maternal age on maturation timing and larval quality. A paper describing the results is currently in preparation. The major findings are that maternal age is not related to oil globule size; however, it is related to maturation timing, with older mothers spawning earlier in the spring. Additionally, broods from twenty-five pregnant quillback rockfish were analyzed for multiple paternity, and many were found to have larvae from multiple fathers. Multiple paternity was not related to the age of the female, but may be related to the size. These projects are completed and the data are currently being analyzed and organized into manuscripts.

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b. Stock Assessment

GULF OF ALASKA

Pelagic shelf rockfish – ABL

The pelagic shelf rockfish assemblage in the Gulf of Alaska is comprised of three species: dusky rockfish (*Sebastes variabilis*), yellowtail rockfish (*S. flavidus*), and widow rockfish (*S. entomelas*). This assemblage is 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. However, in April 1998, a NPFMC Gulf of Alaska Fishery Management Plan amendment went into effect that 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.

Gulf-wide, dusky rockfish are the most abundant species in the assemblage, whereas yellowtail and widow rockfish make up a very small proportion of the biomass in Alaska waters. Dusky rockfish have one of the most northerly distributions of all rockfish species in the Pacific. They range from southern British Columbia north to the Bering Sea and west to Hokkaido Is., Japan, but appear to be abundant only in the Gulf of Alaska (GOA).

Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the AFSC biennial trawl surveys in this region. In 2009, a trawl survey was conducted in the GOA, and a full assessment was done for pelagic shelf rockfish. We continue to recommend using the average of exploitable biomass from the three most recent trawl surveys to determine the recommended ABC for widow and yellowtail rockfish. For dusky rockfish, the age-structured model used previously was updated with the most recent data and altered slightly by splitting fishery catch into two time periods (1977-1990 and 1991-2009) and reducing the model weight on the earlier time period. Implementing this change resulted in an improved model fit to fishery catch.

For the pelagic shelf rockfish assemblage, ABC and OFL for dusky rockfish are combined with the ABC and OFL for widow and yellowtail rockfish. For the 2010 GOA fishery, we recommend a maximum allowable ABC for the pelagic shelf rockfish of 5,059 mt. This ABC is similar but slightly lower than last year's ABC of 5,231 mt. The stock is not overfished, nor is it approaching overfishing status.

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4. Slope Rockfish

a. Research

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

GULF OF ALASKA

Rockfish Reproductive Study – Kodiak Laboratory

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, northern rockfish, the rougheye rockfish complex (rougheye and blackspotted rockfish), shortraker rockfish and other members of the slope complex. Scientists from the Kodiak Laboratory have been working with NMFS North Pacific groundfish observers stationed at the fish processors in Kodiak to obtain rockfish samples. This collection request began in February 2009 and will continue until the end of 2011 but it is anticipated that most samples will be obtained during the Rockfish Pilot Program in the months of May through November. In addition, on-going sampling requests have been submitted to the Alaska Department of Fish and Game large and small mesh surveys occurring in September and October, MACE acoustic surveys occurring in February and March, and the RACE Gulf of Alaska survey occurring during the summer months of 2009. Additional funds were obtained from the National Cooperative Research Program to fund a charter during November 2009, December 2009, and January 2010. During this charter Pacific ocean perch, rougheye, blackspotted, shortraker, northern and dusky rockfish samples were collected. It is anticipated that this research will not only enable scientists to derive reproductive parameter estimates needed for stock assessment but to examine these parameters over a number years to assess variability and causes of variability in these parameters. During the upcoming year studies on the reproductive biology of Pacific ocean perch and rougheye rockfish will be completed. During 2011 it is anticipated studies on the reproductive biology of blackspotted and shortraker rockfish will be completed.

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

Experimental Trawl/Acoustic Survey for Rockfish

Scientists from ABL, REFM and RACE divisions of the Alaska Fisheries Science Center have been collaborating on a joint North Pacific Research Board grant to investigate new rockfish survey designs. The project objective was to evaluate an experimental survey design (TAPAS, Trawl Acoustic Presence Absence Survey) to reduce the variability in estimated biomass for Pacific ocean perch (POP). The design is a variant of adaptive sampling and uses acoustic information to distinguish strata of different densities. In addition to planned trawl stations, additional trawl tows are conducted in high density fish areas identified during the cruise. The rationale of the design is to reduce sampling variability by allocating more sampling effort in the areas of higher fish density. Reducing the uncertainty of biomass estimates for rockfish with patchy distributions has been identified as an assessment and management priority.

First, we analyzed historical acoustic data from NMFS trawl surveys to identify a threshold to define high density rockfish patches. We then used these results to conduct simulation studies to determine when the TAPAS design was most efficient. These simulations were used to design a field application of the design.

From August 2-13, 2009, we chartered the F/V *Sea Storm* to field test our sampling design ideas. Fifty-nine tows were completed (40 background and 19 patch tows). In practical terms, the design and sampling algorithm worked well in the field. However, the results of the field study showed little gains in precision over simple random sampling (assuming the same total sample size). Bootstrap results indicate that the published estimator for the biomass variance for TAPAS may be biased. Increases in precision for TAPAS were hindered by a weak relationship between the localized acoustic signals and CPUE, and relatively low variance in the background stations. Patches also were sometimes ephemeral, and when returning to tow a station, the hydroacoustic signal had diminished. Further analysis will evaluate the performance of the survey design with respect to the variance of biomass estimates under alternative definitions of patch areas. The patch definition for rockfish may benefit from utilizing acoustic variance in addition to the mean to differentiate from other species.

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Catch Efficiency of Longlines for Shortraker and Rougheye Rockfish in Alaska

Demersal rockfish of the family *Sebastes* can be difficult to assess with bottom trawl gear because they may inhabit untrawlable rocky habitats. In contrast, longline gear can often be successfully fished in these areas; however, many factors can affect longline catch rates besides fish density. In field studies conducted in 1994 and 1997 at 19 sites off Southeast Alaska, comparative data were collected on longline catch rates of shortraker (*Sebastes borealis*) and rougheye rockfish (*Sebastes aleutianus*) and on fish densities calculated from observations from a manned submersible. The purpose of these studies was to estimate the catchability coefficient of these two species on longline gear. On separate occasions, rockfish behavior in the presence of longline gear was observed from the submersible. Understanding the behavior of these rockfish in the presence of longline gear will guide the application of their catch rates in stock assessments. Although the data were collected more than 10 years ago, analysis of these data was just initiated this year, and a manuscript is being prepared.

Densities of shortraker rockfish based on observations from the submersible varied from 0 to 6,813 fish per square kilometer (mean of all sites = 2,709, S.D. = 3,095, n = 19). Densities of rougheye rockfish varied from 0 to 11,102 fish per square km (mean of all sites = 5,170, S.D. among sites = 5,416, n = 19). For shortraker rockfish, the linear regression of density and catch rate was not significant (F-ratio = 0.562, r = 0.423, p-value = 0.464). Rougheye rockfish catch rate was also not related to density at an α of 0.05, but was at an α of 0.1 (F-ratio = 3.085, r = 0.626, p-value = 0.097). The non-significance could be due to sample sizes, clumped distributions, or rockfish behavior on longline gear.

On dives where rockfish were observed during a longline set, the number of free-swimming fish increased throughout a set at a quicker rate than fish were caught. Shortraker and rougheye rockfish were attracted to the longline but many were not being caught even when baited hooks were available. We may have detected this trend because we did not observe the longline for a long enough period, or because rockfish are out-competed by other bait predators. Despite not knowing the cause of the reluctance of shortraker and rougheye rockfish to bite a baited hook, this behavior may affect the relationship between longline CPUE and density. We continue to analyze these data and interpret the appropriateness of longline gear as an index of abundance for shortraker and rougheye rockfish.

For more information, contact Cara Rodgveller at (907) 789-6052.

Rockfish Reproductive Study

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, northern rockfish, the rougheye rockfish complex (rougheye and blackspotted rockfish), shortraker rockfish and other members of the slope complex. Scientists from the Kodiak Laboratory have been working with NMFS North Pacific groundfish observers stationed at the fish processors in Kodiak to obtain rockfish samples. This collection request began in February 2009 and will continue throughout the remainder of the year but it is anticipated that most samples will be obtained during the Rockfish Pilot Program in the months of May through November. In addition, sampling requests have been submitted to the Alaska Department of Fish and Game large and small mesh surveys occurring in September and October, MACE acoustic surveys occurring in February and March, and the RACE Gulf of Alaska survey occurring during the summer months of 2009. Additional funds have been obtained from the National Cooperative Research Program to fund a charter within the winter months. This will enable scientists to obtain rockfish samples during the period of the year when no directed fisheries or survey work are occurring. It is anticipated that this research will not only enable scientists to derive reproductive parameter estimates needed for stock assessment but to examine these parameters over a number years to assess variability and causes of variability in these parameters.

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

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS

Pacific ocean perch (POP) – Beginning in 2005, Pacific ocean perch assessments are conducted on a two year cycle to coincide with planned Aleutian Islands surveys. There has not been a new survey since 2006. Catch data were updated and the projection model was run using results from the 2008 assessment model as the starting point.

Age 3+ biomass for 2010 is up slightly from 2009. According to last year's assessment, spawning biomass has trended slightly downward since 2002. Spawning biomass is projected to be 133,000 t in 2010 and decline slightly to 131,000 t in 2011.

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 123,000 t, 0.057, and 0.068 respectively. There are reliable estimates of the 2010 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$; and $B>B_{40\%}$ (133,000 t > 123,000 t). Therefore the POP reference fishing mortality is defined in Tier 3a. For this tier, F_{ABC} is constrained to be $\leq F_{40\%}$, and F_{OFL} is constrained to be equal to $F_{35\%}$. The 2010 and 2011 ABCs associated with the $F_{40\%}$ level of 0.057 are 18,860 t and 18,680 t, respectively, which are the Plan Team's recommended values. The 2010 and 2011 OFLs under Tier 3a are 22,400 t and 22,200 t, respectively.

ABCs are set regionally based on the proportions in combined survey biomass. For 2010, this procedure apportions the ABC as follows: BS = 3,830 t, Eastern Aleutians (Area 541) = 4,220 t, Central Aleutians (Area 542) = 4,270 t, Western Aleutians (Area 543) = 6,540 t. For 2011, the same procedure apportions the ABC as follows: BS = 3,790 t, Eastern Aleutians (Area 541) = 4,180 t, Central Aleutians (Area 542) = 4,230 t, Western Aleutians (Area 543) = 6,480 t. The OFL is not regionally apportioned.

Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Northern rockfish - Beginning in 2005, northern rockfish assessments are being conducted on a two year cycle to coincide with planned Aleutian Islands surveys. There has not been a new survey since 2006. Catch data were updated and the projection model was run using results from the 2008 assessment model as the starting point.

Age 3+ biomass has been on an upward trend since 2002. According to last year's assessment, spawning biomass has been increasing slowly since 1977. Spawning biomass is projected to be 69,300 t in 2010.

The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for B40% (55,300 t), F40% (0.043), and F35% (0.051). Because the female spawning biomass of 69,300 t is greater than B40%, sub-tier "a" is applicable, with maximum permissible FABC =F40% and FOFL =F35%. Under Tier 3a, the maximum permissible ABC is 7,240 t, which is the recommendation for the 2010 ABC. Under Tier 3a, the 2010 OFL is 8,640 t for the Bering Sea/Aleutian Islands combined. A combined ABC and OFL are again set for the Bering Sea and Aleutian Islands in 2010. As the catch has routinely been lower than the ABC, a catch of 4,500 t was assumed as the 2010 catch, in order to make projections to 2011. The recommended ABC and OFL for 2011 are 7,290 t and 8,700 t, respectively.

Model projections indicate that this stock is neither overfished nor approaching an overfished condition. Estimation of the probability that the stock will fall below *B20%* within 3-5 years will be addressed in the next full assessment.

Shortraker/rougheye rockfish - The shortraker rockfish assessment was separated from the blackspotted and rougheye rockfish complex in 2008. Prior to 2008, shortraker and rougheye rockfish were assessed with a two-species surplus production model that accounted for potential covariance in catch estimates. The 2008 assessment applied a single-species surplus production model to BSAI shortraker rockfish.

Beginning in 2005, rockfish assessments are being conducted on a two year cycle to coincide with planned Aleutian Islands surveys. However, there has not been a new survey since 2006. Since shortraker rockfish are in Tier 5 and there has been no new survey biomass estimate, the results are the same as in 2008.

Shortraker rockfish survey biomass is 17,200 t, which is the same as the 2008 assessment. In last year's assessment, total biomass was estimated to have trended slowly downward since 1984.

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 the surplus production model. At the present time, the Plan Team and SSC recommend that Tier 5 management is retained for these stocks. ABC is therefore set at the maximum permissible level (F_{ABC}) under Tier 5, which is 75% of *M*. The accepted value of *M* for these stocks is 0.030 for shortraker rockfish, resulting in an FABC value of 0.023.

The biomass estimate for 2010 is 17,200 t for shortraker rockfish, leading to a BSAI OFL of 516 t and an ABC of 387 t. It is not possible to determine whether these species are overfished or whether they are approaching an overfished condition because they are managed under Tier 5.

Blackspotted/rougheye rockfish complex - Fish previously referred to as rougheye rockfish are now recognized as consisting of two species, the rougheye rockfish (*Sebatses aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*). The blackspotted and rougheye complex assessment was separated from shortraker rockfish and assessed with an age-structured model in 2008.

Beginning in 2005, rockfish assessments are being conducted on a two year cycle to coincide with planned Aleutian Islands surveys. There has not been a new survey since 2006. Catch data were updated and the projection model was run using results from the 2008 assessment model as the starting point.

Total biomass for 2010 was estimated at a value of 21,200 t, up slightly from 2009. In last year's assessment, spawning biomass was estimated to have trended slowly upward since 1998, but was projected to decline slightly after 2009. Projected spawning biomass for 2010 (AI only) is 6,570 t.

The Plan Team and SSC recommended that 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 6,570 t is less than $B_{40\%}$, (6,720 t, AI only), sub-tier "b" would be applicable, with an adjusted $F_{40\%}$=maxF_{ABC} =0.039 and an adjusted F35% = F_{OFL} = 0.047. Under Tier 3b, the maximum permissible ABC is 547 t (EBS and AI combined), which is the recommended 2010 ABC. Under Tier 3b, the 2010 OFL is 669 t for the Bering Sea/Aleutian Islands combined. The Plan Team continues to recommend setting a combined BSAI OFL and ABC. Since the catch has routinely been lower than the ABC, the catch of the previous year was assumed as the 2010 catch, in order to make projections to 2011. The recommended ABC and OFL for 2011 are 531 t and 650, respectively (both values are BSAI-wide). Model projections indicate that this stock complex is neither overfished nor approaching an overfished condition.

The assessment authors also responded to an SSC request to consider the implications of adopting area-specific ABCs for this stock complex. The age-structured assessment model for blackspotted/rougheye was first accepted by the BSAI Plan Team in 2008. At that time, the ABCs which would result from a single BSAI model as well as an AI-only model were presented, as well as information on stock structure and a comparison of potential area-specific ABCs to recent area-specific catches. More progress has been made on the issue of stock structure in 2009, including: 1) a symposium at the February, 2009 SSC meeting on genetic techniques pertaining to stock structure; 2) the formation of an SSC-Plan Team working group charged with developing guidelines for determining stock structure; and 3) the presentation of the report of the working group at the September, 2009 Plan Team meeting. The working group report identified various types of data to be considered when evaluating stock structure. The current status is that the template outlined in the working group report will be applied to BSAI blackspotted/rougheye and presented to the Plan Team in September, 2010.

Other Rockfish Complex - The BSAI "Other Rockfish" are also managed on a two year cycle to coincide with years when an Aleutian Islands survey is conducted. The BSAI "other rockfish" assessment considers the eight species that have been caught at least once during AFSC research surveys or appeared in more than 1% of observed fishery hauls between 1990 and 2001. The 2008 Eastern Bering Sea Slope survey data are included in this year's assessment. Catches in 2008 have been revised and the 2009 catch has been included. Separate estimates of natural mortality (M) and biomass for shortspine thornyheads (SST; M=0.03), the most common species in the other rockfish complex, and the remaining species (M=0.09 based on dusky rockfish) in the complex were used.

Since there has not been a new Aleutian Islands survey since 2006, the assessment results are the same as in 2009. Trends in spawning biomass are unknown. Stock biomass, as measured by trawl surveys of the EBS slope is the same as in 2008.

The recommended approach for setting FABC is using the maximum allowable catch under Tier 5 ($F_{ABC} = 0.75 \times M$). Multiplying these rates with the best estimates of SST and other "other rockfish" biomass yields 2008 ABCs of 481 t in the EBS and 554 t in the AI. The 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 1,380 t for 2010 and 2011.

As a Tier 5 complex, it is not possible to determine whether "other rockfish" are overfished or approaching an overfished condition.

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

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Pacific Ocean Perch - 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 2008's assessment for the 2009 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 2009), we run a full assessment with all new survey and fishery data accumulated since the last full assessment. A new analysis was conducted in the full assessment this year in which changes in fishery patterns were examined. Overall, the analysis showed that the fishery has changed over time, moving to shallower depths and areas closer to port. The fishery is now being prosecuted over a longer period of time since the implementation of the GOA Rockfish Pilot Project. We made changes to fishery selectivity and estimated three time blocks based on changes from large factory trawlers to smaller catcher boats. For the 2010 fishery, we recommended the maximum allowable ABC of 17,584 t from the revised model. This ABC is a 16% increase from last year's ABC of 15,111 t. This increase was attributed to a lower catchability parameter, not the change in recommended fishing mortality from 0.06 to 0.12. The change in the recommended fishing mortality rate is due to different fishery selectivity. While fishing will be taking place at a higher rate for a section of the population, fishing mortality is much lower in the older years of the population due to the dome-shaped nature of the current selectivity curve. The stock is not overfished, nor is it approaching overfishing status.

For more information contact Dana Hanselman at (907) 789-6054, dana.hanselman@noaa.gov.

Northern Rockfish - Northern rockfish is the second most abundant slope rockfish in the Gulf of Alaska. 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 2008's assessment for the 2009 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 2009), we run a full assessment with all new survey and fishery data accumulated since the last full assessment. The main change for the 2009 assessment model was a consistent method of assigning year-specific likelihood weights. Because of sparse biological sampling for northern rockfish, the new method combined both the number of hauls and the number of samples. For 2010, we recommended an ABC of 5,100 t, the maximum allowable ABC. This ABC is 17% higher than the 2009 ABC. Northern rockfish is not subjected to overfishing, is not currently overfished, and is not approaching a condition of overfishing.

For more information, contact Jon Heifetz at (907) 789-6054, jon.heifetz@noaa.gov.

Rougheye and Blackspotted Rockfish - A separable age-structured model is the primary assessment tool for Gulf of Alaska rougheye and blackspotted rockfish. This consists of an assessment model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model which uses results from the assessment model to predict future population estimates and recommended harvest levels. For Gulf of Alaska rockfish in alternate (even) years we present an executive summary to recommend harvest levels for the next (odd) year.

Orr and Hawkins (2008) formally verified the presence of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*), in what was once considered a single variable species with light and dark color morphs. Hereafter we refer to these two species together as the rougheye rockfish complex. A new at-sea field identification pamphlet was prepared and will be tested with genetic samples in the 2009 NMFS groundfish trawl survey to determine whether rapid and accurate identification of the two species can occur.

When observers and survey biologists can reliably identify both species, we can begin to develop a rationale for mixed species assessments and the potential implications for overfishing a weaker stock. We are also beginning to examine whether differences in life history characteristics (e.g., age and growth) exist for the two species. When combined with accurate species-specific catch and survey data, such information will help determine whether one species is a weaker stock and has a potential for overfishing.

The 2009 assessment methodology was very similar to the 2007 model. Results from a previous sensitivity analysis were incorporated to improve model stability. For the 2010 fishery, we recommended the maximum allowable ABC of 1,302 t. This is a 1.4 % increase from last year's ABC of 1,284 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. Female spawning biomass is well above target levels, with projected spawning biomass stable. The stock is not overfished, nor is it approaching overfishing status.

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

Shortraker and Other Slope Rockfish - Shortraker rockfish and "other slope rockfish" are distinct management categories in the Gulf of Alaska (GOA), but their assessments are presented in a combined report because both assessments are based on biomass estimates from trawl surveys, instead of modeling. "Other slope rockfish" are comprised primarily of sharpchin, harlequin, silvergray, and redstripe rockfish, plus a number of minor species. 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 2009, and therefore a full assessment was completed in fall 2009 for shortraker rockfish and "other slope rockfish". As in previous assessments since 1994, an average of the Gulf-wide biomass from the three most recent trawl surveys (presently the 2005, 2007, and 2009 surveys) was used to determine current exploitable biomass. This results in an exploitable biomass of 40,626 mt for shortraker rockfish and 76,867 mt for "other slope rockfish". Applying either an F=0.75M or an $F=F_{40\%}$ rate (depending on the species) to these values of exploitable biomass results in recommended ABCs for the Gulf of Alaska in 2010 and 2011 of 914 mt for shortraker rockfish and 3,749 mt for "other slope rockfish". Compared with ABCs in 2008 and 2009, this is a slight increase for shortraker rockfish, but a 13% decrease for "other slope rockfish". Much of this decrease for "other slope rockfish" is attributable to the low biomass for silvergray rockfish in the 2009 trawl survey. Neither shortraker rockfish nor "other slope rockfish" is considered overfished in the Gulf of Alaska, and neither is approaching overfishing status. Gulfwide catch of shortraker rockfish was 598 mt in 2008, and estimated catch in 2009 was 535 mt. Gulfwide catch of "other slope rockfish" in 2008 was 809 mt, and estimated catch in 2009 was 846 mt.

Shortraker rockfish have long been considered one of the most difficult rockfish species to age. In 2005, the AFSC REFM Division's Age and Growth Task developed a new, experimental technique for ageing otoliths of this species. However, a 2008 validation study (based on carbon 14 levels in the otoliths) of the shortraker ageing method was not successful. Thus, alternative validation techniques will be necessary to verify the ageing methodology. Because of the lack of direct validation for the ageing method, and the consequent uncertainty about the ages, production ageing for shortraker rockfish has now been put on hold. Although we hope to move to an age-structured assessment for shortraker rockfish at some time in the future, better validation of the shortraker rockfish ageing methodology is needed before we do so.

For more information contact Dave Clausen at (907) 789-6049, dave.clausen@noaa.gov.

1. **Thornyheads**

b. Stock Assessment

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Thornyheads continue to be on a biennial stock assessment schedule to coincide with the timing of the NMFS trawl survey data. New assessment information includes updated biomass and length compositions from the 2009 NMFS trawl survey data, total catch weight for 2007, 2008 and partial 2009 data and length composition from the 2007 and 2008 longline fisheries. Additionally, Relative Population Numbers (RPN's) and weight and size composition from the AFSC 2008 and 2009 longline surveys were included.

Estimates of spawning biomass are not available for thornyheads since they are assessed under Tier 5. Thornyhead biomass from the 2009 GOA trawl survey showed a decline of 9% relative to the 2007 survey results. However, most of this decrease was observed in the central GOA with a decrease of 24%. Biomass increased by 54% and 10% in the Western and Eastern Gulf areas, respectively.

Thornyhead rockfish are in Tier 5 and will likely remain there until such time as satisfactory age data can be generated and an age structured model can be developed. Age assessment is currently hampered by insufficient age data for this species; two recent studies showed widely variable maximum ages of 115 and 150 years, highlighting the difficulty in ageing thornyheads. It is possible that production ageing could occur, but only for individuals younger than 10 years of age. An average natural mortality (M) of 0.03 is used in this assessment as it is currently considered the best estimate based on the age data available.

The 2010 ABC recommendation from the current assessment (where F_{ABC} =0.0225) is 1,770 t and the OFL (F_{OFL} =0.03) is 2,360 t. Information is insufficient to determine stock status relative to overfished criteria. Catch levels for this remain below the TAC and below levels where overfishing would be a concern.

For shortspine thornyhead (and a number of other species), it is critically important to the assessment that the GOA trawl surveys continue and that they extend to 500m in order to cover the range of primary habitat for this (and other) species.

An examination of the trophic relationships of shortspine thornyheads suggests that the direct effects of fishing on the population are likely to be the major ecosystem factors to monitor for this species, because fishing is the dominant source of mortality for shortspine thornyheads in the Gulf of Alaska, and there are currently no major fisheries affecting their primary prey. However, if fisheries on the major prey of thornyheads—shrimp and to a lesser extent deepwater crabs—were to be re-established in the Gulf of Alaska, any potential indirect effects on thornyheads should be considered.

For further information contact Sandra Lowe (206) 526-4230.

6. Sablefish

a. Research

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2009 Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2009. 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

2009, the thirty-first annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Aleutian Islands was conducted. One hundred-fifty-two longline hauls (sets) were completed during May 30 - August 26, 2009 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*), shortspine thornyhead (*Sebastolobus alascanus*), arrowtooth flounder (*Atheresthes stomias*), and Pacific cod (*Gadus macrocephalus*). A total of 74,444 sablefish were caught during the survey. Sablefish, shortspine thornyhead, Greenland turbot (*Reinhardtius hippoglossoides*), spiny dogfish shark (*Squalus acanthias*), and lingcod (*Ophiodon elongates*) were tagged and released during the survey. Length-weight data and otoliths were collected from 1,860 sablefish. Killer whales *(Orcinus orca)* took fish from the longline at ten stations in the Bering Sea region and two stations in the western Gulf of Alaska, and one station in the central Gulf of Alaska. This was the highest killer whale depredation ever observed in the Bering Sea and severely affected catches in this region. Sperm whales *(Physeter macrocephalus)* were often present during haul back and were observed depredating on the longline at five stations in the eastern Gulf and five stations in the central Gulf of Alaska. These numbers represent a high incidence of sperm whale interactions in the central Gulf but the number observed in the eastern Gulf was much lower than that experienced in 2008.

Several special projects were conducted during the 2009 longline survey. Lingcod were tagged with archival temperature/depth tags in the West Yakutat and central Gulf of Alaska regions. Photographs of sperm whales observed during the survey were taken for contribution to the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) sperm whale catalog. A NOAA Hollings Scholar intern conducted a hooking injury project for sablefish. During this project, tagged sablefish were examined for prior hooking injuries and injury location and severity were recorded. This information, along with data from a previous tagging study, will be used to help understand mortality that occurs as a result of hooking injury.
A 2-day experiment was conducted near Yakutat July 21-22 to test new methods for quantifying sperm whale depredation rates. Acoustic recorders were deployed during fishing operations to passively collect the acoustic recording of sperm whale sounds during gear retrieval. Sperm whales use echolocation signals for navigation and detecting objects underwater. A "creak" is a rapid series of clicks in short succession which may indicate that a whale is homing in on a prey item. Enumerating the number of "creaks" that occur during hauling operations may provide a quantitative means of evaluating sperm whale depredation.

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

New Longline Survey Database, Website, Video, and At-Sea Data Collection

The Alaska Fisheries Science Center conducts annual longline surveys to estimate the relative abundance of major groundfish species, especially sablefish, on the continental slope of the eastern Bering Sea, Aleutian Islands, and the Gulf of Alaska. An SQL server database was developed over several years and is near completion. A website was created to provide survey catches and population indices to the public. This website it s now live and data can be accessed at http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_lsd.htm. A short video describing the longline survey was created this year for use as an outreach tool on the AFSC website, NOAA Tube, and on informational video monitors located in the vestibule of the Auke Bay Laboratories facility at Lena Point. This video can be viewed at http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.php.

Ruggedized hand-held computers ("Polycorders") have been used for many years on the longline survey for on-deck collection of data. However, because these computers are breaking and are no longer manufactured or serviced, we recently purchased new hand-held computers (Juniper "Allegro") for data collection on the longline survey. They are currently (spring 2010) being programmed and tested so that they can be used during this field season.

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

Auke Bay Laboratory Sablefish Tag Recovery Program

The ABL MESA Program continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database during 2009. Total sablefish tag recoveries for the year should exceed 600 when all are received. One fish at liberty for 30.9 years was recovered in 2009; it was released off Cape Suckling and recovered near Chichagof Island. Two other fish were out just over 30 years: one was released and recovered off Icy Bay and the second was released off Portlock Bank, Alaska and recovered off the Queen Charlotte Islands, Canada. Twenty-three sablefish tagged with archival tags as juveniles were recovered in 2009. 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. Eleven thornyheads and five turbot were recovered in 2009, as well as four spiny dogfish that had been tagged with special pop-off archival tags.

Releases in 2009 totaled 3,388 adult sablefish (including 14 released with archival tags), 783 shortspine thornyheads, 70 Greenland turbot (including 42 with archival tags), 29 lingcod (all archival), and 312 juvenile sablefish (including 75 archival).

For more information, contact Phil Rigby at (907) 789-6653 or phillip.rigby@noaa.gov, or Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Juvenile Sablefish Studies

Juvenile sablefish studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2009. A total of 237 juvenile sablefish (age 1+) were tagged with spaghetti tags and released during a cruise to St. John Baptist Bay near Sitka between August 28th-September 2nd. During the cruise, 75 juvenile sablefish were also implanted with electronic archival tags. Approximately 164 rod hours with sport gear were recorded to catch the fish that were tagged during the cruise. Total catch-per-unit-effort (CPUE) equaled 2.00 sablefish per rod hour fished. This was the highest CPUE since 2005, but still considerably lower than catch rates in the 1990s. 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 nearshore rearing areas to the age at which they are intercepted by the fishery. Since 2003, a total of 601 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 received three archival tag returns from the 2008 fishery, and several more have also been received from the 2009 fishery. In June 2010, we are attempting a new project in which we will explore for and tag juvenile sablefish west of Kodiak Island to aid in determining movement patterns of western Gulf of Alaska juveniles. The St. John Baptist Bay juvenile sablefish tagging cruise will be conducted again in 2010 from August 16-22.

For more information, contact Dana Hanselman at (907) 789-6054, dana.hanselman@noaa.gov.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Relative to the 2008 assessment, we made no substantive changes to the 2009 assessment. We added relative abundance and length data from the 2009 longline survey, relative abundance and length data from the 2008 longline and trawl fisheries, and age data from the 2008 longline survey and longline fishery were added to the assessment model. A NMFS Gulf of Alaska trawl survey was conducted in 2009, and its biomass estimate and associated lengths were added. We also included responses to a March 2009 Center for Independent Experts review panel of sablefish assessment in Alaska.

The fishery abundance index was up 5% from 2007 to 2008 (the 2009 data are not available yet). The survey abundance index increased 2% from 2008 to 2009 following a 16% decrease from 2006 to 2008. Relative abundance in 2009 is level with 2000, and is near the all-time low for the domestic longline survey. The Gulf of Alaska 2009 trawl survey estimate fell 2% from 2007, and is at its lowest since 1999. Spawning biomass is projected to be lower from 2010 to 2013, and then stabilize.

Sablefish are currently below biomass targets. We recommended the maximum permissible yield for 2010 from an adjusted $F_{40\%}$ strategy, which equals an ABC of 15,230 t. This maximum permissible yield for 2010 is a 5% decrease from the 2009 ABC of 16,080 t. This decrease is supported by three low years in the domestic longline survey abundance estimate and two subsequent low trawl survey abundance estimates. There is also little evidence of any large incoming recruitment 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 be 13,658 t in 2011 and 12,592 in 2012.

Projected 2010 spawning biomass is 35% of unfished spawning biomass. Spawning biomass has increased from a low of 30% of unfished biomass in 2001 to a projected 35% in 2010. The 1997 year class has been an important contributor to the population but has been reduced and should comprise only 12% of the spawning biomass. The 2000 year class appears to be larger than the 1997 year class, and is now 92% mature and should comprise 23% of the spawning biomass in 2010.

Center for Independent Experts (CIE) Review of Alaska Sablefish Assessment

A 3-day workshop was held by the authors of the Alaska sablefish assessment to consider recent suggestions made during a 2009 Center for Independent Experts review of the assessment and an industry-sponsored review. Prior to the workshop, all available relevant information pertaining to the sablefish population was synthesized in order to consider alternative modeling approaches. The workshop participants were provided with high resolution data from available scientific surveys as well as age and length information from observed fishing vessels aggregated by time and management area. Simulated datasets that captured the general characteristics of fishery data were also provided in a high-resolution format so that detailed spatial models could be considered.

Stock assessment experts outside of the Auke Bay Laboratories participated in the workshop, as well as scientists from within the lab. Two primary products are expected from the workshop. The first is a report describing the key findings and recommendations for further development of research and modeling of sablefish. The second product, yet to be developed, will be a set of potential models to go forward with in 2010 or 2011 for the sablefish assessment.

Key recommendations developed during the workshop were: (1) Develop generalized linear models for the longline survey and fishery abundance indices to statistically incorporate factors such as whale depredation, spatial effects, and hyperstability; (2) Consider spatially explicit modeling of the population, particularly to incorporate effects of differing fishery selectivity patterns in different regions; and (3) Update the sablefish movement model to include growth to different size classes and explicit choice of temporal comparisons.

For more information, contact Dana Hanselman at (907) 789-6054 dana.hanselman@noaa.gov.

7. Flatfish

a. Research

Habitat Studies – FBE Newport OR

Field studies around Kodiak have examined how biogenic seafloor structure influences the distribution of juvenile flatfish, particularly age-0 yr northern rock sole *Lepidopsetta polyxystra*. Juvenile aggregate in shallow coastal waters (<50m), where they associate with seafloor characterized by sparse to dense coverage of ampharetid polychaete worm tubes. The presence/absence and coverage of these structure forming polychaetes can vary dramatically between years. During the summers 2008 and 2009, the ampharetid polychaete worm *Sabellides sibirica* was more common than during the preceding 7 years, forming a 'turf' that extended from 21m to more than 30m; a 1 km wide habitat feature fringing the shoreline. Age-0 flatfish density increased with depth, being highest at the edge of the worm turf, where the worms were patchy, and lowest in the dense turf. Dietary studies reveal that juvenile flatfish actively forage upon the polychaetes that form this habitat. In addition, benthic community analysis demonstrates that the benthic infauna and epifauna associated with the turf are both more numerous and more diverse than inshore areas without the turf. Fish from trawl samples are currently being worked up to determine whether fish associated with the worm turf habitat differ in size or condition from those captured away from the worm turf. Lastly, we are experimenting with other measures of fish condition and growth, including lipid analysis and RNA/DNA ratios, to determine if these metrics can help elucidate the role that this biogenic habitat plays in the nursery function of Kodiak coastal embayments.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

Juvenile Flatfish (Rock Sole and Pacific Halibut) – Kodiak Laboratory and FBE Newport

Researchers from the Fisheries Behavioral Ecology Program and the Kodiak Laboratory have been investigating the processes affecting juvenile flatfish distribution, growth and survival within nursery areas around Kodiak Island, AK. Juvenile flatfish typically utilize nearshore, shallow coastal waters in Alaska as nursery areas. Field studies around Kodiak Island, AK reveal that biogenic seafloor structures constitute a critical component of essential fish habitat for juvenile flatfish in these areas and that juvenile flatfish abundance is highly correlated with abundance of ampharetid polychaete *Pseudosabellides sibirica* worm tubes. In some years, concentrated aggregations of *P. sibirica* form a dense lawn covering large sections of the seafloor in the bays around Kodiak. Juvenile flatfish, most notably northern rock sole *Lepidopsetta polyxystra*, aggregate along the shallow (inner) edge of this habitat where tube density is low to moderate and patchy. From 2007 to 2009, researchers conducted a series of integrated field and laboratory studies to examine the ecological processes controlling this fish-habitat relationship. One hypothesis that was tested was that juvenile flatfish aggregate in areas with worm tubes to feed either directly upon the worms or upon associated fauna. During the summer months of 2008 and 2009, > 1,000 age 0 rock sole were collected in two bays around Kodiak Island with differing densities of worm tubes. Differences in the diet composition, feeding activity, and general body condition of fish between and within the bays were examined. Additionally, benthic sampling was conducted to assess the differences in prey availability between the habitats. Substantial differences in the diet composition of juvenile rock sole between the worm tube habitat and areas devoid of worms were detected. Generally polychaetes were the most important prey in the diets of rock sole collected along the edge of the worm habitat; whereas, cumaceans and/or harpacticoid copepods were the predominant prey consumed in shallow waters devoid of worms. Ampharetid polychaetes were nearly absent in the diets of fish collected in shallow waters but they occurred in the majority of the stomachs collected in the worm habitat. In general, both feeding activity and invertebrate biomass were greater in the worm habitat compared to shallower waters. The preliminary results suggest that areas of low to moderate worm tube coverage may provide enhanced feeding opportunities for juvenile rock sole both directly as an additional food source and indirectly by supporting a higher biomass of prey. It appears that foraging behavior is an important factor influencing the distribution of juvenile flatfish relative to polychaete worm habitat in coastal nurseries of Alaska.

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

b. Stock assessments

BERING SEA

Yellowfin sole - The current assessment model was modified in 2008 to accommodate the sex-specific aspects of the population dynamics of yellowfin sole. The model now 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. The model retains the utility to fit combined sex data inputs.

The 2009 stock assessment incorporates the 2009 catch and survey biomass, the age compositions from the 2008 survey and 2008 catch and an update of weight-at-age estimates using biological data through 2008. The 2009 EBS bottom trawl survey resulted in a biomass estimate of 1,740,000 t, a decrease of 17% from the 2008 point estimate. Part of this decline is believed to be the effect of colder water temperature on survey catchability rather than actual changes in abundance. The stock assessment model indicates that the stock has been slowly declining over the past twenty years, although still at a fairly high level, 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. The 2009 catch of 107,528 t represents the largest flatfish fishery in the United States and the five-year average exploitation rate has been 4% for this stock. This assessment features an estimate of the relationship between survey catchability and annual mean bottom water temperature and also estimates a Ricker form of the spawner recruit relationship within the model. Results indicate that catchability, averaged over 25 years, = 1.12.

Several models were analyzed for this assessment. The models differed by changing whether natural mortality (*M*) or catchability (*Q*), or both, were estimated as free parameters in the model to determine the uncertainty of these key parameters and their effect on the model estimates. The SSC determined in 2006 that the reliability of the spawner recruit relationship estimated in the yellowfin sole assessment warranted moving this stock to Tier 1 management. In the yellowfin sole stock assessment model, a Ricker form of the stock-recruit relationship was fit to the estimates of female spawning biomass and recruitment and estimates of F_{MSY} and B_{MSY} were calculated, assuming that the fit to the stock-recruitment data points represent the long-term productivity of the stock. Results from these Tier 1 calculations for yellowfin sole indicate that the harmonic mean of the F_{MSY} estimate is very close to the geometric mean value of the F_{MSY} estimate due to the low variability in the parameter estimates. This result indicates that the estimates of F_{MSY} are obtained with very little uncertainty. To better understand how uncertainty in certain parameter estimates affects the Tier 1 harvest policy calculations for yellowfin sole, the following analysis was undertaken. Selectivity, catchability, natural mortality and recruitment variability (R sigma) were selected as important parameters whose uncertainty may directly affect the pdf of the estimate of F_{MSY}. Twelve different model configurations were chosen to illustrate the effect of a range of uncertainly in these individual parameter estimates (0.4 and 0.9 for M and 0.8, 1.0, 1.2 and 1.4 for R sigma) and how they affect the estimate of the harmonic mean of F_{MSY}.

Results indicated that increases in recruitment variability would have the largest effect on the pdf of the estimate of $F_{MSY,}$ whereas the uncertainty in the other parameters did not.

The Tier 1 recommendations for this stock are as follows: The estimate of B_{MSY} from the present assessment is 333,000 t. The 1978-2004 spawner recruit data were used as the basis to determine the Tier 1 harvest recommendation. This provided an $F_{ABC} = F_{harmonic}$ mean F_{msy} = 0.12. The $F_{OFL} = F_{MSY} = 0.13$ The product of the harmonic mean of F_{MSY} and the geometric mean of the projected 2010 biomass estimate produced the recommended ABC of 219,400 t and OFL of 233,600 t.

Model projections indicate that this stock is neither overfished nor approaching an overfished condition. Although the stock is presently above $B_{40\%}$ and B_{MSY} , it is predicted to slowly decrease in the near future due to below average recruitment from the last 5 years.

Northern rock sole - The assessment model was modified last year to accommodate the sex-specific aspects of the population dynamics northern rock sole. The model now 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. The model retains the utility to fit combined sex data inputs.

Changes to the input data for the 2009 assessment include a new maturity schedule from a recent published analysis of a histological examination of northern rock sole ovaries collected from the Bering Sea. Other new inputs include: addition of the 2008 fishery age composition, 2008 survey age composition, the 2009 catch biomass and 2009 trawl survey biomass point estimate and standard error. The 2009 bottom trawl survey resulted in a biomass estimate of 1,769,000 t, only 75% of the 2009 point estimate of 2,031,000 t. Part of this decline is believed to be the effect of colder water temperature on survey catchability rather than actual changes in abundance. The assessment continued the investigation of catchability (q) began in 2002. As in past assessments, a value of 1.4 obtained from a trawl "herding" experiment was used as the mean of a prior distribution on q. The updated value from this assessment gives a q estimate of 1.5. Natural mortality was estimated as a free parameter (with q constrained as stated above) giving the best fit for both sexes at about M = 0.15. The model estimates that the biomass of rock sole has increased the past five years after declining from an earlier peak value observed in 1997. The increase is due to strong recruitment from the 2001, 2002 and 2003 year classes which are now contributing to the population biomass. The stock assessment model estimates the 2010 biomass of rock sole at 1,769,000 t, a small increase over 2007 and about 2% more than the previous peak level observed in 1997.

The SSC determined in 2006 that the reliability of the spawner recruit relationship estimated in the northern rock sole assessment warranted moving this stock to Tier 1 management. In the northern rock sole stock assessment model, a Ricker form of the stock-recruit relationship was fit to the estimates of female spawning biomass and recruitment and estimates of F_{MSY} and B_{MSY} were calculated, assuming that the fit to the stock-recruitment data points represent the long-term productivity of the stock. Results from these Tier 1 calculations indicate that the harmonic mean of the F_{MSY} estimate is very close to the geometric mean value of the F_{MSY} estimate due to the low variability in the parameter estimates. This result indicates that the estimates of F_{MSY} are obtained with very little uncertainty. To better understand how uncertainty in certain parameter estimates affects the Tier 1 harvest policy calculations for northern rock sole, the following analysis was undertaken. Selectivity, catchability, natural mortality and recruitment variability (R sigma) were selected as important parameters whose uncertainty may directly affect the pdf of the estimate of F_{MSY}. Twelve different model configurations were chosen to illustrate the effect of a range of uncertainly in these individual parameter estimates (0.4 and 0.9 for M and 0.8, 1.0, 1.2 and 1.4 for R sigma) and how they affect the estimate of the harmonic mean of F_{MSY}.

Results indicated that increases in recruitment variability would have the largest effect on the pdf of the estimate of $F_{MSY,}$ whereas the uncertainty in the other parameters had little effect.

Since northern rock sole qualify as a Tier 1 stock, the 2009 assessment was calculated using Tier 1 methodology. Using the 1978-2002 spawner-recruit data set for the Tier 1 harvest recommendation, the Tier 1 2010 ABC harvest recommendation is 239,900 t (F_{ABC} = 0.153) and a 2010 OFL of 243,400 t ($F_{OFL} = F_{MSY} = 0.155$). The northern rock sole harvest is from a stable fishery that lightly exploits the stock because it is constrained by prohibited species catch limits and the BSAI optimum yield limit. Model projections indicate that this stock is neither overfished nor approaching an overfished condition. Usually the fishery only takes a small portion of the northern rock sole ABC, but there will be more room in cap this year because the pollock ABC is lower.

Flathead sole - The latest assessment updated the previous by incorporating new catch, discard, survey biomass, length composition, and age composition data. The 2009 fishery length composition, and age compositions from the 2006 and 2007 fisheries, based on observer data, were new to the assessment in 2009. Mean bottom temperatures were also updated. The 2009 trawl survey biomass estimate of 418,800 t was only 77% of the 2008 estimate of 545,500 t. As with yellowfin sole and northern rock sole, the decrease in survey biomass is believed to be correlated with colder bottom water temperatures during the survey in 2009.

The 2009 stock assessment model estimates that the age 3+ biomass decreased from 798,000 t in 2008 to 775,500 t in 2009, a 3% decrease. Similarly, the model estimate of female spawning biomass has declined 1% from 246,000 t in 2008 to 241,500 t in 2009. This is a stock which has been in a slow decline since 1994 when a peak total biomass level of 998,200 t was estimated. The decline has been the result of below average recruitment in over the past decade, although above average recruitment has been observed in recent years.

The SSC has determined that 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 $B_{40\%}$=137,000 t, $F_{40\%}$=0.28, and $F_{35\%}$=0.34. Because projected spawning biomass for 2010 (233,000 t) is above $B_{40\%}$, flathead sole is in sub-tier "a" of Tier 3. The ABCs for 2010 and 2011 are set at the maximum permissible values under Tier 3a, which are 69,200 t and 68,100 t, respectively. The 2010 and 2011 OFLs under Tier 3a are 81,800 t and 72,500 t, respectively.

Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Alaska plaice - New for the 2009 stock assessment of Alaska plaice was the debut of a two-gender stock assessment model to explicitly model males and females, which exhibit dimorphic growth. The 2009 assessment incorporated the 2009 shelf survey biomass estimate (529,700 t) and the 2009 catch data into the stock assessment model as well as the 2008 survey age composition. The survey biomass estimate was 4% higher in 2009 than in 2008, stable compared to the highly variable survey biomass estimates observed in recent years). The stock is estimated to be at a high and stable level (well above $B_{40\%}$) with relatively stable recruitment since the 1970s combined with recent good recruitment and a low level of harvest which is typically bycatch from other target fisheries. Catchability investigations do not indicate a temperature effect as shown for some of the other shelf flatfish.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates are $B_{40\%}$ = 204,800 t, $F_{40\%}$ = 0.58, and $F_{35\%}$ = 0.77. These are high values for flatfishes, but these values are the consequence of Alaska plaice maturing before recruiting to the fishery. Given that the projected 2010 spawning biomass of 487,500 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2010 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2010 ABC of 224,000 t. The OFL was determined from the Tier 3a formula, which gives a 2010 OFL of 278,000 t.

The total estimated biomass of Alaska plaice is at a high level and is increasing. 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 only as bycatch and is mostly discarded.

Other flatfish - 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 2009. Because of insufficient information about these species, no model analyses are possible. The latest assessment incorporates 2009 total catch and discard and 2009 trawl survey information. The 2009 EBS bottom trawl survey resulted in biomass estimates of 103,600 t, about the same as the 2008 estimate. The biomass of these species in the Aleutian Islands is 16,400 t from the 2006 survey, the highest observed since surveys began in 1983.

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 2010 ABC of 17,300 t for the "other flatfish" species. The corresponding 2010 OFL is 23,000 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. Insufficient information about these species makes model analysis impossible. 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 0.20. 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. Proportionally more butter sole are caught in the fishery than in the trawl survey. In response to the SSC's concern about the disproportionate amount of butter sole caught in the fishery relative to the survey, the authors note that this species is at the northern extent of its range, is at times captured in large quantities in a few trawl hauls, and thus the CV's are quite large.

Greenland turbot - This year's Greenland turbot assessment model included updated 2008 and 2009 catch data, EBS shelf survey 2009 biomass and length composition estimates, and aggregated longline survey data index for the EBS and Aleutian Islands regions through 2008. The 2009 EBS shelf trawl survey biomass estimate of 11,000 t was down by about 19% from the 2008 estimate and estimates from the last three years average about 68% of the long-term mean value from this survey. The 2008 EBS slope trawl survey biomass estimate was 17,900 t compared to the next most recent (2004) estimate of 36,600 t. Most of this difference was attributed to the lack of Greenland turbot found in the 400-600 m depth strata compared to the other years.

In contrast to last year when Stock Synthesis 2 was used, this year the updated Stock Synthesis 3 (SS3) was used for modeling the Greenland turbot population.

The projected 2010 female spawning biomass is 40,000 t. Compared to the 2009 spawning biomass of 44,900 t this represents a decrease, consistent with the general decline prevalent since the mid 1970s. Recruitment appears to have improved somewhat in recent years, particularly the 2008 year class.

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.

There was discussion about the large differences in model-estimated time series of Age 1+ biomass between the previous and current year's assessments, which used SS2 and SS3 respectively. These differences, along with variation in fishery- and sex-specific selectivities, contributed to uncertainties in interpreting the results of the model. Because of these uncertainties and the inability to differentiate the influence of factors such as the varying sex specific selectivities and the use of the SS3 (vs. SS2) model itself, the team discussed the merits of using the ABC results of the current model vs. using results from last year's model and rolling over the ABC from last year or using the projected 2010 ABC from last year's assessment.

There was also some discussion about the merits of using results of the current model or going with a Tier 5 designation. The Team decided to accept the current model results and recommend the maximum permissible ABC from this year's model, abandoning the stair-step approach recommended last year.

Accordingly, updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 24,300 t, 0.26, and 0.32, respectively. Projected spawning biomass for 2010 is 40,000 t, placing 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 6,120 t for 2010 and 5,370 t for 2011. In keeping with past management, the ABC was apportioned on the basis of 69% EBS and 31% AI. The OFLs for 2010 and 2011 under the Tier 3a formula are 7,460 t and 6,860 t, respectively.

To address lack-of-fit issues, the newest version of the SS software was used and attempts were made to improve fits to all data. However, shifts in Greenland turbot sex-ratios within surveys and between fisheries made fitting the data very difficult. The slope survey is critical because it covers the habitat range of Greenland turbot and, unlike the longline survey, the results are not potentially compromised by killer whale depredation. In the event that the slope trawl survey is cancelled, future ABCs would likely be reduced because of increased uncertainty. Because a significant component of the population occurs in the Aleutian Islands, regular surveys of that region would also be beneficial.

Arrowtooth flounder - The present assessment continues to utilize catchability as a function of the annual average bottom temperature during the EBS shelf trawl survey and also uses the EBS shelf trawl survey sex ratios as prior information to estimate sex-specific population numbers at age. All shelf, slope and Aleutian Islands trawl surveys biomass and size compositions are included into the assessment model. This year's EBS shelf bottom trawl survey resulted in a biomass estimate of 453,560 t, a 22% decrease from the 2008 survey. The 2008 slope survey biomass estimate was 96,200 t, by far the highest biomass ever reported on the slope. The 2006 Aleutian Islands trawl survey estimate of 229,000 t was the highest ever estimated in that region. The stock assessment model indicates that the biomass is at its highest level since observations began in 1975 due to episodes of above average recruitment in the 1980s and again in the period 1998 to the present. The stock remains very lightly harvested with fish caught primarily as bycatch in other fisheries. Discarding occurs at a rate exceeding 50%.

Since more female arrowtooth flounder are caught in trawl surveys throughout Alaska compared to males, and because the oldest female fish have been determined to be older than the oldest males, it is hypothesized that there are different natural mortality values for each sex. With the female natural mortality rate fixed at 0.2, male natural mortality was profiled over a range of values to determine which value provided the best fit to all the observable population characteristics and still gave reasonable estimates of male selectivity to the survey trawl. The male natural mortality rate that provided the best fit was 0.35. With the stock assessment model configured in this way, the population biomass was estimated at 1,086,200 t.

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 296,800 t, 0.24, and 0.29, respectively. Given that the projected 2010 spawning biomass of 807,100 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2010 were calculated under sub-tier "a" of Tier 3. The recommended F_{ABC} was set at the $F_{40\%}$ (0.24) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2010 ABC of 156,000 t. The OFL fishing mortality rate under Tier 3a is $F_{35\%}$ (0.29), which translates to a 2010 OFL of 191,000 t.

The ABC recommendation is for the combined harvest of arrowtooth flounder and Kamchatka flounder, which are difficult to distinguish and had similar biomass trends from the EBS trawl survey since 1991. Ecosystem considerations of predator-prey dynamics of arrowtooth flounder in the Bering Sea indicated that the top prey species of arrowtooth flounders are juvenile pollock. However, juvenile arrowtooth flounder in the Bering Sea are an important prey for adult pollock. The ramification of increases of one of these species, with decreases of the other, has unknown consequences due to this duality of the predator-prey relationship.

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Arrowtooth flounder - The 2009 survey biomass and length data, catch for 2008 and 2009, 2007 and 2008 fishery length data were added to the model. The estimated age 3+ biomass from the model increased by an order of magnitude since 1961 and peaked at about 2.2 million t in 2006. Since then the stock has stabilized. Female spawning biomass in 2009 was estimated at 1,252,550 t, a 4% decline from the projected biomass from the 2007 assessment. The results of the 2009 GOA survey indicate that arrowtooth flounder are still the highest biomass groundfish species and remain lightly harvested.

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.

Arrowtooth flounder has been determined to fall under Tier 3a. The 2010 ABC using $F40\%$=0.183 is 215,882 t, which is 5,630 t less than the 2009 ABC. The 2010 OFL using $F35\%$ (0.219) is 254,271 t. The 2011 ABC and OFL were projected by setting 2010 catches equivalent to the average 5 year F (0.0206).

The recommended ABC for arrowtooth flounder in 2010 is equivalent to the maximum permissible ABC. The stock is not overfished nor approaching an overfished condition. Catch levels for this stock remain below the TAC and below levels where overfishing would be a concern.

Area apportionments of arrowtooth flounder ABCs for 2010 and 2011 are based on the fraction of the 2009 survey biomass in each area. The new ABC recommendation for 2010 is slightly lower than that recommended for 2009 using last year's full assessment model (269,237 t). The ABC is apportioned in proportion to the survey biomass results, by area.

Gulf of Alaska flatfish - 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. New data for the shallow water flatfish complex from the 2009 assessment included final total catch from 2008, current catch for 2009 and the 2009 NMFS bottom-trawl survey biomass estimates.

Stock status for shallow water flatfish is based on the NMFS bottom trawl survey (triennial from 1984 to 1999 and biennial from 1999 to 2009). Survey abundance estimates for the shallow-water complex were lower in 2009 compared to 2007; decreasing by 37,630 t. By species, abundance estimates increased between 2007 and 2009 for southern rock sole and English sole, while all other species in the complex (northern rock sole, yellowfin sole, butter sole, starry flounder, sand sole and Alaska plaice) showed decreases in abundance.

Northern and southern rock sole are managed in Tier 4 while other shallow water flatfish are in Tier 5, since maturity data are not available. The F_{ABC} and F_{OFL} values for southern rock sole were estimated as:
$F_{40\%}$=0.162 and $F_{35\%}$ = 0.192, respectively. For northern rock sole the values are: $F_{40\%}$=0.204 and $F_{35\%}$ =0.245. Other flatfish ABCs were estimated with F_{ABC}=0.75 M and F_{OFL}=M.

The ABC and OFL for 2010 and 2011 shallow-water flatfish are lower than the 2008 and 2009. The GOA Plan Team agrees with authors recommended ABC for the shallow water flatfish complex which was equivalent to maximum permissible ABC. Information is insufficient to determine stock status relative to overfished criteria. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

Flatfish consume a variety of benthic organisms. Fish prey make up a large part of the diet of rock sole adults and possibly sand sole (although the sample size was small for sand sole). Other flatfishes consume mostly polychaetes, crustaceans and mollusks. Area apportionments of shallow water flatfish ABC's (using F40% = FABC) for 2010 and 2011 are based on the fraction of the 2009 survey biomass in each area

The deep water flatfish complex is comprised of Dover sole, Greenland turbot, and deep sea sole. Catch and trawl survey biomass data for Greenland turbot and deepsea sole are updated for 2009. For Dover sole, the assessment model presented in 2007 is updated with 2008 and 2009 fishery catch and size compositions, 2009 trawl survey biomass, and 1987 and 2007 trawl survey age compositions. Six alternative model configurations exploring selectivity parameterizations are presented, but none outperform the base model.

An age-structured model is used to determine stock status for Dover sole. Dover sole female spawning biomass was relatively flat until 1991 and then declined until 2006. Spawning biomass has been unchanged since 2006. Dover Sole are in Tier 3a while 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 2010 and 2011 ABC and OFLs.

For the Dover sole Tier 3a assessment the 2010 ABC using $F_{40\%}$=0.119 is 6,007 and 6,142 t for 2011. The 2010 OFL using $F_{35\%}$=0.149 is 7,436 t and 7,603 t for the 2011 OFL. The recommended 2010 and 2011 ABC's and OFL's for the deep water flatfish complex are equivalent to the maximum permissible ABC. The stock assessment author noted that the 2008 catch of deepsea sole (8 t) exceeded the average catch of deepsea sole for 1978-1995 (6 t). The Plan Team discussed whether biomass data were reliable for application of Tier 5 assessment methods to deepsea sole and Greenland turbot, and requested that the authors include survey CV and M estimates for all species in the complex in the next assessment.

Information is insufficient to determine stock status relative to overfished criteria. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

Area apportionments of deep water flatfish (*excluding Dover sole*) are based on proportions of historical catch. Area apportionments of Dover sole (using *F40%*) are based on the fraction of the 2009 survey biomass in each area.

Flathead sole - Survey biomass decreased from 280,290 t in 2007 to 225,377 t in 2009 (20% decline). Projected female spawning biomass is estimated at 110,387 t for 2010. Two models were presented for this assessment. The base model was an age-structured model that was unchanged from 2007. A new model was presented that estimated selectivity between sexes. The fishery catch and length compositions for 2008 and 2009 were incorporated in the models. The 2007 fishery catch and length compositions were updated. The 2009 GOA groundfish survey biomass estimate and length composition data were added to the model. Survey biomass estimates and length compositions were recalculated for all survey years.

The Plan Team encouraged the author to continue investigating approaches to model selectivity, but recommended using the authors' base model. The Plan Team disagreed with the authors' choice to use the different scaling of male selectivity relative to females. The mechanisms for the resulting differences between the sex-specific survey and fishery selectivities were unclear. The Plan Team also encouraged the author to investigate length based selectivity and examine age data from the fishery. Flathead sole are determined to be in Tier 3a based on the age-structured model. The Team's preferred model gives a 2010 ABC using $F_{40\%}$ (0.406) of 47,422 t which is 958 t higher than the 2009 ABC. The 2010 OFL using $F_{35\%}$ (0.530) is 59,295 t. The stock is not overfished nor approaching an overfished condition. Catch levels for this stock remain below the TAC and below levels where overfishing would be a concern.

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10. Walleye pollock

a. Research

Echo Integration-Trawl Surveys

GULF OF ALASKA

Winter echo integration-trawl surveys in the vicinity of Shumagin Islands and Sanak Trough, along the shelf breaks from Sanak Island to Unalaska Island and southeast of Chirikof Island, in the Shelikof Strait area, and Marmot Bay

The MACE Program conducted a winter echo integration-trawl (EIT) survey aboard the NOAA ship *Oscar Dyson*, targeting walleye pollock in the Shumagin Islands, Sanak Trough, and along the shelf break from Sanak Island to Unalaska Island. The Shumagin Islands portion of the survey was conducted 15-18 February along parallel transects. Transects were spaced 5-nmi apart within Shumagin Trough, 1-nmi apart east of Renshaw Point, and 2.5-nmi apart elsewhere. The Sanak Trough survey was conducted 18-19 February along transects spaced 2-nmi apart. The shelfbreak was surveyed 19-20 February using a combination of zigzag and 6-nmi apart parallel transects.

In the Shumagin Islands, the densest walleye pollock aggregations were located in Shumagin Trough and off Renshaw Point, although the Renshaw Point quantities were significantly less than detected in earlier surveys. Age-1 (9-15 cm FL) walleye pollock were the dominant age group by numbers in Shumagin Trough and in the mouth of Stepovak Bay. Elsewhere, age-2 (17-24 cm FL), and, to a lesser extent, age-3 fish (25-32 cm FL), were numerically dominant. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 33% developing, 48% pre-spawning, 16% spawning, and 2% spent. The maturity composition of females longer than 40 cm was 0% immature, 50% developing, 48% pre-spawning, 1% spawning, and 1% spent. The mean gonado-somatic index (GSI: ovary weight/body weight) for mature pre-spawning females was 0.09. The pollock EIT survey abundance estimate in the Shumagin Islands area was 2.4 billion pollock weighing 63,300 metric tons, based on catch data from 7 trawl hauls and acoustic data from 326 nmi of survey transects.

The densest pollock aggregations in Sanak Trough, which consisted of only adult pollock, were located in the western part of the Trough close to the seafloor and on the shelf to the west of the Trough in dense, on-bottom schools. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 15% developing, 51% pre-spawning, 23% spawning, and 10% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 13% developing, 54% pre-spawning, 10% spawning, and 23% spent. The large percentage of spent females indicated that the survey timing was late. The average GSI for pre-spawning females was 0.16. The abundance estimate for Sanak Trough of 16 million pollock weighing 31,400 t, based on catch data from 2 trawl hauls and acoustic data from 91 nmi of survey transects, was the second lowest in the time series.

Acoustic backscatter was measured along 134 nmi of survey tracklines along the shelf break from Sanak Island to Unalaska Island. No walleye pollock were observed. Pacific ocean perch were found in low concentrations over bottom depths of 200-300 m from and were caught in the single trawl conducted.

The MACE Program also conducted winter EIT surveys aboard the *Oscar Dyson,* targeting walleye pollock along the shelfbreak southeast of Chirikof Island, in the Shelikof Strait area, and in Marmot Bay. The shelf break was surveyed during 20-22 March along parallel transects spaced 6-nmi apart. The Shelikof Strait sea valley was surveyed from south of Chirikof Island to north Kuliak Bay on the Alaska Peninsula during 22-28 March along parallel transects spaced 7.5-nmi apart. Marmot Bay was during 29-31 along parallel transects spaced 1- or 2-nmi apart.

Very few walleye pollock were located along the shelf break southeast of Chirikof Island. However, dense Pacific ocean perch acoustic backscattering was detected in this area. The 19 walleye pollock captured in the AWT hauls ranged from 35 to 60 cm FL with a mode of 43 cm FL. None of the walleye pollock were in a spawning or spent condition, but the small sample size prevented further analysis of these data. The abundance estimate for the area from Chirikof

Island to the mouth of Barnabas Trough was 600 thousand pollock weighing 400 t, based on catch data from 6 trawl hauls and acoustic data from 145 nmi of survey transects.

In the Shelikof Strait area, the densest walleye pollock aggregations were detected within the Strait proper between Cape Kuliak and Wide Bay. Most walleye pollock were generally located within 50 m of the seafloor over bottom depths exceeding 200 m. Trawl hauls conducted within Shelikof Strait proper contained a mixture of age groups, with age-1 and -2 fish dominating most catches by number. Between the mouth of the Strait and the Semidi Islands, catches were distributed between age 1, age 2, and older fish. Older fish heavily dominated catches at the southernmost end of the survey area between the Semidi Islands and Chirikof Island. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 45% developing, 44% pre-spawning, 10% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 52% developing, 39% pre-spawning, 6% spawning, and 3% spent. These results are similar to previous survey results in terms of the relatively low numbers of spawning and spent female fish, which suggests that the survey timing was appropriate. A logistic model provided a reasonable fit to the female maturity-at-length data and predicted that 50% of females were mature at a length of 47 cm. The average GSI for mature pre-spawning females was 0.13. The pollock abundance estimate for Shelikof Strait was 1.8 billion pollock weighing 266,000 t, based on catch data from 12 trawl hauls and acoustic data from 692 nmi of survey transects.

The densest pollock aggregations in Marmot Bay occurred northwest of Spruce Island in midwater layers between 50 m and 75 m in depth over bottom depths of 100-175 m, with most fish ranging in length from 33 to 42 cm FL. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 11% developing, 27% mature pre-spawning, 61% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 33% developing, 59% pre-spawning, 8% spawning, and 0% spent. A logistic model provided a reasonable fit to the female maturity-at-length data and predicted that 50% of females were mature at a length of 42 cm. The average GSI for mature pre-spawning females was 0.14. The abundance estimate for Sanak Trough was 35 million pollock weighing 19,800 t, based on catch data from 4 trawl hauls and acoustic data from 91 nmi of survey transects.

BERING SEA

Winter echo integration-trawl survey in the southeast Aleutian Basin near Bogoslof Island

The MACE Program conducted an EIT survey aboard the NOAA ship *Oscar Dyson* 7-13 March 2009, which targeted walleye pollock in the southeastern Aleutian Basin near Bogoslof Island. The survey comprised 35 north-south parallel transects spaced 3-nmi apart, which covered 1,870 nmi^2 of the Central Bering Sea Convention Specific Area.

Most of the adult pollock biomass (86%) was concentrated north of Samalga Pass with a minor component distributed northeast of Umnak Island (14%). Based on catch data from five trawl hauls, the pollock size composition in both regions ranged between 41 cm and 70 cm FL, and was characterized by a dominant mode at about 55 cm FL. The unweighted maturity composition for males was 0% immature, 0% developing, 77% pre-spawning, 22% spawning, and 1% spent. The female maturity composition was 0% immature, less than 1% developing, 97% pre-spawning, 1% spawning, and 1% spent. The average GSI for mature pre-spawning females was 0.17. The pollock abundance estimates for the southeastern Aleutian Basin area were 73 million fish weighing 0.110 million metric tons (t). This was the lowest abundance of fish estimated since these surveys began in 1988.

Summer echo integration-trawl survey on the eastern Bering Sea shelf

The MACE Program conducted an echo integration-trawl (EIT) survey of midwater walleye pollock (*Theragra chalcogramma*) between 9 June and 7 August 2009 aboard the NOAA ship *Oscar Dyson*. The survey design consisted of 31 north-south transects spaced 20 nautical miles (nmi) apart from Port Moller, Alaska across the U.S.-Russia Convention Line to the Cape Navarin area of Russia. The survey's primary objective was to collect 38 kHz echo integration and trawl information to estimate daytime midwater walleye pollock abundance and distribution. Additional survey sampling included conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts to characterize the Bering Sea shelf physical oceanographic environment, and supplemental trawls to improve species identification using multiple frequency techniques. Macrozooplankton and micronekton layers (principally euphausiids) were sampled and a new euphausiid index of abundance was computed from backscatter at 4 frequencies (18, 38, 120, and 200 kHz). Additionally, light level sensors, Simrad ME70 multibeam sonar, and a lowered echosounding system were utilized to measure underwater light levels, characterize the three-dimensional size and shape properties of juvenile fish schools, and to measure fish target strength, respectively. Seabird species abundances were recorded along transects.

Survey results showed that ocean conditions were cold in 2009, as in the previous three years, compared to 2000-2005. About two-thirds of the summed acoustic backscatter at 38 kHz observed during the 2009 survey was attributed to adult or juvenile walleye pollock. The remaining 38 kHz backscatter was attributed to an undifferentiated plankton-fish mixture, or in a few isolated areas, to Pacific ocean perch or unidentified fish. As in 2008, the majority of the pollock biomass in the U.S. Exclusive Economic Zone (EEZ) was located to the west and southwest of St. Matthew Island between the 100 m and 200 m isobaths. Estimated pollock abundance in midwater (between 16 m from the surface and 3 m off bottom) in the U.S. EEZ portion of the Bering Sea shelf was 8.08 billion fish weighing 0.924 million metric tons; in the Russian EEZ, there were 9.7 million fish weighing 0.005 million metric tons (<1% of the total midwater biomass). Of the pollock observed in the region east of 170°W (9.6% of total biomass) most were inside the Steller Sea Lion Conservation Area (SCA) and the predominant length mode was 55 cm. In the U.S. west of 170°W (89.8% of total biomass) modal lengths were 13, 31 and 23 cm, respectively. The percentage of walleye pollock biomass found to the west of 170°W has increased steadily since 2002. In Russia modal lengths were 43, 51, and 29 cm, with proportionally more adults and fewer juveniles than in adjacent U.S. waters.

Preliminary age results using a NMFS bottom trawl survey age-length key indicated that inside the U.S. EEZ, age-1 and -3 fish were dominant numerically (62% and 20%, respectively) and together represented 52% of the total biomass. Walleye pollock ages 4+ totaled only 6% of the population numerically and made up 36% of the total biomass. Analyses of walleye pollock vertical distribution indicated that 93% of adult biomass was within 40 m of the seafloor. Juveniles were found both near the seafloor and higher in the water column; 17% of juvenile biomass was within 50 m of the surface.

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

Epipelagic Trawl Surveys to Determine Abundance of Age-0 Walleye Pollock and Understand Impacts of Climate Change 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 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 Ocean Carrying Capacity (OCC) researchers in 2000–2009, with surveys planned for 2010 and onward. These surveys have been part of an international effort, the Bering-Aleutian Salmon International Survey (BASIS) program. Epipelagic trawl surveys have occurred each year in late summer/early fall (August-October) to assess the abundance and condition of these fish at the end of their early marine growth period and 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 BASIS time series on age-0 walleye pollock is presently the only shelf-wide data available during 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. In addition, 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 BASIS results have been used to document the rapidly changing marine conditions in the EBS during the past eight 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 2006-2009. These shifts altered fisheries distributions and have the potential to affect the overall ecology of this region. 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.

b. Stock assessments

GULF OF ALASKA

The age-structured model developed using AD Model Builder and used for GOA W/C/WYK Pollock assessments in 1999-2008 is fundamentally unchanged. This year's pollock chapter features the following new data: (1) 2008 total catch and catch at age from the fishery, (2) 2009 biomass and age composition from the Shelikof Strait EIT survey, (3) 2009 biomass and length composition from the NMFS bottom trawl survey, and (4) 2009 biomass and length composition and 2008 age composition from the ADF&G crab/groundfish trawl survey. Model fits to fishery age composition data were good in most years. The fit of Shelikof Strait EIT survey age composition show 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. General trends in survey time series fit reasonably well and model fits to survey biomass estimates were similar to previous assessments. The model was unable to fit all the 2009 survey estimates simultaneously. Both the NMFS bottom trawl survey and the ADF&G surveys showed large increases in biomass in 2009, while the Shelikof Strait EIT showed only a slight increase and remains close to historically low levels. For a pollock population to increase by the amount indicated by the NMFS bottom trawl survey, recruitment to the population would have to have been very large, yet available information (including the length information from the NFMS and the ADF&G surveys) does not support recruitment of this magnitude.

The 2009 biomass estimate of Shelikof Strait fish ≥43 cm (a proxy for spawning biomass) increased by 60% from the 2007 estimate, apparently due to above average recruitment to the spawning population. Additional EIT surveys in winter 2009 covered the Shumagin Islands spawning area, Sanak Gully, Chirikof, and Marmot Bay. In comparison to 2008, biomass estimates were higher with the exception of Chirikof, where very few pollock were found. An exploratory survey along the shelf break from Sanak Island west to Unimak Island did not detect significant quantities of pollock. The 2009 ADF&G crab/groundfish survey biomass estimate increased 43% from 2008. The initial estimate 2007 year class is 1.7 times average recruitment, and was abundant in both Shumagin area and Shelikof Strait in the 2008 EIT surveys. Initial estimates of year-class strength are highly uncertain, and there have been several instances recently when an initial estimate of year class size decreased as more information accumulated.

The assessment author chose to use the same model as last year with three elements to make it more precautionary. This model fixed the NMFS bottom trawl survey catchability (q) at 1.0, applied a more conservative harvest rate than the maximum permissible F_{ABC} and set the 2007 year class equal to the average. These conservative elements reduce the recommended ABC to approximately 50% of the model point estimate. However, they seem warranted given the above average estimate of the 2007 year class, inconsistencies in the 2009 survey data, and the continued low spawning biomass in Shelikof Strait and other spawning areas.

The model results produced an estimated 2010 spawning biomass of 184,567 t, or 30% of unfished spawning biomass. The $B_{40\%}$ estimate is 248,000 t. This represents a 4% increase from the 2008 assessment, and reflects both the increase in mean weight at age during spawning and a decrease in average recruitment. Estimates of 2009 stock status indicate that spawning biomass remains low.

Pollock are not overfished nor are they approaching an overfished condition. Catches remain well below levels where overfishing would be a concern. Because model estimated 2010 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) and using an average value for the 2007 year class (the estimate was 70% above average). The projected 2010 age-3+ biomass estimate is 756,550 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 2010 based on this precautionary model configuration, adjusted harvest control rule, and average 2007 year class is 77,150 t (F_{ABC} =

0.14) for GOA waters west of 140°W longitude. **The ABC is 75,500 for 2010** (reduced by 1,650 t to account for the Prince William Sound GHL). The 2010 OFL under Tier 3b is 103,210 t (F_{OFL}= 0.19).

Southeast Alaska pollock are in Tier 5 and the ABC and OFL recommendations are based on natural mortality (0.30) and the biomass from the 2009 survey. The biomass from the 2009 NMFS bottom trawl survey increased to 41,088 t. This results in a **2010 ABC of 9,245 t**, and a **2010 OFL of 12,326 t**.

A presentation was made by the FOCI program at the November Plan Team meeting to assist in evaluating the magnitude of the 2009 year class of pollock in the GOA. This year most of the indices indicated the year class to be "average." The Plan Team felt that the direct observations of pre-recruit pollock have more influence on projection specifications than those derived from indirect observations (e.g., via covariates). For example, juveniles observed in the winter surveys generally provide more reliable estimates of subsequent year-classes. The Team requests that clearer scenarios on the application of the FOCI prediction for actual management be developed since the applicability to near-term management questions appear to be limited. Perhaps FOCI resources would be better applied to predicting medium term productivity changes that can be applied to pollock and other species.

The assessment was updated to include the most recent data available for area apportionments within each season (Appendix C of the GOA pollock chapter). The assessment accounted for results of vessel comparison experiments conducted between the *R/V Miller Freeman* and the *R/V Oscar Dyson* in Shelikof Strait in 2007 and in the Shumagin/Sanak area in 2008 which found significant differences in the OD/MF ratio. The estimated ratio for the Shelikof Strait was 1.132, while the ratio for the Shumagin and Sanak areas (taken together) was 1.31. When calculating the distribution of biomass by area, multipliers were applied to surveys conducted by the *R/V Miller Freeman* to make them comparable to the *R/V Oscar Dyson*. Adding the vessel comparison to the apportionment analysis is a transitional step until all recent surveys are done by the *R/V Oscar Dyson*.

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

EASTERN BERING SEA

New data in this year's assessment include the following:

- Updated total catch for 2008 and a preliminary estimate of the 2009 catch.
- Biomass estimates from the 2009 bottom trawl survey and the 2009 echo-integration trawl (EIT) survey. The estimate from the bottom trawl survey was 2.28 million t, down 25% from the 2008 estimate, and the lowest point in the 1982-2009 time series. The estimate from the EIT survey was 0.924 million t, down 7% from last year's survey, and the lowest point in the 1979-2009 time series.
- Age composition data from the 2009 bottom trawl survey, updated age composition data from the 2008 EIT survey, and preliminary age composition data from the 2009 EIT survey (based on the age-length key from this year's bottom trawl survey, supplemented with 100 otoliths from this year's EIT survey). The 2009 survey age compositions confirm that the 2006 year class is of above-average strength, though not as strong as estimated previously.

- Age and size composition data and weight-at-age data from the 2008 fishery (in addition, age composition data from the first part of the 2009 fishery were used in sensitivity testing).

Consistent with the estimates produced in last year's assessment, age 3+ biomass of EBS walleye pollock declined steadily from 2003-2008 due to poor recruitment from the 2002-2005 year classes, with the age 3+ biomass for 2008 estimated to be the lowest in the time series since 1980 (one change from last year's assessment is that the 2001 year class, formerly estimated to be below average, is now estimated to be average). Spawning biomass is estimated to be 29% below *BMSY* in 2009. The 2006 year class is reliably estimated to be above average, however, so spawning biomass is projected to increase in the near future (15% below *BMSY* in 2010 and near *BMSY* by 2012, if the stock is fished at the maximum permissible ABC).

Updated analyses of survey and fishery data show a less optimistic increase compared to predictions from the 2008 assessment. While the form of the model remained the same, an improved method for projecting future weight at age was developed and accepted for application. The age-3 and older biomass has been declining since 2003, and the 2010 biomass is the lowest since 1980. Spawning biomass has been declining since 2004, but the current assessment indicates that 2009 should be a turning point, and the 2010 spawning biomass should increase by about 13%. The spawning biomass is projected to be near B_{msy} by 2012.

Walleye pollock in the eastern Bering Sea typically have been monitored with regular annual bottom trawl and biennial acoustic surveys. However, 2009 marked the fourth consecutive year that both surveys were conducted. The results of the 2009 bottom trawl survey suggested that pollock abundance was slightly higher than expectations (but was lower than the 2008 value). However, the acoustic survey data indicated that pollock abundance was lower than expected based on expectations from the 2008 assessment. Combining these results and recent fishery observer information in an integrated analysis indicated that a lower catch limit of 813,000 t for 2010 was appropriate given the new information. (Previous analysis indicated that the stock and management control rule would be above 1.0 million t for 2010.)

The updated estimate of B_{MSY} from the present assessment is 1.86 million t, compared to 1.92 million t from last year's assessment. Projected spawning biomass for 2010 is 1.32 million t, placing EBS walleye pollock in sub-tier "b" 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 0.373, up from last year's value of 0.332.

The harvest ratio of 0.373 is scaled according to the Tier 1b formula and then multiplied by the geometric mean of the projected fishable biomass for 2010 (3.152 million t) to obtain the maximum permissible ABC for 2010, which is 813,000 t. This ABC is 88% higher than the 2010 yield of 433,000 t that would correspond to a Tier 3b strategy based on a $B_{40\%}$ value of 2.35 million t.

The OFL harvest ratio under Tier 1a is 0.421, the arithmetic mean of the ratio between MSY and the equilibrium fishable biomass corresponding to MSY. The product of this ratio, rescaled according to the Tier 1b formula, and the geometric mean of the projected fishable biomass for 2010 gives the OFL for 2010, which is 918,000 t. The current projection for OFL in 2011 given a 2010 catch of 813,000 t is 1.22 million t. The walleye pollock stock in the EBS is not overfished and is not approaching an overfished condition.

The Council reviewed and discussed the assessment prepared by AFSC scientists at the December meeting and was satisfied that the updated information and downward revision of the ABC was appropriate.

The prognosis for 2010 and beyond is for improved stock levels because the 2006 year class remains above average, and early indications are that the 2008 year class may also be high (based on the acoustic survey). While survey data continue to play a critical role for advising fisheries management, the Bering Sea Integrated Ecosystem Research Program (BSIERP) continues and is due to complete fieldwork in late 2010. This project is multifaceted and an important component will serve to evaluate current management practices in light of new information on ecosystem processes.

ALEUTIAN ISLANDS

There were no new data for this assessment, and the last Aleutian Islands survey was in 2006. The stock is estimated to be near $B_{30\%}$.

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11. Dogfish and Other Sharks

a. Research

Spiny Dogfish Ecology and Migration

Spiny dogfish are a long-lived, slow-growing species. Data collected from 2004-2007 in cooperation with the AFSC Sablefish Longline Survey, the Alaska Observer Program, the Alaska Department of Fish and Game, and the University of Alaska Fairbanks were examined to determine the growth, age structure, demographic characteristics, and ecology of the species in the Gulf of Alaska. Results suggest that spiny dogfish are among the slowest growing species of shark and grow to a larger size, older age, and mature later in the Gulf of Alaska than other regions in which they occur. Demographic analyses also suggest that the species has a low rate of natural mortality and fecundity, which combined with the age assessment suggest that the species can only tolerate a low level of fishing mortality. Diet analysis revealed that spiny dogfish feed primarily on shrimp and squid, but are also have a generalized diet and are opportunistic feeders. Spiny dogfish tend to feed on small fish and invertebrates when young and incorporate larger prey items as they grow, which is reflected in an increasing trophic level as the fish grows.

Scientists at the Auke Bay Laboratories have begun an annual tagging program for spiny dogfish including both numerical Peterson disk tags and pop-off archival tags. Eighty numeric tags and fifteen pop-off tags were deployed in Yakutat Bay in the summer of 2009, and four of the latter tags have transmitted data to date. Data from the four pop-off tags, which include temperature, depth, and geographic location, are still being analyzed.

b. Stock assessments

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Sharks in Alaskan Waters

The shark assessment chapters from 2008 for the Bering Sea/Aleutian Islands (BSAI) and for Gulf of Alaska (GOA) were updated for the 2010 fishing year and presented to the North Pacific Fishery Management Council's Groundfish Plan Teams in November 2009.

Incidental catch estimates for sharks are now available from the NMFS Alaska Regional Office (AKRO). Incidental catch for sharks was updated with the most recent AKRO estimates, and incidental catch from the years 1997–2007 was established as a baseline for identifying options for setting future sustainable incidental catch limits for sharks in the BSAI and GOA. Bottom trawl survey biomass data were updated for the 2009 Eastern Bering Sea (EBS) shelf. Previous survey data were available from NMFS AFSC bottom trawl surveys in the EBS shelf (1979–2009), EBS slope (historical 1979-1991, and new time series 2002, 2004, 2008), and Aleutian Islands (1980–2006). Previous trawl survey data were available from NMFS AFSC bottom trawl surveys conducted triennially and biennially in the GOA (1984–2009).

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 2003-2009 were updated from the AKRO's Catch Accounting System. In the BSAI, average incidental catch of Pacific sleeper sharks from 1997–2007 (598 mt) represented 11.6% of the available Pacific sleeper shark biomass from BSAI bottom trawl surveys in 1996–2007 (total of the average biomass from three surveys was 5,168 mt). Historically, BSAI survey catches of Pacific sleeper sharks were rare, and abundance trends from the surveys were unreliable as evidenced by the high uncertainty in the biomass estimates. However, the new EBS slope bottom trawl survey (2002, 2004 and 2008) showed a substantial biomass of Pacific sleeper sharks on the EBS slope in 2002 (25,445 mt) but not in 2004 (2,260 mt) or 2008 (2,037 mt). The EBS shelf survey did not encounter sharks in 2007 or 2008 and the biomass estimates were zero, but the EBS slope survey did encounter sharks in 2008 (2,051 mt). In 2009 only spiny dogfish were encountered on the shelf survey and biomass was estimated at 72 mt. Spiny dogfish and salmon sharks were rarely encountered in commercial fisheries or bottom trawl surveys in the BSAI. Therefore, spiny dogfish and salmon sharks were not assessed separately in the BSAI.

In the GOA, average bycatch of spiny dogfish from 1997–2007 (703 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). The 2001 survey did not include the eastern GOA; hence, it may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the eastern GOA. Average bycatch of Pacific sleeper sharks from 1997–2007 (316 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 (64 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. A working group has been convened, headed by staff at the Auke Bay Laboratories and including staff from ADF&G, AFSC, and IPHC to address this issue. Results are expected to be presented in 2010 to the November Groundfish Plan Team and December Science and Statistical Committee meetings of the North Pacific Fishery Management Council.

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

Salmon shark life history

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, age and growth, and diet. Eight salmon sharks have been collected to date and it is anticipated more salmon sharks will be examined in the upcoming fall pollock fisheries.

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

14. Other Species

a. Research

Octopus life history – RACE Groundfish Kodiak/REFM collaboration

Initial stock assessments of octopus within the Gulf of Alaska have revealed that there is little life history information available for this group. RACE biologists at the Kodiak Laboratory in collaboration with REFM biologists in Seattle initiated a life history study of Giant Pacific Octopus during 2009. This study will co-occur with gear experimentation studies to examine the feasibility of an octopus fishery. During the fall pod cod fishery, 25 giant pacific octopus specimens were obtained. The condition of the reproductive tract was assessed and samples were preserved for future histological analysis. In addition structures for aging (beak, statolith, and stylet) were dissected out and preserved. Pictures were taken of the reproductive structures to be utilized in a guide to identifying the reproductive stage of octopus in the future. Additional octopus samples will be collected during spring and fall charters that will occur during April 2010 and during September and October 2010.

For more information, contact Dr. Christina Conrath, (907)481-1732.

15. Grenadiers

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA
Grenadiers in Alaska

In 2009, 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 2008 and presented new survey information and updated catches for 2009. 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. For the 2009 update, revised biomass estimates for giant grenadier were computed that included new longline survey and trawl survey data from 2009. These estimates are: eastern Bering Sea (EBS), 518,778 mt; Aleutian Islands (AI), 1,027,637 mt; and Gulf of Alaska (GOA), 597,884 mt. Similar to the 2008 full assessment, we applied an F=M=0.078 approach 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, 30,349 mt; AI, 60,117 mt, and GOA, 34,976 mt. When these values are compared with the estimated catches of giant grenadier, it appears that giant grenadier are not being overfished at this time. However, the reported longevity, slow growth, and deep-sea habitat of this species make it susceptible to overfishing. Because of these special concerns for susceptibility of giant grenadier to overharvest, fishery managers should closely monitor future catches to ensure that overfishing does not occur.

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 recommended in 2009 that grenadiers be re-classified as "in the fishery", in which case an official assessment would be required. It is likely that a future NPFMC amendment to the Groundfish Management Plans will change the management status of grenadiers in Alaska.

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D. Other Related Studies

Recovery of Deep-Water Sponges and Sea Whips from Bottom Trawling

Deep-water habitat-forming biota is sensitive to anthropogenic disturbance. Interactions between bottom trawls and seafloor habitat have been the focus of much research in recent years. The relative effect of bottom trawls on benthic habitat depends on many factors including gear configuration, the geological characteristics of the seafloor, depth, and sensitivity of the habitat-forming species present. Stable deep-water habitats experience low levels of natural disturbance, are more susceptible to trawl effects, and recover more slowly than shallow-water habitats. The response of sessile benthic epifauna to trawl disturbance varies among taxa. In the short-term, deep-water sponges and anthozoans (corals, anemones, sea whips) are particularly sensitive to trawl disturbances. Little is known, however, about the long-term effects of trawl-induced damage to these important deep-water habitat-forming invertebrates. The objective of this study is to document moderate to long term recovery of deep-water sponges and sea whips following disturbance from fishing gear. Results from this study will resolve questions about the persistence of damage in the benthic ecosystem and could reduce the uncertainty of parameter estimates used within the Fujioka (2006) habitat impacts model. Improved accuracy of model output will provide fishery managers greater insight when evaluating fishery impacts and will aid in decision-making when contemplating habitat conservation measures, such as area closures.

In 1996, Freese et al. (1999) used a bottom trawl equipped with "tire gear" to examine short-term effects of trawling on benthic invertebrates in the Gulf of Alaska. This gear was similar to that used in the commercial rockfish *Sebastes* spp. trawl fishery. Eight trawls were made southwest of Salisbury Sound in southeast Alaska in an area where zero or minimal trawling occurred since the 1970s. In 1998, the area was officially closed to trawling. Based on video data collected through direct observations with the *Delta* submersible, Freese et al. (1999) found a significant decrease in density and an increase in damage to sponges (tentatively identified as the demosponges *Esperiopsis* sp., *Mycale* sp., and *Geodia* sp.) and sea whips (tentatively identified as *Stylea* sp.) in trawled versus reference sites. About 70% of large sponges and 55% of sea whips were damaged by a single trawl pass. In a follow up study one year post-trawl, no new colonization or evidence of repair or regrowth of sponges occurred (Freese 2001).

In 2009, the site was revisited to examine recovery dynamics of sponges and sea whips 13 years post trawling. In 1996, Freese et al. marked the trawl paths and submersible transects on the seafloor with flags attached to fiberglass stalks. Thirteen years later, we successfully relocated 12 of 14 markers and completed 7 transects within trawl paths as well as 7 reference transects outside trawl paths. These data will be used to compare sponge and sea whip disposition in trawled versus reference areas. Additionally, we obtained close-up video of individual sponges both inside and outside the trawl paths to further examine the incidence of injury and the rate of recovery of damaged sponges. In total, we completed 16 dives with the *Delta* submersible. In some areas, trawl evidence, including seafloor gouging, boulder displacement, and sponge damage, was still apparent. The original flags were no longer attached to their fiberglass stalks and the stalks were easily confused with sea whips. In order to facilitate the potential for continued monitoring of seafloor recovery, we deployed new markers that should be easier to find and more durable than the originals. Preliminary processing of the video transects was completed during the winter and spring of 2009/2010. Cursory data analyses revealed that the abundance of sponges was lower and the incidence of damaged sponges within trawled transects was higher than within the reference transects. Species composition also differed between trawl and reference transects.

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

Recruitment and Response to Damage of an Alaskan Gorgonian Coral

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 exist that detail recruitment and recovery of deep-water corals. This information is key to understanding long-term effects of anthropogenic disturbances, such as commercial fishing, on the population dynamics of benthic habitat. The research described here will determine recruitment and recovery rates of the gorgonian coral *Calcigorgia spiculifera,* a species distributed broadly in the Gulf of Alaska and along the Aleutian Islands at depths that range from 18 to at least 329 m. *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. The bauplan of *C. spiculifera* is similar to many other gorgonian corals commonly found throughout the North Pacific Ocean including *Fanellia* spp., *Plumarella* spp., and *Thouarella* spp. Therefore, sensitivity to disturbance, rate of recovery, and recruitment of *C. spiculifera* is likely to be similar to other gorgonian species and thus results from this research could be applied broadly. Recovery rate and recruitment data are lacking in the Fujioka (2006) habitat impacts model. Reduced uncertainty of model parameters will improve model predictions and will help guide fisheries managers in making decisions regarding benthic habitat conservation measures, including area closures. This research will assess the sensitivity and recovery of a deep-water coral, and it will provide necessary data to validate and improve the output of the Fujioka (2006) habitat impacts model.

In August 2009, a team of four divers located and tagged 48 *Calcigorgia spiculifera* colonies in Kelp Bay, southeast Alaska. Of that total, 9 colonies were fitted with settlement rings equipped with natural rock tiles. The settlement rings were epoxied to the seafloor and on future site visits, a subsample of the tiles will be collected and inspected for adhesion of coral planulae, i.e., recruitment. The remaining 39 tagged colonies were ascribed to three damage treatment groups and a control group to assess the sensitivity and recovery of disturbed coral. The damage treatments were designed to mimic actual damage that can occur from passing fishing gear. These treatments were performed *in situ* and included deflection, gorgonian 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. The deflection treatment was completed by passing a simulated trawl footrope over each colony. This resulted in immediate dislodgement of one coral colony. Subsequent monitoring of the damaged corals will detail the long-term effects of disturbance. This is a multi-year study that requires additional site visits and observations. Field operations are scheduled for June and September 2010 and additional site visits in 2011 and beyond if necessary.

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

Nearshore Fish Assemblages in the Chukchi Sea near Barrow, Alaska

The Arctic is changing rapidly and information on fish populations is necessary to make informed management decisions regarding potential effects from development (e.g., oil and gas) and global climate change. This is especially true in shallow, nearshore habitats that are often ignored in fisheries surveys. To establish long-term monitoring sites and with support from Alaska's North Slope Borough, we sampled nearshore fish assemblages at six sites in the

Chukchi Sea in August 2007, 2008, and 2009, and September 2009. At each site, fish were captured with two gear types: a beach seine in waters <5 m deep and a small bottom trawl at two depths (5 m and 8 m). A total of 15,030 fish representing 20 species were captured in 24 beach seine hauls, and 3,221 fish representing 23 species were captured in 48 trawl tows. Species composition differed by gear type, among years, and within 2009. Total beach seine catch was dominated by capelin (82%), and total trawl catch was dominated by Arctic cod (56%). Among years for both gear types (August only), capelin accounted for 96%, 4% and 27% of the total catch, whereas Arctic cod accounted for <1%, 46%, and <1% of the total catch. In 2009, total catch and species richness was greater in September (7,861 fish, 20 species) than in August (2,633 fish, 13 species). In addition to capelin and Arctic cod, other forage fish and subsistence species that we captured were Pacific sand lance, saffron cod, and rainbow smelt. Annual variability in catch and species composition can likely be attributed to different environmental conditions. For example, Arctic cod dominated the total catch only in 2008; this was the coldest year that we sampled (water temperatures <2.0° C and ice persisted until mid-August). The shallow, nearshore environment of the Chukchi Sea provides important habitat for many fish species and is extremely vulnerable to disturbance. Because changes in community structure are expected from continued warming and loss of sea ice in the Arctic, with unknown consequences to existing stocks and food webs, long-term monitoring of nearshore fish assemblages is warranted.

For more information, contact Scott Johnson at (907) 789-6063, scott.johnson@noaa.gov.

Bycatch Studies – RACE Conservation Engineering

Salmon Excluders

Two cruises were conducted under exempted fishing permits, in March and August of 2009, to test improved excluder devices. Due to concerns over clogging in the excluders, the versions tested in 2009 used a panel that blocks escape portals during regular towing and opens them during scheduled periods of slower towing ("flapper excluders"). Many of these devices are currently being used in the fishery, but the most recent version provided by a major net manufacturer had not been tested for effectiveness. A September 2009 test used that version, which places the excluder just ahead of the codend, further back in the net than previous excluders. NMFS cameras and sonars were provided for both cruises, and we participated in all planning and several outreach workshops. We also partially funded a workshop at the flume tank in St. Johns, Newfoundland for October 2009.

Reduce trawl damage to seafloor invertebrates

In October 2009, the North Pacific Fishery Management Council (NPFMC) recommended implementing regulations requiring modified sweeps for Bering Sea flatfish fisheries. These sweeps were developed over the last five years by a collaboration of RACE Division scientists and the Bering Sea bottom trawl fleet. Work in this area in 2009 focused on providing research results to the NPFMC and other stakeholders as they decide whether to require these trawl sweep modifications for the Bering Sea flatfish fisheries. We also conducted research to explore variations of the sweep modifications that would help fishermen transition to their use. A nine-day research cruise in June tested whether smaller-diameter sweep cables, which would alleviate handling problems associated with the modifications, would still effectively herd flatfish.

Crab Mortalitity Rates After Trawl Encounters

From August 8 - 24, scientists aboard the F/V *Pacific Explorer* from the Conservation Engineering and Shellfish groups of the AFSC's Resource Assessment and Conservation Engineering Division collected data to estimate the mortality rates of red king crab (*Paralithodes camtsactcus*) after passage under the groundgear of commercial bottom trawls. This followed the methods of similar research on Tanner and snow crabs in 2008. Crabs were recaptured after passing under the central and side sections of a trawl footrope, as well as after contacting the sweeps ahead of the trawl. Crabs were also assessed after capture by a similar net fished ahead of the trawl, to estimate and account for the effect of capture and handling. Finally, we evaluated the effectiveness of modifications to sweeps and footrope that were expected to reduce crab mortality. More than 3,700 crabs from 73 trawl hauls were assessed for reflex impairments, while more than 738 were assessed and then held in onboard tanks to establish the association between these impairments and the probability of mortality. This research was primarily supported by a grant from the North Pacific Research Board, with additional support form the NMFS Bycatch Reduction Engineering Program and National Cooperative Research Program.

Industry Video Systems to Speed Fishing Gear Improvements

Five underwater video systems continue to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. These systems saw relatively light use in FY 2009. A principal factor in this reduction is that a number of vessels and fishing companies have acquired their own systems. Apparently, at least some of them found the video provided by NMFS systems useful enough that they wanted the capability available full time.

For more information, contact Dr. Craig Rose at (206)526-4128.

RACE Habitat Research Team

[Section has not been updated for 2010]

For additional information, see http://www.afsc.noaa.gov/RACE/groundfish/hrt/default.php or contact Dr. Bob McConnaughey, (206) 526-4150.

E. Other Items

GIS Resources

Data

Etopo1 (http://www.ngdc.noaa.gov/mgg/global/global.html)
"ETOPO1 is a 1 arc-minute global relief model of Earth's surface that integrates land topography and ocean bathymetry. It was built from numerous global and regional data sets, and is available in "Ice Surface" (top of Antarctic and Greenland ice sheets) and "Bedrock" (base of the ice sheets) versions. Historic ETOPO2v2 and ETOPO5 global relief grids are deprecated but still available."

Large Marine Ecosystems (LME) (http://www.lme.noaa.gov/)

“Large Marine Ecosystems (LMEs) are relatively large areas of ocean space of approximately 200,000 km² or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas.”

Bing Maps and other data for use in Arcview and ArcInfo (http://resources.esri.com/help/9.3/arcgisonline/about/start.htm#map_types.htm#)
“ArcGIS users can access a collection of online basemaps, imagery, and overlays from ESRI. Standard maps are available at no cost to ArcGIS users for internal use or for non-commercial external use. A subscription fee is required for users who wish to publish applications that use ArcGIS Online maps for commercial use.”

NOAA's National Geophysical Data Center (NGDC) has been building high-resolution digital elevation models (DEMs) of select U.S. coastal regions. For more information see http://www.ngdc.noaa.gov/dem/ and
http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html.

New GIS Tools
Simple Vector Renderer from Buck Stockhausen (William.Stockhausen@noaa.gov) Plot vector quantities in ArcGIS using the right symbols. The jar file is an Arc Engine extension for ArcGIS Desktop that accounts for geographic transformations and frame rotations. This is still in development, so Buck is interested in any feedback you might have. Also, he would appreciate an acknowledgment on any figures you produce using it.

Hawth’s Analysis Tools for ArcGIS is now changing to Geospatial Modeling Environment (GME) and is available at http://www.spatialecology.com/gme/. “The Geospatial Modeling Environment (GME) is a platform designed to help to facilitate rigorous spatial analysis and modeling. GME provides you with a suite of analysis and modeling tools, ranging from small 'building blocks' that you can use to construct a sophisticated work-flow, to completely self-contained analysis programs. It also uses the extraordinarily powerful open source software R as the statistical engine to drive some of the analysis tools. One of the many strengths of R is that it is open source, completely transparent and well documented: important characteristics for any scientific analytical software. GME has dependencies on three other software packages: R, StatConn, and ArcGIS.”

Software
ESRI’s Arcview and ArcInfo version 10 is arriving in June. Some of the major enhancements include a new search engine for documentation, the ability to check out licenses, a time slider that enables one to step through time enabled layers, and automate map production with Python and map books. For additional information see http://www.esri.com/software/arcgis/whats-new/new-features.html.

For more information, contact Jan Benson (206) 526-4183.

APPENDIX I - Alaska Fisheries Science Center Groundfish-Related Publications and Documents In Press – January 2008 through April 2009

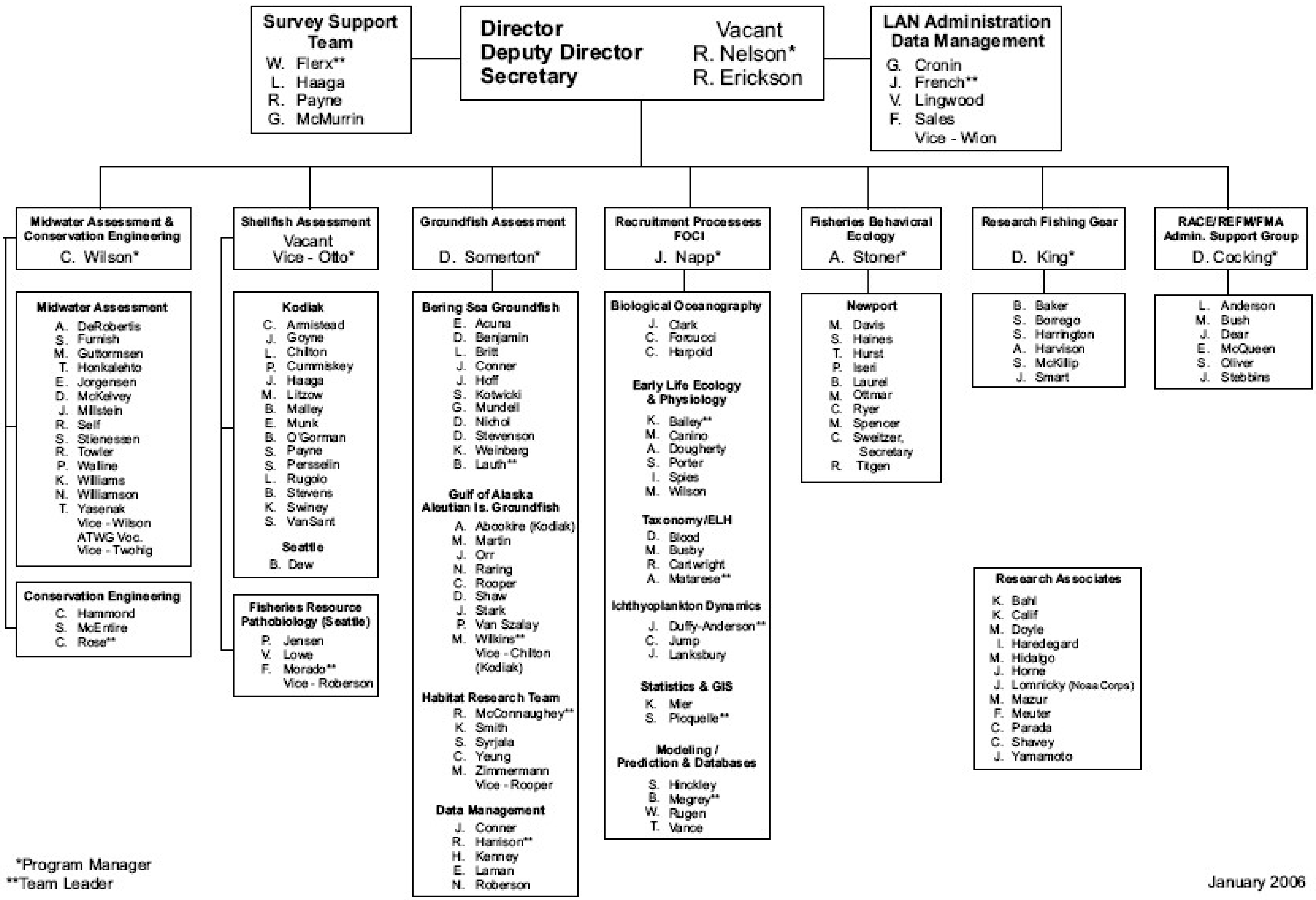
(AFSC authors in bold text)

Alaska Fisheries Science Center (AFSC) Peer-Reviewed Journal Reports and Technical Memoranda in 2009 (AFSC authors are in bold).

Note: Listings of 2008 Groundfish Stock Assessment Reports and AFSC Processed Reports are accessible by following the links provided below to the appropriate AFSC web page.

[This appendix will be compiled and provided later.]

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION
ORGANIZATION CHART
2006



*Program Manager
**Team Leader

January 2006

APPENDIX III.--RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION

Patricia Livingston -- Director

Loh Lee Low -- Deputy Director

Administrative Support	Age Determination Unit	Status of Stocks and Multispecies Modeling	Resource Ecology and Ecosystems Modeling	Socio-Economic Assessment
Ito, Daniel -- NEPA coordinator	Kimura, Dan -- Supervisor	Hollowed, Anne -- Supervisor	Aydin, Kerim BActing Supervisor	Felthoven, Ron -- Leader
Goiney, Bernie	Anderl, Delsa	Conners, Liz	Buckley, Troy	Haynie, Alan
	Benson, Irina	Dorn, Martin	Derrah, Christopher	Hiatt, Terry
	Gburski, Chris	Greig, Angie	Lang, Geoffrey	Lew, Dan
	Goetz, Betty	Gaichas, Sarah	Yang, Mei-Sun	Sepez, Jennifer
	Hutchinson, Charles	Ianelli, James		Seung, Chang
	Johnston, Chris	Logerwell, Libby		
	Kastelle, Craig	Lowe, Sandra		
	Foy, Dan	Munro, Peter		
	Kautzi, Lisa	Pearce, Julie		
	Shockley, Wes	Spencer, Paul		
	Short, Jonathan	Thompson, Grant		
	Piston, Charlses	Turnock, Jack		
	Brogan, John	Stockhousen, Buck		
		Wilderbuer, Thomas		
		Neidetcher, Sandi		
		McDermott, Susanne		

ADP

Blaisdell, Mark

Wennberg, Sherrie

Revised April 2005

APPENDIX IV - Auke Bay Laboratory Marine Ecology and Stock Assessment (MESA) Program Staff

Name	Duties
Phil Rigby	Program Manager
Doris Alcorn	Seafloor Ecology, Outreach
Dave Clausen	Rockfish, Grenadiers, Alaska Groundfish
Dave Csepp	Forage Fish, Hydroacoustics
Jeff Fujioka	Sablefish, Rockfish, Stock Assessment, Effects of Fishing
Dana Hanselman	Sablefish, Rockfish, Stock 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
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
Christine Kondzela	Rockfish Genetics
Sharon Hawkins	Forage Fish Genetics
Ed Farley	Epipelagic Trawl Survey in Bering Sea, Age-0 Walleye Pollock