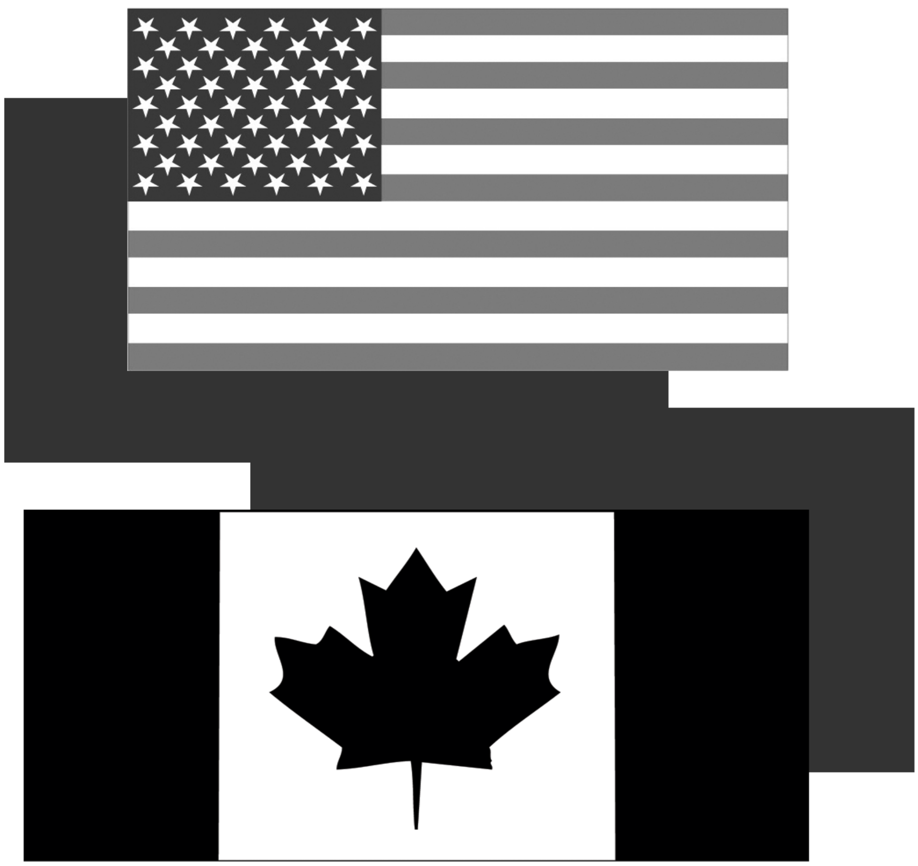
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

53rd Annual Meeting of the TSC

May 1-2, 2012
Newport Beach, California



Appointed by the Second Conference on Coordination of Fisheries Regulations between Canada and the United States

Compiled by the Pacific States Marine Fisheries Commission

History of TSC Meeting Locations, Hosts and Chairpersons

YEAR	DATES	LOCATION	HOST	CHAIR
1984	June 20-22	British Columbia	Westrheim	Rigby
1985	June 25-27	Juneau, AK	Morrison	Westrheim
1986	June 19-19	Ashland, OR	Demory	Westrheim
1987	June 9-11	Seattle, WA	Jagielo	Demory
1988	June 7-9	Carmel, CA	Henry	Demory
1989	June 6-9	Ladysmith, BC	Saunders	Jagielo
1990	June 5-7	Sitka, AK	Bracken	Jagielo
1991	June 4-6	Newport, OR	Barss	Wilkins
1992	May 5-7	Seattle, WA	Jagielo	Wilkins
1993	May 5-7	Point Lobos, CA	Thomas	Saunders
1994	May 3-5	Nanaimo, BC	Saunders	Saunders
1995	May 2-3	Seattle, WA	O'Connell	Bracken
1996	May 7-9	Newport, OR	Barss	O'Connell
1997	May 6-8	Tiburon, CA	Thomas	Barss
1998	May 5-7	Olympia, WA	Jagielo	Barss
1999	May 4-6	Seattle, WA	Methot	Barnes
2000	May 9-10	Nanaimo, BC	Saunders	Barnes
2001	May 8-10	Newport, OR	Schmitt	Schmitt
2002	May 7-8	Point Lobos, CA	Barnes	Methot
2003	May 6-7	Sitka, AK	O'Connell	Jagielo
2004	May 4-5	Coupeville, WA	Wilkins	Jagielo
2005	May 3-4	Parksville, BC	Stanley	Stanley
2006	May 2-3	Otter Rock, OR	Parker	Stanley
2007	April 24-25	Santa Cruz, CA	Field	Brylinsky
2008	May 6-7	Seattle, WA	Wilkins	Brylinsky
2009	May 5-6	Juneau, AK	Clausen	Clausen
2010	May 5-6	Nanaimo, BC	Stanley	Clausen
2011	May 3-4	Astoria, OR	Phillips	Clausen
2012	May 1-2	Newport Beach, CA	Larinto	Clausen

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A. Overview and Terms of Reference

During the Conference on Coordination of Fisheries Regulations Between Canada and the United States (April 1959, Vancouver B.C.), the Ad Hoc Committee on Trawl Fishery Regulations recommended that the governments of Canada and the United States establish a continuing group made up of administrative and technical representatives of Oregon, Washington and Canada to review trawl regulations, to exchange information of status of bottom fish stocks, and to continue, enhance and coordinate bottom fish research programs. The Technical Sub-committee (TSC) was then created by the Committee on Trawl Fishery Regulations (now the Canada-U.S. Groundfish Committee) at the trawl committee meeting held in Seattle, Washington, on November 4, 1959. The TSC first met in Portland, Oregon, on January 19-20, 1960. Dr. K.S. Ketchen (Canada) served as Chairman. Member agencies at the time were the Fisheries Research Board of Canada (now the Department of Fisheries and Oceans), Washington Department of Fisheries (now the Washington Department of Fish and Wildlife), Fish Commission of Oregon (now the Oregon Department of Fish and Wildlife), and the California Department of Fish and Game. In 1972, two more agencies became members – the Alaska Department of Fish and Game and the U.S. Bureau of Commercial Fisheries (now the National Marine Fisheries Service).

The TSC has met at least annually since 1960 and submitted a processed report of each meeting to its Parent Committee.

These terms of reference did not apply to Pacific halibut, whose research and management are the responsibility of the International Pacific Halibut Commission:

1. Exchange information on the status of groundfish stocks of mutual concern and coordinate, whenever possible, desirable programs of research.
2. Recommend the continuance and further development of research programs having potential value as scientific basis for future management of the groundfish fishery.
3. Review the scientific and technical aspects of existing or proposed management strategies and their component regulations relevant to conservation of stocks or other scientific aspects of groundfish conservation and management of mutual interest.
4. Transmit approved recommendations and appropriate documentation to appropriate sectors of Canadian and U.S. governments and encourage implementation of the recommendations.

The TSC has exhibited considerable flexibility in reacting to the diverse problems of the dynamic groundfish fishery off western Canada and the United States. It has coordinated coastwide fishery statistics and research projects; created working groups to deal in depth with specific problems; scheduled workshops at which appropriate specialists met to jointly deal with specific problems and exchange data and information; and provided an on-going forum for exchange of data, procedures, and regulations. The TSC has identified problems associated with the utilization and management of groundfish resources of importance to both countries; often well in advance of public or agency awareness. The concerns expressed in 1962 by the TSC over the development of foreign fisheries and recommendations for stock assessments were significant. TSC-coordinated Canada-U.S. research on Pacific ocean perch provided the basis for negotiation of bilateral fishing agreements between the United States and Japan and the USSR. Furthermore, the continually updated information provided the basis for quotas imposed in 1977 by Canada and the United States when they both promulgated their 200-mile zones of extended jurisdiction.

B. Executive Summary

The TSC met May 1-2, 2012 in Newport Beach, California. This year's meeting was hosted by the California Department of Fish and Game (list of attendees is attached). The meeting was chaired by Dave Clausen, AFSC Auke Bay Lab. As is done each year at the meeting, participants review previous year (2011) research achievements and projected current year (2012) research for each agency. Each agency also submits a written report summarizing groundfish accomplishments for the previous year.

The TSC again noted the valuable ongoing work of the Committee of Age Reading Experts (CARE) (http://care.psmfc.org/), a long-standing TSC Working Group that was originally created by the TSC in 1982. The purpose of CARE is to facilitate among agencies the standardization of groundfish age determination criteria and techniques. Sandra Rosenfield (Washington Department of Fish and Wildlife, representing CARE) reported on CARE activities in 2011 and on CARE committee reports that year. CARE holds a biennial workshop involving all member agencies, the most recent of which was in April 2011. It was noted that at three agencies, a key age reader will be retiring soon. Because of their many years of cumulative experience, this will represent a significant loss to the ageing community.

The TSC made **one substantive new recommendation at the 2012 meeting:** that a workshop be held on **the topic of developing ROV surveys for use in rockfish stock assessments**. Although there have been ROV/submersible workshops in the past, including the non-lethal survey symposium at the American Fisheries Society meeting in 2011 (discussed above), there is interest in holding another workshop specific to ROV rockfish surveys. Many agencies and universities are conducting ROV surveys on the west coast, but few are incorporating these data into stock assessments. This workshop would provide the opportunity to learn from other research groups' ROV survey successes and failures and make progress towards using ROV data as a non-lethal method for stock assessment. To maximize attendance, the preferred location and workshop is in Seattle in late winter or spring of 2013. Kristen Green (Alaska Department of Fish and Game), Lynne Yamanaka (Canada DFO), and Theresa Tsou (Washington Department of Fish and Wildlife) offered to collaborate on planning this workshop.

Other important topics discussed at the meeting included: 1) problems most agencies now face with declining budgets. For example, in the U.S., the Interjurisdictional Fisheries Act (IFA) budget will likely be cut, which is problematic because it is the source of much funding for state fisheries agencies; and 2) marine protected areas (MPAs) continue to be a major topic at recent TSC meetings. California, Oregon, and British Columbia in particular have established or are in the process of establishing MPAs, although MPAs also exist in Alaska and Washington State. California's MPAs are especially large and will encompass 15% of all state waters.

Following the conclusion of the TSC meeting, a workshop was held to discuss, compare and develop best practices of reconstructing species-specific catches from grouped species landing data. This workshop came about as a result of a 2011 TSC recommendation.

It was noted that long time TSC member **Dave Clausen** will be retiring from NOAA in Fall 2012. Dave made exceptional contributions to the TSC over 20 + years, and he will be missed.

The 54th Annual Meeting of TSC is scheduled for **April 30 – May 1, 2013,** in Seattle Washington, to be hosted by the AFSC.

C. Minutes of the Technical Subcommittee

Minutes
53rd Annual Meeting of the
Canada-U.S. Groundfish Committee's
Technical Subcommittee (TSC)
May 1-2, 2012

Back Bay Marine Science Center
600C Shellmaker Road
Newport Beach, CA 92660
(http://www.backbaysciencecenter.org/map_bbsc.html)

Chair: Dave Clausen, AFSC
Host: Traci Larinto, CDFG

Tuesday, May 1

I. Call to Order – Dave Clausen, Chair, called the meeting to order at 8:15 am

II. Appointment of Secretary – Kenin Greer, CDFG, Los Alamitos

III. Introductions

Reports that were made available online before the meeting, or provided at the meeting, including the 2011 TSC report, and the 2012 reports from SWFSC, CDFG, ODFW, WDFW, NWFSC, IPHC, DFO, AFSC, ADFG and CARE. The 2012 report will be compiled by Stephen Phillips.

List of Participants

Dave Clausen	Alaska Fisheries Science Center, NOAA, Auke Bay Lab, Juneau, AK (Dave.Clausen@noaa.gov)
Alison Dauble	Oregon Department of Fish and Wildlife, Newport, OR (Alison.D.Dauble@state.or.us)
Claude Dykstra	International Pacific Halibut Commission, Seattle, WA (claude@iphc.int)
Kristen Green	Alaska Department of Fish and Game, Sitka, AK (Kristen.Green@alaska.gov)
Xi He	Southwest Fisheries Science Center, NOAA, Santa Cruz, CA (Xi.He@noaa.gov)

Traci Larinto	California Department of Fish and Game, Los Alamitos, CA (TLarinto@dfg.ca.gov)
Sandy Rosenfield	CARE chair, Washington Department of Fish and Wildlife, Olympia, WA (Sandra.Rosenfield@dfw.wa.gov)
Kate Rutherford	Science Branch, Pacific Biological Station, Canada DFO, Nanaimo, BC (Kate.Rutherford@dfo-mpo.gc.ca)
	Theresa Tsou Washington Department of Fish and Wildlife, Olympia, WA (Tien-Shui.Tsou@dfw.wa.gov)
Tom Wilderbuer	Alaska Fisheries Science Center, NOAA, Seattle, WA (Tom.Wilderbuer@noaa.gov)
Lynne Yamanaka	Science Branch, Pacific Biological Station, Canada DFO, Nanaimo, BC (Lynne.Yamanaka@dfo-mpo.gc.ca)

IV. Approval of 2011 Report

The 2011 Report was approved with minor corrections at 8:45 am

V. Approval of 2012 Agenda

The 2012 Agenda was approved at 8:50 am. It was decided to retain the "yelloweye rockfish working group" in the agenda as a place holder, as well as "marine mammal predation on groundfish". There was discussion on whether the TSC meeting could be shortened to just a single day, but everyone agreed that future meetings should be scheduled for a day and a half. The present TSC meeting is an exception due to the scheduling of the catch reconstruction workshop on the second day.

VI. Working Group Reports

A. Committee of Age Reading Experts (CARE) reported by Sandra Rosenfield, WDFW

There was no 2012 CARE meeting, and the next meeting will be in Seattle in 2013. CARE committees reports from 2011 were reviewed.

- Manual/glossary committee: The rockfish section was updated and reviewed and work will begin on new sections for hake, lingcod, and skates. Review is underway on new sections on QA/QC and Pacific halibut ageing.
- Website committee: The CARE website is hosted by PSMFC. The committee plans to add photos from the 2011 meeting, 2010 production numbers, and structure exchanges. The committee is still working on preparing an online summary of age structures by agency per the TSC to CARE recommendation in 2010. The CARE representative informed the TSC that three CARE member agencies (DFO, IPHC, and SWFSC) have agreed to compile and forward an on-line summary of archived ageing material. Two other agencies, WDFW and ODFW have also agreed, pending

approval. The AFSC already maintains a publicly accessible on-line archive of its ageing collections. The ADF&G Age Lab declined to participate in the summary since they already maintain their own website.

- Charter committee: No work was done on the charter which has been in place since 2000.
- Sablefish committee: The committee discussed ageing issues with examples of known-age sablefish. The group plans to develop a technical document and to update the CARE manual.

CARE report was reviewed. The CARE mandate regarding agency exchanges was questioned by a CARE member.

CARE to CARE Recommendations
2009 – No work was done on adding information on the working groups to the charter.
2011 – CARE has made progress on the 2011 recommendations, including the manual working group, and asked all members to review the method and validation information for each species.

TSC to CARE Recommendations
See section X. of these minutes regarding a recommendation about the online summary of age structures and a thank you to CARE.

General Comments
WDFW and ODFW both acknowledge that they want to continue to participate in CARE but with only 1 or 2 agers it is difficult to increase participation.

AFSC has a new ageing manual available on the AFSC website.

B. Trawl & Longline Survey Workshop

Rick Stanley, DFO, and Malcolm Wyeth, DFO, met with staff from AFSC this year in an informal trawl workshop. Malcolm has produced minutes from the 2010 multi-agency Trawl and Setline Survey Workshop.

C. Yelloweye rockfish working group

The yelloweye rockfish working group has not formally met in recent years; however, interest in maintaining the group continues. Yelloweye rockfish continue to constrain fishing opportunities on the west coast. WDFW, ODFW and CDFG are all interested in developing nonlethal surveys (e.g., ROV surveys). DFO uses ROV data for an index of abundance (yelloweye and quillback rockfish) but does not estimate overall biomass from the data. ADFG uses ROV data for stock assessment purposes (yelloweye rockfish and lingcod). John Butler, SWFSC, has used ROV data to estimate biomass for bocaccio that was well within the bounds of the formal stock assessment. Mary Yoklavich, SWFSC, has used a manned submersible to estimate cowcod biomass. WDFW is interested in doing ROV work with the IPHC to compare the two survey methods (ROV vs. longline).

ADF&G plans to do an ROV survey in late summer 2012 to assess yelloweye rockfish in Southeast Alaska.

Ian Stewart, NWFSC, recently held a workshop discussing available yelloweye rockfish data.

At the annual AFS meeting in Seattle in 2011, Liz Clarke, NWFSC, and Teresa Tsou, WDFW, convened a symposium on various non-lethal survey methods titled "Alternative Survey Strategies: Technology, Research, Methods, and Applicability". Presentations were given on the use of ROV, AUV, manned submersibles, and drop cameras. Additionally, Mary Yoklavich, John Butler, and Liz Clarke have completed a comparative survey of ROV, AUV and manned submersibles, but the paper is not yet available.

Following further discussion on visual survey methods, the TSC recommended that a workshop be held to discuss how to use visual, nonlethal surveys in stock assessments. Kristen Green and Lynne Yamanaka drafted the recommendation. The TSC agreed that the workshop should be held in early 2013, and if that was not possible it should be held in conjunction with the Western Groundfish Conference in 2014 (see Section X., "TSC to itself" recommendations).

VII. Other Topics

A. Marine Reserves

ODFW has 3 new state marine reserves/marine protected areas proposed in legislation. This will bring the total to 5 state reserves by 2015. They have plans in place for long-term year-round monitoring & assessment in these state marine reserves/MPAs aimed at nearshore species, but not specifically groundfish species. The reserves are relatively small in size.

CDFG has marine protected areas (MPAs) in place in three of the four regions, and their Fish and Game Commission is in the process of adopting MPAs for the final region (North Coast). These MPAs represent 15% of all state waters which are now reserves or limited use/take areas. Monitoring plans are in place for the 3 established regions and will be developed for the fourth region once the MPAs are adopted.

DFO - National Ocean Policy: *Canada's recent Oceans Action Plan is set to realize the goals of the policy by maximizing the use and development of oceans technology, establishing a network of marine protected areas, implementing integrated management plans, and enhancing the enforcement of rules governing oceans and fisheries, including rules governing straddling stocks.*

The Canadian groundfish industry has worked with E-NGOs to develop a "trawl footprint" to address sponge reef and coral conservation in British Columbia. This is a progressive move by industry to freeze the extent of the trawlable fishing ground in B.C. and to include sponge and coral catch limits in the trawlable areas.

B. <u>Genetics and stock structure</u>

DFO has been conducting genetics work on blackspotted/rougheye rockfish and yellowtail rockfish.

SWFSC has been working on larval fish genetics.

ODFW conducted a blue rockfish morphology pilot study and has found differences in morphology between the solid and blotched blue. No genetics identification has been done, but samples were collected for future genetics work.

1. <u>Western Groundfish Conference 2012</u>
   Claude Dykstra reported that the 2012 Western Groundfish Conference in Seattle was well-attended with about 215 conferees. The next Western Groundfish Conference will be Feb. 10-14, 2014, in Victoria, B.C. The organizing committee will consist of Rick Stanley (co-chair), Lynne Yamanaka (co-chair) and Kate Rutherford of Canada DFO, Scott Buchanan (co-chair) and Keri Taylor of Archipelago Marine Research, and Claude Dykstra and Kirsten MacTavish of the IPHC. The IPHC holds the money used for the conference and is willing to continue doing so.

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

In general, due to the shortened meeting, the agencies spoke briefly on the topics and referred people to their agency reports for detailed information.

A. <u>Agency Overviews</u>

CDFG took over the California Recreational Fisheries Survey sampling program from PSMFC because the state would not renew the contract (unions were opposed). They have hired almost 70 new staff to man the program, and staffing is stable now.

SWFSC's Groundfish Analysis Team Lead at the Santa Cruz Lab, Steve Ralston, retired at the end of 2011 and has been replaced by John Field. Steve Lindley is now the director of the Fisheries Ecology Division at the Santa Cruz Lab.

ODFW is planning to move to a mandatory 11:1 staff to manager ratio, from the previous 6:1 ratio. There will be substantial restructuring cuts in the next 5 years to the Marine Resource Program within the agency. This restructuring has the potential to restrict advancement.

WDFW : Long-time employee Farron Wallace changed jobs in 2011 and now works for the AFSC Observer Program. Dayv Lowry is now the lead for Puget Sound groundfish and forage fish.

DFO's Tammy Corrine is on maternity leave and Neil Dayton is filling in. Upcoming retirements include Rick Stanley (2013) and Bill Eisner (September 2012).

ADFG's Dave Carlisle (October 2012) and Doug Woodby are retiring; Doug has been replaced on the North Pacific Council Scientific and Statistical Committee by Sherri Dressel. Chris Siddon has been hired to take Doug's place. He will transition into that position in fall 2012.

AFSC has a new Deputy Director, Steve Ignell, who previously was the Deputy Director at the Auke Bay Lab. Summer surveys are coming up and due to increasingly restrictive travel budgets this may affect travel that is not related to field work.

IPHC is currently in an agency review with results soon to be released. They have a new Assistant Director, Steve Keith. A database administrator position is being hired along with a replacement for Steven Hare, formerly the IPHC's Chief Stock Assessment Scientist.

The Interjurisdictional Fisheries Act (IFA) budget was cut, which is problematic because it is the source of much funding for state fisheries agencies. PSMFC received the money, lost it all, but got some back. This may affect the TSC.

Sport fish Restoration Act (SFRA) monies may be reviewed as well.

B. <u>Multispecies Studies</u>

1. *CDFG* has taken over the recreational sampling program for the state.

   SWFSC is continuing their annual midwater trawl surveys for juvenile rockfish. These data are to be used in stock assessments.

   ODFW conducts both recreational and commercial monitoring and is hoping to increase recreational shore and estuary sampling. ODFW has completed multiple maturity and movement studies for nearshore species. There have also been baseline monitoring studies for two years at each of the two pilot marine reserves. Hypoxia has been of increasing concern off Oregon, and ODFW is working with Oregon State University to monitor this.

   WDFW conducted ongoing monitoring as well as nearshore rockfish tagging. The agency duplicated the IPHC longline survey off Cape Flattery at a different time of the year (fall) and found more dogfish then. A bycatch study for the recreational rockfish hook-and-line fishery was conducted in WDFW Catch Area 4B. Another recreational survey was done to verify the number of boats. Also, WDFW found a difference in catch rates between what fishermen remember and what actually occurs. A new voluntary recreational private boat logbook was established to help with species identification and reporting of bycatch.

DFO staff continues to participate in the Strait of Georgia Ecosystem Research Initiative. DFO has developed a formal stock assessment prioritization flowchart (titled “Probability Susceptability Analyses” that includes > 300 species) to help them determine which species to assess. They conducted an email survey about recreational fishing activity.

ADFG continued port sampling for commercial species, the charter boat operator’s logbook program, and conducted a mail survey for sport species.

C. By Species

1. Pacific Cod

   DFO will be conducting a Pacific cod stock assessment in 2012 to be reviewed in 2013.

   IPHC collected length-frequencies for 15 Pacific cod per skate, and also length data for lampreys. In addition, they looked at old vs. new scars on the Pacific cod as well as on Pacific halibut in Washington and Oregon.

2. Nearshore Rockfish

   CDFG nearshore landings have declined in recent years due to the economic downturn and cost of fuel.

   ODFW has been conducting a black rockfish PIT tagging study for 10 years. Recovery rates have been consistent each year and show an annual exploitation rate of 3.2-4.9%. The results were included in the last stock assessment for black rockfish in 2007, but there is potential to use these data in the next assessment. ODFW conducted a pilot study to distinguish morphological differences between the two blue rockfish types (solid and blotched).

   DFO conducted two stock assessments: yelloweye (inside management unit) and quillback rockfish (coastwide). Yelloweye rockfish was found to be 12% of initial biomass in1918. Quillback rockfish was 30% outside and 27% inside of initial biomass in 1918. Yellloweye rockfish was listed as a species “of special concern” prior to the assessment. Quillback rockfish is under consideration for a “ threatened” listing under Canada’s Species at Risk Act.

   ADFG last conducted habitat mapping in Southeast Alaska using multibeam from a state research vessel in 2010. They are now planning an ROV survey this summer for the Central Southeast Outside Area. In ADF&G’s Westward Area (Kodiak Island, etc.), they have been conducting a tagging study of black and dark rockfish.

3. Shelf/Slope Rockfish
   CDFG has been ageing copper rockfish using otoliths and including otolith measurements in preparation for the next stock assessment.

   SWFSC conducted stock assessments for greenspotted, widow and blackgill rockfish, an assessment update and rebuilding analysis for bocaccio, and a status report for cowcod.

   DFO conducted a synchronous assessment of 5 "data-poor" rockfish (splitnose, sharpchin, harlequin, redstripe and greenstriped) in addition to a bocaccio stock assessment. Yellowmouth rockfish is being assessed as to whether it should be listed as "threatened".

   ADFG now requires rockfish release devices on ALL recreational charter boats. They are looking at depth of capture & trauma on deck (+/- 10 min) to see if there are species-specific depth tolerance limits.

   IPHC is conducting a study on the use of whisker hooks to reduce rockfish bycatch in the Pacific halibut fishery.

   AFSC has conducted much research that is detailed in their report. They conducted research on rougheye rockfish barotrauma for fish taken in 600-700 feet of water. After catching the fish by longline, they used ship-board recompression chambers to gradually return the fish to their initial pressure. The majority survived and symptoms of exophthalmia and everted stomachs disappeared. Other items: there still do not appear to be any easily identifiable characteristics to visually separate rougheye and blackspotted rockfish. The 2011 Gulf of Alaska trawl survey caught by far the most silvergray rockfish ever since the time series began in 1984, and silvergray rockfish now ranks third in biomass among Gulf of Alaska rockfish.

   AFSC Kodiak lab is doing maturity work on Pacific ocean perch, shortraker, dusky, and northern rockfishes to update previous studies.

   On May 8 and 9, 2012, there will be a barotrauma workshop in Portland.

4. Thornyheads
   CDFG reports that buyers are getting better at separating shortspine from longspine although some still report "unspecified thornyheads"; more outreach is needed to resolve this.

   AFSC is still having significant problems with ageing thornyheads, and at this time it does not appear that production ageing is possible.

5. Sablefish

CDFG reported an increase in sablefish catch mainly due to increased trip limits and the implementation of catch shares management in the trawl fishery which allowed CA fishermen to trade their whiting shares for sablefish.

DFO will conduct a stock assessment for sablefish in 2013; ongoing surveys are detailed in their agency report. Management strategy evaluation work is ongoing.

ADFG has been conducting mark-recapture studies, which show recent good recruitment. Also, annual longline surveys are conducted to measure catch per unit effort and relative abundance.

AFSC annual longline surveys that started in 1979 continue, a maturity study was conducted near Kodiak in December 2011, and archival tag returns were analyzed to discern movements and temperature preferences – some fish showed daily vertical movement.

6. Pacific halibut and IPHC activities

IPHC

The genetics study continued, and work was focused on using genetics to estimate male/female ratios because the commercial fishery lands dressed fish, for which sex cannot be determined. Sex ratios for commercial landings are presently based on ratios in the IPHC longline survey.

Tagging experiments were conducted to determine location and attachment techniques for archival tags. It appears that halibut can shed internal archival tags. Also, initial studies were conducted using geomagnetic tags which hold promise for providing more detailed information on movements, but the tags may have issues with the magnetic field in the North Pacific.

An age validation study using bomb radiocarbon for the Bering Sea was concluded.

Water column profilers were used during the 2008-2011 IPHC surveys. Data from 2009 and 2010 are available online.

A pilot bait study was conducted to compare bycatch rates, size of halibut, and sex of catch. Baits included chum salmon, which has been the standard used for many years, pollock, herring, and pink salmon. Chum salmon is becoming prohibitively expensive as bait and harder to obtain. In 2012, a larger-scale, coast-wide bait experiment will be conducted.

IPHC longline survey - Yelloweye rockfish and spiny dogfish biological information are sometimes obtained, along with sablefish data. In 2011, the survey was expanded off Washington State and Oregon into shallower and deeper waters as well as into the Strait of Juan de Fuca and Puget Sound proper. In Puget Sound, bycatch was primarily sixgill shark, and no rockfish were caught. Experiments may be conducted in future years to expand the depth coverage of the survey in other areas. Permits are needed for Canada and California to expand the survey in those waters.

WDFW and *ODFW* take dockside samples of rockfish caught on this survey.

DFO has a sampler onboard during the IPHC survey to collect additional bycatch data.

Ichthyophonus, a parasite, which may be very prevalent in salmon and herring, was sampled at three locations in 2011 in conjunction with the USGS. The results found very high prevalence of the parasite in halibut (77% incidence in Prince William Sound and 45% coast-wide average). This study will be extended in 2012 to more areas. The USGS is also looking at the presence in herring, where the parasite has been shown to reduce growth rates.

7. Flatfish

DFO conducted a productivity susceptibility analysis on 17 flatfish species, and results have been published.

AFSC will conduct a spawning/maturity study on Bering Sea flatfish, including yellowfin sole, Alaska plaice, Greenland turbot, and arrowtooth flounder. The Bering Sea yellowfin sole fishery appears to be well managed.

8. Lingcod

DFO's next lingcod stock assessment has been shifted to 2015. The University of British Columbia through an NSERC grant will be conducting a management strategy evaluation for lingcod aimed at identifying harvest options for the small boat groundfish fleet.

AFSC has received archival tag returns from lingcod caught and released during the sablefish longline survey but the data have not yet been analyzed.

9. Pacific Whiting (Hake)

CDFG: 2011 saw a huge reduction in catch (2400 t in 2010 vs. 5 t in 2011) as fishermen traded whiting quota shares for sablefish.

DFO: The first joint Pacific whiting assessment was conducted under the Canada-U.S. Hake treaty and showed a strong 2008 year class in both the catch and survey. Stock abundance is estimated to be 33% of the unfished equilibrium level, which is below the target of 40%.

10. Walleye Pollock

AFSC: After 5 years of poor recruitment, the Bering Sea pollock stock is rebounding with an estimated biomass of 2 million metric tons. Much more information about pollock is in the AFSC report.

11. Dogfish and other sharks

There was an ageing workshop in Seattle this spring for spiny dogfish. Work has been done using vertebrae to age young fish, but it is unsure if vertebrae will work well on all ages. Vertebrae are stained and sectioned for ageing.

DFO has received data from pop-up tags that were placed on 8 sixgill sharks, but has not analyzed the data yet. Aerial surveys were conducted for basking sharks, an endangered species, but none were sighted. Four sightings were received through the basking shark sighting network. A population genetics study for blue shark in the North Pacific is almost complete.

SWFSC has been tagging blue sharks building on CDFG's shark tagging project.

AFSC has received data from 45 pop-up tags on spiny dogfish but has not analyzed this yet.

12. Skates
AFSC: There are six skate nursery areas in the Bering Sea that are areas of concern and worthy of special protection.

DFO is working with Moss Landing Marine Labs and AFSC to conduct age validation for big and longnose skate using bomb radiocarbon dating. They have developed a skate identification guide that was sent to all fishermen.

CDFG is working with fish buyers to increase sorting of skates which is now required.

13. Grenadiers
AFSC has collected genetic samples from giant grenadier to look for sub-populations. Otolith morphology for this species is highly unusual because it varies substantially between fish as well as within individuals.

14. Other Species
DFO has an experimental fishery for hagfish.

ODFW has an ongoing fishery for hagfish that is closely monitored.

CDFG has a hagfish fishery that peaked and has started to decline. There is a new fishery for human consumption; the previous hagfish fishery was for the eelskin business.

CDFG completed a study to develop growth curves for kelp greenling.

There was discussion about albacore and that the West Coast treaty was under review.

D. Other Related Studies

1. Ecosystem Studies
   ODFW is collaborating with OSU to map state territorial waters and has about 66% completed, including about 75% of the rocky habitat. A south coast kelp biomass survey was completed in 2011.

   ADFG is doing some bioenergetics work and food web modeling.

   AFSC: The North Pacific Research Board has been funding a large-scale research study in the Bering Sea, the "Bering Sea Integrated Ecosystem Research Program" from 2007-2012. A similar study in the Gulf of Alaska, the "Gulf of Alaska Integrated Ecosystem Research Program" began in 2010 and will last until 2014. The AFSC has been a major participant in both studies.

E. Other Items

1. Marine mammal predation on groundfish
   Claude Dykstra (IPHC) talked about studying marine mammal depredation on groundfish during the AFSC sablefish and IPHC longline surveys. Depredation by killer whales is overtly seen (lips or heads remain on the hooks), whereas depredation by sperm whales is not as evident but also occurs. Attempts at deterrence, such as using sonic devices, have not been successful. The whales do not depredate on fish that are in longline snarls, although the reason for this is unclear.

IX. Progress on 2011 Recommendations

A. From TSC to itself

The Scientific and Statistical Committee of the Pacific Council has requested Washington, Oregon, and California to reconstruct groundfish catch histories as far back as possible. Canada has also undertaken catch reconstructions for some rockfish species and will proceed with reconstructions for all groundfish species. The TSC in its discussions noted that each agency is doing this independently and recommends a possible workshop to be held to discuss, compare and develop best practices of reconstructing species-specific catches from grouped species landing data. The goal of the workshop would be to produce consistent methods among agencies. TSC members are to investigate the utility of such a workshop and the possibility of adding a day for initial discussion at the PacFin meeting already scheduled in October.

Traci Larinto (CDFG) organized this workshop, which was held in Newport Beach, CA on May 2, 2012 immediately following the conclusion of the TSC meeting.

X. 2012 Recommendations

A. From TSC to itself

The TSC recommends that a workshop be held on the topic of developing ROV surveys for use in rockfish stock assessments. Although there have been ROV/submersible workshops in the past, including a non-lethal survey symposium at AFS in 2011, there is interest in holding another workshop specific to ROV rockfish surveys. Many agencies and universities are conducting ROV surveys on the west coast, but few are incorporating these data into stock assessments. This workshop would provide the opportunity to learn from other research groups' ROV survey successes and failures and make progress towards using ROV data as a non-lethal method for stock assessment. To maximize attendance, the preferred location and date for this workshop is in Seattle in late winter or spring of 2013. Potential workshop topics include habitat mapping, ROV survey design, new video technology, data analysis (including post-processing of video data). This agenda would ideally take place over a two day period. If necessary, the workshop could be tied into the TSC May meeting in 2013 or the Western Groundfish Conference in 2014. Kristen Green, Lynne Yamanaka, and Theresa Tsou offered to collaborate on workshop planning.

B. TSC to CARE

The TSC thanks CARE for their continued good work and would like to acknowledge their continued work to support the online posting of otolith archives by member agencies in light of their many other work pressures.

C. TSC to Parent Committee

The TSC recommended that the Parent Committee support development of a workshop on how to incorporate visual (e.g., ROV) surveys into stock assessments.

XI. Selection of Next Chairperson and Schedule and Location of 2013 Meeting

Traci Larinto, CDFG, was selected as the next Chairperson. The 2013 TSC meeting will be held in Seattle, WA hosted by AFSC at the NOAA facility on Sandpoint Way April 30-May 1, 2013.

XII. Adjourn ~5:00 p.m. May 1, 2012.

D. Parent Committee Minutes

Minutes of the 53rd Annual Meeting
of the
Canada-U.S. Groundfish Committee
(a.k.a. "Parent Committee")

I. Call to Order

Mr. Stephen Phillips, PSMFC, represented the United States and Lynne Yamanaka, DFO, represented Canada. The meeting was called to order at 8:22 am, Wednesday, May 2, 2012.

II. Rapporteur

Kenin Greer, CDFG, was appointed secretary for the meeting.

III. The Agenda

The agenda, following the format of previous meetings, was approved.

IV. The 2010 Parent Committee meeting minutes

The Parent Committee minutes were adopted as presented

V. The 2009 Parent Committee recommendations

There were no Parent Committee recommendations

VI. 2010 Parent Committee Recommendations

Parent Committee agrees with the 2012 TSC recommendation to support hosting a workshop on using visual survey data in stock assessments.

VII. 2011 Meeting Location

Parent Committee agrees with the proposed location and schedule for the 2013 TSC and Parent Committee Meeting: Seattle, WA, Tuesday April 30 and Wednesday May 1, 2013. AFSC has offered to host the meeting.

VIII. Other Business

a. The Parent Committee thanks Dave Clausen for his 20 plus years of service on the TSC and thanks him for his work as chairman at the TSC meeting.
b. The Parent Committee thanks PSMFC for its ongoing support for the Annual TSC meetings.
c. The TSC thanked Traci Larinto for hosting the TSC meeting and shuttling folks to and from the meeting site.

IX. The Parent Committee meeting was adjourned at 8:25 am, Wednesday May 2, 2012.

E. Agency Reports

Report of the Technical Subcommittee
of the
Canada-United States Groundfish Committee

AGENCY REPORTS

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1. ALASKA FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERES SERVICE

2. CANADA, BRITISH COLUMBIA GROUNDFISH FISHERIES

3. INTERNATIONAL PACIFIC HALIBUT COMMISSION (IPHC)

4. NORTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

5. SOUTHWEST FISHERIES SCIENCE CENTER, NATIONAL MARINE FISHERIES SERVICE

6. STATE OF ALASKA – ALASKA DEPARTMENT OF FISH AND GAME

8. STATE OF CALIFORNIA – DEPARTMENT OF FISH AND GAME

7. STATE OF OREGON – OREGON DEPARTMENT OF FISH AND WILDLIFE

8. STATE OF WASHINGTON – WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

Alaska Fisheries Science Center
of the National Marine Fisheries Service

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

April 2012

Compiled by Wayne Palsson, Tom Wilderbuer, and David Clausen

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

A. Agency Overview

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

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

RACE DIVISION

The core function of the Resource Assessment and Conservation Engineering (RACE) Division is to conduct quantitative fishery surveys and related ecological and oceanographic research to measure and describe the distribution and abundance of commercially important fish and crab stocks in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska and to investigate ways to reduce bycatch, bycatch mortality, and the effects of fishing on habitat. The staff is comprised of fishery and oceanography research scientists, geneticists, pathobiologists, technicians, IT Specialists, fishery equipment specialists, administrative support staff, and contract research associates. The status and trend information derived from both regular surveys and associated research are analyzed by Center stock assessment scientists and supplied to fishery management agencies and to the commercial fishing industry. RACE Division Programs include Fisheries Behavioral Ecology, Groundfish Assessment Program (GAP), Midwater Assessment and Conservation Engineering (MACE), Recruitment Processes, Shellfish Assessment, and Research Fishing Gear. These Programs operate from three locations in Seattle, WA, Newport, OR, and Kodiak, AK.

In 2011, one of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish species of the northeast Pacific Ocean and Bering Sea. Regularly scheduled bottom trawl surveys in Alaskan waters include an annual survey of the crab and groundfish resources of the eastern Bering Sea shelf and biennial surveys of the Gulf of Alaska (odd years) and the Aleutian Islands and the upper continental slope of the eastern Bering Sea (even years). Two major bottom trawl surveys of groundfish resources were conducted during the summer of 2011 by RACE Groundfish Assessment Program (GAP) scientists: the annual eastern Bering Sea shelf survey, the biennial eastern Bering Sea Continental Slope survey, and the biennial survey of the continental shelf of the Gulf of Alaska. In 2012 GAP scientists will again conduct the annual Bering Sea shelf survey, the Bering Sea Slope Survey, the Chukchi Survey and the biennial Aleutian Island survey of the continental shelf and upper continental slope resources.

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

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

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

REFM DIVISION

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

Islands and Gulf of Alaska, conduct research to improve the precision of these assessments, and provide management support through membership in regional groundfish management teams.

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

AUKE BAY LABORATORIES

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

In 2011 field research, ABL's MESA Program, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish longline survey in Alaska. Other field and laboratory work by ABL included: 1) continued juvenile sablefish studies, including routine tagging of juveniles and electronic archival tagging of a subset of these fish; 2) a sablefish maturity study conducted jointly with the AFSC RACE Division; 3) tagging studies of spiny dogfish in the Gulf of Alaska; 4) recompression experiments on rougheye rockfish; 5) a large-scale, epipelagic trawl survey of the eastern Bering Sea shelf conducted by ABL's EMA Program that provides annual data on abundance of age-0 walleye pollock; and 6) an upper trophic level fisheries oceanography survey of the Gulf of Alaska.

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

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

B. Multispecies Studies

1. Stock Assessment and Surveys

2011 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP
The thirtieth in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 4 August 2011 aboard the AFSC chartered fishing vessels *Arcturus* and *Alaska Knight*, which bottom trawled at 376 stations over a survey area of 144,600 square nautical miles. Researchers processed and recorded the data from each trawl catch by identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. Supplementary biological and oceanographic data collected on the bottom trawl survey was also collected to improve understanding of life history of the groundfish and crab species and the ecological and physical factors affecting their distribution and abundance.

Survey estimates of total biomass on the eastern Bering Sea shelf for 2011 were 3.11 million metric tons (t) for walleye pollock, 911 thousand t for Pacific cod, 2.40 million t for yellowfin sole, 1.98 million t for rock sole, 26.2 thousand t for Greenland turbot, and 187 thousand t for Pacific halibut. There were slight increases in estimated total biomass compared to 2010 levels for Pacific cod, yellowfin sole, and Greenland turbot and slight decreases for walleye pollock, rock sole, and Pacific halibut.

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

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

2011 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska– RACE GAP
The twelfth in a series of comprehensive bottom trawl surveys of groundfish resources in the Gulf of Alaska (GOA) region was conducted from May 18 through August 15, 2011 with actual trawling occurring from May 22nd to August 14th. This regional survey began in 1984 and was conducted triennially until 1999 and was then conducted biennially thereafter. The standard GOA survey area, established in 1999, begins at the U.S.-Canada border at Dixon Entrance (54° 30' N latitude) in the south and extends north and west along the shelf and slope to the Islands of the Four Mountains at the base of the Aleutian Islands (170° W longitude). Sampling depths range from approximately 15 to 1,000 m during a typical survey. Commercially and ecologically valuable species of flatfish, roundfish, rockfish, and invertebrates inhabit the area. In many areas rocky bottom conditions provide abundant substrate for many species of bottom-oriented including bryozoans, hydroids, sponges and corals, and these invertebrate communities, in turn, provide essential habitat for juveniles and adults of many groundfish species. The major survey objective is to continue the time series to monitor trends in distribution, abundance, and population biology of important groundfish species and to describe and measure various biological and environmental parameters. Secondary objectives include investigating fish and

invertebrate life histories (trophic relationships, reproductive biology, groundfish systematics, etc) and improving survey methodology.

Survey fishing was conducted aboard two chartered commercial trawlers, the F/V *Ocean Explorer* and the F/V *Sea Storm*, during the 85 day period. The survey design is a stratified-random sampling scheme based 59 strata of area, depth terrain (shelf, slope, gully) and applied to a grid of 5x5 km^2 cells. These cells are the sampling frame of possible trawl stations. Stations are allocated amongst the strata using a Neyman scheme weighted by stratum areas, cost of conducting a tow, past years' data, and the ex-vessel values of key species. Some 812 were originally planned. Occupied stations were sampled with 15-minute tows using standardized RACE Poly Nor'Eastern four-seam bottom trawls rigged with roller gear. Catches were brought aboard and sorted, counted, and weighed by species. Individual length measurements, age structures, and other biological data and specimens are collected from samples of important species in each catch.

Successful hauls were made at 612 of the planned 812 stations or at nearby alternate sites, ranging in depth from 14 to 688 m. Because of late funding, a third vessel capable of deeper tows was not available for contract, so upper portions of the slope from 700 to 1000 m were not sampled and not as many stations were accomplished as planned. However, the two contracting vessels were accommodating and extended their contract time to make up for some of loss of sampling power. Just over 375.3 mt fish of fish and 6.7 mt of invertebrates were captured during the survey, and the catch consisted of 178 fish taxa and 471 invertebrate taxa. Not surprisingly, arrowtooth flounder was the most abundant species found in the survey, followed by Pacific ocean perch, walleye pollock, Pacific cod, and giant grenadier as dominant species by weight.

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

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

The MACE Program conducted a summer 2011 acoustic-trawl (AT) survey aboard the NOAA ship *Oscar Dyson,* targeting walleye pollock (*Theragra chalcogramma*) along the Gulf of Alaska (GOA) shelf. The survey, initially intended to cover the GOA from the Islands of Four Mountains eastward to Yakutat, was cut short by 16 days due to ship-related mechanical and personnel issues and so reached only as far east as Chiniak Trough. This summer survey curtailment followed cancellation of the winter acoustic-trawl survey efforts in the GOA and Bogoslof Island region due to vessel maintenance delays coupled with budget constraints.

The summer GOA shelf survey included smaller-scale surveys in several bays and around islands including Morzhovoi Bay, Sanak Trough, Pavlof Bay, the Shumagin Islands area (comprising Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Mitrofania Island, Nakchamik Island, Shelikof Strait, Chiniak Trough, Barnabas Trough, and Alitak Bay. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and near-bottom backscatter was sampled with a poly Nor'eastern (PNE) bottom trawl. A Methot trawl was used to target midwater macro-zooplankton, age-0 walleye pollock, and other larval fishes. Additional survey sampling included conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts to characterize the physical oceanographic environment. A number of specialized sampling devices were used during the survey, including light level sensors, a lowered echosounding system to measure target strength, and a trawl-mounted, stereo camera ("Cam-Trawl") designed to aid in determining species identification and size of animals encountered at different depths. A Simrad ME70 multibeam sonar was used to develop a trawlability index along with accompanying drop video camera deployments to groundtruth bottom classification.

The GOA shelf survey was conducted between 14 June and 12 August and consisted of 36 north-south transects spaced 20 nautical miles (nmi) apart covering the shelf and shelf break. Morzhovoi Bay, Pavlof Bay, and Sanak Trough were surveyed between 22 and 25 June along transects spaced 2 nmi apart. The Shumagin Islands were surveyed on 7-8 July along transects spaced 2.5 nmi apart in West Nagai Strait and Unga Strait, 2.0 nmi apart east of Renshaw Point, and 1.0 nmi apart in Popof Strait. Mitrofania Island was surveyed 9-10 July along transects spaced 3.5 nmi apart. Nakchamik Island was surveyed 11-12 July along transects spaced 3.0 nmi apart. Shelikof Strait was surveyed from 16 to 21 July along transects spaced 10 nmi apart (except the 3 northernmost transects, which were 20 nmi apart). Chiniak and Barnabas Troughs were surveyed between 7 and 12 Aug along transects spaced 6.0 nmi apart. Alitak Bay was surveyed 10-11 August along transects spaced 3.0 nmi apart in the outer bay, and along zig-zag transects in the inner Deadman Bay area because of the narrowness of the bay.

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

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

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

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

Status of Stocks and Multispecies Assessment Task-REFM

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

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

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

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

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

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

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

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

Gulf of Alaska Project: Fisheries Oceanographic Surveys - ABL

The Gulf of Alaska Project in 2011 conducted the first Upper Trophic Level (UTL) fisheries oceanographic survey as part of the North Pacific Research Board's (NPRB) Gulf of Alaska Integrated Ecosystem Research Program (GOA Project) which focuses on comparing and contrasting ecological function in the southeast and central regions of the Gulf of Alaska (GOA). This fisheries oceanographic study is investigating how environmental and anthropogenic processes affect trophic levels and dynamic linkages among trophic levels, with emphasis on fish and fisheries, marine mammals, and seabirds. It is interdisciplinary in nature and consists of four components that link together to form a fully integrated ecosystem study of the GOA, which are the Upper Trophic Level (UTL), Middle Trophic Level (MTL), the Lower Trophic Level (LTL), and Ecosystem modeling.

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

Four fisheries oceanographic surveys were conducted off southeast Alaska and Kodiak Island during summer and fall by the F/V *Northwest Explorer*, a chartered commercial trawler. Fish samples were collected using a midwater rope trawl (Cantrawl model 400). During the survey, the trawl was either fished at depth to verify acoustic targets or modified to fish at the water surface by stringing buoys along the headrope. Surface tows were made at predetermined grid stations and were 30 minutes in duration, while midwater trawls targeting specific layers varied in duration. Immediately after the trawl was retrieved, catches were sorted by species and standard biological measurements (length, weight, and maturity) were recorded. Whole age-0 marine fish, juvenile salmon, and forage fish were collected and frozen for transportation to the laboratory for food habits, energetic, and genetic analyses. A “live box” was attached to the codend of the survey trawl at predetermined grid stations to collect live age-0 rockfish in the southeast GOA region. Once the “live box” was retrieved, live *Sebastes* specimens were immediately transferred to an aerated live well on deck and transported to ABL for feeding and growth rate studies.

Acoustic data were collected by a Simrad ES-60 echosounder and a hull-mounted 38 kHz splitbeam transducer. Acoustic transects, orthogonal to shore, were run between all rope trawling stations. To verify constituent species observed in the acoustic record, opportunistic trawls targeted midwater aggregations that the surface trawl would not sample. As the survey progressed, the acoustic echogram was monitored in real time for unusual or interesting aggregations along transects. Catches from midwater trawls were sorted by species and length and weight samples were measured whenever sufficient (>30) numbers were caught.

Physical oceanographic data were collected at gridded survey stations by deploying a conductivity, temperature, and depth meter (CTD) with ancillary sensors. These provided vertical profiles of salinity, temperature, fluorescence, photosynthetic available radiation (PAR), and dissolved oxygen. Water samples for nutrients (N, P, Si), chlorophyll *a*, phytoplankton, and microzooplankton were also collected (surface 10m, 20m, 30m, 40m, and 50m depth).

Zooplankton and ichthyoplankton samples were collected at gridded stations using double oblique bongo tows from the surface to within 5 meters of bottom, with a maximum depth of 200 m. Neuston tows were also made at the surface with a Sameoto sampler.

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

2. Research

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

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

Contact Stan.Kotwicki@noaa.gov

Detecting Temporal Trends and Environmentally Driven Changes in the Spatial Distribution of Groundfishes and Crabs on the Eastern Bering Sea Shelf-RACE GAP

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

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The Alaska Coral and Sponge Initiative (AKCSI): a NOAA Deep Sea Coral Research and Technology Program regional fieldwork initiative in Alaska--RACE GAP

Beginning in FY2012, the NOAA Deep Sea Coral Research and Technology Program (DSCRTP) will be sponsoring field research program in the Alaska region for three years (FY2012-2014) to better understand the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats. In anticipation of the upcoming fieldwork, a workshop was held Anchorage, Alaska in September 2010 to identify research priorities for the region. These priorities were largely derived from ongoing research needs and objectives identified by the DSCRTP, the North Pacific Fishery Management Council and Essential Fish Habitat-Environmental Impact Statement (EFH-EIS) process. The research priorities included:

- Determine the distribution, abundance and diversity of sponge and deep-sea coral in Alaska (and their distribution relative to fishing activity)
- Compile and interpret habitat and substrate maps for the Alaska region
- Determine deep-sea coral and sponge associations with Fishery Management Plan species (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems to fisheries production
- Determine impacts of fishing by gear type and testing gear modifications to reduce any impacts
- Determine recovery rates of deep-sea coral and sponge communities in Alaska from disturbance or mortality
- Establish a long-term monitoring program to determine the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

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

- Identify and map areas of high abundance of Primnoa corals in the Gulf of Alaska using existing data, augmented by new multibeam mapping and ROV transects.
- Determine the distribution and areas of high abundance and diversity of deep-sea corals and sponges in the Gulf of Alaska and Aleutian Islands through modeling and through

field sampling using underwater cameras.

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

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

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

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

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

The study site, Kelp Bay, Southeast Alaska, offers hundreds of *C. spiculifera* colonies concentrated at depths easily accessible to scuba divers. Field operations in Kelp Bay began in August 2009 when a team of four divers located and tagged 48 *C. spiculifera* colonies. Of that total, 9 colonies were fitted with settlement rings equipped with removable tiles. The remaining 39 tagged colonies were ascribed to three damage treatment groups and a control group. The damage treatments were designed to mimic actual damage that can occur from a passing trawl. These treatments were performed *in situ* and included deflection, soft tissue excision, and branch severance. Video of each colony was recorded before and after the treatments were performed to establish baseline coral characteristics and to identify immediate treatment effects. Since the initial site visit, the dive team has returned to observe the tagged corals on three additional occasions (June 2010, September 2010, and August 2011). On each visit, subsamples of the stone tiles were collected and preserved in solution for subsequent inspection in the laboratory for adhesion of coral recruits. Damaged and control colonies were also videoed so that comparisons can be made to pretreatment images. At least one subsequent site visit is planned for 2013 to allow additional tile collections and to capture long-term effects of disturbance.

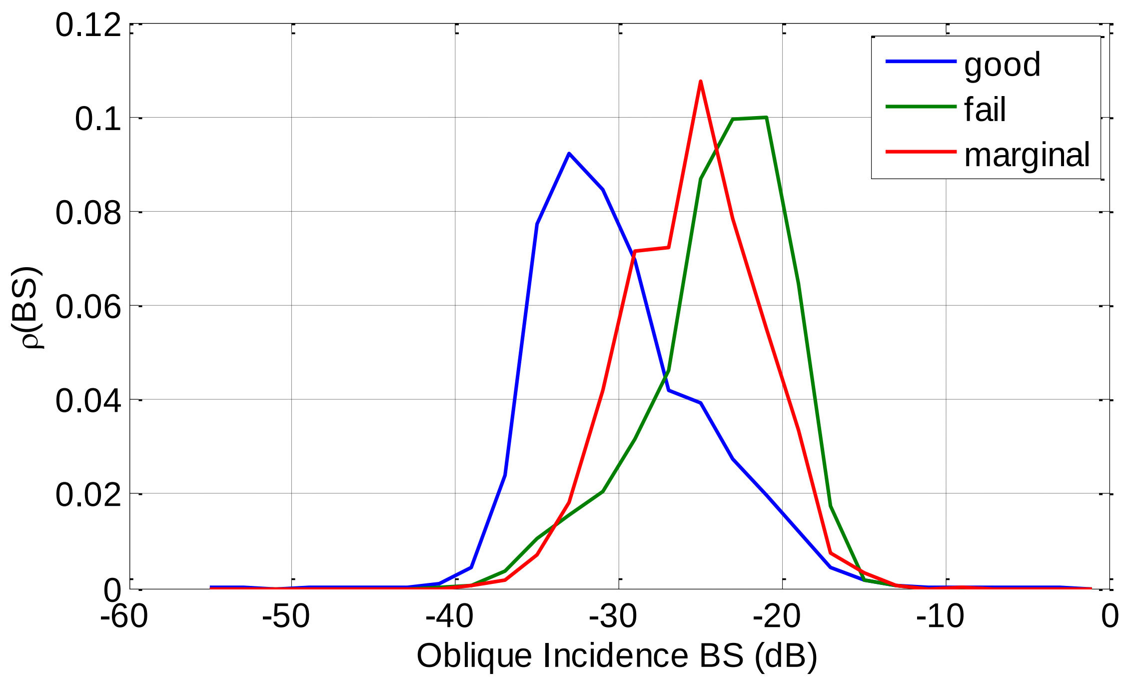
For more information, contact Patrick Malecha at (907) 789-6415 or pat.malecha@noaa.gov.

Mapping Untrawlable Habitats in the Gulf of Alaska-RACE GAP

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

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

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



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

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

Bathymetric Analysis of the Gulf of Alaska and Aleutian Islands-RACE GAP

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

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

RACE Recruitment Processes

The Recruitment Processes Program's overall goal is to understand the mechanisms that determine whether or not marine organisms survive to the age of "recruitment." Recruitment for commercially fished species occurs when they grow to the size captured or retained by the nets or gear used in the fishery. For each species or ecosystem component that we study, we attempt to learn what biotic and abiotic factors cause or contribute to the observed population fluctuations. These population fluctuations occur on many different time scales (for example, between years, between decades). The mechanistic understanding that results from our research is applied by us and by others at the Alaska Fisheries Science Center to better manage and conserve the living marine resources for which NOAA is the steward. Below are research activities focusing on multiple species and ecosystem effects and research on individual species are found in Section C By Species.

Late Spring Larval Fish Abundance in the Gulf of Alaska- RACE Recruitment Processes

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

Doyle et al., 2009) for consistency or variability, and for evaluation of synchronous responses among species.

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

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

<u>Early Life History and Ecological Gradients-RACE Recruitment Processes</u>

A second project seeks to identify major early life history and ecological gradients among GOA fish species has been carried out by performing Principal Component Analysis ordination on a data matrix of species by early life history and ecological traits (numerically expressed). In addition, species have been assigned to groups based on their association with end-points of these gradients and associated ecological risk and resilience characteristics have been discerned. This research has yielded a conceptual framework for evaluating the exposure and response of fish species to the pelagic environment during early life. The working hypothesis is that we can utilize similarities in reproductive and early life history characteristics among species to identify: 1) ecologically-determined species groups that are pre-disposed to respond to environmental forcing during early life in similar ways, and 2) plausible environmental predictors of early life history aspects of recruitment variation.

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

<u>GOA IERP Historical Ichthyoplankton Retrospective</u>

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

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

Larval Fish Community Composition in the Southeastern Bering Sea

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

Strong Participation in and Leadership of IERP activities

The Program remains a strong contributor to the IERP activities in Alaska. Scientists from the Program contributed 4 manuscripts to the first Bering Sea special issue to be published in *Deep-Sea Research II* in early 2012 and another 3 manuscripts were submitted for peer review in the second special issue. Several scientists are either Principal Investigators (Janet Duffy-Anderson) or collaborators (J. Napp) on new NSF-supported BEST synthesis grants. J. Napp continues to serve on the Science Advisory Board for the Bering Sea Project.

Special Issue #1

Bachelor, N., Ciannelli, L., Bailey, K.M. and Bartolino, V. Do walleye pollock exhibit flexibility in where or when they spawn based on variability in water temperature*? Deep Sea Research II*, in press.

Smart, T., Duffy-Anderson, J.T., Horne, J., Farley, E., Wilson, C., and Napp, J. Influence of environment on walleye pollock eggs, larvae, and juveniles in the Southeastern Bering Sea. *Deep Sea Res. II*, in press.

Stabeno, P.J., Farley, E., Kachel, N., Moore, S., Mordy, C., Napp, J.M., Overland, J.E., Pinchuk, A.I., and Sigler, M. A comparison of the physics, of the northern and southern shelves of the eastern Bering Sea and some implications to the ecosystem. *Deep-Sea Research II*, in press.

Stabeno, P.J., Moore, S., Napp, J.M., Sigler, M., and Zerbini, A. Comparison of warm and cold years on the southeastern Bering Sea shelf. *Deep-Sea Research II*, in press.

Special Issue #2

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

Smart, T., Duffy-Anderson, J. and Siddon, E. Vertical distributions of the early life stages of walleye pollock in the eastern Bering Sea. Deep-Sea Res., II, submitted.

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

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

Increasing Our Knowledge of the Chukchi Sea Ecosystem
-Ichthyoplankton samples from the second RUSALCA cruise (Russian – American Long-Term Census of the Arctic) are undergoing analysis and we are preparing for a third cruise in summer 2012. In summer 2010 and 2011, a NOAA/BOEM (Bureau of Ocean Energy Management)-supported cruise to the Chukchi was conducted with colleagues from PMEL and NMML. We occupied hydrographic transect lines off Cape Lizburne, Point Hope, Cape Lay, Icy Cape, Wainwright, and Barrow Canyon including the international Distributed Biological Observatory lines. In addition to plankton tows, we deployed biophysical moorings that examined temporal variability in plankton in the area off Icy Cape, Alaska near oil/gas lease sites. The biophysical moorings were inside clusters of moorings with passive acoustic recorders to detect marine mammal vocalizations. In 2012, we will re-occupy transect stations and engage in a new survey (Arctic Eis) which surveys both the water column (CTD, plankton tows, acoustics, surface and midwater trawls) and the bottom (bottom trawls). Fish trawls will be taken at stations spaced 30 nm apart and CTDs and plankton tow stations are 15 nm apart by latitude and 30 nm apart by longitude.

Scientific Exchange
In November 2014, the National Oceanic and Atmospheric Administration's Alaska Fisheries Science Center and the International Pacific Halibut Commission will co-host the 9th International Flatfish Ecology Symposium in Seattle, WA. This Symposium is organized every 3 years and provides an international platform for flatfish scientists and managers to meet, share their research, and discuss management applications. Past topics addressed by the meeting have included population-level connectivity, latitudinal variation, critical habitat, recruitment dynamics, stock structure, bycatch impacts, and climate change implications. A theme for the 9th

Symposium will be the role of flatfishes in the trophic landscape, a critical concept that has far-reaching implications for global large marine ecosystems. The host organizers are looking to partner with other organizations in the Pacific Northwest and Canada to host an exceptional meeting. Anyone interested in serving on the local organizing committee and/or sponsoring the meeting please contact Janet Duffy-Anderson (NOAA) at Janet.Duffy-Anderson@noaa.gov or Tim Loher (IPHC) at Tim@iphc.int.

RACE Habitat Research Team (HRT)

RACE scientists of the Habitat Research Team (HRT) continue research on essential habitats of groundfish including identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, investigating activities with potentially adverse effects on EFH, such as bottom trawling, and benthic community ecology work to characterize groundfish habitat requirements and assess the ecological consequences of fishing gear disturbances. Research in 2011 was primarily focused on evaluating acoustic backscatter and infaunal prey as predictors of groundfish distributions in the eastern Bering Sea (EBS). An analysis of short-term bottom trawl effects was also completed.

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

Habitat Modeling

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

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

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

A field experiment will be conducted in 2012 to determine the (statistical) benefits and (operational) costs of five different acoustic systems, based on comparisons of backscatter acquired along strong gradients of groundfish abundance. The five systems include two hull-mounted hydrographic-quality multibeam echosounders, a towed high-resolution side scan sonar and the prototype Klein 7180 long-range side scan sonar system (LRSSS; which also incorporates an independent 38 kHz single-beam echosounder). The LRSSS is a prototype system that was purpose-built for our fish-habitat research. It is distinguished from all other sonar systems by its ability to collect fully adjusted quantitative information about seafloor characteristics and is thus ideally suited for modeling applications. The very large swath coverage (to 1.0 km) and high maximum tow speed (12 kts) of the LRSSS greatly increase the efficiency of survey operations thereby reducing costs and the time required to complete missions. The LRSSS towfish also measures basic water-quality properties (chlorophyll-a, concentrations of dissolved organic matter and turbidity), which are being investigated for use in the next generation of EBS habitat models.

The Effects of Fishing

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

[1] McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.
[2] McConnaughey, R.A. and S.E. Syrjala. 2009. Statistical relationships between the distributions of groundfish and crabs in the eastern Bering Sea and processed returns from a single-beam echosounder. ICES J. Mar. Sci. 66: 1425-1432.
[3] Yeung, C. and R.A. McConnaughey. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES J. Mar. Sci. 65: 242–254.

of fishing are possible, site-specific responses are likely and local studies are advisable because of variation in the composition of the benthos and differences in the intensity, severity and frequency of both natural and anthropogenic disturbances.

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

The well-documented development of commercial trawl fisheries in the EBS since 1954 presented a unique opportunity to investigate the chronic effects of bottom trawling on soft-bottom benthos.[4,5] Using detailed accounts of closures and fishing activity, it was possible to reconstruct historical effort and identify untrawled (UT) areas immediately adjacent to areas that had been heavily trawled (HT) over many years. For most of the benthic invertebrate species examined, it was determined that biomass and mean body size were reduced as a result of heavy trawling, suggesting a general population decline. In a few cases, greater overall biomass accompanied the observed body-size reduction, suggesting a proliferation of relatively small individuals in the HT area. The only exception to the pattern of smaller individuals in the HT area was red king crab. In this case, mean body size was greater in the HT area, due to substantially fewer small crabs in the HT area than in the UT area. Since biomass in the HT area was lower than that in the UT area, the red king crab response to chronic bottom trawling was fewer individuals of greater mean size. Overall, these effects on body size were relatively small when compared with natural variability in a large, adjacent area closed to commercial trawling. From a community perspective, the HT benthos was less diverse, was dominated by the purple-orange seastar (*Asterias amurensis*), had less emergent epifauna and less biogenic substrate (shell) resulting in reduced structural complexity, and was more patchy overall.

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

[4] McConnaughey, R.A., K. Mier and C.B. Dew. 2000. An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea. ICES J. Mar. Sci. 57: 1377-1388.
[5] McConnaughey, R.A., S.E. Syrjala and C.B. Dew. 2005. Effects of chronic bottom trawling on the size structure of soft-bottom benthic invertebrates. Pages 425-437 in P. W. Barnes and J. P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

that live in the seafloor (infauna) and the physical-chemical properties of the surficial sediments were characterized with two pairs of grab samples collected prior to trawling for epifauna. Changes in seafloor morphology were assessed with side scan sonar surveys that were conducted prior to any sampling or commercial trawling disturbance and again after the commercial-trawl disturbance.

Catch-per-Unit Effort (CPUE) data were analyzed for 24 taxonomic groups (ranging from species to order) before and after trawling. In addition to the BACI design, covariates (depth, water temperature, and various sediment measurements) were included in the analyses to minimize effects of random variations in the habitat. Ultimately, there was no evidence that the covariates were associated with changes in the CPUEs due to any commercial trawling effects. “Statistically significant” effects of commercial trawling were found in three of the 24 taxonomic groups. But given the level of the test that was used in the analysis ($\alpha \leq 0.10$), one would expect to find 2.4 significant results due to nothing more that random variation in the data. Hence, we concluded that the CPUEs of epifauna were not substantially affected by the level of commercial trawling used in this experiment. The study area was revisited during the following summer and the after-treatment sampling protocol was repeated to assess whether any long-term (one year) effects on CPUE could be observed. Again, only minimal effects were observed and could not be differentiated from random variation. The effects of trawling observed in the side scan imagery also were negligible, probably due to the naturally disturbed condition of the seabed. However, some degree of physical disturbance did occur based on distinctive patterns in the post-trawl imagery that were not present in the imagery acquired prior to the commercial trawling. Details of the analyses and results of this study are currently being written up for publication.

In 2011, the HRT also developed plans for a bottom-trawl-impact study in the Northern Bering Sea Research Area, a previously unfished area that may have potential for future fisheries development under a climate change scenario. This effort involved multiple workshops to gather input from native communities and interested scientists as well as preliminary experimental design work. The project is on hold pending further action by the North Pacific Fishery Management Council.

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

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

Yellowfin sole, northern rock sole, and Alaska plaice are three common flatfish that co-occur on the southeastern Bering Sea (EBS) shelf in depths usually not exceeding 100 m. Their small mouths are adept at preying on infauna, especially polychaete worms. The average diet of Alaska plaice consists of almost 60% polychaetes by weight. For yellowfin sole, which has the most varied diet of the three, polychaetes still comprise over a quarter of their diet by weight.

Polychaetes and clams were the most dominant groups, each comprising 35-60% by weight of each infauna sample. They were also the only prey groups that frequently averaged over 50% of stomach content weight. Sediment grain size was the most important factor in determining the type of infauna assemblage in the habitat. Grain size becomes smaller, i.e., sediment becomes muddier, the further from shore (or deeper the water). Clams dominated the infauna biomass on the sandy inner shelf (0-50 m depth) (Fig. 2). The "muddy sand" of the middle shelf (50-100 m) had the highest infauna biomass, which was dominated by deposit-feeding polychaetes.

Prey availability strongly influenced diet choices. Stomach contents of all three flatfish generally reflected the infauna assemblage of the habitat where they were collected. Alaska plaice clearly adapted to prey availability – they ate mostly clams on the inner shelf, although their primary prey are polychaetes. All flatfish switched to eating more polychaetes on the middle shelf - even yellowfin sole, whose primary prey are amphipods and clams.

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

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

Miscellaneous Projects

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

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

Resource Ecology and Ecosystem Modeling Program (REFM/REEM)

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

Groundfish Stomach Sample Collection and Analysis

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

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

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

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

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

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

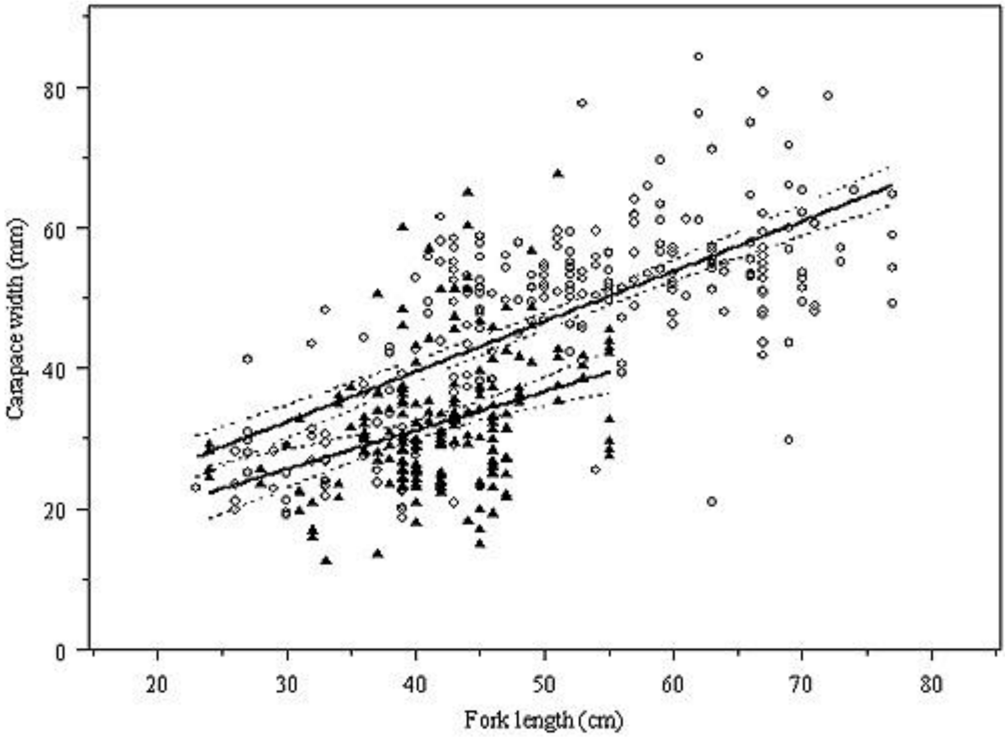


Figure 1. The sizes (carapace width, mm) of *C. opilio* consumed by sizes (fork length, cm) of great sculpin (circles) and warty sculpin (triangles) in the eastern Bering Sea. The regressions with 95% confidence intervals for each sculpin species are shown.

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

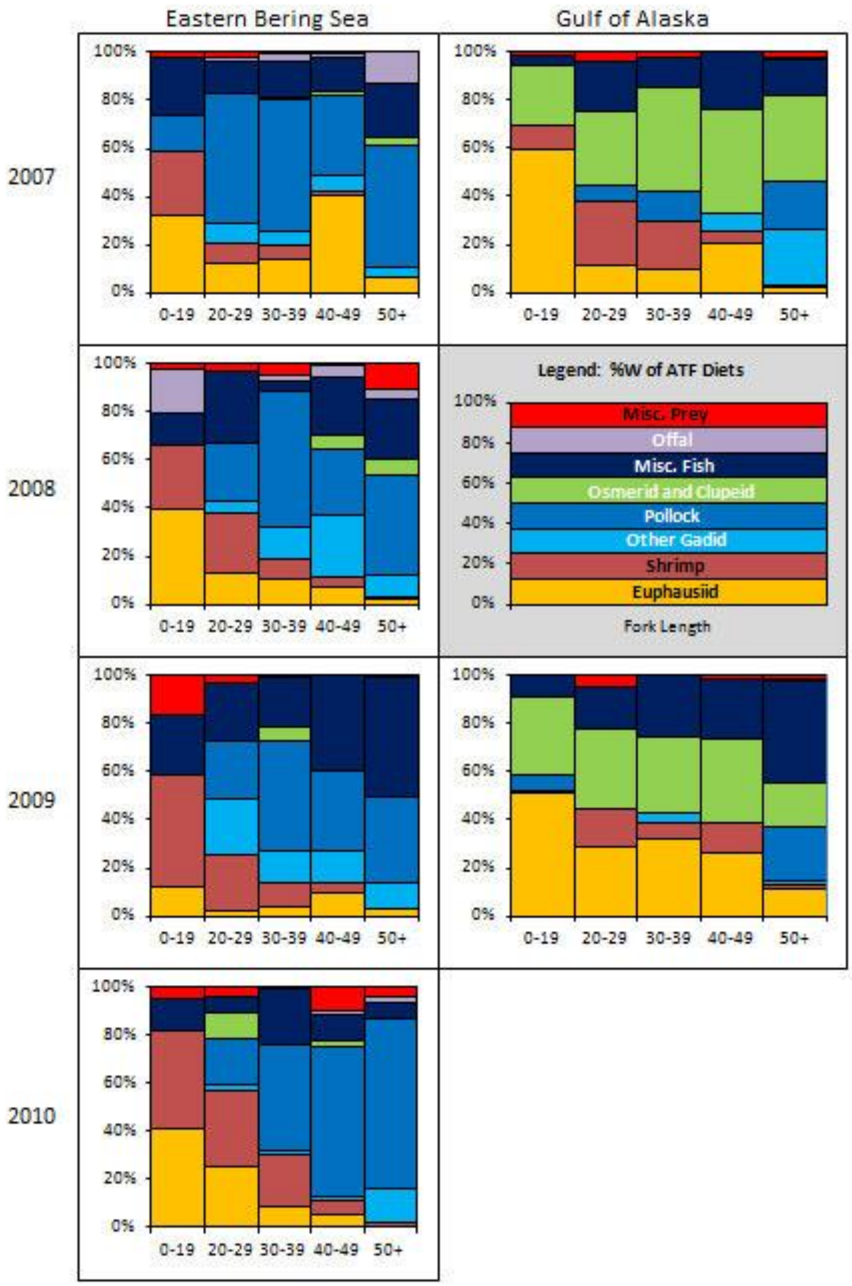


Figure 2. Summer diet composition, by weight (%W), of arrowtooth flounder from recent years in the eastern Bering Sea and Gulf of Alaska.

The Arctic cod (*Boreogadus saida*) is an ecologically important inhabitant in Arctic waters that extends its distribution southward into the eastern Bering Sea during colder years. The Arctic cod, known to be a predator of a variety of zooplankton and a prominent prey for many birds, marine mammals, and other fishes, is a nodal species in the Arctic marine foodweb. Arctic cod are caught during the AFSC groundfish and crab surveys in the eastern Bering Sea, especially during colder summers. These 253 Arctic cod ranged in length from 6 to 26 cm fork length (FL), with the large majority of the stomach samples obtained from fish between 10 and 18 cm FL. The diet of these Arctic cod consisted mostly of small crustaceans in all the size categories examined, but chaetognaths tended to decrease in importance with increasing size of Arctic cod while fishes (Teleostei) and slightly larger crustaceans (Decapoda; shrimp and crabs) were consumed primarily by Arctic cod over 15 cm (Fig. 3). A consistent, more general trend with increasing size was the gradual decrease in pelagic prey (chaetognaths, copepods, euphausiids, and hyperiid amphipods) and the gradual increase in more benthically oriented prey (gammarid amphipods, mysids, cumaceans, and decapod crustaceans). When analyzed, the stomach samples collected in 2010 may provide some geographically interesting results, as the majority of them were collected in the northern Bering Sea between Saint Matthew Island and the Bering Strait.

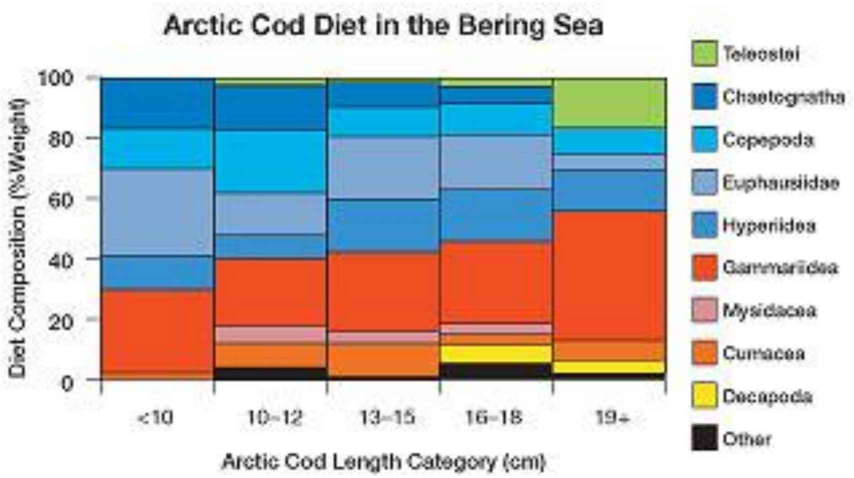


Figure 3. Summer diet composition of 6- to 26-cm FL Arctic cod in the eastern Bering Sea.

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

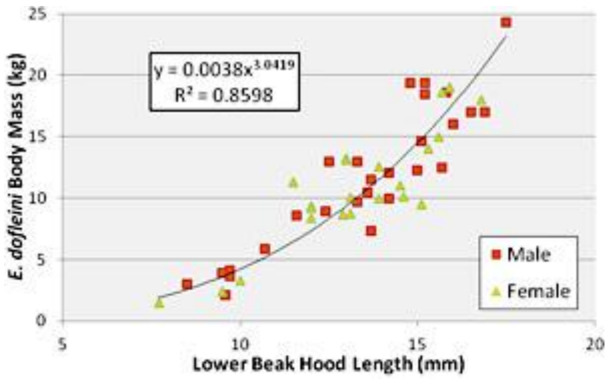


Figure 4. The relationship between beak-size and body-mass for *Enteroctopus dofleini*. Although each sex is distinguished in the plot, the regression is independent of sex because this can rarely be determined from the remains in the predator stomachs.

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

Seabird – Fishery Interaction Research

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

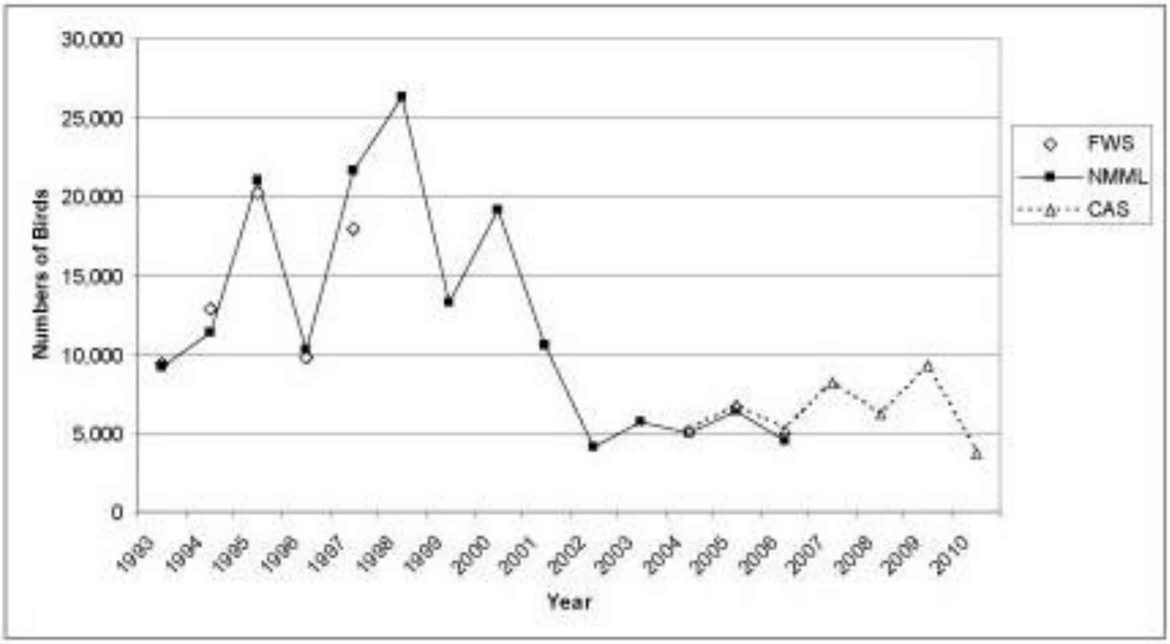


Figure 6. Total seabird bycatch in the Alaskan demersal longline groundfish fishery as estimated by three overlapping methods during the period 1993 through 2010. FWS = U.S. Fish and Wildlife Service; NMML = Alaska Fisheries Science Center National Marine Mammal Lab; CAS = Catch Accounting System.

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

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

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

Multi-species and Ecosystem Modeling:

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

AFSC researchers completed the development of a preliminary mass-balance food web model for the continental shelf of the eastern Chukchi Sea (Fig. 7). The model provides a snapshot of community structure averaged over an annual time scale and describes key structural and functional components of the eastern Chukchi Sea food web. The majority of biomass in this ecosystem was concentrated in benthic invertebrates (Fig. 8) and accordingly most of the mass flow above trophic level 2.0 was through this group. Mass flows to higher trophic levels through pelagic groups like zooplankton were an order of magnitude less. Arctic cod, *Boreogadus saida*, were the principal fish prey connecting production between lower and upper trophic levels. Seabirds and marine mammals collectively consumed about 75% of total arctic cod production.

To gain a broader perspective on the structure and function of the eastern Chukchi Sea, comparisons were drawn with the nearby subarctic eastern Bering Sea, using a set of system metrics derived from a common modeling framework. The total biomass density (t km^2) of the eastern Chukchi Sea was nearly equal the eastern Bering Sea but had less than half the total production (t km^2/yr). In practical terms, this fundamental difference between the eastern Chukchi Sea and eastern Bering Sea implies that the Chukchi may not be as resilient to fishing or other mortality agents such as a wide-spread oil spill.

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

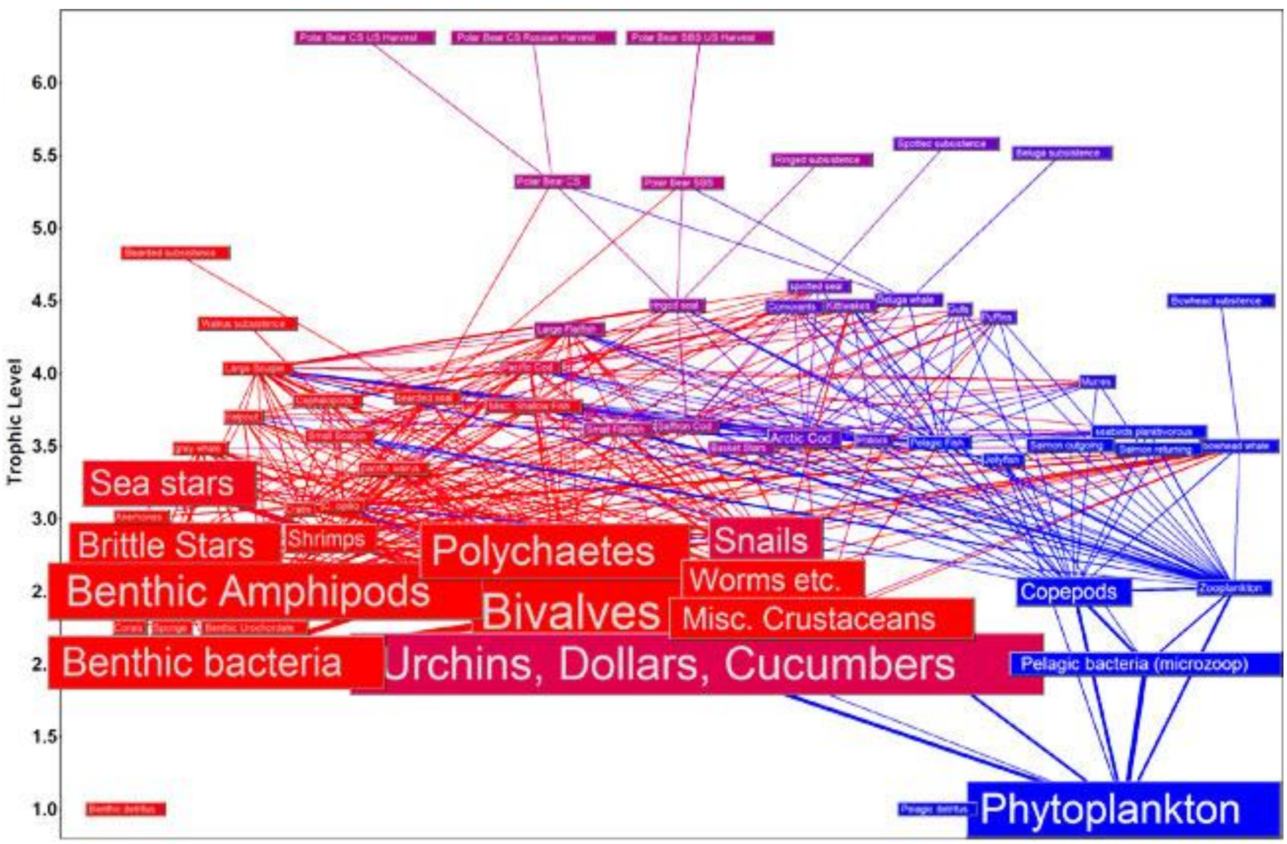


Figure 8. Food web diagram of the eastern Chukchi Sea. The boxes are arranged vertically by trophic level and box size is proportional to biomass density. Red colored boxes are associated with the benthic trophic pathway and blue denotes the pelagic pathway.

Preliminary simulations from the Forage Euphausiid Abundance in Space and Time (FEAST) model of the eastern Bering Sea were produced. FEAST is a high resolution model that uses a Regional Oceanography Model System as platform and has two-way feedback with a Nutrient-

Phytoplankton-Zooplankton-Benthos module. FEAST is part of the Bering Sea Integrated Ecosystem Research Program (BSIERP), a partnership between the North Pacific Research Board and NSF, funding 35 linked projects on the Bering Sea. Fish movement is modeled seasonal movement of pollock as a function of prey density and temperature (measured as growth). Both hindcasts and forecasts of FEAST were run; in the forecast version, FEAST will be used as the real world model for management strategy evaluations.

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

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

Ecosystem Considerations

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

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

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

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

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

Outreach Activities

AFSC scientists and visual information specialists created activities about current AFSC research as part of the Pacific Science Center's (PSC) Science Communication Fellowship Program. The program helps bring scientists and public audiences together to promote the understanding and appreciation of current scientific research. These activities were presented by AFSC scientists during the 2011 Polar Science Weekend (Fig. 9). Polar Science Weekend, now in its sixth year, is an annual event presented jointly by the PSC and the University of Washington's Applied Physics Laboratory, funded by the National Aeronautics and Space Administration. Funding from the NPRB also supported some of the AFSC activities. The "Polar Detectives" activity challenged visitors to solve "the case of the missing ice," and complete a puzzle of the Arctic, then, adding seals and other marine mammals to the picture, they learned why ice is important to these animals. Next, participants tossed seals into a mini-Arctic, complete with ice floes, and found out what happens as the global temperature rises and the amount of ice decreases. In the "How Old Is a Fish?" activity, visitors searched for otoliths in the head of a stuffed fish and discovered how fish are aged. "This group has no kids!" said one girl as she looked at the age composition of one population of fish, learning why it's important to determine the age of fish. At "Stinky Slimy Stomachs," young scientists took fish from a basket, measured the length and then discovered what it ate, learning that fish of different sizes may eat different prey. "Eeeuw, that's gross...can I touch it?" was often heard as children poked at semi-digested prey from fish stomachs that were on display. "Bering Sea Food Webs" complemented the food habits activity by allowing visitors to construct food webs that illustrated how productivity, prey-competition and predator-prey relationships cascade through an ecosystem.

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

C. By Species

1. Pacific Cod

a. Research

Juvenile Pacific Cod Movement, Habitat, and Overwintering Study-RACE Kodiak Lab

In 2011, researchers from the Kodiak Laboratory continued work on a project examining the seasonal habitat use and over wintering habits of juvenile Pacific cod, *Gadus macrocephalus,* within nearshore nursery areas of Kodiak Island, AK. Previous investigations have focused on the nursery requirements of age-0 and age-1+ juvenile Pacific cod mainly during the summer. The current project is an extension of this prior work and focuses on examining the habitat use patterns of older juvenile age classes (age 2+) still residing in the nursery areas. The project examines the hypotheses that older juvenile Pacific cod preferentially utilize bare substrate habitats and show strong site fidelity prior to the winter season and that juvenile cod winter migratory behavior will be variable among individuals. In 2010, a laboratory study was completed that examined the effects of intra-peritoneal tag implantation on juvenile cod and the results indicated this is a valid technique. In the fall of 2011, 8 juvenile cod were captured in the field and fitted with acoustic transmitters. A combination of acoustic telemetry and a drop camera system was used to acquire habitat patch use of individual cod. In addition, a passive gate telemetry system was utilized to document the movement of individual cod transiting outside the nursery during the winter. Preliminary results suggest juvenile cod winter migratory behavior was highly variable among the tagged individuals. Some individuals briefly transited the acoustic gate during late September/ early October while others resided in the vicinity of the gate throughout the winter months. Upcoming work in 2012 will focus on acquiring additional habitat use data through the fall months and further documenting the winter migratory behavior patterns of juvenile cod. Results from this project will contribute significant knowledge about essential fish habitat requirements of juvenile cod. For further information, please contact Brian Knoth (907) 481-1731.

Age-0 Pacific Cod Pilot Tagging Study-RACE Kodiak Lab

In September, 2011, 40 age-0 Pacific cod, *Gadus macrocephalus,* were tagged with a variety of marker tag types to assess the feasibility of developing a large-scale tagging study. The objectives of this pilot study were to utilize a variety of tag types to examine retention rates, ease of application, and visible fish trauma caused by the tag. Tag types that were utilized were Visible Implant Elastomers (Northwest Marine Technology), t-bar and streamer (Floy, Hallprint), and fingerling (Floy). The fish were maintained at the Kodiak Laboratory sea water facility and evaluated after 30 and 120 days. For smaller, early season fish (captured in July) Visible Implant Elastomers appear to have the most promise but care will need to be utilized in both location of implantation and color choice. For larger, later season fish t-bar tags may provide the best compromise between ease of tagging and retention rates. These tags were retained well but were particularly injurious to smaller fish. This study will continue in the upcoming year with additional testing of t-bar and Visible Implant Elastomer tags. For further information, please contact Christina Conrath (907) 481-1732.

Diel vertical migration of Pacific cod in Alaska-RACE GAP

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

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

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

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

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

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

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

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS

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

The accuracy of age readings for this stock has been a continuing concern, mainly because the mean size at age from age readings does not match the first three clear modes of cod length frequencies in the Bering Sea trawl survey. Other issues have been the natural mortality rate, the trawl survey catchability coefficient, the modeling of commercial selectivity (variable or not, asymptotic or not, fishery by fishery) and the modeling of growth (constant, cohort-specific, year-specific). In 2011, five candidate models (1, 2b, 3, 3b, and 4) were considered for the 2012 OFL/ABC specifications. Model 1 was the 2010 preferred model, whose main features were:

(i) Natural mortality *M* = 0.34 fixed externally.
(ii) Commercial length compositions fitted, not commercial CPUE. Length-specific commercial selectivities, estimated in blocks of years, some forced to be asymptotic.
(iii) Trawl survey age composition and CPUE fitted. Age-specific trawl survey selectivity with annually varying left limb. Trawl survey catchability fixed at 0.77, which in the 2009 assessment had resulted in the average product of catchability and selectivity of 60-80 cm fish being 0.47, the value estimated from a small set of data from archival tag recoveries.
(iv) A single schedule for mean length at age estimated internally for all years. Standard deviation of length at age a linear function of mean length at age, estimated externally.
(v) Assumed age reading bias of +0.4 y at all ages.
(vi) Length composition data not used where age composition data were available.

The other models were as follows:

- Model 2b was the same as Model 1 except that the pre-1982 trawl survey data were left out and the author made a number of small but helpful housekeeping changes to the model configuration.
- Model 3 was the same as Model 2b except that aging error parameters were estimated internally.
- Model 3b was the same as Model 3 except that the standard deviation of length at age was estimated internally, the mean length-at-age data were left out of the likelihood, and all length frequency data were used.
- Model 4 was the same as Model 3b except that all age composition data were left out of the fit (to avoid the whole issue of aging error).

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

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

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

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

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

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

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

$B_{40\%}$ for this stock is estimated to be 104,000 t and projected spawning biomass in 2012 according to Model 3 is 121,000 t, so this stock is assigned to Tier 3a. Neither the author nor the Plan Team saw any compelling reason to recommend OFL or ABC values lower than prescribed by the standard control rule. The current values of $F_{35\%}$ and $F_{40\%}$ are 0.53 and 0.44.

At present, the ABC of Pacific cod is apportioned among regulatory areas based on the three most recent trawl surveys. The apportionments based on the average area-specific biomass estimates from the 2007-2011 surveys are 32% in the Western GOA, 65% in the Central GOA, and 3% in the Eastern GOA. An alternative that is used in the Bering Sea - Aleutian Islands based on a Kalman filter approach would result in apportionments of 35% in the Western GOA, 61% in the Central GOA, and 4% in the Eastern GOA. For further information, contact Dr. Grant Thompson at (541) 737-9318.

2. Walleye Pollock

a. Research

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

The eastern Bering Sea (EBS) shelf is a highly productive ecosystem, where atmospheric forcing, duration and extent of sea ice cover, and transport through ocean passes in the Aleutian Islands dominate the physical processes on the shelf. Inter-annual variability in these processes is believed to influence the distribution, feeding, growth, and recruitment of important fisheries stocks. Physical oceanographic features (e.g. sea surface temperature (SST), fronts, mixed layer depth) and lower trophic level dynamics (e.g. primary production, zooplankton prey availability) also are critical to understanding migration, distribution, and survival of forage fish. Research on the interaction between physical oceanography, plankton, and forage fish such as age-0 walleye pollock (*Theragra chalcogramma*) and juvenile Pacific salmon (*Oncorhynchus spp.*) has been conducted annually by Auke Bay Laboratories Ecosystem Monitoring and Assessment Program researchers in 2000–2011, with surveys planned for 2012 and onward. These surveys are part of a joint effort with other AFSC/NOAA programs, including the Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), the RACE Division's Midwater Assessment and Conservation Engineering (MACE) Program, and ABL's Habitat Assessment and Marine Chemistry (HAMC) Program to examine recruitment processes of walleye pollock. Larval fish and oceanographic information are collected during spring followed by epipelagic trawl and midwater acoustic surveys during late summer/early fall (August-October). The surveys provide information to assess the abundance and condition of these fish during the larval stages and at the end of their early marine growth period, prior to their first winter.

The few large-scale studies of walleye pollock in the Bering Sea have mainly focused on their distribution in relation to sea-ice conditions (Wyllie-Echeverria 1995). In contrast, the seasonal time series on critical life stages of walleye pollock is presently the only shelf-wide data available to examine marine survival from spring to fall in the EBS. This time series provides integrated information on energy density, diet, abundance, and distribution in relation to changing ocean conditions. Such information coupled with an age-0 abundance index provides a unique opportunity to evaluate survival of juvenile walleye pollock relative to the reproductive output estimated from pollock stock assessments. For example, we have found a direct correlation ($r^2 = 0.73$) between the energy content of age-0 pollock (kJ/fish) and the number of age-1 recruits as predicted in the pollock stock assessment. These data are currently being considered by the North Pacific Fishery Management Council to help reduce the uncertainty in stock assessments for EBS walleye pollock.

Our survey results have been used to document the rapidly changing marine conditions in the EBS during the past ten years and provide baselines and analogues for different climate regimes. The EBS SST's underwent large-scale warming from 2002-2005 followed by substantial cooling in 2006-2011. These shifts altered fisheries distributions and have the potential to affect the overall ecology of this region. Coincident with changes in the SST we have observed changes in the energy density (kJ/g) of age-0 pollock. Currently, age-0 pollock appear to have maximized their energy content. The extent of winter sea ice and its rate of retreat influences spring bloom dynamics, secondary production, and the spatial extent of the cold-water pool during the summer. Because most fish growth occurs during the summer, the winter and spring climatic forcing along with summer atmospheric and oceanographic conditions will dramatically affect fish distribution and production. For more information, contact Ed Farley at (907) 789-6085 or ed.farley@noaa.gov.

Walleye Pollock in the Bering Sea- RACE Recruitment Processes

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

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

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

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

<u>Examining Genetic Stock Structure of Walleye Pollock in the NE Pacific-RACE Recruitment Processes</u>

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

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

<u>Walleye Pollock Feeding Ecology- RACE Recruitment Processes</u>

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

b. Stock Assessment

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

The age-structured model developed using AD Model Builder and used for GOA W/C/WYK pollock assessments in 1999-2010 is unchanged. This year's pollock assessment features the following new data: (1) 2010 total catch and catch at age from the fishery, (2) 2011 biomass and length composition from the NMFS bottom trawl survey, and (3) 2011 biomass and length composition from the ADF&G crab/groundfish trawl survey. Recent estimates from both surveys are fit adequately by the model, and there are no large residuals to the fit to recent age data. The fit of Shelikof Strait acoustic survey age composition shows large residuals at age 2 and age 3 in 2006-2009 due to inconsistencies between the initial estimates of abundance and subsequent information about the magnitude of these year classes. The acoustic surveys were cancelled in winter of 2011 so less information was available to assess stock trends and status. Model fits are similar to previous assessments and general trends in survey time series fit reasonably well. The discrepancy between the NMFS trawl survey and the Shelikof Strait acoustic survey biomass estimates in the 1980s accounts for the poor model fit to both time series during those years. The survey time series in the last three years (2009-2011) appear consistent in showing increases, but the magnitudes of the change vary between survey biomass estimates.

The Plan Team concurred with the author's recommendation to use the standard model projection and the more conservative adjusted $F_{40\%}$ harvest rate. There are some elements of risk-aversion in this recommendation, such as fixing trawl catchability at 1.0. Until an ABC framework is in place that deals explicitly with scientific uncertainty, the author suggests (and the Team agreed) that this approach is reasonable. Because model estimated 2012 female spawning biomass is below $B_{40\%}$, the W/C/WYK Gulf of Alaska pollock are in Tier 3b. The Plan Team accepted the author's recommendation to reduce F_{ABC} from the maximum permissible using the "constant buffer" approach (first accepted in the 2001 GOA pollock assessment). The projected 2012 age-3+ biomass estimate is 863,840 t (for the W/C/WYK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock being below $B_{20\%}$ will be negligible in all years. Therefore, the ABC for 2012 based on this precautionary model configuration and adjusted harvest control rule is 108,440 t (F_{ABC} = 0.14) for GOA waters west of 140°W longitude, an increase of 22% from the 2011 ABC. **The ABC is 105,670 for 2012** (reduced by 2,770 t to account for the Prince William Sound GHL). The 2012 OFL under Tier 3b is 143,720 t (F_{OFL}= 0.19). In 2013, the recommended ABC and OFL are 114,560 t (reduced by Prince William Sound GHL) and 155,400 t, respectively.

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

EASTERN BERING SEA

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

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

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

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

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

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

The OFL harvest ratio under Tier 1a is 0.60, the arithmetic mean of the ratio between MSY and the equilibrium fishable biomass corresponding to MSY. The product of this ratio and the geometric mean of the projected fishable biomass for 2012 sets the OFL for 2012, which is 2.47 million t. The current projection for OFL in 2013 given a 2012 catch equal to the Plan Team's recommended ABC is 2.84 million t.

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

ALEUTIAN ISLANDS

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

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

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

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

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

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

Following the Tier 5 formula with M=0.20, OFL for 2012 is 22,000 t. The OFL for 2013 is the same.

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

3. Shelf Rockfish

Stock Assessment-Gulf of Alaska

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

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

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

For the 2012 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 5,118 mt. This ABC is 10% more than last year's ABC of 4,663 t. The increase in ABC is attributable to both changes in age at maturity estimates and to a 15% increase in the trawl survey biomass estimate from 2009 to 2011. The stock is not overfished, nor is it approaching overfishing status. For more information, contact Chris Lunsford, ABL, at (907) 789-6008 or chris.lunsford@noaa.gov.

4. Slope Rockfish

a. Research

Recompression Experiments on Rougheye Rockfish with Barotrauma - ABL

Because rockfish (*Sebastes* spp.) are physoclystic, i.e., their gas bladders are closed off from the gut, they often suffer internal injuries from rapid, internal air expansion when caught. There is some evidence that recompression may greatly increase the survival of barotrauma-injured rockfish. However, survival can be species specific, therefore, it is important to gauge the impacts on each species of interest. Rockfish that have been studied previously in barotrauma research have not been deep-water dwelling. Rougheye rockfish (*S. aleutianus*) are a federally managed species in Alaska, and most of the catch occurs at depths from ~600-1200 ft. In 2011, ABL scientists sampled rougheye rockfish in inside waters of southeast Alaska at depths from 500 to 800 feet. All fish exhibited external signs of barotrauma including exophthalmia ("pop-eye"), an everted esophagus, and ocular emphysema (air bubble under the cornea). We tagged 47 fish and released these at depths of 200-250 ft, and 21 others were recompressed in portable pressure tanks and slowly brought back to surface pressure over the course of 48 hours. Of these

21, 13 survived and are currently held at the ABL facility in Juneau for long term monitoring. After re-pressurization, fish no longer had exophthalmia or an everted esophagus. In many cases ocular emphysema also disappeared. This result is noteworthy because it is the deepest known successful capture and recompression of any rockfish species, which suggests there is potential to conduct scientific tagging studies to track movements and behavior of deepwater rockfish species.

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

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

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

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

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

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

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

Rockfish Reproductive Studies-RACE Kodiak Lab

RACE groundfish scientists initiated a multi-species rockfish reproductive study in the Gulf of Alaska with the objective of providing more accurate life history parameters to be utilized in stock assessment models. There is a need for more detailed assessment of the reproductive biology of most commercially important rockfish species including: Pacific ocean perch, *Sebastes alutus,* the rougheye rockfish complex (rougheye and blackspotted rockfish, *S. aleutianus* and *S. melanostictus*), shortraker rockfish, *S. borealis* and other members of the slope complex. The results for Pacific ocean perch and preliminary results for rougheye rockfish are presented below. During the upcoming year, blackspotted, shortraker, and northern rockfish maturity studies will be completed. In addition, samples will be collected to enable researchers to examine the inter-annual variability in reproductive parameters of Pacific ocean perch. For further information, please contact Christina Conrath (907) 481-1732.

Rougheye Rockfish Maturity in GOA-RACE Kodiak Lab

The recent discovery that rougheye rockfish are two species, now distinguished as 'true' rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further accents the need for updated reproductive parameter estimates for the members of this species complex. Current estimates for age and length at maturity for this complex in the GOA are derived from a study with small sample sizes, few samples from the GOA, and an unknown mixture of the two species in the complex. A critical step in improving the management of this complex is to understand the reproductive biology of the individual species that comprise it, as it is unknown if they have different life history parameters. This study re-examines the reproductive biology of one of these species, *S. aleutianus*, within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Preliminary results from this study indicate age and length at 50% maturity for this species are 26.3 years and 48.8 cm FL. These values are older and larger than values of 19 years and 43.9 cm FL currently being utilized in the stock assessment of the GOA rougheye rockfish complex. It is unknown whether these larger and older values are a result of a more geographically appropriate sampling plan or the exclusion of *S. melanostictus* from the analyses. These updated values for age and length at maturity have important implications for stock assessment and are likely to result in more conservative catch limits for this species in the GOA. For further information, please contact Christina Conrath (907) 481-1732.

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

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

Rockfish Maturity in the Aleutian Islands-REFM/REEM

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

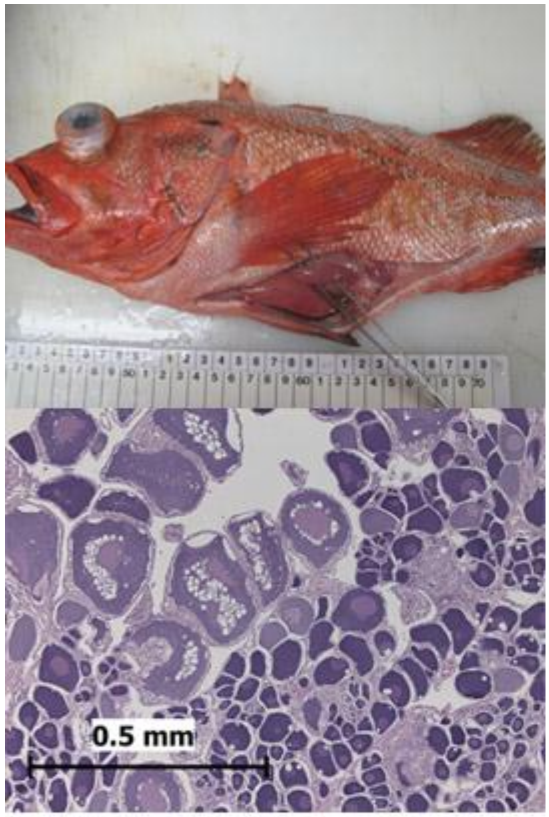

Figure 5. Macroscopic (a) and histological (b) view of an ovary from a large-sized blackspotted rockfish collected in April 2010. There was no evidence of vitellogenesis in the histological view.

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

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

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

The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. We propose to examine the productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish, *S. variabilis*) in three different habitat types. Low relief, high relief rocky/boulder, and high relief sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska will be sampled using both drop camera image analysis and modified bottom trawls. We will sample these habitats examining differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success within the different habitat types. This research will enable us to examine the importance of different habitat types for these rockfish species providing data critical for both protecting essential habitat as well as effective management of these species. This research will commence during 2012 and will continue through 2014. For further information contact Christina Conrath, (907) 481-1732

b. Stock Assessment

Pacific Ocean Perch (POP)

BERING SEA AND ALEUTIAN ISLANDS

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

Age 3+ biomass for 2012 is down slightly from the 2011 level projected a year ago. Spawning biomass is projected to be 221,000 t in 2012 and decline slightly to 214,000 t in 2013.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby, qualifying Pacific ocean perch for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 158,000 t, 0.061, and 0.074 respectively. Spawning biomass for 2012 (221,000 t) is projected to exceed $B_{40\%}$ (158,000 t), thereby placing POP in sub-tier "a" of Tier 3. The 2012 and 2013 catches associated with the $F_{40\%}$ level of 0.061 are 29,400 t and 28,300 t, respectively. In 2010, the Plan Team recommended an adjusted ABC approach until the next Aleutian Islands survey, which would keep the recommendation steady at 24,700 t for 2012, followed by an increase to 28,300 t in 2013. The Plan Team continues to endorse this approach. The 2012 and 2013 OFLs are 35,000 t and 33,700 t.

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

GULF OF ALASKA
Pacific ocean perch (POP), *Sebastes alutus*, is the dominant fish in the slope rockfish assemblage and has been extensively fished along its North American range since 1940. Since 2005, Gulf of Alaska rockfish have been moved to a biennial stock assessment schedule to coincide with the biennial AFSC trawl survey that occurs in this region. In even years (such as 2010's assessment for the 2011 fishery) when there is only new catch information, we run only the projection model with updated catch data for single-species, age-structured assessments. In odd years (like 2011), we run a full assessment with all new survey and fishery data accumulated since the last full assessment. In 2011, a full stock assessment was produced. The 2011 Gulf of Alaska trawl survey biomass estimate was the highest since 2005. For the 2012 fishery, we recommended the maximum allowable ABC of 16,918 t which was stable from last year's ABC of 16,997 t. The stock is not overfished, nor is it approaching overfishing status. For more information, contact Dana Hanselman at (907) 789-6626 or dana.hanselman@noaa.gov.

Northern Rockfish

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

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

GULF OF ALASKA

The northern rockfish, *Sebastes polyspinis*, is a locally abundant and commercially valuable member of its genus in Alaskan waters. As implied by its common name, northern rockfish has one of the most northerly distributions among the 60+ species of *Sebastes* in the North Pacific Ocean. Since 2005, Gulf of Alaska (GOA) rockfish have been moved to a biennial stock assessment schedule to coincide with the AFSC trawl survey. An age-structured assessment (ASA) model is used to assess northern rockfish in the GOA; the data used in the ASA model includes the trawl survey index of abundance, trawl survey age and length composition, fishery catch biomass, and fishery age and length composition. Updated catch data is the only data available in even years, while in odd years a full assessment is run that includes both updated survey and catch data since the last full assessment. A new method was introduced in the 2011 full assessment to blend multiple sources of maturity data. A new maturity study was recently published that differed substantially from the previous maturity study. Because of these differences, the data from these two studies were fit simultaneously inside the model, allowing the uncertainty in the maturity curve to be propagated through the assessment. An additional analysis examined the optimal binning of age composition data and adjusted the maximum age fit in the model accordingly. The result was a recommended ABC for 2012 of 5,509 t; this ABC was 13% higher than the 2011 ABC of 4,857 t. The GOA northern rockfish stock is not subjected to overfishing, is not currently overfished, and is not approaching a condition of overfishing. For more information, contact Pete Hulson, ABL, at (907) 789-6060 or pete.hulson@noaa.gov.

Shortraker Rockfish

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

Estimated shortraker rockfish biomass is 17,500 t, which is identical to the 2010 assessment biomass estimate. Overall, total biomass has trended slowly downward from 28,900 t in 1980.

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

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

GULF OF ALASKA-ABL Contribution
Shortraker rockfish has been its own separate management category in the Gulf of Alaska (GOA) since 2005. Previously, it had been grouped with rougheye rockfish in the "shortraker/rougheye" management category. Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the AFSC biennial trawl surveys in the GOA. Because these surveys occur in odd years, one was conducted in 2011, and therefore a full assessment for shortraker rockfish was completed in fall 2011. Shortraker rockfish has always been classified into "tier 5" in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level, in which the assessment is mostly based on biomass estimates from trawl surveys, instead of modeling. As in previous assessments since 1994, an average of the Gulf-wide biomass from the three most recent trawl surveys (presently the 2007, 2009, and 2011 surveys) is used to determine current exploitable biomass. This results in an exploitable biomass of 48,626 mt for shortraker rockfish. The NPFMC's "tier 5" ABC definitions state that F_{ABC} $\leq 0.75M$, where M is the natural mortality rate. Using an M of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 1,081 mt for the GOA in 2012. This is an increase of 18% compared to the 2010 and 2011 ABCs of 914 mt. The increase is due to the relatively large biomass for shortraker rockfish found in the 2011 trawl survey that now goes into the calculation of current exploitable biomass. Gulfwide catch of shortraker rockfish was 457 mt in 2010, and estimated catch in 2011 was 522 mt. Shortraker rockfish is not considered overfished in the GOA, nor is it approaching overfishing status. For more information, contact Dave Clausen at (907) 789-6049 or dave.clausen@noaa.gov.

Blackspotted/rougheye Rockfish Complex

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

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

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

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

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

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

Additionally, we include brief summaries of rougheye and blackspotted rockfish speciation, the stock structure template, and current research in the "Evidence of Stock Structure" section of the 2011 Stock Assessment and Fishery Evaluation (SAFE) report. For more information, contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

Other Rockfish Complex

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

biomass, as measured by trawl surveys of the Aleutian Islands and the EBS slope, are assumed the same as the 2010 assessment.

F_{ABC} was set at the maximum allowable under Tier 5 ($F_{ABC} = 0.75M$). Multiplying these rates by the best biomass estimates of shortspine thornyhead and other rockfish species in the "other rockfish" complex yields 2012 and 2013 ABCs of 710 t in the EBS and 570 t in the AI. The assessment uses a three survey weighted average to estimate biomass in similar fashion to the methodology used in the Gulf of Alaska rockfish assessments. OFL was set for the entire BSAI area, which under Tier 5 is calculated by multiplying the best estimates of total biomass for the area by the separate natural mortality values and adding the results, which yields an OFL of 1,700 t for 2012 and 2013.

The "other rockfish" complex is not being subjected to overfishing. It is not possible to determine whether this complex is overfished or whether it is approaching an overfished condition because it is managed under Tier 5. For further information, contact Paul Spencer at (206) 526-4248.

GULF OF ALASKA-ABL Contribution

"Other Rockfish" in the Gulf of Alaska (GOA) is a new management category that was implemented by the North Pacific Fishery Management Council (NPFMC) in 2012. The category is comprised of the 15 rockfish species that were previously in the "Other Slope Rockfish" category together with yellowtail and widow rockfish. The latter two species were formerly in the "Pelagic Slope Rockfish" category along with dusky rockfish, but dusky rockfish is now managed as a stand-alone species and the Pelagic Slope group has been dissolved. The primary species of "Other Rockfish" in the GOA are sharpchin, harlequin, silvergray, and redstripe rockfish; most of the others are at the northern end of their ranges in Alaska and have a relatively low abundance here. Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the AFSC biennial trawl surveys in the GOA. Because these surveys occur in odd years, one was conducted in 2011, and therefore a full assessment for "Other Rockfish" was completed in fall 2011. All species in the group have always been classified into "tier 5" or "tier 4" (only sharpchin rockfish is "tier 4") in the NPFMC definitions for ABC and overfishing level, in which the assessment is mostly based on biomass estimates from trawl surveys, instead of modeling. As in previous assessments since 1994, an average of the Gulf-wide biomass from the three most recent trawl surveys (presently the 2007, 2009, and 2011 surveys) is used to determine current exploitable biomass. This results in a current exploitable biomass of 85,774 mt for "Other Rockfish". Applying either an $F_{ABC} \leq F_{40\%}$ rate for sharpchin rockfish or an $F_{ABC} \leq 0.75M$ (M is the natural mortality rate) for the other species to the exploitable biomass for "Other Rockfish" results in a recommended ABC in the GOA of 4,045 mt for 2012. This is an increase of 8% compared to the 2010 and 2011 ABCs of 3,749 mt for "Other Slope Rockfish". The increase is mostly due to the addition of yellowtail rockfish to the group in 2012 and the large biomass of silvergray rockfish in the 2011 trawl survey. Gulfwide catch of "Other Slope Rockfish" was 942 mt in 2010, and estimated catch in 2011 was 849 mt. "Other Rockfish" is not considered overfished in the Gulf of Alaska, nor is it approaching overfishing status.

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

5. Thornyheads

Stock Assessment

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

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

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

6. Sablefish

a. Research

2011 Sablefish Longline Survey - ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2011. The survey is a joint effort involving the AFSC's Auke Bay Laboratories and Resource Assessment and Conservation Engineering (RACE) Division. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978 to 1994 and also samples gullies not sampled during the cooperative longline survey. In 2011, the thirty-third annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Bering Sea was conducted. One hundred-fifty-two longline hauls (sets) were completed during May 25 – August 28, 2011 by the chartered fishing vessel *Ocean Prowler*. Sixteen kilometers of groundline were set each day, containing 7,200 hooks baited with squid.

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

Several special projects were conducted during the 2011 longline survey. Lingcod and spiny dogfish were tagged with archival temperature/depth tags in the West Yakutat and central Gulf of Alaska regions. Forty-five satellite pop-up tags were deployed on spiny dogfish throughout the Gulf of Alaska. Information from these tags will be used to investigate the movement patterns of spiny dogfish within and out of the Gulf of Alaska. Additionally, genetic tissue and otoliths of giant grenadier were sampled to see if geographic stock structure exists and to determine if three distinct otoliths shapes identified in previous work correspond to different subspecies or subpopulations. Finally, opportunistic photo identification of both sperm and killer whales were collected for use in whale identification projects. For more information, contact Chris Lunsford at (907) 789-6008 or chris.lunsford@noaa.gov.

Sablefish Tag Program - ABL

The ABL MESA Program in 2011 continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database. Total sablefish tag recoveries for the year were around 653. Eighteen percent of the recovered tags in 2011 were at-liberty for over 14 years, and about 10 percent of the total 2011 recoveries were recovered over 1,000 nautical miles (great circle distance) from their release location. The tag a- liberty, the longest was for approximately 34 years, and the greatest distance traveled of a 2011 recovered sablefish tag was 1,731 nautical miles. Eight sablefish tagged with archival tags were recovered in 2011. Data from these electronic archival tags, which will provide information on the depth and temperature experienced by the fish, are still being analyzed.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, and spiny dogfish are also maintained in the Sablefish Tag Database. Fourteen thornyheads, three archival turbot tags, and three archival lingcod tags were recovered in 2011. These are the first lingcod recoveries since the start of lingcod tagging in 2007.

Releases in 2011 totaled 5,183 adult sablefish (including six with archival tags and five with pop-up satellite tags), 948 juvenile sablefish (including 125 with archival tags), 910 shortspine thornyheads, 45 spiny dogfish with pop-up satellite tags, 32 lingcod with archival tags, and 68 Greenland turbot (including 29 with archival tags). For more information, contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

Juvenile Sablefish Studies - ABL

Juvenile sablefish studies have been conducted by the Auke Bay Laboratories in Alaska since 1984 and were continued in 2011. A total of 823 juvenile sablefish (age 1+) were tagged with spaghetti tags and released during a cruise to St. John Baptist Bay near Sitka between July 12th-16th. During the cruise, 125 juvenile sablefish were implanted with electronic archival tags. Approximately 100 rod hours were recorded to catch the fish that were tagged during the cruise. Total catch-per-unit-effort (CPUE) equaled 7.83 sablefish per rod hour fished. This was the highest CPUE since 1994, and 3.6 times greater than 2010. This relatively small bay is the only known location in Alaska where juvenile sablefish have been consistently found on an annual basis.

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

Sablefish Maturity Study – RACE and ABL

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

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

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

Sablefish Archival Tagging Study - ABL

During the 1998, 2000, 2001, and 2002 AFSC longline survey, 600 sablefish were implanted and released with electronic archival tags that recorded depth and temperature. These archival tags provide direct insight into the vertical movements and occupied thermal habitat of a fish. 127 of these tags have been recovered and reported from commercial fishing operations in Alaskan and Canadian waters. Analysis of these data began in earnest in 2011, and 104 of these tags have been analyzed to date. Temporal resolution of depth and temperature data ranged from 15 minutes to one hour, and data streams for an individual fish ranged from less than a month to greater than five years. Sablefish exhibited a wide range of patterns in vertical movements and occurred mostly between 200 m – 800 m depth, though many fish often would spend shorter periods at depths >1000 m. Variability in vertical movement patterns were likely a function of individual variability and location of the fish (though horizontal locations were not recorded by the archival tags). Most fish regularly exhibited diel movement patterns and moved to deeper waters during the winter months, a pattern possibly related to spawning behavior. Sablefish typically occurred in waters between 3°-7° C with most occurring between 4°-6° C. Fish released along the slope of the eastern Bering Sea typically occurred in colder waters than those released along the slope of southeast Alaska. These results are preliminary and further analyses are ongoing. For more information, contact James T. Murphy (907) 789-6027 or at james.t.murphy@noaa.gov.

Age and Sex-Structured Sablefish Movement Model - ABL

Sablefish have been tagged annually during longline surveys in the Gulf of Alaska, Aleutian Islands, and the slope of the eastern Bering Sea shelf since the late 1970s. Almost all tagged sablefish are captured by longline and trawl fisheries with a small number captured by research surveys. Most recoveries occur in Alaskan waters with some occurring in British Columbia and a few along the West Coast of the United States.

In 1991, ABL scientists Jon Heifetz and Jeff Fujioka published a sablefish movement model utilizing tagging data from 1979-1987. Heifetz and Fujioka analyzed sablefish movement based on size-at-release. This study by Heifetz and Fujioka has been extended in 2011 by adding sex and age-structure to the model and incorporating tagging data through 2009. At time of tagging, the sex and age of the sablefish is not known but can be assigned by utilizing sex-specific length and age data collected during the surveys. Most sablefish recoveries are reported back to ABL without any sex data; however, only those recoveries with sex information were utilized in the current study. Preliminary results indicate moderate to substantial difference in movement patterns between ages. Younger sablefish tend to move towards or remain in western areas of the Gulf of Alaska, while older sablefish tend to move towards or remain in eastern areas. Whether sex-specific differences in movements occur is uncertain and requires further analysis. These findings are similar to the length-based results of Heifetz and Fujioka but can be readily utilized into future spatial age-structured assessment models.

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

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

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

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

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

7. Yellowfin sole

Stock Assessment - Bering Sea

This year's EBS bottom trawl survey resulted in a biomass estimate of 2.40 million t, compared to last year's survey biomass of 2.37 million t (an increase of 1 percent). The stock assessment model indicates that yellowfin sole have slowly declined over the past twenty years, although they are still at a fairly high level (57% above B_{MSY}), due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 5 of the past 20 year classes have been at or above the long term average. However, the 2003 year class appears to be as strong as any observed since 1983 and should contribute to the reservoir of female spawners in the near future. The 2011 catch of 151,000 t represents the largest flatfish fishery in the U.S. and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

New data for this year's assessment include:

- 2010 fishery and survey age compositions
- 2011 trawl survey biomass point estimate and standard error
- estimates of the discarded and retained portions of the 2010 catch
- estimate of total catch through the end of 2011.

The current assessment model allows for the input of sex-specific estimates of fishery and survey age composition and weight-at-age and provides sex-specific estimates of population numbers, fishing mortality, selectivity, fishery and survey age composition and allows for the estimation of sex-specific natural mortality and catchability. It also features the inclusion of estimates of time varying fishery selectivity, by sex.

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

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock. Accordingly, yellowfin sole qualify for management under Tier 1. The estimate of B_{MSY} from the present assessment is 341,000 t. Corresponding to the approach used in recent years, the 1978- 2005 stock-recruitment data were used this year to determine the Tier 1 harvest recommendation. This provided a maximum permissible ABC harvest ratio (the harmonic mean of the F_{MSY} harvest ratio) of 0.10. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.11. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2012 biomass estimate produces the author- and Plan Team-recommended 2012 ABC of 203,000 t, and the corresponding product using the OFL harvest ratio produces the 2012 OFL of 222,000 t. For 2013, the corresponding quantities are 207,000 t and 226,000 t, respectively.

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

8. Northern Rock Sole

a. Research

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

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

The Influence of Polychaete Tube Habitat on the Prey Availability, Feeding Habits, and Condition of Juvenile Rock Sole. – RACE Kodiak Lab in Collaboration with the Newport Fish Behavioral Ecology Program:
The final analyses for this project were completed in 2011. Briefly, the abundance of juvenile flatfish (most notably northern rock sole) is highly correlated with abundance of ampharetid polychaete *Pseudosabellides sibirica* worm tubes in coastal nurseries around Kodiak Island, AK. In some years, concentrated aggregations of *P. sibirica* can form a dense lawn covering large sections of the seafloor in the bays around Kodiak. Juvenile northern rock sole *Lepidopsetta polyxystra*, aggregate along the edge of this habitat where tube density is low to moderate and patchy. We conducted a series of integrated field and laboratory studies to examine the ecological processes controlling this fish-habitat relationship. For this study, we specifically tested the following hypotheses: 1) areas of worm tube habitat will contain both a higher density and greater diversity of benthic fauna versus adjacent areas with bare, sandy substrate, 2) the diet composition and feeding activity of age-0 rock sole residing in worm tube habitat will differ

from those fish residing in adjacent waters devoid of worm tubes, and 3) the condition of age-0 rock sole residing in worm tube habitat will be higher compared to rock sole found in adjacent areas without worm tubes. The results indicate the density of benthic fauna (potential prey) was significantly higher in the worm tube habitat in comparison to adjacent areas devoid of worms. In addition, the diet composition of rock sole residing in the worm habitat was significantly different than fish residing in adjacent areas, with bare substrate. It was clear that rock sole residing in the worm habitat were feeding primarily on the worms themselves. Rock sole residing in the worm tube habitat were not in better condition than fish residing in adjacent areas of bare substrate. After settlement in July, rock sole residing in bare substrate habitat had higher condition values than sole residing in the worm habitat. By the end of their first growing season in September, there were no discernible differences in rock sole condition between the habitats. This may indicate greater movement of rock sole between habitats over the course of the summer or this may highlight the predation refuge value of the worm tube habitat for juvenile rock sole, especially during July when the rock sole are potentially more vulnerable to predation due to their small size. Overall, it is clear that worm tube habitat positively influenced the density of benthic fauna in the nurseries. In addition, the worm tube habitat altered the foraging behavior of juvenile rock sole and the worms themselves were an important food source at deeper depths. However, it is not apparent if these factors created enhanced foraging opportunities for juvenile rock sole, as displayed through higher condition values in the worm tube habitat. The results suggest that when present, the presence of worm tube habitat could have implications for nursery productivity by influencing the prey availability and food habits of juvenile flatfish. This manuscript will be published in FY 2012. For further information, please contact Brian Knoth (907) 481-1731.

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

b. Stock Assessment

The northern rock sole stock is currently at a high and increasing level due to strong recruitment from the 2001, 2002 and 2003 year classes which are now contributing to the mature population biomass. The 2011 bottom trawl survey resulted in a biomass estimate of just under 2 million t, 4% lower than the 2010 point estimate. The northern rock sole harvest primarily comes from a high value roe fishery conducted in February and March which usually takes only a small portion of the ABC because it is constrained by prohibited species catch limits and market conditions.

The stock assessment model indicates that the stock declined in the late 1990s and early 2000s due to poor recruitment during the 1990s but is now projected to increase in the near future due to the recently observed strong recruitment. It is currently estimated at twice the B_{MSY} level.

New information for the 2011 analysis include:

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

The current assessment model allows for the input of sex-specific estimates of fishery and survey age composition and weight-at-age and provides sex-specific estimates of population numbers, fishing mortality, selectivity, fishery and survey age composition and allows for the estimation of sex-specific natural mortality and catchability. It also features the inclusion of estimates of time varying fishery selectivity, by sex.

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

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

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

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

9. Flathead Sole

a. Research

Contrasting the Maturation, Growth, Spatial Distribution and Vulnerability to Environmental Warming of Hippoglossoides robustus (Bering flounder) with H. elassodon (flathead sole) in the Eastern Bering Sea

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

b. Stock Assessment

BERING SEA

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

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

- updated 2010 fishery catch and preliminary 2011 fishery catch
- updated 2010 fishery size compositions and preliminary 2011 fishery size compositions
- estimated survey biomass and standard error from the 2011 EBS trawl survey
- size compositions from the 2011 EBS trawl survey
- age compositions from the 2010 EBS trawl survey
- mean bottom temperature from the 2011 EBS trawl survey

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

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

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying flathead sole for management under Tier 3. The current values of these reference points are $B_{40\%}$=133,000 t, $F_{40\%}$=0.28, and $F_{35\%}$=0.34. Because the projected spawning biomass for 2012 (250,000 t) is above $B_{40\%}$, flathead sole is in sub-tier "a" of Tier 3. The ABCs for 2012 and 2013 were set at the maximum permissible values under Tier 3a, which are 70,400 t and 69,200 t, respectively. The 2012 and 2013 OFLs under Tier 3a are 84,500 t and 83,100 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

The assessment was updated as follows:

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

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

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

10. Alaska Plaice

Stock Assessment

The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2011 survey biomass was 520,000 t, a at about the same level as the past three years and largely consistent with estimates from resource assessment surveys conducted since 1985. Of interest in 2010 is that the combined results of the eastern Bering Sea shelf survey and the northern Bering Sea survey indicate that 38% of the Alaska plaice biomass was found in the northern Bering Sea in 2010. The stock is expected to remain at a high level in the near future due to the presence of a strong year class estimated from 2002. Exploitation occurs primarily as bycatch in the yellowfin sole fishery and has averaged only 1% from 1975-2011.

New data for 2011 included:

the updated 2011 survey catch
- fishery catch through 15 October 2011
- 2011 trawl survey biomass estimate and standard error
- 2011 length composition of survey catch
- 2010 survey age composition

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

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

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

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

11. Greenland Halibut (Turbot)

a. Research

Greenland Halibut- RACE Recruitment Processes

Spawning in Greenland halibut (*Reinhardtius hippoglossoides*) occurs along the continental slope and in submarine canyons in the EBS. Eggs were found in Bering and Pribilof Canyons and over the adjacent slope during February and March, confirming that spawning occurs in these regions. Larvae were present over the slope, outer shelf and middle shelf in winter and spring, and settled juveniles were collected over the shelf in September. Oceanographic modeling approaches that simulate larval advection from spawning to nursery habitats indicate depth-discrete variations in transport pathways from submarine canyons to the adjacent shelf contribute to interannual variability in transport trajectories. Overall, data highlight specific physical mechanisms of delivery that are modulated by large-scale atmospheric and oceanographic forcing, potentially varying the degree of slope-shelf connectivity for Greenland halibut and other slope-spawning species.

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

Greenland Halibut and Pacific Halibut- RACE Recruitment Processes

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

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

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

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

b. Stock Assessment

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

This year's Greenland turbot assessment model included:

- updated 2010 and 2011 catch data
- 2011 EBS shelf survey biomass
- 2011 EBS shelf survey length composition estimates
- additional years of NMFS bottom-trawl shelf survey age data
- updated fishery catch-at-length data for longline and trawl gear from 2004-2011.

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

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

Team's ABC and OFL recommendations. Greenland turbot is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

12. Arrowtooth Flounder

a. Research

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

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

b. Stock Assessment

BERING SEA

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

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

New input data include:

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

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

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

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

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

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

The estimated age 3+ biomass from the model has increased by an order of magnitude since 1961 and peaked at about 2.2 million t in 2006. Since then the stock has stabilized. The age 3+ biomass estimates are slightly higher in the current assessment than the projected 2009 assessment estimates. Female spawning biomass in 2011 is estimated to be 1,238,210 t, a <1% decrease from the projected 2011 biomass from the 2009 assessment.

Arrowtooth flounder has been determined to fall under Tier 3a. The 2012 ABC using $F_{40\%}$=0.174 is 212,882 t, a slight decrease from the 2011 ABC of 213,150 t. The 2012 OFL using

$F_{35\%}$=0.207 is 250,100 t. The 2013 ABC (212,033 t) and OFL (249,066 t) were estimated using the projection model and catch in 2012 estimated using the recent 5-year average (F=0.020).

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

13. Other Flatfish

a. Research

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

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

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

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

b. Stock Assessment

BERING SEA

The "other flatfish" complex currently consists of Dover sole, rex sole, longhead dab, Sakhalin sole, starry flounder, and butter sole in the EBS and Dover sole, rex sole, starry flounder, butter sole, and English sole in the AI. Starry flounder, rex sole, and butter sole comprise the vast majority of the species landed. For example, Starry flounder and rex sole comprised 90% of the "other flatfish" catch in 2011. Because of insufficient information about these species, no model analyses are possible and trawl survey estimates are used to determine stock biomass. The latest assessment incorporates 2011 total catch and discard and 2011 trawl survey information. The 2011 EBS bottom trawl survey resulted in biomass estimates of 94,200 t, 18% lower than the 2010 estimate. The biomass of these species in the Aleutian Islands is 13,100 t from the 2010 survey.

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

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

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

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

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

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

The sex and age-structured model for Dover sole is similar to what was presented in 2009. The model fit the survey biomass relatively well, but underestimated large catches in the early 1990s. The model resulted in unrealistically high biomass values and was substantially different than the previous model estimates. The author and Team were concerned with this and concluded that further evaluation was needed and was inappropriate to apply for management recommendations. Some parameters converged at their bounds and the selectivity estimates seemed questionable.

The Team agrees with the author's recommendation to move Dover sole into Tier 5 until the model can be more fully evaluated. The Plan Team requested a review of the revised model in September 2012.

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

Dover Sole were previously in Tier 3a but due to the aforementioned concerns about the validity of the model the Plan Team recommended that it be moved to Tier 5. Both Greenland turbot and deepsea sole are in Tier 6. The Tier 6 calculation (based on average catch from 1978-1995) for the remaining species in the deep water flatfish complex ABC is 183 t and the OFL is 244 t. These values apply for 2012 and 2013 ABC and OFLs. For the Dover sole Tier 5 assessment the 2012 and 2013 ABC using F_{ABC}=0.75*M = 0.064 results in 4,943 t. The 2012 and 2013 OFL using F_{OFL}=M = 0.085 results in 6,590 t. The combined ABC (5,126 t) and OFL (6,834 t) for the deep water flatfish complex are used for management of the deep water complex. The ABC is equivalent to the maximum permissible ABC.

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

14. Dogfish and Other Sharks

a. Research

Spiny Dogfish Ecology and Migration - ABL

Scientists at the Auke Bay Laboratories are continuing an annual tagging program for spiny dogfish including both numerical Peterson disk tags and pop-off, electronic archival tags. Thirty-five pop-off and >300 numeric tags were deployed in Yakutat Bay in the summers of 2009 and 2010, and a further 45 pop-off tags were deployed during the annual AFSC longline survey in 2011. To date, all of the 2009 and 2010 pop-off tags have been "recovered" (i.e., the data is downloaded from them, but they are not physically recovered), as well as most of the 2011 tags (12 tags are still at liberty), and the remaining tag is programmed to pop-off and transmit its data in May 2012. Recovered data from the pop-off tags, which includes temperature, depth, and geographic location, are still being analyzed. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Spiny Dogfish Improved Aging Methods - ABL

Staff from ABL, AFSC REFM Division, and the University of Alaska Fairbanks are participating in a North Pacific Research Board funded project to investigate alternative aging methods for spiny dogfish. The project kicked off with a three day workshop on aging methods, which was also attended by age readers from WDFW and NWFSC. This project aims to compare the previous method of aging the dorsal fin spines with a new technique developed that uses the vertebrae. The groups that participated in the workshop will also participate in an inter-lab portion of the project comparing variability of the ages read (of each structure) between labs. Results of this project will be presented at the Center for Age Reading Excellence (CARE) meeting next April. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Salmon Shark Life History – Race Kodiak in collaboration with ABL and the Alaska Department of Fish and Game

Sharks in Alaska waters are currently managed as a part of the 'Other Species' group by the North Pacific Fishery Management Council. Shark catches within the Gulf of Alaska (GOA) are dominated by three species, the spiny dogfish, *Squalus acanthias*, the Pacific sleeper shark, *Somniosus pacificus*, and the salmon shark, *Lamna ditropis*. While not the target of commercial fisheries, salmon sharks are captured by recreational fishers and as bycatch in several fisheries within the GOA. The stock assessment and management of this species is hindered by a lack of life history data to input into models. Parameters needed to support stock assessment include reproductive timing and periodicity, fecundity, and improved age and length at maturity estimates. The life history of this species is being examined by researchers at the Kodiak Laboratory. Salmon sharks captured incidentally in other fisheries are being collected and dissected to examine: length at maturity, fecundity, reproductive periodicity, and age and growth. To date, 19 female salmon sharks have been obtained at the Kodiak Laboratory during the fall months with additional specimens collected by researchers at the Alaska Department of Fish and Game and researchers at Auke Bay Laboratories. For further information, please contact Christina Conrath (907) 481-1732.

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

b. Stock Assessment

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

There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI or GOA, and most incidentally captured sharks are not retained. Catch estimates from 2003-2011 were updated from the NMFS Alaska Regional Office's Catch Accounting System. The shark assessment for the BSAI was only an executive summary. Catch estimates from the Catch Accounting System were updated; total catch in the BSAI from 2010 was 53 mt and the estimated catch for the assessment in 2011 was 148 mt. The primary species caught in the BSAI is the Pacific sleeper shark.

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

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

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

15. Other Species

Assessment of Grenadiers in Alaska - ABL

In 2011, a brief Executive Summary assessment was done for grenadiers in Alaska and incorporated as an appendix to the North Pacific Fishery Management Council’s (NPFMC) annual Stock Assessment and Fishery Evaluation Report. The Executive Summary provided an update to the full assessment for grenadiers done in 2010 and presented new survey information and updated catches for 2011, but ABC recommendations remained the same as in the full assessment. Giant grenadier (*Albatrossia pectoralis*) is by far the most abundant grenadier in Alaska at depths <1,000 m, is the major bycatch species in directed fisheries for sablefish and Greenland turbot, and is the only grenadier species to warrant management concern in Alaska at present. Therefore, the assessments have been based on giant grenadier serving as a proxy for entire grenadier group. Current biomass estimates for giant grenadier are: eastern Bering Sea (EBS), 592,271 mt; Aleutian Islands (AI), 1,141,526 mt; and Gulf of Alaska (GOA), 597,884 mt. Based on the NPFMC’s “tier 5” definition for ABC, we applied an F=*M*=0.078 approach (*M* is the natural mortality rate) to these biomass estimates to compute overfishing levels (OFLs) for giant grenadier in each region, and then multiplied the OFLs by 0.75 to compute the following ABCs: EBS, 34,648 mt; AI, 66,779 mt, and GOA, 34,976 mt. When these values are compared with the estimated catches of giant grenadier, it appears giant grenadier are not being overfished at this time.

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

D. Other Related Studies

Fisheries Resource Pathology Program – RACE

As a disease program, we frequently get inquiries regarding the nature of encountered anomalies. It is our goal to develop a web-based reference site or information center. Therefore, we inspected numerous fish and shellfish for assorted visual anomalies during the 2011 EBS RACE survey. Abnormalities were photographed, excised, and placed in fixative for subsequent microscopic diagnosis and for genetic characterization of the respective etiological agent. Species analyzed included Pacific cod, northern rock sole, Arctic cod, Bering founder, walleye pollock, Greenland turbot, and Pacific herring.

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

Spectral Irradiance Logger –RACE

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

Systematics Program-RACE GAP

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

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

Salmon Excluders-RACE MACE

AFSC Conservation Engineering (CE) scientists participated in tests and refinement of the salmon excluder designs in February and March 2011. CE scientists provided and operated underwater video and sonar equipment to directly observe gear, assuring effective tuning of devices. Chinook salmon escape rates were between 25 and 40%, while chum salmon escape rates remained in the 10 – 15% range. Pollock escape was insignificant at less than 1%. The North Pacific Fisheries Research Foundation placed a technician aboard Gulf of Alaska vessels to demonstrate correct tuning and operation of the new excluder design to promote transfer of this technology to that fleet. The AFSC provided the camera systems used by this technician from our CE “loaner pool.” BREP funding was also used for travel to a Fall 2011 workshop at the fishing gear testing facility in St. Johns, Newfoundland to develop new designs to improve escape rates for both salmon species. For further information, contact Craig Rose (Craig.Rose@noaa.gov).

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

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

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

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

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

APPENDIX I - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

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

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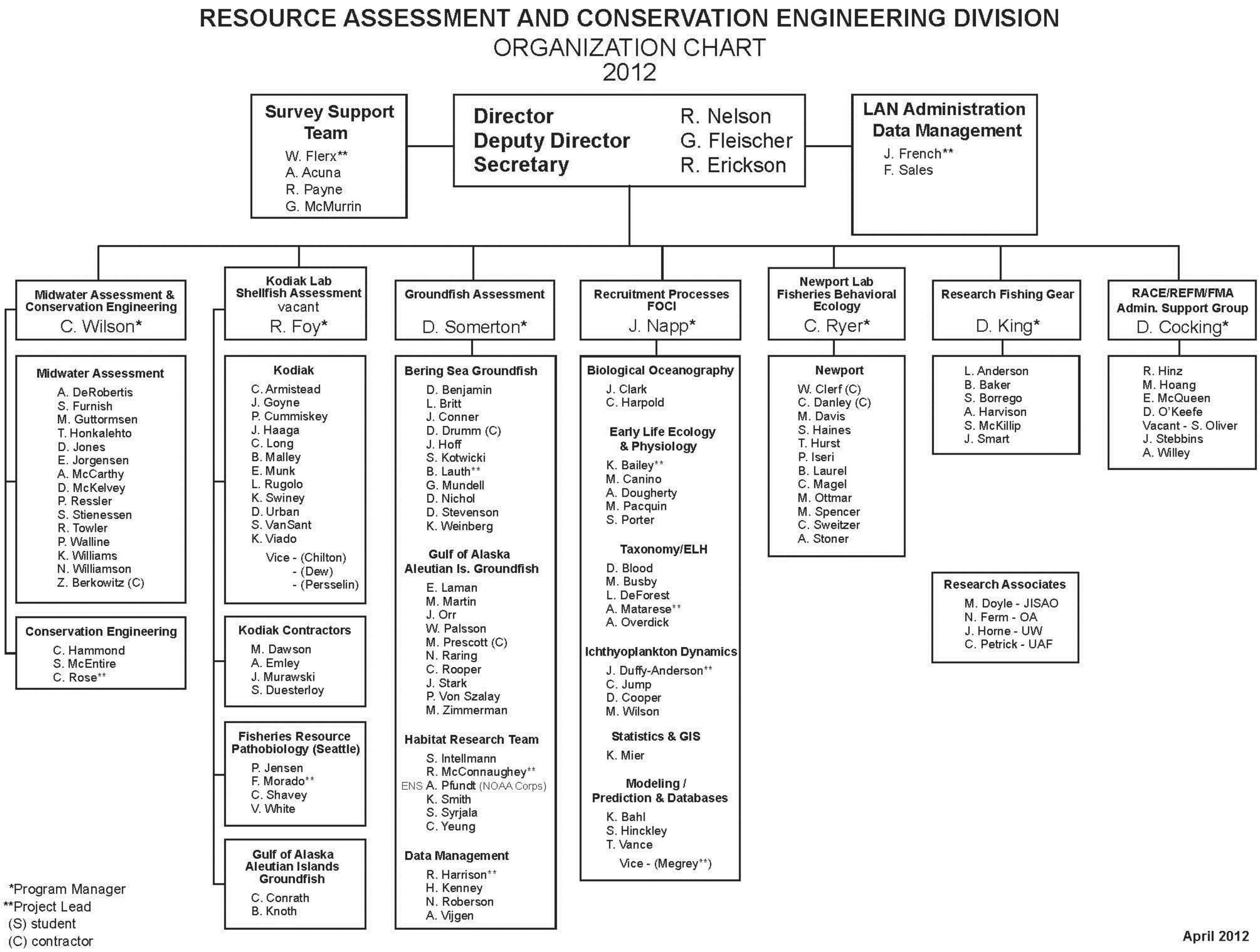
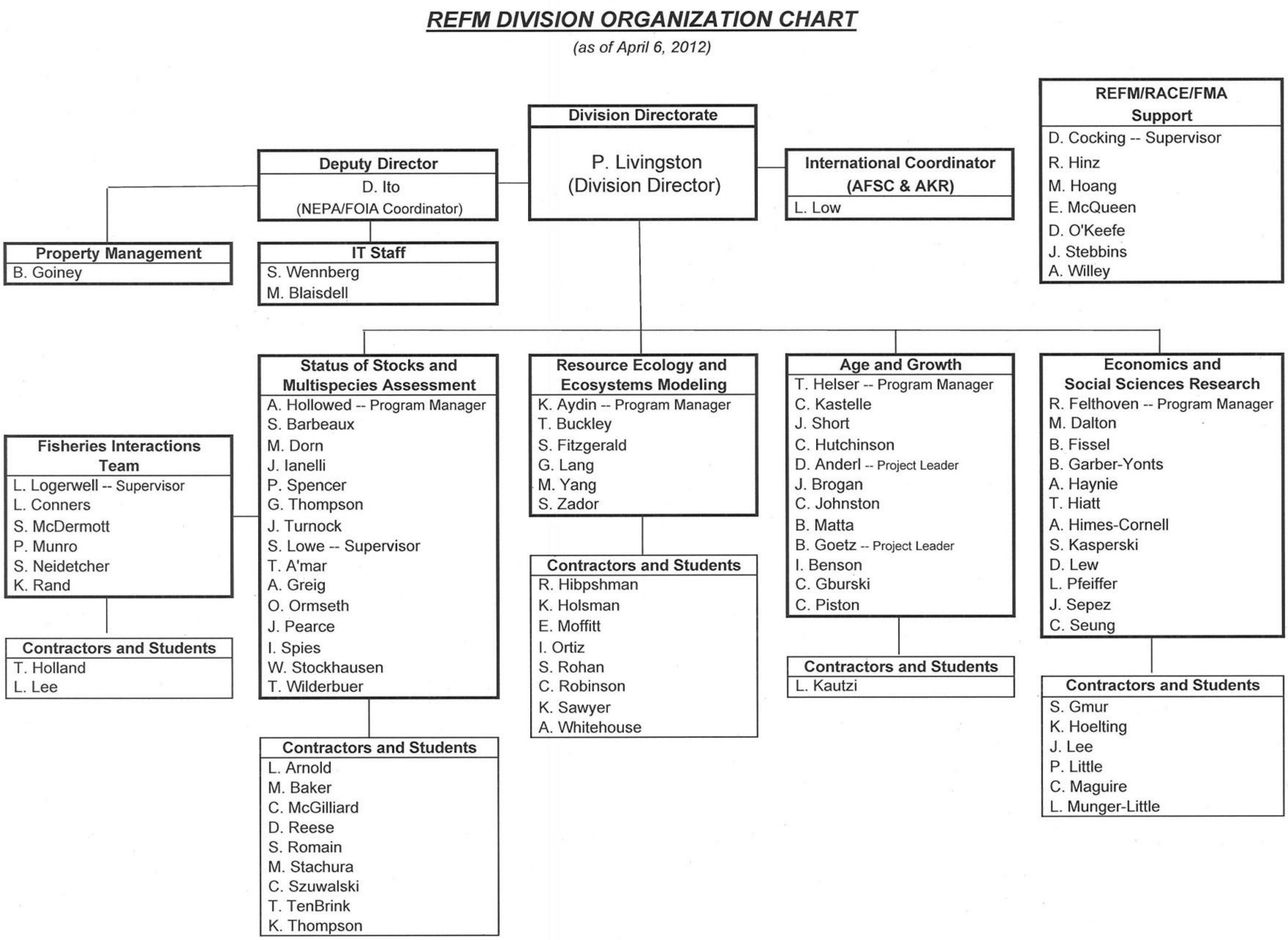
APPENDIX II. RACE ORGANIZATION CHART



APPENDIX III. REFM ORGANIZATION CHART



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

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

Other ABL Staff Working on Groundfish-related Research

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

CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2011

May 2012

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REVIEW OF AGENCY GROUNDFISH RESEARCH, STOCK ASSESSMENT, AND MANAGEMENT

A. Agency overview

Fisheries and Oceans Canada (DFO), Science Branch, operates three principal facilities in the Pacific Region: the Pacific Biological Station (PBS), the Institute of Ocean Sciences (IOS), and the West Vancouver Laboratory (WVL). These facilities are located in Nanaimo, Sidney and West Vancouver, British Columbia (BC), respectively. Dr. Laura Richards is the Regional Director of Science. The Divisions and Sections are as follows:

Division Heads in Science Branch reporting to Dr. Richards are:

Canadian Hydrographic Service	Mr. David Prince (Acting)
Ocean Science	Mr. Robin Brown
Salmon & Freshwater Ecosystems	Mr. Mark Saunders
Marine Ecosystems & Aquaculture	Dr. Laura Brown

Section Heads within the Marine Ecosystems & Aquaculture Division (MEAD) are:

Groundfish	Mr. Greg Workman
Invertebrates	Mr. Graham Gillespie
Pelagic Fish Research & Conservation Biology	Mr. Jacob Schweigert
Applied Technologies	Mr. Henrik Krieberg
Aquaculture and Environmental Research	Dr. Steven MacDonald

Groundfish research and stock assessments are conducted in the Groundfish Section. Groundfish specimen ageing and hydroacoustic work are conducted in the Applied Technologies Section. The Canadian Coast Guard operates DFO research vessels. These research vessels include the *W.E. Ricker*, *J.P. Tully*, *Vector*, and *Neocaligus*. A replacement vessel for the *W.E. Ricker* has been delayed until 2014 or beyond.

The Pacific Region Headquarters (RHQ) of Fisheries and Oceans Canada is located at 401 Burrard Street, in Vancouver, BC, V6C 3S4. Management of groundfish resources is the responsibility of the Pacific Region Groundfish Coordinator (Mr. Neil Davis, Acting) within the Fisheries and Aquaculture Management Branch (FAM). Fishery Managers receive assessment advice from MEAD through the Canadian Centre for Scientific Advice Pacific (CSAP) review committee. The Chair of CSAP (Ms. Marilyn Joyce) advises the Regional Management Committee on stock status and the biological consequences of fisheries management actions and works in consultation with the Canadian Stock Assessment Secretariat (CSAS) in Ottawa. Research documents can be viewed on the CSAS website http://www.dfo-mpo.gc.ca/science/advice-avis/index-eng.html.

The trawl, Sablefish, rockfish, Lingcod, North Pacific Spiny Dogfish, and halibut fishery sectors continue to be managed with Individual Vessel Quotas (IVQs). IVQs can be for specific areas or coastwide. Within the general IVQ context, managers also use a suite of management tactics including time and area specific closures and bycatch limits. Details for the February 2012 to February 2013 integrated fisheries management plan can be viewed at http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/ground-fond_2012-13.pdf

A shift in the funding of industry collaborations, particularly in conducting cooperative surveys, was required after the *Larocque* court decision of June 23, 2006. Prior to the *Larocque* decision, compensation provided to fishers for their data collection services took the form of the proceeds of the unavoidable fish kills in the research surveys, less any samples retained for detailed scientific analysis. In instances where these proceeds did not cover the cost of the research survey, the department allowed fishers to catch additional fish for payment purposes. Post-*Larocque* these "top up" payments for fishing activities are no longer possible. Larocque Relief Funding, to replace fish allocations, was provided in 2007 and will continue to fund surveys through March 2012. Larocque Relief Funding has ended and new funding is secured from Ottawa for the April 2012 to March 2013 surveys.

B. Multispecies or ecosystem models and research

1. Stock Assessment Prioritization

A Groundfish Section stock assessment prioritization and scheduling plan was developed in 2011 and early 2012. This first plan covers 10 years (2012-2021) but the process calls for it to be reviewed and updated every five years, rolling forward over time. The current schedule focuses on 39 "Type A" species which includes species identified as being conservation concerns (i.e., Bocaccio, Basking Shark, etc.) and species which are important to the First Nations, commercial and recreational fisheries. The frequency of assessment for Type A species ranges from 1 year (i.e., Pacific Hake), to 2 years (Sablefish and Pacific Cod), to 5 or 10 years for the remaining Type A species depending on importance to the fisheries.

The timing of assessment for species that have been flagged as conservation issues by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is synchronized with the timing of COSEWIC re-assessments.

The remaining 200+ non-commercial fish species that can be considered to lie within the Groundfish research mandate are classified as Type B species. The current process calls for a fast screening of the relative abundance trends in surveys and commercial CPUE for each of these species every five years. The fast screening is designed to provide a short-list of the 20-30 Type B species that should receive more detailed consideration in order for them to be scheduled into the coming 10 year workplan.

2. Ecological Risk Assessment for the Effects of Fishing (ERAEF)

A pilot study application of the Ecological Risk Assessment for the Effects of Fishing (ERAEF) framework was completed in 2011 for a portion of the groundfish bottom trawl fishery in Hecate

Strait, British Columbia. ERAEF was developed as a tool to inform an Ecosystem-based Approach to fisheries management in Australia. The method uses a hierarchical approach to risk assessment that allows it to efficiently assess ecological risk from fishery or non-fishery impacts for hundreds of species, habitats, and ecological communities. The pilot study was initiated by Groundfish Science to investigate whether ERAEF could be a useful tool for providing timely advice on groundfish fishery impacts, and to learn how ERAEF risk scores could be used to help prioritize groundfish science advisory activities. The overarching goals of the pilot study were to (i) determine how the Australian framework could be adapted to the context of British Columbia groundfish fisheries; and (ii) develop an understanding of how ERAEF could inform prioritization of research and management activities for marine ecosystems in British Columbia.

Pilot study results demonstrated that ERAEF could be readily used to assess fishery impacts for a wide range of BC groundfish species using existing knowledge and data. In addition, some elements of the ERAEF framework could be applied at the present time to provide timely advice on non-fishery impacts on groundfish species in British Columbia. However, further methods development would be necessary before broad-scale implementation in British Columbia, including the delineation of habitat and community assessment units. Additional advantages of the approach include: bringing issues to the table that are not traditionally assessed, promoting the use of clearly defined objectives to assess ecosystem impacts, and helping identify areas where further research is needed. Future applications of ERAEF, or some elements of ERAEF, are currently under consideration as a means to provide science input to groundfish managers.

3. Strait of Georgia Ecosystem Research Initiative Project

Groundfish Staff continued to participate in the Strait of Georgia Ecosystem Research Initiative Project in 2011. The Central Theme of this Ecosystem Research Initiative is "The Strait of Georgia in 2030", i.e. what might the Strait of Georgia be like in 2030. The research conducted within this Initiative is designed to align with the Departmental goals of ensuring a healthy and productive aquatic ecosystem in the Strait of Georgia, and to support sustainable fisheries and aquaculture in the Strait. This research initiative currently comprises over thirty research projects and involves over fifty researchers. Details can be found at http://www-sci.pac.dfo-mpo.gc.ca/sogeri/default_e.htm. This 5-year project will be concluded in 2012.

4. NSERC Canadian Capture Fisheries Research Network (CCFRN)

Starting in 2010, Groundfish staff have been participating in the National Sciences and Engineering Research Council of Canada's (NSERC) *Canadian Capture Fisheries Research Network*. The CCFRN is a collaboration of academic researchers, the fishing industry, and government researchers and managers from across Canada. The Network includes 33 academics from 13 universities, working with collaborators in the Canadian fishing industry, DFO, and provincial governments. The Network is industry-driven and focussed on projects that have the active collaboration of each sector. The Network will link with other strategic networks and coordinate with DFO programs, where appropriate.

The vision of the Network is to re-shape fisheries research in Canada, bringing together industry, academia and government on priority research questions and linking existing research so that it is useful to industry and management. The research of the Network is aimed at increasing knowledge that will enhance the ecological sustainability, socio-economic viability and management of Canadian fisheries. Specifically, the research objectives are to:

- overcome information gaps for important commercial fisheries and improve the use of industry information in assessment and management;
- enhance ecological sustainability while achieving operational efficiency; and improve the basis for the ecosystem approach to fisheries management.

The Network will provide a forum for sharing research objectives and results that will build capacity in each sector; as well as establish a tradition of collaborative, strategic fisheries research in Canada that is expected to extend beyond its timeline. In addition, the Network will train a cohort of new researchers that will be equipped to meet the research challenges of a new fisheries management regime.

The information and technological advances gained through the research of the Network will have a significant impact on the sustainability, viability and competitiveness of Canada's capture fisheries industry, and will provide environmental and socio-economic benefits. The research will build upon and inform the development of policies and strategies for the management of capture fisheries in Canada and internationally. Details can be found at: http://www.nsercpartnerships.ca/How-Comment/Networks-Reseaux/CCFRN-CCRRN-eng.asp

5. Summary of Research Surveys in 2011

A number of multi-species trawl surveys are conducted by the Groundfish Section and Groundfish staff participate in trawl surveys conducted by other groups. For a summary of research trawl survey activity in 2011, please see Appendix 2. Other research surveys conducted in 2011 include longline, ROV and trap surveys. These surveys are described under their respective species programs below.

C. By species

1. Pacific Cod

i Research program

Three-hundred and ninety (390) dorsal fin rays from the 2009 Hecate Strait synoptic survey were analysed for ageing in 2010. Age and length data are now available in the groundfish database. A request for ageing analysis of 1500 dorsal fin rays from the 2010 West Coast Vancouver Island, and the 2011 Hecate Strait and Queen Charlotte Sound synoptic surveys has been placed for 2012. In addition, fins and otoliths from specimens less than 35 cm in length will be collected during the 2012 shrimp and synoptic surveys. These samples will be analysed with the intention of developing improved techniques for ageing young Pacific cod.

ii. Stock Assessments

No new stock assessments for Pacific Cod were conducted in 2011. Dr. Robyn Forrest and Mr. Rob Kronlund are preparing background materials and potential models for an assessment in 2012, due for review in 2013. This work will include feedback simulation studies to explore the performance of alternative models and harvest control rules for this species.

2. Rockfish – inshore

i. Research programs in 2011 and planned for 2012

1. <u>Surveys on the Inside (PMFC Area 4B)</u>

A research longline survey designed for the Inside waters East of Vancouver Island and initiated in 2003, surveyed the southern half of the study area in 2011. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records and fishermen consultations. The hard bottom survey areas were then overlain with a 2 km by 2 km grid and survey blocks were stratified by area and depth (41 – 70 m and 71 – 100 m) and selected for sampling at random. Twenty-one days of DFO ship time are allocated in August for this survey in 2012 which will cover the northern half of the study area.

A Phantom HD2+2 remotely operated vehicle (ROV), acquired by DFO Science in 2007 has been used to develop visual survey methods for inshore rockfish. A forward looking video camera (paired lasers), DIDSON sonar unit, scanning sonar, and ultra-short baseline (USBL) underwater acoustic positioning are standard equipment used on the ROV for visual surveys. Surveys to assess inshore rockfish stocks in and adjacent to the Rockfish Conservation Areas (RCAs) were conducted in March and June 2011 in central and northern portions of the west coast of Vancouver Island. An ROV survey is not planned for 2012.

2. <u>Surveys on the Outside (PMFC Areas 3CD, 5ABCDE)</u>

Since 2003, a third technician has been deployed on the annual International Pacific Halibut Commission (IPHC) Area 2B setline survey to collect hook-by-hook catch data and conduct biological sampling of non-Halibut catch (Yamanaka et al. 2011; Flemming et al. 2011). The third technician has been supported by Larocque funds between 2007 and 2011. Other funding has been secured for this survey program in 2012.

In collaboration with the halibut industry, a research longline survey was designed and conducted in the outside BC coastal waters in 2006. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records and fishermen consultations. The hard bottom survey areas were then overlain with a 2 km by 2 km grid (matched with the adjacent trawl survey grid) and survey blocks were stratified by area and depth and chosen at random. Approximately 200 survey sets are targeted annually. The survey covers the coastwide Outside waters over two years, alternating annually between the north and the south. Three chartered fishing vessels conduct this survey between August 15 and September 15. In 2011, the southern portion of BC was surveyed and plans for 2012 are to survey in the northern region. This survey was supported by Larocque funds and other funding has been secured for the program in 2012.

ii. Stock assessment

The National Advisory Process (NAP) and Committee On the Status of Endangered Wildlife In Canada (COSEWIC) status reports were prepared for Yelloweye and Quillback Rockfishes in 2006. COSEWIC reviewed the status of Yelloweye Rockfish in November 2008 and recommended a Special Concern status for both designatable units in BC. Quillback Rockfish was also reviewed by COSEWIC in the fall of 2009 and COSEWIC has recommended a threatened status. http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

There are two designatable units of Yelloweye Rockfish in BC; an Inside stock that generally extends from Malcolm Island to Victoria in the protected waters East of Vancouver Island and an Outside stock that includes all other areas of the BC coast (extending to SE Alaska and Oregon). An Inside management unit Yelloweye Rockfish stock assessment was presented to the Canadian Science Advisory Process (CSAP) in April 2011 (Yamanaka et al. 2011). Stock status is evaluated using a reference case Bayesian surplus production model run. This model run estimates that the stock biomass in 2009 is at 780 tonnes (coefficient of variation [CV] 0.46), which is 12% (CV 0.43) of the initial biomass of 6466 t (CV 0.40) in 1918. There is a 5% probability that the Inside Yelloweye Rockfish population in 2009 is greater than the fisheries Limit Reference Point (LRP), consistent with Fisheries and Oceans Canada's (DFO's) fishery decision-making framework incorporating the Precautionary Approach. The population is likely within the Critical Zone.

A coastwide Quillback Rockfish stock assessment was presented to CSAP in May 2011. Unlike Yelloweye Rockfish, Quillback Rockfish is considered a coastwide stock; however, the assessment is conducted separately for the Inside and the Outside management units. Stock status is assessed using a Bayesian state space surplus production model where fishing is the only source of mortality for the stock. In 2011, median biomass (B2011) for the Outside management unit is 6,480 tonnes (coefficient of variation [CV] 1.21) and 37.7% (CV 0.65) of the biomass in 1918. Similarly for the Inside management unit, B2011 is 2,668 tonnes (CV 0.60) and 27.4% (CV 0.47) of the biomass in 1918.

iii. Management

A specific Species at Risk (SARA) management plan for Yelloweye Rockfish is required as it is listed under SARA as Special Concern. Work on this management plan is underway.

Public consultations on the pending Quillback Rockfish listing under SARA will be conducted in 2012. Subsequent to the consultations, the Minister of Fisheries and Oceans will make a decision on whether to list Quillback Rockfish as threatened.

3. Rockfish – shelf

i. Research Programs in 2011

There was no directed biological research work on shelf rockfish in 2011.

ii. Stock assessments in 2011

Work on the synchronous assessment of five rockfish (Splitnose, Sharpchin, Harlequin, Redstripe, and Greenstriped) was continued in 2011 and will be reviewed in the fall of 2012. Completion was delayed owing to conflicting tasks. A Bocaccio assessment was started in 2011 and will be reviewed in May 2012.

iii. Research activities planned for 2012

Completion of a Yellowtail Rockfish genetics paper is planned but requires a sample from the Strait of Georgia, which is proving difficult to obtain.

DFO staff continues to collaborate with NMFS-AFSC staff on the study of Blackspotted and Rougheye Rockfish. Genetics samples from all major surveys are now being collected and analysed with the results shared with U.S. counterparts. Preliminary results were presented in a poster at the 2012 Western Groundfish Conference.

iv. Stock assessments planned for 2012

A coastwide Silvergray Rockfish assessment is tentatively planned for 2012.

4. Rockfish – slope

i. Research programs

The Slope Rockfish Program remains responsible for the assessment of rockfish species living on the marine continental slope of British Columbia (BC). The program also tackles a variety of other issues: COSEWIC listing requirements, oceanographic exploration, software development for the R statistical platform, and scientific research in marine ecological modelling.

The Groundfish Section at the Pacific Biological Station (PBS) conducts a suite of synoptic surveys that covers most of BC's ocean bottom ecosystems, including those on the continental shelf and slope. The survey team gathers information on abundance and biology (lengths, weights, maturity, otoliths, etc.). The Slope Rockfish Program, headed by Andrew M. Edwards (PBS research scientist) and including Rowan Haigh (PBS research biologist), focuses on the development of models and software tools for the analysis of data pertaining to groundfish and other species. We also retain the interest of two scientists – Jon T. Schnute (PBS scientist emeritus) who contributes time and expertise; and Paul J. Starr who works for the Canadian Groundfish Research and Conservation Society and plays an integral role in the stock assessments assigned to our program.

In 2011, work continued on maintaining and upgrading the suite of PBS packages for the R statistical platform:

PBSmodelling	http://cran.r-project.org/web/packages/PBSmodelling/index.html
PBSmapping	http://cran.r-project.org/web/packages/PBSmapping/index.html
PBSadmb	http://cran.r-project.org/web/packages/PBSadmb/index.html
PBSddesolve	http://cran.r-project.org/web/packages/PBSddesolve/index.html
PBSfishery	http://code.google.com/p/pbs-fishery/

In particular, we contracted Nicholas Boers (Computer Science, Grant MacEwan University, Edmonton AB) to upgrade the GIS package PBSmapping. Nick is the original computer programmer for this package and remains the primary source for the C-code therein.

Additionally, our group contracted Phillip Morrison to conduct an initial literature search on the interactions between climate and groundfish recruitment, which we hope to incorporate into our population models at some point.

Research continues on various aspects of marine ecological modelling.

ii. Stock assessment

In 2011, our group presented the first BC stock assessment of Yellowmouth Rockfish (*Sebastes reedi*) featuring a population model. The assessment covered the entire BC coast; however, the primary habitat for this species occurs in Queen Charlotte Sound (central BC).

Yellowmouth Rockfish supports the third largest rockfish fishery in BC with an annual coastwide TAC (total allowable catch) of 2,444 t. The trawl fishery receives 96.77% of the coastwide TAC, with the rest allocated to the hook and line fishery. Stock status was assessed using an annual two-sex catch-at-age model tuned to five fishery-independent trawl survey series (West Coast Haida Gwaii synoptic, Goose Island Gully historic, Queen Charlotte Sound synoptic, Queen Charlotte Sound shrimp, and West Coast Vancouver Island synoptic), annual estimates of commercial catch since 1940, and age composition data from two of the survey series (6 years) and the commercial fishery (18 years).

Results are reported for the two model runs (estimated natural mortality M and M fixed at 0.047; numeric ranges below refer to the 5 to 95% credible intervals derived from Bayesian output).

Spawning biomass (mature females only) at the beginning of 2011 is estimated to be in the range of 0.431-0.829 or 0.289-0.547 of the equilibrium unexploited value. The estimated exploitation rates peak in the mid-1960s due to the large catches by foreign fleets, and peak again (though not as high) in the late 1980s to early 1990s due to the rise of the BC fishery. The exploitation rate for 2010 is estimated to be in the range 0.010-0.036 or 0.026-0.059 for the two models.

Based on the DFO *Sustainable Fisheries Framework*, Precautionary Approach compliant limit and upper reference points of $0.4B_{\mathrm{MSY}}$ and $0.8B_{\mathrm{MSY}}$ were calculated (where B_{MSY} is the spawning biomass at the maximum sustainable yield). The spawning biomass at the start of 2011 has a probability of 1.0 of being above $0.4B_{MSY}$, and of 1.0 or 0.99 of being above $0.8B_{MSY}$.

Constant catch projections at 1,500 t/year (which is close to the average catch from 2006 to 2010 of 1,440 t) over 5 years predict that the spawning biomass at the start of 2016 would have a probability of 1.0 or 0.997 of remaining above $0.4B_{MSY}$, and of 0.997 or 0.940 of remaining above $0.8B_{MSY}$.

Both model runs estimate that since 1987 there have been no recruitment events as large as those observed in the early 1960s and early 1980s. Recruitment anomalies for Yellowmouth Rockfish appear six years later than similar events for Pacific Ocean Perch (POP).

iii Research activities for 2012

A Pacific Ocean Perch stock assessment is being conducted in 2012 for the stocks that were not considered in the Queen Charlotte Sound assessment (published as Edwards et al. 2012); specifically these are PMFC areas 3CD (off the west coast of Vancouver Island) and areas 5DE (off Haida Gwaii).

If funding becomes available, we will collaborate with Jackie King (PBS Nanaimo) on a project called "Understanding Climate Impacts on Groundfish Recruitment". For all groundfish species for which we can produce recruitment indices, we will identify climate signals in year-class success and subsequent recruitment strength to the fisheries. Observed signals can elucidate the ecological pathways linking climate and ocean variability to the population dynamics of commercially important groundfish species. In addition, the identification of these pathways will support the future development of decision support tools for the provision of stock assessment advice.

Other potential projects might include the effects of ocean acidification on groundfish assemblages with Debby Ianson (IOS Sidney); technical aspects of dealing with zeros in proportions-at-age data, and workshops on PBSmodelling.

5. Sablefish

i. Research activities in 2011 and planned for 2012

The Sablefish Research and Assessment Survey Program includes the following program components:

a) A **Traditional Standardized Program** (1990-2010)

This program was not conducted in 2011 and is unlikely to be resumed. This program included standardized sets at nine (9) offshore fishing localities and biological sampling. Starting in 1990, one set was made in each of five (5) depth intervals in each locality. Since 1999, additional shallower and deeper depth intervals have been added, removed and changed. However, the 5 core intervals have remained the same over time. Catch rates from these core sets extend a stock abundance index series and Sablefish are sampled for data on size and growth.

b) A **Traditional Tagging Program** (1991-2007, hiatus in 2008-2011)

This program captures Sablefish for tagging and release at historical tagging locations. Sets are made in the 9 traditional standardized program localities as well as five (5) tagging-only localities. The protocol for this program is to release a specified number of tagged fish in each locality. Low catch rates in some areas in previous years have resulted in survey vessels being required to re-set additional strings in an area. Tag-recoveries from these sets can be used for studying movement, obtaining estimates of gear selectivity, and deriving an index of tagging-based abundance.

c) A **Randomized Tagging Program** (2003-2011)

This program captures Sablefish for tagging and release following a depth and area stratified random survey design. The catch rate data can be used to derive an index of stock abundance. Tag-recoveries can be used for deriving estimates of gear selectivity, studying movement, and deriving an index of tagging-based abundance. The survey also provides biological samples.

d) An **Inlets Program** (1995-2011)

This program includes standardized sets at four (4) mainland inlet localities. Sablefish are tagged and released from inlet sets and are sampled for biological data.

The annual Research and Stock Assessment Survey Program will be conducted in the fall of 2012, but will include only the randomized program (c) and the inlets program (d).

ii. Stock assessment activities in 2011 and planned for 2012

A Sablefish assessment was conducted in 2010 (Cox et al. 2011); the next scheduled assessment is planned for late 2013. Sablefish stock assessment and management in British Columbia is conducted collaboratively by DFO and the Canadian Sablefish Association. The collaboration is formalized as a Joint Project Agreement that identifies the respective responsibilities of the two parties and provides a mechanism for joint contributions to fishery management and science activities for Sablefish. Annual survey activities are conducted using fishing vessels chartered from the Sablefish longline trap fleet.

Fishery reference points are based on a target spawning biomass at maximum sustained yield, B_{MSY}, with limit and upper stock reference points at $0.4B_{\mathrm{MSY}}$ and $0.8B_{\mathrm{MSY}}$, respectively. Conservation objectives relate to (*i*) maintaining the spawning biomass above the limit reference point of $0.4B_{\mathrm{MSY}}$ in 95% of years projected over two Sablefish generations (~36 years), and (*ii*) implementing an acceptable probability of stock decline over 10 years that scaled from 0.5 at the target biomass to 0.05 at the limit reference point. A multi-gear, age-structured, catch-at-age model was fitted to historical data to create stock scenarios that captured uncertainty in natural mortality, growth, and future recruitment variability. Stock reconstructions suggest stock status is currently below B_{MSY} for all scenarios. A closed-loop feedback simulation approach was used to evaluate the relative performance of candidate management procedures that are distinguished by the choice of survey data, assessment model assumptions, harvest control rule specifications, and future regulations related to at-sea release of sub-legal Sablefish. Candidate management procedures were robust to the uncertainties considered as indicated by a consistently low probability ($p < 5\%$) of breaching the limit reference point over two Sablefish generations (~36 years) regardless of the management procedure or stock scenario. Expectations for stock growth toward the target reference point over two Sablefish generations range from B_{MSY} or greater to levels near, but not above B_{MSY} under the more pessimistic scenarios.

Performance of management procedures based on the stratified random trap survey alone suggested the legacy standardized trap survey could be discontinued without creating a conservation concern, and could also achieve reduced catch variability relative to the use of both surveys. Increases in expected conservation and catch performance due to adopting an avoidance option for sub-legal Sablefish, or a full retention option, were small relative to the performance attained by the existing size limit tactic, but these effects are likely underestimated due to suspected violations of assumptions related to trawl gear selectivity.

The coastwide quota for the 2012/13 fishing year was set at approximately 2,300 t based on the catch recommendation from the preferred management procedure. The same management procedure, which uses the results of the annual randomized survey, will be used to generate a catch recommendation for the 2013/14 fishing year. Sablefish is next scheduled for a full stock assessment in late 2013, the results of which will provide advice for the 2014/15 fishing year and subsequent 2 fishing years.

Development of the management strategy evaluation for BC Sablefish in 2010 added modeling of retained and released catches to the age-structured operating model. A 55 cm fork length minimum legal size limit in British Columbia means that sub-legal fish are released by regulation. Work in 2012 will focus on improvements to the modeling of releases by gear sector and simulation evaluation of the B_{MSY}-based reference points. The longline trap and longline hook sectors of the Sablefish fishery in BC received Marine Stewardship Council certification on July 29, 2010. Certification was awarded with conditions related to (*i*) assessment of stock status relative to fishery reference points and in particular whether the stock is fluctuating around the target reference point, (*ii*) evaluation of the impacts of bycatch of the rougheye/blackspotted rockfish complex, (*iii*) evaluation of existing sea-bird bycatch data and improvement of seabird bycatch monitoring data collection.

6. Flatfish

i. Research program in 2011

Ongoing data collection in support of the flatfish research program continued in 2011 with samples being collected during two Groundfish synoptic bottom trawl surveys, the first in Hecate Strait / Dixon Entrance and the second in Queen Charlotte Sound. Additional samples were collected by port samplers in Vancouver and Prince Rupert as well as by at-sea observers deployed on bottom trawl vessels. During surveys biological data were collected from all flatfish species encountered.

A productivity susceptibility analysis (PSA) was applied to seventeen flatfish species in 2011 to estimate potential risk from bottom trawl fishing in Hecate Strait and Dixon Entrance as part of a pilot study application of an Ecological Risk Assessment for the Effects of Fishing. PSA methods were taken from methodology developed by NOAA (http://nft.nefsc.noaa.gov/PSA_pgm.htm). Flatfish species included in the analysis included both directed (e.g., Dover Sole, Petrale Sole) and non-directed (e.g., Speckled Sanddab, Deepsea Sole) species. The results of this analysis are published in the Canadian Technical Report of Fisheries and Aquatic Sciences series.

ii. Research activities planned for 2012

Biological data collection for all flatfish species will continue in 2012 with fishery independent samples coming from the West Coast Vancouver Island synoptic survey and the West Coast Haida Gwaii survey.

iii. Stock assessments planned for 2012

No stock assessments are planned for 2012/2013.

7. Lingcod

i. Research programs in 2011

A Lingcod (*Ophidodon elongatus*) egg mass survey was conducted by DFO SCUBA divers at Snake Island Reef and Entrance Island Reef in the Strait of Georgia in February 2012. This survey was undertaken to add to the existing time series from Snake Island Reef, one of the primary index sites, and to provide an ongoing source of biological and relative abundance information for Strait of Georgia Lingcod.

ii. Research activities planned for 2012

Starting in 2012, Dr. Murdoch McAllistair from the University of British Columbia will be leading a multi-year research project aimed at using management strategy evaluation to identify economically viable harvesting options for the BC small boat groundfish fleet. This project is funded by the National Sciences and Engineering Research Council of Canada's (NSERC) *Canadian Capture Fisheries Research Network.* The outside Lingcod fishery will be used as an initial case study for this research, with the Lingcod portion of the research focusing on the question of how seasonal differences in habitat use and vulnerability to capture between male and female Lingcod affect management performance for different harvest options. DFO staff will be collaborating on this project.

iii. Stock assessments planned for 2012

A stock assessment of the inside (Strait of Georgia) Lingcod stock is planned for May 2013. As part of the assessment, a management strategy evaluation (MSE) approach will be used to provide harvest advice. MSE will be used to compare performance measures based on stock status and yield for alternative harvest strategies identified by groundfish managers and a multi-stakeholder working group. This comparison will enable managers to identify which harvest strategy provides the most acceptable trade-off between performance measures, while ensuring that the objectives and risk tolerances identified by both the DFO Precautionary Approach Framework and stakeholders are met.

8. Pacific Hake

i. Research program

Triennial (until 2001), then biennial acoustic surveys, covering the known extent of the Pacific Hake stock have been done since 1995. A full survey, ranging from California to northern British Columbia was done in 2011. The estimated biomass from this survey was 521,000 metric tonnes, the lowest estimate since the beginning of the time series in 1995. The abundance was dominated by three-year old fish from the 2008 yearclass and nearly all these fish were in United States (US) waters, thus only (7%) of the overall biomass was in Canadian waters at the time of the survey. Following the 2010 assessment, nearly all of the data sources available for Pacific Hake were reconstructed and thoroughly re-evaluated by US scientists, with input from Canadian scientists. These improved data streams were updated for 2012 with the addition of new age distributions from the 2011 fishery and acoustic survey, as well as the 2011 acoustic survey biomass index.

ii. Stock Assessment in 2011

The majority of the Canadian Pacific Hake catch for the 2011 season was taken from the Southwest coast of Vancouver Island in the third quarter (July-Sept), however the shift in temporal and spatial distribution of Pacific Hake was still apparent with much of the catch being taken from the Quatsino region North of Brooks Peninsula and from Goose Island Gully in Queen Charlotte Sound (PMFC 5A and 5B). The increased fishing in the Strait of Juan de Fuca seen in the 2009 fishery was not apparent in 2010 or 2011; word has spread amongst the fishing community that the fish caught there in 2009 were too small for processors to handle. The joint venture (JV) fishery took place in July-September, ending earlier than usual due to sporadic catches. The total allocation for 2011 with 15% carryover from 2010 was 109,706 mt. The domestic sector was allocated 77,454 mt of this and caught 45,949 mt (59%). The JV quota for 2011 was 32,251 mt of which only 10,108 mt (31%) was taken. Many fishermen commented that Pacific Hake seemed to be coming into the canyons from deeper waters for short periods only and because of this some of them were making longer tows in deeper waters to fill their quota.

Management of Pacific Hake is now under Treaty between Canada and the United States. The 2011 harvest advice was prepared jointly by Canadian and US scientists working under the treaty, with considerable efforts by the two teams to align data and assumptions in the two assessment models. The models were SS and CCAM, respectively prepared by the US and Canadian assessment teams. Results from the two assessments were combined within a single document that was reviewed by the Pacific Hake Stock assessment review (Scientific Review Group; SRG) panel. The SS model was selected as the base model by the assessment team (and endorsed by the SRG). The CCAM model was used for sensitivity analyses. Results from the two models were very similar. In particular, both SS and CCAM showed a high degree of sensitivity to parameterization of the survey selectivity function and this was selected as the primary axis of uncertainty in the analysis. Therefore, decision tables were presented showing: i) within-model uncertainty (from Bayes posterior of base SS model); and ii) among-model uncertainty, showing results from two SS and two CCAM models with alternative parameterisation of survey selectivity. Uncertainty in catch advice was large due to inability of the models to resolve inconsistencies between age composition data (showing large incoming year classes) and the low 2011 survey index. The 2011 acoustic survey data resulted in a dramatically lower estimate of stock abundance and a higher estimate of recent exploitation rates, compared with results from the 2011 assessment. The mismatch between the 2009 and 2011 survey results cannot be resolved and is an indication of the inherent uncertainty of this assessment.

Note that in 2009, survey results were contaminated by huge numbers of Humboldt Squid that occurred all along the Pacific Coast. It had not been possible to distinguish squid from Pacific Hake acoustically and the 2010 review (STAR) panel had recommended that the 2009 survey abundance index be removed from the assessment entirely. Re-analysis of the acoustic survey data by NOAA's acoustic team during 2010 enabled confidence intervals to be placed on the 2009 estimate of Pacific Hake abundance. The acoustic team also re-analysed all the raw acoustic data since 1995 and applied a kriging methodology to recalculate indices of abundance with confidence intervals. Addition of confidence intervals that could be attributed to the presence of Humboldt Squid to the 2009 index led to the decision to re-instate this data point (with CV) into the assessment. All survey data prior to 1995 were removed from the analysis, as these were known to contain bias due to subjective inflation factors that had been applied to account for the fact that these surveys did not cover the same extent (spatially or depth-wise) as surveys since 1995. Furthermore, raw data were no longer available for the earlier surveys and it was therefore impossible to apply the same kriging methodology to recalculate the index of abundance. The review panel supported the removal of pre-1995 survey data and re-instatement of the 2009 data in the 2011, and subsequently 2012, assessments.

A notable feature of the 2011 and 2012 assessments was the appearance of an apparent strong 2008 year class in the 2010 and 2011 commercial catch data and in the 2011 survey data. This apparent above-average recruitment event was strongly influential on model results in 2011 and continues to have an influence on the 2012 assessment, although estimates of its magnitude have been downweighted by the low 2011 survey index point. The strength of the 2008 year class continues to be uncertain in the assessments. Its true magnitude is unlikely to be resolved until it has been observed in the fishery and survey several more years. The exceptionally large 1999 year class has all but moved through the fishery, although a very small proportion of 12 year old fish from this year class were still present in the 2011 Canadian fishery. It is estimated that the cumulative removal from the 1999 cohort exceeds 1.2 million metric tonnes.

The median estimate of spawning stock abundance for 2012 is at 33% of the unfished equilibrium level (ranging from 11% to 86%), therefore below the target biomass of 40% of the unfished equilibrium level. The current assessment estimates that the stock is expected to stay near this level for the next two years as the 2008 year class grows and is supplemented by additional year classes. However, estimates of year class abundance after 2008 are even more uncertain than the estimate for 2008. Although the stock is estimated to be near its target level, it should be noted that the population is dominated by a single year class that is likely not yet fully mature.

The final decision on catch advice for the 2012 fishing season was made at the meeting of the International Pacific Hake Joint Management Committee in Vancouver on March 14-15, 2012. A coastwide adjusted TAC of 251,809 mt for 2012 was established, which is consistent with the default harvest rate of F-40 percent with a 40/10 adjustment. The final document is posted at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Whiting-Management/upload/2012-TAC-rec.pdf

9. Elasmobranchs

1. Research programs in 2011

The satellite tags from the eight Sixgill Sharks (*Hexanchus griseus*) that were tagged in the Strait of Georgia in March 2011 have popped-up and relayed data. Aerial surveys for Basking Sharks (*Cetorhinus maximus*) were conducted monthly May to September in 2011 in two areas of historic high abundance: Barkley and Clayoquot Sounds; and Rivers Inlet. No sharks were sighted. Four Basking Shark sightings were received through the Basking Shark Sightings Network (toll-free number or online form). A population genetics study for blue shark in the North Pacific is almost completed with collaborators from California, Alaska, Hawaii and Japan.

ii. Stock assessment(s) in 2011

There were no elasmobranch assessments in 2011.

iii. Management

In 2011, to aid in fisher and on-board observer identification of skates, an identification guide "Skates of British Columbia" was produced and distributed to all licence holders. New management measures will be put in place in the recreational fishery in 2011, with non-retention of all shark species other than North Pacific Spiny Dogfish and Salmon Shark (*Lamna dirtopis*). A daily limit of 4 and an annual possession limit of 8 was implemented for North Pacific Spiny Dogfish. A daily limit of 1 and an annual possession limit of 2 was implemented for Salmon Shark. Previously, the daily limit for all shark species was 20 per species, with an annual possession limit of 40 per species.

iv. Research activities for 2012.

Ongoing collaboration with the Alaska Fisheries Science Center and Moss Landing Marine Labs, on a collaborative project on bomb dating for age validation of Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*) will be initiated. A population genetics study for Salmon Shark in the North Pacific will begin with collaborators from Alaska, California and Mexico. A population genetics study of Sixgill Sharks in BC will be conducted, and is to include the investigation of polyandry. Age determination studies on Spotted Ratfish will be completed in 2012.

C. Other related studies

1. Statistics and Sampling

i. Biological sampling and database work in 2011

Principal Statistics and Sampling activities in 2011 included the ongoing population of the groundfish biological database (GFBio). This database now includes almost 9,071,000 specimens. Data entry activities continue to concentrate on the input of current port sampling and observer biological data and recent research cruises. The groundfish trawl fishery continues to be covered by 100% dockside and virtually 100% observer coverage. These observers also provided 258 length/sex/age samples and 195 length samples in 2011. Port samplers provided an additional 51 samples, all with ageing structures (length/sex/age/weight). The focus of their sampling efforts was from those fisheries not covered by at-sea observers. As of December 31, 2011 the port sampling office in Prince Rupert closed as the shutdown of one of the major processing plants and the increased transport of fish to the lower mainland greatly reduced access to sampling opportunities.

Statistics and Sampling staff also took the lead DFO role in assisting Industry and ENGO personnel in data analysis to support development of a plan to freeze and shrink the extent of bottom trawling on the BC coast. It is expected that the plan will be implemented in early 2012.

ii. Catch monitoring in 2011

Staff continued to play a key role in development of a new Regional Catch Monitoring information system as well being actively involved in the Groundfish Hook and Line Catch Monitoring Program and a Recreational Catch Monitoring Working Group. Staff has also begun to participate in regional Commercial Salmon Monitoring meetings.

iii. Field work in 2011

Staff participated on various bottom trawl surveys (see Summary of Groundfish Surveys below) including the Hecate Strait and Queen Charlotte Sound groundfish trawl surveys, the West Coast Vancouver Island, and Queen Charlotte Sound shrimp trawl surveys, as well as the Pacific Hake hydroacoustic survey, and Lingcod dive survey. This group also included the port sampling activity (1.8 person-years) in the Vancouver and Prince Rupert areas. Staff continued to enhance GFBioField, the integrated (paper-less) data capture system for surveys.

iv. Proposed field and database work for 2012

Port sampling will continue in 2012, however, the port sampling position previously in Prince Rupert has been re-assigned to the Pacific Biological Station. Sampling by at-sea observers will be substituted in place of samples from landed catches for Prince Rupert.

Staff will participate in bottom trawl surveys to the west coast of Vancouver Island and the west coast of Haida Gwaii, the shrimp trawl surveys off the west coast of Vancouver Island and in Queen Charlotte Sound, and Lingcod dive survey in the Strait of Georgia. Staff will also play a significant role in a new Strait of Georgia survey to be conducted in March 2012.

Development of "GFCatchAll" as a comprehensive database that will include all known sources of groundfish catch (1900-present) will be started in 2012. This project was supposed to be initiated in 2011, but was delayed owing to other tasks.

APPENDIX 1. REVIEW OF CANADIAN GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for the 2011 calendar year are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2011 were 81,121 t, an increase of 5% from the 2010 catch. The major species in the trawl landings were Pacific Hake (56%), Arrowtooth Flounder (6%), Pacific Ocean Perch (5%), Yellowtail Rockfish (5%), and Walleye Pollock (5%). Trawl production was distributed amongst areas 3C (35%), 3D (28%), 5B (13%), 5D (7%), 5A (7%), 4B (4%), 5E (4%), and 5C (1%).

Canadian landings of groundfish caught by gear other than trawl in 2011 totalled 6,268 t. Landings of Sablefish by trap and longline gear accounted for 2,676 t, approximately 29% by trap gear, 70% by longline gear and 1% by unspecified. Landings of species other than Sablefish by trap, longline, handline and troll gear accounted for 3,592 t (46% rockfish, 22% Lingcod, 18% North Pacific Spiny Dogfish, and 12% skates).

2. Recreational fisheries

Each year, Fisheries Management Branch of DFO conducts creel surveys and collects fishing lodge logbooks for the recreational angling fishery in the four south coast regions.

For the Strait of Georgia, in 2011, the estimates were generated from a combination of creel surveys and fishing lodge reports and covered the months of February to November. Provisional estimates of 2011 catches, landings and releases, for this 10-month period were 26,095 fish for Lingcod, 23,246 fish for all rockfish species, 124 fish for Pacific Halibut, 7,183 fish for Rock Sole, 3,536 fish for Starry Flounder, 7,958 fish for North Pacific Spiny Dogfish, 5,963 fish for greenlings, 2,203 fish for Pacific Cod and 2,031 fish for other groundfish species.

For the Strait of Juan de Fuca catch estimates have been generated from creel surveys and fishing lodge reports for the months of February to November. Provisional estimates for this 10-month period are 8,123 fish for Lingcod, 13,422 for all rockfish species, 2,519 fish for Pacific Halibut, 1,042 fish for rock sole, 1,285 fish for other flatfish species, 10,235 fish for North Pacific Spiny Dogfish, 6,271 fish for greenlings, and 1,289 fish for other groundfish species.

Along the west coast of Vancouver Island catch estimates have been generated from creel surveys and fishing lodge reports. Data are available for June to October. Provisional estimates of 2011 catches were 24,334 fish for Lingcod, 33,209 fish for all rockfish species, 27,224 fish for Pacific Halibut, 914 fish for North Pacific Spiny Dogfish, 575 fish for greenlings, and 1,443 fish for other groundfish species.

In Johnstone Strait catch estimates have been generated from creel surveys and fishing lodge reports for June to August. Provisional estimates of 2011 catches were 4,125 fish for Lingcod, 10,703 fish for all rockfish species, 6,708 fish for Pacific Halibut, 1,879 fish for flatfish species, 1,054 fish for greenlings, 940 fish for North Pacific Spiny Dogfish and 2,814 fish for other groundfish species.

3. Joint-venture fisheries

In 2011, 15 Canadian catcher vessels delivered Pacific Hake and incidental species to a single processing vessel in a co-operative fishing arrangement. This fishery took place mainly off the southwest portion of Vancouver Island (area 3C). A total of 9,717 t of Pacific Hake was processed by one vessel from the Netherlands. The estimated catch breakdown by area was 63% from area 3C, 19% from area 3D, and 18% from area 5B. The quotas and catches are outlined below:

Nation	Species	Quota (t)	Catch (t)
Poland	Pacific Hake	32,848	9,717
	Walleye Pollock	incidental	161
	Rockfish spp.	incidental	319
	Other	incidental	3

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific Hake off British Columbia in 2011.

APPENDIX 2. SUMMARY OF BOTTOM TRAWL SURVEYS IN 2011

1. Multi-Species Small mesh (SHRIMP) bottom trawl Survey

An annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island was initiated in 1973. In 1998, areas in Eastern Queen Charlotte Sound were added. The survey is conducted using a shrimp bottom trawl without an excluder device. As a result, groundfish can make up a significant portion of the catch in many of the tows. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Catch per unit effort is a useful indicator of stock status but additional information such as the size and age composition of the catch improves the usefulness of the index. Consequently, a program was initiated in 2003 to collect biological samples from all groundfish species caught during the survey.

The groundfish section routinely places two staff on board for the duration of the survey. Five different groundfish staff participated in the shrimp survey in 2011. Groundfish staff provide assistance in catch sorting and species identification and also collect biological samples from selected species. Since 2010 the goal has been to collect a small subset of information from as many different species in each tow as possible, as opposed to detailed information from only a few species. As such, most of the biological sampling effort has been focused on length by sex data as opposed to collecting ageing structures. Ageing structures were collected from Rougheye/ Blackspotted Rockfish and Bocaccio.

The 2011 survey was conducted onboard the W.E. Ricker and ran from April 26 to May 23. A total of 185 tows were conducted. The total catch weight of all species was 24,071 kg. The mean catch per tow was 276 kg, averaging 18 different species of fish and invertebrates in each. The most abundant fish species encountered was North Pacific Spiny Dogfish (*Squalus acanthias*), followed by Arrowtooth Flounder (*Atheresthes stomias*) and Eulachon (*Thaleichthys pacificus*). Biological data was collected from a total of 24,071 individual fish from 43 different species.

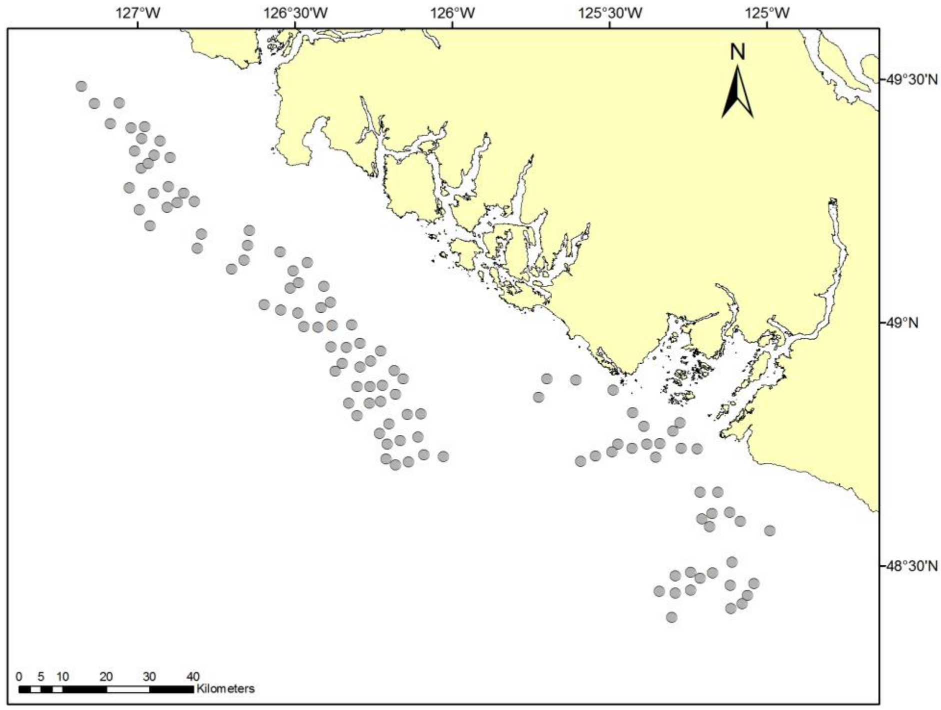

Figure 1. West Coast Vancouver Island set locations of the 2011 Multi-species Small Mesh Bottom Trawl Survey

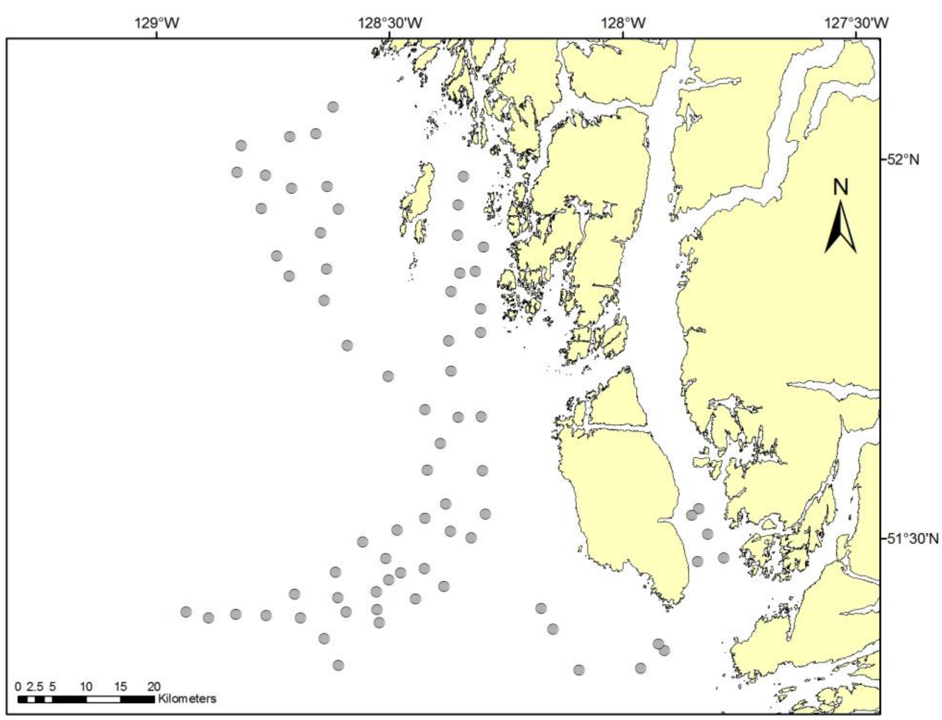

Figure 2. Eastern Queen Charlotte Sound set locations of the 2011 Multi-species Small Mesh Bottom Trawl Survey

Table 1. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the West coast Vancouver Island set locations of the 2011 Multi-species Small Mesh Bottom Trawl Survey.

Species	Num. Tows	Catch (kg)	Biomass (t)	Rel. Error
North Pacific Spiny Dogfish	56	8,699	6,293	0.26
Pacific Herring	50	2,372	1,598	0.27
Arrowtooth Flounder	71	1,425	1,233	0.21
Pacific Cod	41	1,252	1,166	0.57
Canary Rockfish	11	649	947	0.95
Eulachon	57	599	430	0.14
Yellowtail Rockfish	23	562	459	0.37
Rex Sole	71	361	325	0.11
Lingcod	49	342	314	0.21
Pacific Ocean Perch	19	292	270	0.44
Pacific Hake	59	258	202	0.27
Walleye Pollock	31	236	227	0.54
Flathead Sole	52	188	133	0.21
Sablefish	29	186	169	0.39
Pacific Halibut	26	165	121	0.19
Slender Sole	73	148	127	0.12
Spotted Ratfish	32	93	64	0.26
Longnose Skate	24	83	63	0.22
Darkblotched Rockfish	19	67	59	0.73
Dover Sole	51	64	52	0.25
English Sole	29	58	47	0.23
Big Skate	2	47	36	0.77
Petrale Sole	24	24	21	0.20
Greenstriped Rockfish	22	22	21	0.30
Pacific Sanddab	9	21	18	0.62

Table 2. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the eastern Queen Charlotte Sound set locations of the 2011 Multi-species Small Mesh Bottom Trawl Survey.

Species	Num. Tows	Catch (kg)	Biomass (t)	Rel. Error
North Pacific Spiny Dogfish	27	2,028	1,316	0.64
Arrowtooth Flounder	67	1,902	1,378	0.15
Eulachon	60	1,877	1,330	0.19
Yellowtail Rockfish	28	1,781	7,493	0.92
Silvergray Rockfish	5	630	2,906	0.96
Pacific Ocean Perch	28	611	535	0.63
Walleye Pollock	25	563	376	0.31
Blackbelly Eelpout	52	380	299	0.26
Flathead Sole	53	272	205	0.18
Dover Sole	37	250	171	0.23
Spotted Ratfish	44	129	95	0.23
Rex Sole	54	111	88	0.33
Longnose Skate	22	101	65	0.25
Bocaccio	1	99	463	1.01
Slender Sole	54	84	63	0.19
Redstripe Rockfish	3	38	170	0.95
Pacific Herring	17	36	30	0.72
Pacific Hake	35	30	22	0.25
Redbanded Rockfish	8	29	92	0.91
Sablefish	18	21	16	0.33
Pacific Halibut	5	17	13	0.47
Lingcod	5	13	8	0.45
English Sole	9	12	9	0.45
Canary Rockfish	2	10	39	0.97
Pacific Cod	4	10	7	0.52

2. Groundfish Synoptic bottom trawl surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive groundfish multi-species bottom trawl survey strategy that covers most of the BC Coast. The objectives of these surveys are to provide fishery independent abundance indices of as many benthic and near benthic fish species available to bottom trawling as is reasonable while obtaining supporting biological samples from selected species. The abundance indices and biological information are incorporated into stock assessments, status reports, and research publications.

The surveys follow a random depth stratified design. Fishing sites are predetermined by randomly selecting survey blocks (2 km x 2 km) within each depth strata. If a survey block is not fishable for any reason it will be abandoned and the vessel will proceed to the next block.

There are four surveys, two of which are conducted each year. The Hecate Strait survey and the Queen Charlotte Sound survey are conducted in odd-numbered years while the West Coast Vancouver Island survey and the West Coast Haida Gwaii (formerly Queen Charlotte Islands) survey are conducted on even-numbered years. Surveys are conducted on both chartered commercial vessels and government research vessels. The Hecate Strait survey and the West Coast Vancouver Island survey are conducted on a Canadian Coastguard research trawler while the Queen Charlotte Sound survey and the West Coast Haida Gwaii are conducted on chartered commercial fishing vessels.

In 2011 the Hecate Strait and Queen Charlotte Sound surveys were conducted.

3. Hecate Strait Groundfish Synoptic Bottom Trawl Survey

The Hecate Strait Groundfish Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 24 and June 21. We conducted a total of 203 tows; 186 were successful and 12 were failures due to hang ups or insufficient bottom time. We rejected 15 blocks based on on-grounds inspection.

A total of 15 different DFO staff and one contractor participated in the survey.

The mean catch per tow was 493 kg, averaging 21 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (*Atheresthes stomias*), Spotted Ratfish (*Hydrolagus colliei*), and North Pacific Spiny Dogfish (*Squalus acanthius*). Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 34,823 individual fish of 76 different species. Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 3. 2011 Hecate Strait survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels) per survey stratum.

Depth Stratum (m)	Rejected Prior	Rejected Inspected	Failed	Success	Not Fished	Total
50 - 125	0	14	3	71	0	88
125 - 200	0	0	2	51	0	53
200 - 330	0	0	4	50	0	54
330 - 500	0	1	3	14	0	18
Total	**0**	**15**	**12**	**186**	**0**	**213**

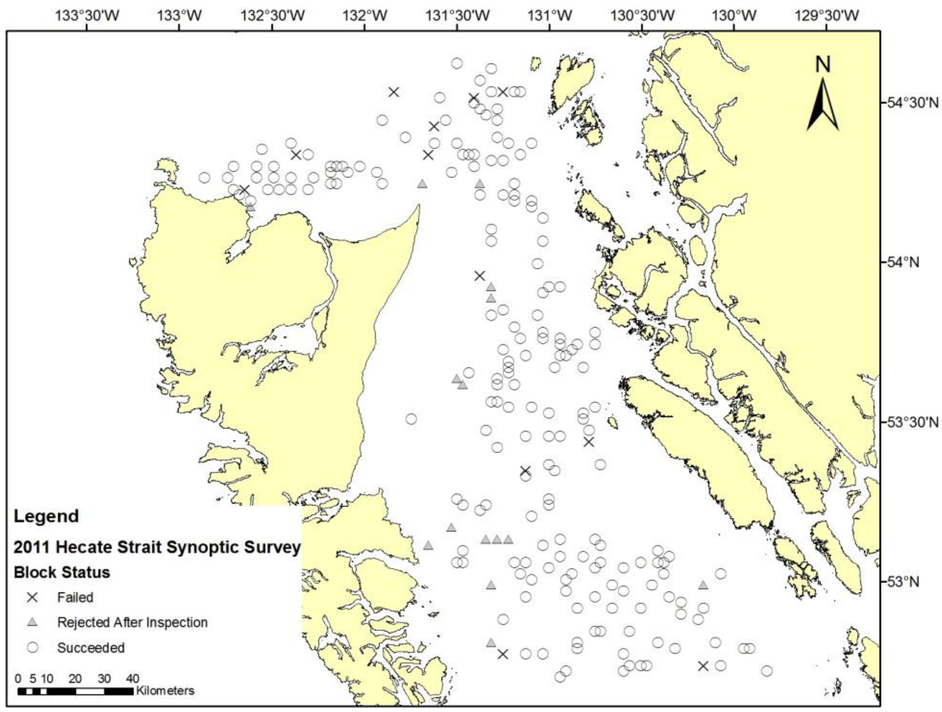

Figure 3. Final status of the allocated blocks for the 2011 Hecate Strait survey.

Table 4. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2011 Hecate Strait survey. The total catch weight of all species was 99,136 kg.

Species	Num. Tows	Catch (kg)	Biomass (t)	Rel. Error
Arrowtooth Flounder	134	23,721	15,917	0.14
Spotted Ratfish	182	18,047	15,551	0.16
North Pacific Spiny Dogfish	145	6,567	5,289	0.44
Dover Sole	115	6,200	4,248	0.19
Rex Sole	121	4,643	2,772	0.16
English Sole	121	4,046	3,265	0.20
Pacific Halibut	121	3,507	3,468	0.36
Pacific Cod	126	2,475	1,887	0.26
Southern Rock Sole	88	2,139	2,358	0.18
Yellowtail Rockfish	35	2,020	1,873	0.56
Walleye Pollock	96	1,596	1,096	0.32
Big Skate	48	1,483	1,301	0.21
Redstripe Rockfish	16	993	673	0.67
Flathead Sole	57	946	516	0.29
Silvergray Rockfish	57	921	621	0.25
Redbanded Rockfish	42	754	755	0.30
Petrale Sole	81	632	401	0.18
Yellowmouth Rockfish	4	536	288	0.74
Longnose Skate	47	504	396	0.19
Sand Sole	57	491	554	0.21
Quillback Rockfish	41	491	396	0.26
Lingcod	51	479	375	0.26
Pacific Ocean Perch	58	479	322	0.33
Canary Rockfish	20	428	274	0.49
Starry Flounder	9	333	317	0.81

4. Queen Charlotte Sound Groundfish Synoptic Bottom Trawl Survey

The Queen Charlotte Sound Groundfish Multi-species Bottom Trawl Survey was conducted on the F/V Nordic Pearl between July 5 and July 31. We conducted a total of 280 tows; 252 were successful and 13 were failures due to insufficient bottom time. We rejected 36 blocks based on on-grounds inspections.

A total of 6 different DFO staff and 5 contractors participated in the survey.

The mean catch per tow was 312 kg, averaging 19 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (*Atheresthes stomias*), Pacific Ocean Perch (*Sebastes* alutus), and Silvergray Rockfish (*Sebastes brevispinus*.) Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 31,636 individual fish of 62 different species. Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 5. Queen Charlotte Sound survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels) per survey stratum.

Depth Stratum (m)	**Rejected Prior**	**Rejected Inspected**	**Failed**	**Success**	**Not Fished**	**Total**
1: South 50 to 125 m	0	4	0	38	0	42
2: South 125 to 200 m	0	6	2	67	0	75
3: South 200 to 330 m	0	6	3	25	0	34
4: South 330 to 500 m	0	1	1	8	0	10
5: North 50 to 125 m	0	9	2	10	0	21
6: North 125 to 200 m	0	8	4	51	0	63
7: North 200 to 330 m	0	2	1	45	0	48
8: North 330 to 500 m	0	0	0	8	0	8
Total	**0**	**36**	**13**	**252**	**0**	**301**

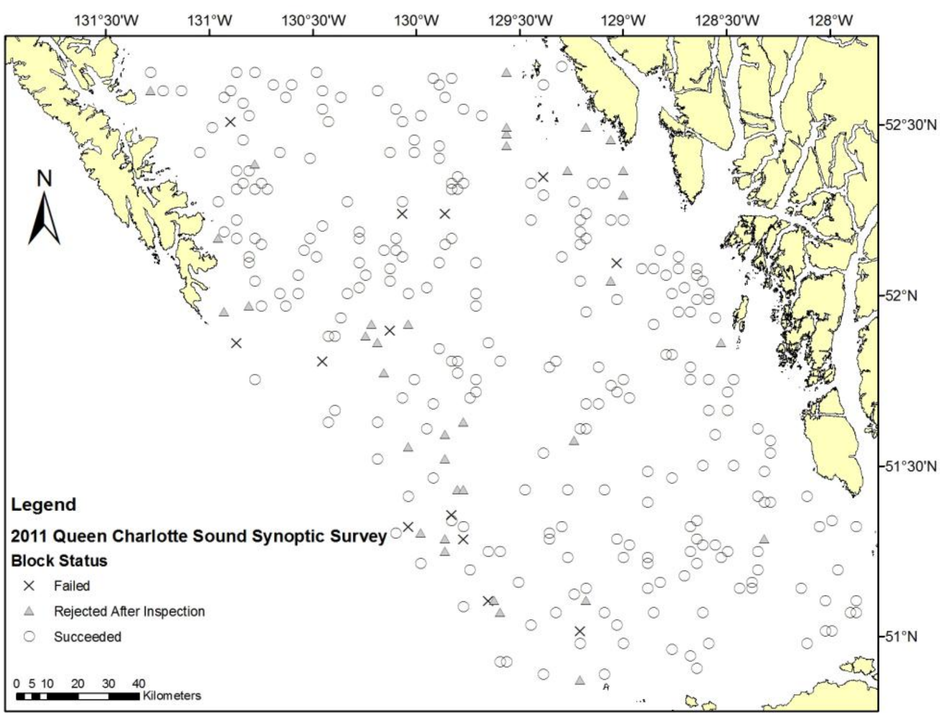

Figure 4. Final status of the allocated blocks for the 2011 Queen Charlotte Sound survey.

Table 6. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2011 Queen Charlotte Sound survey. The total catch weight of all species was 85,582 kg.

Species	Num. Tows	Catch (kg)	Biomass (t)	Rel. Error
Arrowtooth Flounder	231	16,535	13,703	0.18
Pacific Ocean Perch	148	15,206	12,644	0.25
Silvergray Rockfish	164	5,500	3,964	0.19
Walleye Pollock	108	3,789	2,683	0.55
Redstripe Rockfish	65	3,301	2,793	0.41
Yellowmouth Rockfish	55	3,000	2,650	0.38
Rougheye Rockfish	59	2,538	2,849	0.73
Sharpchin Rockfish	84	2,509	2,252	0.44
Dover Sole	169	2,244	1,708	0.12
Rex Sole	204	2,143	1,608	0.11
Yellowtail Rockfish	50	2,089	1,454	0.46
Spotted Ratfish	208	1,757	1,868	0.22
Splitnose Rockfish	34	1,746	1,363	0.78
Pacific Hake	61	1,702	1,313	0.28
North Pacific Spiny Dogfish	124	1,451	1,461	0.33
Pacific Cod	98	1,265	1,046	0.21
Redbanded Rockfish	112	1,167	846	0.24
Canary Rockfish	45	1,143	830	0.33
Shortspine Thornyhead	90	1,093	855	0.10
Sablefish	112	959	812	0.11
English Sole	67	789	851	0.40
Southern Rock Sole	48	777	946	0.26
Lingcod	75	712	682	0.31
Pacific Halibut	56	673	656	0.19
Petrale Sole	110	627	493	0.29

APPENDIX 3. PARTIAL LIST OF GROUNDFISH RELATED REPORTS WITH 2011 PUBLICATION DATES.

<u>PRIMARY</u>

Carruthers, T.R., McAllister, M.K., Taylor, N.G. 2011. Spatial surplus production modelling of Atlantic tuna and billfish. *Ecological Applications 21:2734-2755*

Edwards, A.M. 2011. Overturning conclusions of Lévy flight movement patterns by fishing boats and foraging animals. *Ecology,* 92(6):1247-1257.

James, A., Plank, M.J, and Edwards, A.M. 2011. Assessing Lévy walks as models of animal foraging. *Journal of the Royal Society Interface,* 8(62):1233-1247.

King, J.R., V.N. Agostini, C.J. Harvey, G.A. McFarlane, M.G. Foreman, J.E. Overland, E. DiLorenzo, N.A. Bond and K.Y. Aydin. 2011. Climate forcing and the California Current ecosystem. ICES Journal of Marine Science. 68: 1199-1216.

Stanley, R. D., McElderry, H., Mawani, T., and Koolman, J. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. ICES Journal of Marine Science. 2011; doi:10.1093/icesjms/fsr058.

Taylor, N.G., McAllister, M., Lawson, G., Carruthers, T and Block, B. 2011. Atlantic Bluefin Tuna: A Novel Multistock Spatial Model for Assessing Population Biomass. *PLoS ONE 6:e27693*

OTHER PUBLICATIONS

Cox, S.P., Kronlund, A.R., Lacko, L. 2011. Management procedures for the multi-gear Sablefish (Anoplopoma fimbria) fishery in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/063. viii + 45 p.

DFO. 2011. Management procedures for the multi-gear Sablefish (Anoplopoma fimbria) fishery in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/025.

Flemming, R.G., Yamanaka, K.L., Cooke, K., and Dykstra C. 2011. Summary of non-Halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 28 to July 20, 2009. Can. Tech. Rep. Fish. Aquat. Sci. 2971: viii + 87 p.

Gallucci, V., Taylor, I., King, J.R., McFarlane, G.A. and McPhie, R.P. 2011. Spiny Dogfish (*Squalus acanthias*) Assessment and Catch Recommendations for 2010. CSAS Res. Doc. 2011/034

Haigh, R. and Yamanaka, K.L. 2011. Catch history reconstruction for rockfish (*Sebastes* spp.) caught in British Columbia coastal waters. Can. Tech. Rep. Fish. Aquat. Sci. 2943: viii + 124 p.

Keightley, S.J., Edwards, A.M., and Holt, C.A. 2011. Potential for using multivariate autoregressive models to investigate dynamics of British Columbia groundfish communities, including appraisal of the LAMBDA software package. Can. Tech. Rep. Fish. Aquat. Sci. 2968: iv + 24 p.

King, J.R., McAllister, M., Holt, K. and Starr, P. 2011. Lingcod (*Ophiodon elongatus*) stock assessment and yield advice for outside stocks in British Columbia. CSAS Res. Doc. 2011/124.

McPhie, R.P. and King, J.R. 2011. Lingcod (*Ophiodon elongatus*) Egg Mass and Reef Fish Density SCUBA Survey in the Strait of Georgia, February 15-25, 2010 and 2011. Can. Tech. Rep. Fish. Aquat. Sci. 2932: x + 33 p.

Stewart, I.J., Forrest, R.E., Grandin, C., Hamel, O.S., Hicks, A.C., Martell, S.J.D., and Taylor, I.G. 2011. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2011. Final SAFE document. 17 March 2011. Available online: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Whiting-Management/Treaty-docs.cfm

Yamanaka, K.L., McAllister, M.K., Etienne, M-P., Obradovich, S.G., Haigh, R., and Olesiuk, P.F. 2011. Stock Assessment for the inside population of Yelloweye Rockfish (*Sebastes ruberrimus*) in British Columbia, Canada for 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/129. xiv + 134 p.

Yamanaka, K.L., Flemming, R.G., Cooke, K., and Dykstra C., 2011. Summary of non-Halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 28 to August 12, 2008. Can. Tech. Rep. Fish. Aquat. Sci. 2970: viii + 81 p.

APPENDIX 3. GROUNDFISH STAFF IN 2012

Greg Workman	Section Head
Schon Acheson	Technician, Pacific Hake, port sampling and surveys
Bill Andrews	Technician, surveys
Kristina Anderson	Technician, Sablefish and surveys
Karina Cooke	Technician, Database support and surveys, Inshore Rockfish
Andrew Edwards	Scientist, Slope Rockfish, Statistical and mathematical modelling, stock assessment
Rob Flemming	Biologist, GIS specialist, database manager, Inshore Rockfish
Robyn Forrest	Scientist, Pacific Cod, Pacific Halibut, stock assessment
Chris Grandin	Program Head, Pacific Hake stock assessment and Port sampling
Rowan Haigh	Biologist, Statistical and exploratory data analysis, Slope Rockfish
Kendra Holt	Program Head, Lingcod, Flatfish stock assessment, ERAEF
Jackie King	Scientist, Elasmobranchs, Climate studies
Brian Krishka	Biologist, Database support and analysis, Flatfish
Rob Kronlund	Program Head Sablefish, Analytical programs
Lisa Lacko	Biologist, GIS specialist and database manager, Sablefish
Sandy McFarlane	Emeritus scientist
Romney McPhie	Biologist, Elasmobranchs
Wendy Mitton	Technician, Sablefish
Norm Olsen	Biologist, Programmer/GIS, Groundfish Statistics, Shelf Rockfish
Kate Rutherford	Biologist, Database manager, Groundfish Statistics, Shelf Rockfish
Jon Schnute	Emeritus scientist
Alan Sinclair	Emeritus scientist
Rick Stanley	Program Head, Shelf Rockfish assessment and biology, Groundfish Statistics.
Maria Surry	Technician, Elasmobranchs
Nathan Taylor	Program Head, Groundfish surveys, Shelf Rockfish, Pacific Hake stock assessment
Jergen Westrheim	Emeritus scientist
Malcolm Wyeth	Biologist, Groundfish surveys
Lynne Yamanaka	Program Head, Inshore rockfish research and stock assessment

2012 IPHC Research Report for TSC

Review of 2011 Projects and Proposals for 2012 International Pacific Halibut Commission Staff

Introduction

This report reviews research conducted by the IPHC staff in the past year as well as research proposed for the upcoming year. The report is divided into three sections: the first section briefly reviews staff changes over the past and upcoming year(s), the second section reviews the status of research conducted in 2011, and the third section presents the preliminary staff research proposals for 2012 and a summary of ongoing projects. This report does not include annual staff tasks such as data collection and processing that are necessary for the management of the fishery.

Research projects are organized into three funding categories that reflect availability and source of research funds. Limited research requiring direct financial support from the Commission is possible under the basic $4.1 million (as of FY2011) government appropriations, although a number of programs can be conducted using only the staff resources that are supported by the appropriations. The three funding categories are:

1) **Funded Research:** Necessary research projects of high priority that can only be conducted with appropriations funding or carryover from 2011;

2) **Contracts and Grants:** Agreements with other parties to conduct specific research. In this case, contracts and grants are shown for projects where the IPHC staff is the principle investigator; and

3) **Research conducted without direct funding:** Necessary research projects of high priority that can be conducted through staff time alone or if sufficient funds are available within the IPHC budget.

Nearly all of the research done by the staff is directed toward one of three continuing objectives of the Commission:

i) Improving the annual stock assessment and quota recommendations;

ii) Developing information on current management issues; and

iii) Adding to knowledge of the biology and life history of halibut.

In each of these areas our routine work program applies the best information and methods available, and our research program aims to improve the information and methods by answering the most important outstanding questions.

SECTION I: STAFFING UPDATES

In late 2011, the IPHC hired an Assistant Director: Steve Keith. This position had been phased out over a decade earlier, but is now reinstated. There currently are several positions open: Database Administrator (newly created), lead Stock Assessment Scientist (Dr. Hare departing effective May 1), Survey Operations Technician (Evangeline White departing end of June), and a Front Office Administrative Assistant (currently vacant). These are in addition to some standard turnover seen in both the port and field sampling seasonal positions.

SECTION II: REVIEW OF RESEARCH CONDUCTED IN 2011

Biological research conducted by the IPHC staff continued in three basic areas: life history, fish movements, and stock composition. Other work addressed fishery management issues, while the assessment group focused on a variety of analyses examining the commercial fishery minimum size limit, effects of bycatch on stock yield, assessment survey design, and harvest policy performance. Most of this was conducted as part of the normal staff duties. Funding for projects outside of staff salaries came from supplemental funding; these and other studies from 2011 are outlined below.

Overview of 2011

Genetic research continued in 2011, focusing primarily on use of genetic analyses for sex identification and also working to complete the population genetics studies begun in 2002. With respect to the former, a manuscript was published in January detailing sex-linkage in three microsatellite markers, suggesting the possibility that genetic techniques might be used to partition commercial catch via the IPHC's port sampling program. During the 2011 commercial fishing season, samplers were placed aboard commercial vessels to collect samples that will be used in a formal analysis of the accuracy of genetic methods relative to the numerical sex partitioning technique presently used in the IPHC stock assessment (see following paragraph). These samples, and others collected by the 2010 undergraduate intern, will be analyzed at the University of Washington's Marine Molecular Biology Laboratory (MMBL) under the supervision of Dr. Lorenz Hauser. In addition, laboratory analyses were conducted in 2011 to add western Aleutian Island and Sea of Okhotsk samples to existing microsatellite- and mitochondrial DNA-based analyses of population structure. Significant genetic population structure has not been detected using samples that span from the Queen Charlotte Islands through the southeast Bering Sea and eastern Aleutian Islands. This is in contrast to a recent publication in which significant Pacific halibut stock structure was reported using samples collected in the western Aleutians, however that analysis did not account for the sex-specific microsatellite marker presence in the samples. Formal statistical analysis and publication of the full results is anticipated in 2012.

The current sex-specific assessment requires information on the sex composition of the population, which is proxied by data from the surveys. We've recently been interested in the potential for sampling the commercial landings for obtaining direct observations of the sex composition of the catch to confirm or correct the current statistical estimation of the sex composition of commercial landings. A pilot study was undertaken in 2010 for this purpose, collecting tissue samples which would be analyzed for genetic sex markers. The results showed it was possible to obtain the necessary samples, but a sufficient number were collected only from Areas 2B and 3A. Additional collections were undertaken in 2011 in additional areas (2B, 3B, 4A, and 4B) to further investigate the potential of this approach. Sample analysis is being conducted under the supervision of Dr. Hauser (MMBL), with results expected later this winter.

IPHC has been engaged for several years in projects examining halibut migrations via tagging. Past studies have used PAT tags to obtain general movement patterns but these have been insufficient in providing data to estimate migration rates and daily movements. Since 2006, IPHC has been testing the suitability of archival tags for halibut, specifically examining different tag types, attachment configurations and tag designs. This work has included small releases of test tags in Areas 2B (2008) and 3A (2009). In addition, since 2009 IPHC has had a long term holding study at the Oregon Coast Aquarium (OCA) of ~30 animals to test different attachment protocols. In 2011, we began looking at the applicability of geomagnetic tags for tracking halibut movements. Geomag tags hold promise for providing much greater movement detail over a greater time horizon but there are as-yet unresolved issues regarding effects on location data by variations in the magnetic field in the north Pacific. Work conducted in 2011 focused on assessing the accuracy of the data recorded by geomag tags by setting out geomag tags at preselected stationary locations in Area 3A.

The collaborative study between the IPHC and the NMFS Alaska Fisheries Science Center (NMFS/AFSC) has concluded that eastern Bering Sea (BS) bomb radiocarbon concentrations during the years of 1944 to 1981 were different from those of the Gulf of Alaska (GOA) during the same time. Based on analysis of otoliths from the BS and GOA, the results suggest the onset of atmospheric ^{14}C in the BS indeed preceded the GOA in both time and signal strength. The BS curve displays an earlier and more rapid increase in ^{14}C, a substantially higher ^{14}C peak, and an exponential post-peak decay that is much less pronounced in the GOA. It is hypothesized that, because of its unique oceanographic conditions, the BS responded differently than the GOA during the peak times of nuclear atmospheric testing in regard to the uptake of atmospheric ^{14}C. The rate at which ^{14}C moves through a body of water may be attributed to factors such as current, wind, ^{14}C reservoirs, and water depth. It is further hypothesized that the atmospheric ^{14}C signature may have traveled through the BS at a faster rate than it did through the GOA, resulting in an earlier ^{14}C pulse which was incorporated into all BS species alive at that time.

Water column profilers were deployed in 2011 on all IPHC survey vessels. This effort is the result of the grant from NOAA for the purchase of profilers in 2008. The profilers collect data on salinity, temperature, dissolved oxygen, ocean acidity (pH), and fluorescence (chlorophyll) throughout the water column, which provide a unique and valuable annual snapshot of oceanic conditions above the continental shelf over most of the northeast Pacific Ocean. Over 1,200 casts were made this year. Data from the first two years of this project, 2009 and 2010, are posted for public use and 2011 data processing is in progress.

A pilot study comparing the IPHC standard survey bait of chum salmon with three alternative bait species was conducted in Area 3A in 2011. The goals were to select one of two competing experimental designs, and to provide information on variance for use in designing a large scale experiment to be carried out in 2012. Alternative baits fished included herring, pollock, and pink salmon. Data analyses showed evidence that the setline weight per unit effort (WPUE) was different among baits, that U32 catch is affected by bait type, and that catch of common species of bycatch was higher using chum salmon than the alternative baits. There is also some concern that the alternative bait types, e.g., herring, are more likely to fall off the hook than chum salmon. A positive result was that the experimental design using a mixed-bait set could be used in the primary experiment, which will greatly improve efficiency and statistical power.

Cooperative data collection continued on the assessment surveys in 2011. Activities took place in almost all surveys regions:

- On the Area 2A surveys, cooperative studies continued with Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW) to collect rockfish (*Sebastes* spp.) bycatch data. In addition, this year we worked with WDFW to conduct 100% hook counts for all stations in the Salish Sea.
- On the Area 2B survey vessels, a third biologist collected hook-by-hook occupancy information for all species, and otoliths, maturities, and lengths for rockfish (except thornyheads) and data were provided to the Canadian Department of Fisheries and Oceans (DFO).
- Cooperative work with the Alaska Department of Fish and Game (ADF&G) resulted in the collection of whole-haul catch data for yelloweye rockfish from survey vessels operating in the Fairweather survey region of Area 3A and in the Sitka, Ommaney, and Ketchikan charter regions of Area 2C.
- In 2011, we began a two-year effort to length and sex the first five spiny dogfish at stations coastwide, exceptions being first three dogfish in B.C. and all dogfish in the Bering Sea). This project began as a request from NMFS/AFSC focused on Alaska and was expanded coastwide to enhance the project.
- Pacific cod subsampling on Bering Sea stations was resumed in 2011 at the request of NMFS/AFSC. Additional information was also collected on lamprey scarring on the cod being sampled.

Also on the assessment surveys, data collection continued in 2011 to increase our understanding of the scope and impact of toothed whale interactions with longline gear, and in particular the impact on setline surveys. Gear damage occurrence was assessed on every set, and additional data were collected when marine mammals were in the area. The protocols for this data collection were developed in concert with other agencies, in particular the NMFS Auke Bay sablefish survey team, who are attempting to quantify the impact of sperm whale depredation on their surveys.

For several years, IPHC has been contracted by NMFS Auke Bay Lab (ABL) to assist with their sablefish data collection program (Project 617.00). In 2003/2004, the program was reviewed and modified to meet the IPHC confidentiality policy and to encompass all vessels, rather than just vessels greater than 60 feet in length. Under a Statement of Work (SOW), NMFS contracts IPHC to collect and review information on sablefish catches during the IPHC port sampler’s logbook interview. Sablefish data are entered by IPHC staff, edited, and an electronic summary provided to the ABL scientists. Vessels are assigned a unique code in the summarized data to preserve confidentiality. In 2011, the Auke Bay scientists came to Seattle to attend a portion of port sampler training to meet the samplers and provided direct training. The SOW was renewed for 2012.

IPHC also received several grants in 2011. NMFS provided a grant for the incremental increase in port sampling costs due to the IFQ program (Project 300.00-81).

For the 2011 undergraduate internship, a study was undertaken to evaluate the need to re-examine the length/weight relationship used by IPHC. Ms. Danielle Courcelles, an Environmental Science major from Simon Fraser University (Burnaby, B.C.), joined the staff for the summer to design, carry out, and report on her analysis of length/weight data she collected in Area 3A. Her sampling of 193 fish of all sizes from Portlock-Seward Gully grounds of Area 3A showed a significant difference in length/weight for fish caught on those grounds, similar to a small study conducted in 1989 by the IPHC staff. The full results will be included in this year's RARA.

Other field activities in 2011 included: (1) placing staff aboard the NMFS/AFSC trawl surveys in the Gulf of Alaska to collect otoliths and data on the relative abundance of juveniles, (2) continued collection of halibut tissue samples on the surveys for studies on mercury and other contaminants by the Alaska Department of Environmental Conservation, and (3) collection of seabird occurrence data on the surveys.

On the quantitative side, the staff of the Assessment Program annually produces the stock assessment, which forms the basis for staff Catch Limit Recommendations. The data that go into the assessment, the assessment itself, and the harvest policy used to determine sustainable catch levels are all continually reviewed and refined. A few of this year's more influential and substantive analyses are summarized to highlight the nature of analytical work in the Assessment Program.

a. The current commercial minimum size limit (MSL) of 32 inches (81.3 cm) has been in place since 1974 when it was increased from 26 inches (66 cm), which had been the MSL since 1940. The change in 1974 was implemented during a time when halibut size-at-age was much greater than is presently the case. The topic of changing (i.e., lowering) the MSL in response to reduced size-at-age arises annually. An analysis was conducted to estimate the biological and fishery impacts of lowering the size limit anywhere from 1 to 16 cm.

b. The North Pacific Fishery Management Council is considering reducing the Pacific halibut Prohibited Species Catch (PSC) limits for the Gulf of Alaska groundfish fisheries. Staff conducted an analysis to estimate the potential directed yield and female spawning biomass impacts from reducing the PSC limits for both trawl and longline fisheries.

c. Data from commercial landings have demonstrated that halibut can occur at depths outside of the 20-275 fathom range of the current setline survey. In addition, within the current depth range there exist areas which for various reasons have no survey stations. In 2011, the IPHC conducted an expanded survey in Area 2A, which included stations from 10-400 fathoms, and for the first time fished stations within the inland waters of the

Salish Sea in WA. This study was a test of survey fishing in deep and shallow waters, but the expansion of stations within the existing 20-275 fathoms grid also examined means to improve the precision of the survey's WPUE index in Area 2A, by increasing sample size.

d. Following a request from Canadian commissioners, staff reviewed the data from the 1995-97 setline surveys in Area 2B, which yielded much higher WPUE values than in subsequent or previous years. The survey design was slightly different in those years, although the range of the survey was similar. We found no evidence that the design was a factor in the higher WPUE values; rather, it was the recruitment of two strong year classes into the fishery. In fact, the design in those years included several stations located outside of the current survey depth range on Dogfish Bank, stations which had very little halibut catch, and these are now excluded from WPUE calculation for reasons of consistency. In addition, examination of adjacent regulatory areas found similar features of the WPUE time series as seen in Area 2B.

e. Work on the harvest policy included updates, potential changes and considerations of its performance in the context of current stock trends and status. Ongoing work on the Management Strategy Evaluation (MSE) included setting up of the general evaluation framework and development of simulation, observation, and estimation components.

f. In previous years, projections of exploitable biomass assumed no changes in population processes and revisions of past population estimates. Alternative assumptions and methods were included in alternative projections that account for potential future changes in size-at-age and ongoing downward revisions of past recruitment estimates and the initial numbers of the projections.

g. An analysis of recent and historical changes in size-at-age was conducted, along with potential mechanisms and implications for the harvest policy.

h. A comprehensive review of the history of IPHC tagging programs was conducted with a focus on halibut migration. The most important finding was the consistency among results of historical and modern tagging programs regarding extensive halibut migratory patterns throughout their life. Implications for harvest policy, bycatch impacts, and stock assessment are discussed in the report.

i. A draft journal paper on the analysis of data from the PIT tag study was also prepared. Model results show that ontogenetic migration in a broadly eastward and southward direction continues for larger fish, when in the recent history of the IPHC, the assumption had been that only smaller, younger fish migrated. Differences in fishing mortality and exploitation rates among areas support the view that exploitation was much heavier in eastern areas than western areas prior to the introduction of a coast-wide stock assessment in 2007.

j. An analysis was prepared on criteria and a potential framework for evaluation, along with pros and cons, of a proposed alternative apportionment method.

2011 Research Publications

IPHC staff noted in **Bold** type.

Erikson, L. M. and **Kong, T. M.** Changes in commercial catch sampling for Pacific halibut 1994 to 2009. Int. Pac. Halibut Comm. Tech. Rep. 54. 35 p.

Galindo, H. M., **Loher, T.**, and Hauser, L. 2011. Genetic sex identification and the potential evolution of sex determination in Pacific halibut (*Hippoglossus stenolepis*). Mar. Biotechnol. 13:1027–1037.

Gilroy, H. L., **Kong, T. M.**, and **MacTavish, K. A.** 2011. Regulations and management decisions of the Pacific halibut fisheries, 1993-2009. Int. Pac. Halibut Comm. Tech. Rep. 55. 112 p.

Kaimmer, S. M. 2011. Special setline experiments 1985-1994 objectives, data formats, and collections. Int. Pac. Halibut Comm. Tech. Rep. 53. 33 p.

Loher, T. 2011. Analysis of match–mismatch between commercial fishing periods and spawning ecology of Pacific halibut (*Hippoglossus stenolepis*), based on winter surveys and behavioural data from electronic archival tags. ICES J. Mar. Sci. 68(10):2240-2251.

Loher, T. and Rensmeyer, R. 2011. Physiological responses of Pacific halibut, *Hippoglossus stenolepis*, to intracoelomic implantation of electronic archival tags, with a review of tag implantation techniques employed in flatfishes. Rev. Fish Biol. Fish. 21(1):97-115.

Loher, T., and **Hobden, J.C.** *In press*. Small-scale spatial structure in longline catches of Pacific halibut (*Hippoglossus stenolepis*): influence of fish length and sex. *Fishery Bulletin* **110**:xxx-xxx.

Loher, T., and **Stephens, S. M.** *In press*. Use of veterinary ultrasound to identify sex and assess female maturity of Pacific Halibut in nonspawning condition. *N. Amer. J. Fish. Mgmt.* (scheduled for publication in the November 2011 issue).

Seitz, A. C., **Loher, T.**, Norcross, B. L., Nielsen, J. L. 2011. Dispersal and behavior of Pacific halibut *Hippoglossus stenolepis* in the Bering Sea and Aleutian Islands region. Aquat. Biol. 12: 225–239.

West, Catherine F., **Wischniowski, S.** and C. Johnston. 2011. Little Ice Age Climate: *Gadus macrocephalus* otoliths as a measure of local variability. In *The Archaeology of North Pacific Fisheries*, edited by Madonna Moss and Aubrey Cannon. University of Alaska Press, Fairbanks.

Section III:
Research Proposed for 2012 - Overview

Projects to be carried out in 2012 consist of new research as well as the continuation of several projects currently underway.

New Research for 2012

1. Prevalence of Ichthyophonus in halibut

In 2011, the IPHC and USGS Marrowstone Marine Field Station conducted a pilot survey to determine prevalence of the parasite *Ichthyophonus* in Pacific halibut sourced from three geographically disparate areas. *Ichthyophonus* was detected in 26.6, 33.8, and 76.7% of halibut sampled from the northern Bering Sea, Oregon coast, and Prince William Sound respectively. Prevalence in Prince William Sound is the highest reported for any Northeast Pacific marine fish species, and is indicative of an epizootic. It is not clear if these infection patterns are unusual, or what effect, if any, *Ichthyophonus* may be having on Pacific halibut population (mortality) or growth dynamics.

This study will further characterize *Ichthyophonus* prevalence across the Pacific halibut's range, to determine overall prevalence rates and to see if the Prince William Sound results are repeatable. Twelve sites will be targeted, spread out over the assessment survey ranging from Oregon to the northern Bering Sea. As there is knowledge regarding herring infection rates in Prince William Sound, Sitka Sound area, and Lynn Canal, these areas are likely to be included in the primary target areas for sample collection. The study may be modified to do a more intensive sampling (stratified by age or size) in the Bering Sea and/or Aleutian Islands where we may be able to source samples from smaller fish from the NMFS trawl survey. IPHC will collect the samples, and the USGS lab in Marrowstone will conduct the culture and testing component. The study will provide a bigger sample size to further understand any differences in prevalence rates based on halibut size, age, and sex.

2. Rockfish bycatch reduction with whisker hooks

Rockfish bycatch is a limiting factor in many areas for the directed halibut fishery. Modified hooks, with a wire appendage sticking out the back of the hook, are finding success in pelagic longlines to reduce turtle bycatch. "Weedless" hooks have been around for some time. The wire is strong enough to reduce light forces (weeds) but light enough to bend out of the way during a forceful hook attack. Applying this technology, spring wires rigged across the hook gap of the typical halibut 16/0 circle hook might reduce the hooking success of rockfish. By varying the spring tension on the wires (using differing wire diameters), we theorize that rockfish catches could be reduced without changing the hooking success for halibut. For this initial work, observations on hooking success would be gathered with a video camera using single hooks deployed probably in southeast Alaska.

3. Growth increment studies on halibut otoliths

IPHC's extensive otolith archive holds a wealth of information about otolith growth. Changes in the annual growth increments over time would be measured and compiled, going back as far as possible into the archives (1920). Otoliths covering a broad set of ages and time periods will be selected, and photographed under high magnification, enabling measurements of annual incremental growth. The measurements will be complied and analyzed to identify if any patterns or trends exit. While not necessarily linked to changes in fish growth, changes in otolith growth may provide insights into processes which affect the growth of halibut.

Continuing Research in 2012

1. PIT tagging study: Double tag experiment

In September 2003, over 2,600 halibut were double tagged with PIT and external wire tags to provide data for estimating PIT tag shedding. Double-tagged fish continue to be recovered, and this section accounts for the premium rewards paid for the recovered tags. Three rewards were paid in 2011, and a similar number are anticipated in 2012.

2. NMFS trawl survey: At-sea data collection

The series of NMFS trawl survey data on halibut, parallel to our assessment survey data, is extremely valuable as a second fishery-independent data source for stock assessment. Trawl data are particularly useful because they include large numbers of juveniles (ages 3-7 yr) that do not appear in large numbers in the setline survey. Otoliths have been collected on the NMFS surveys since 1996 and provide relevant age information. These data are incorporated into IPHC's database of the NMFS haul data, expanded to estimates of relative abundance and age/size composition by IPHC area (NMFS calculates estimates by INPFC area), and stored in a database at IPHC. Project cost is comprised of personnel and travel. In 2011, samplers were deployed on the NMFS Gulf of Alaska and Bering Sea surveys. For 2012, samplers will be deployed in the Bering Sea and Aleutian Island surveys.

3. Water column profiler project (General survey and coastwide)

The IPHC maintains one of the most extensive sampling platforms in the North Pacific. This platform provides enormous potential for collection of valuable oceanographic data. In particular, understanding the dynamics of the structure of the mixed layer depth – a major GLOBEC goal - requires in situ vertical profiling. Since 2001, IPHC has successfully deployed a SeaBird SBE-19 water column profiler during the annual stock assessment survey. A second profiler was added to the program in 2007. In 2009, a NOAA grant provided for the complete outfitting of all chartered survey vessels, resulting in a complete coast-wide deployment capability. Annual costs are directed towards maintenance and calibration of the profilers, and data preparation necessary for submission to the National Ocean Data Center.

4. Undergraduate Internship

One undergraduate will be selected through the intern/co-op programs at regional universities and colleges to do a combination of office and at-sea work based out of the Commission offices during the summer months. The program includes various pre-determined office tasks as well as being assigned a research project then designing and executing said project. A final report and presentation are given at the conclusion of the employment term. The report is usually included in the RARA.

5. Genetic techniques for partitioning commercial catch by gender

For 2011, samples of commercially-caught fish were collected for the purposes of comparing genetic sex identification to the survey length-at-age method presently employed in the stock assessment. In 2010, sufficient samples were collected only from Areas 2B and 3A. In 2011, additional samples were collected from Areas 2B, 3B, 4A, and 4D to further investigate the potential of this approach. In 2012, sample analysis will occur under the supervision of Dr. Lorenz Hauser, of the University of Washington's Marine Molecular Biology Laboratory (MMBL).

6. Histology: Analysis of gonad staging

The staff believes it is necessary to re-evaluate our classification criteria for female gonad maturity stage. The method currently used on the assessment surveys is based on visual criteria established in the early 1990s and modified in 1995. These survey data combined with the age data are important components in the stock assessment model. Four maturity stages are presently assigned to female halibut; immature (F1), maturing (F2), spawning (F3) and resting (F4). Once a female halibut has spawned, the gonad transitions to a resting phase, back to maturing, and then to spawning again. Our criteria for classification also assume that the immature (F1) stage is only seen with immature fish but we are seeing anomalies during the survey that question this assumption. Gonad samples were collected in 2004 from which to base this study. In 2012, proposed work entails looking for a size gradient for oocytes dependent on their location within the gonad, determine the maximum precision for oocyte diameter measurements by oocyte maturation stage, determine a sampling protocol for measurement of oocyte diameters, and contract slide preparation for gonads. We will also begin assessment of archived gonads from a set of previously-prepared slides.

7. Assessment of mercury and contaminants in Pacific halibut

The staff plans on continuing our collaboration with the Alaska Department of Environmental Conservation (ADEC) in 2012, collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading. This work has been ongoing since 2002. Results from a 2002 collection of halibut samples led the Alaska Division of Public Health in 2003 to conclude that the concentrations of heavy metals in Alaskan Pacific halibut were not a public health concern. In 2004, the first results regarding organic pollutants (PCB's, pesticides) were released demonstrating that halibut had the lowest concentrations of the five species (including salmon and sablefish) examined. The Alaska Division of Public Health updated their advice on fish consumption in 2007 with some restrictions on the number of meals of halibut for women of child bearing age and young children. Since 2002, the IPHC has submitted 1,527 samples for testing by ADEC. The IPHC and ADEC are continuing to qualify the data with physical parameters (age, size, and weight) and additional analyses will be done on the samples. ADEC and EPA planned on going ahead with this study regardless of IPHC input. Our involvement in the project has allowed us to provide input on study design, sampling protocols in the field, etc., which will make the resultant information much more robust. In 2011, samples were acquired from the Yakutat/Fairweather inshore, northern Portlock and St. Matthew regions. In 2012, data analysis and writing will be the primary focus. Sampling in 2012 is focused on the Semidi, Seward, Washington and Oregon regions.

8. Archival tags:

Holding tank experiments examining mounting protocols
For 2012, the staff intends to continue holding halibut in tanks at the Oregon Coast Aquarium (OCA) in Newport, OR to investigate alternate mounting protocols for the externally-mounted archival tags. The 2008 releases in Area 2B were our first experience with using an external mount, and that process suggested some revisions and improvements could be possible which would reduce any effect the tags may have on the fish's behavior. Additional improvements to tag design may also be helpful in creating a different mounting device. A total of 30 halibut were captured via hook-and-line and transported live to the OCA. The fish are treated for parasites, examined regularly to assess healing and/or relative infection rates among mounting types, and behavior monitored. At the end of the holding period, fish will be measured to assess relative growth among treatment groups, and tags will be removed to examine the effects of the tag mounts on the tissue and musculature at the attachment site, or internal interactions in the case of an internal-external-streamer modification. The results will support the anticipated use of this type of technology in subsequent years. Expenses for 2012 involve the care and feeding of the fish at OCA.

2009 releases of dummy test tags
External and internal tag recovery rates are being tested in the field release of archival test tags. In August-September 2009, 200 fish were tagged off southern Kodiak Island (in Areas 3A and 3B), half with external tags and half with internal implants. Fish were also tagged with a bright pink cheek tag, and rewards of $100 will be given for all tags recovered. Nine fish were recovered in 2011. Expenses in 2012 consist of tag rewards.

Preparation for coastwide release
In preparation for a coastwide release of archival tags in 2013, the staff has been working with Lotek Wireless (St. John's, NL) on a specific tag design and configuration for IPHC use. Although no field activity is planned for 2012, Lotek is continuing their work on our requirements and construction. Results from the 2009 release of dummy archival tags in Area 3A and the examination of several mounting protocols on fish being held at the Oregon Coast Aquarium will feed into the design of the tag and its attachment to the fish.

Archival tags: Site selection in Area 4B
In 2009, we tagged 773 fish in Area 4B to evaluate tag recovery rates in preparation of a future release of archival tags in the area. Recovery rates of PIT tags released in the Aleutians were quite low, without evidence of recovery hotspots. This suggests that if archival tags were deployed in the Aleutians, we would likely recover relatively few of those tags. This would result in either too few data to draw any conclusions or require that a very large number of tags be initially deployed. Given that archival tags cost $500-1200 each, resorting to a very large deployment would be financially prohibitive and problematic. Our goal is to locate at least two

9. Pilot study to test geomagnetic tag performance in the Gulf of Alaska

In 2011, we deployed both Desert Star and Lotek geomagnetic tags on 30 halibut in two regions of the Gulf of Alaska: in Area 2C, just offshore of southern Prince of Wales Island; and in Area 3A, offshore of southern Kodiak Island. Tagging was restricted to large fish (110-150 cm FL), most likely to be mature females and likely to conduct a spawning migration shortly after tagging, and was divided into two deployment locations because the coastline and bathymetry of the areas are largely perpendicular to one another with respect to the magnetic environment. In Area 2C, total magnetic field gradients run largely parallel to shore, whereas in Area 3A around Kodiak that gradient runs perpendicular to shore. As such, we hypothesized that geomagnetic positioning based on total field strength would more accurately detect onshore-offshore movement in 2C and alongshore migration around Kodiak. Recoveries are expected in 2012 to enable testing of the hypothesis; project expenses are for the rewards.

10. Comparison of alternative baits for assessment survey

Rising bait prices and potentially unstable supplies has prompted the staff to consider alternative baits for the assessment survey. The 2011 pilot study conducted in Area 3A provided a design for a broader study proposed for 2012 to more fully examine catch rate differences between our standard #2 semi-bright chum salmon and other bait types (pollock, pink salmon). A study design is still being prepared but results from the pilot study showed that a mixed-bait set could be used in the experiment, which will greatly improve efficiency and statistical power. Initial plans call for this to be conducted at all stations in the coastwide assessment survey.

Other 2012 Research – Contracts and Grants

1. Alaska port sampling

The commercial fishery port sampling program hires samplers to collect otoliths, halibut lengths, fishing logbook information and landed weight data. The U.S. program includes staffing eight Alaskan ports and Bellingham, Washington. The samplers act as the liaison between the fishing industry and the Commission staff in Seattle. The Commission is responsible for the overall assessment and management of the halibut fishery and the data collected are necessary for stock assessment. The U.S. government adopted the Individual Fishing Quota (IFQ) allocation program in 1995. This grant (#300.00-81) provides funds to the IPHC for the incremental cost increase to the Commission sampling program due to the IFQ program. The grant is generated from the NMFS IFQ Fee Collection Program.

2. Water column profiler project (Coastwide)

The IPHC maintains one of the most extensive sampling platforms in the north Pacific. This platform provides enormous potential for collection of valuable oceanographic data. In particular, understanding the dynamics of the structure of the mixed layer depth – a major GLOBEC goal - requires *in situ* vertical profiling. Since 2001, IPHC has successfully deployed a SeaBird SBE-19 water column profiler during the annual stock assessment survey (#610.11). A second profiler was added to the program in 2007 (#610.12). In 2009, a NOAA grant provided for the complete outfitting of all chartered survey vessels, resulting in a complete coastwide deployment through Sept. 2011. Annual costs are directed towards maintenance and calibration of the profilers, and data preparation necessary for submission to the National Ocean Data Center. The IPHC received a no-cost extension to the grant for 2012.

3. Alaska catcher vessel logbook and sablefish data collection

IPHC and NMFS Auke Bay Lab (ABL) have a sablefish data collection program (#617.00). The program was reviewed and modified in 2003/2004 to meet the IPHC confidentiality policy and to encompass all vessels rather than just vessels greater than 60 feet. Under a Statement of Work, NMFS contracted IPHC staff to interview the IFQ fishers to review and collect the sablefish information in addition to the halibut information. Logbook data are entered by IPHC staff, matched with landings records, and provided electronically with a summary to the ABL scientists. In the summarized data, the vessels are assigned a unique code to preserve confidentiality.

Assessment and Harvest Policy Studies

1. The stock assessment

The annual stock assessment process comprises a large amount of work including preparation of IPHC data, estimation of bycatch by length in other fisheries, model development and validation, model fitting, examination of residuals, comparison of alternative model specifications, sensitivity tests, evaluation of harvest strategy, incidental analyses, and reporting.

2. Development of IPHC harvest policy

Since 2004, the IPHC harvest policy has been based on maintaining coastwide spawning biomass above a reference level, with options in place to reduce the harvest rate should that level be crossed. Work is continuous, with refinements to calculation of the optimum harvest rate itself in light of our present understanding of stock dynamics, fish movement, new information on commercial length-specific selectivity coming from the PIT tag experiment, and impacts of bycatch mortality when accounting for migration. In a broader sense, our harvest policy should also be robust to the many uncertainties inherent in the assessment and management of a broadly distributed and continually migrating stock, particularly one with individual regulatory area catch limits. A formal approach to evaluate such harvest policy is through Management Strategy Evaluation (MSE). An explicit aim of our MSE project is to develop a procedure for deriving catch limit recommendations that would achieve the desired harvest policy, potentially relying on much simpler calculations and at the same time effective across a range of uncertainties about stock, fishery and management behavior. Such procedures have been developed for other fisheries and it is appropriate to investigate their application to halibut management. In addition, we will examine potential effects of fishing on life history traits.

3. Ongoing analytical and statistical studies in support of halibut management

Every year, the analytical staff engages in a broad range of studies, many unanticipated at the onset of each year, to support halibut management. Examples of recent work include spatio-temporal modeling of setline WPUE, estimation of bycatch impacts on lost yield, surplus production trends, participation and preparation of materials for workshops (apportionment, bycatch, commissioner retreats, etc.), improvements to port sampling programs, among many others. We fully anticipate these side projects to continue to increase in number and scope.

Other Research

1. Seabird occurrence project

During the stock assessment surveys, sea samplers count the number of seabirds in the vicinity of the vessels following gear retrieval. Sampling after the haul addresses the question of where and when certain seabird species occur. These data have been used to identify appropriate seabird deterrent requirements in certain geographic locations. Data have also been collected, using the same protocol, on the NMFS and ADF&G sablefish surveys. IPHC has developed a database to store IPHC seabird occurrence data and the collection project is ongoing.

2. Species identification of amphipods frequenting Pacific halibut

The project intends to document the occurrence and virulence of attacks by predatory amphipods on halibut caught on IPHC surveys and, by inference, the commercial fishery. The commercial industry suffers annual losses of product due to amphipod predation and must adjust its fishing locations and practices in response to predation. Harvester discussions indicate that predation sites are both known and ephemeral, and the virulence may vary interannually at a given site. The specific identity of the amphipods has not been established and it is probable that more than one species is involved. Harvesters are interested in both documentation of predation areas for avoidance, as well as gaining an understanding of the dynamics of the species at given sites, i.e., whether there are cycles of abundance that respond to other factors. Data were collected on all stations during the 2004, 2005, and 2006 stock assessment surveys as part of standard protocol, recording incidence of sand flea predation, and the extent and virulence of the predation. The last year of data collection for this stage of the project was 2006. The 2007 summer intern performed initial analysis of interannual occurrence and virulence. Additional work will be directed at correlated variables.

3. Bycatch sampling on the assessment surveys

Area 2A
Since 2002, the IPHC has worked cooperatively with both the Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW) to collect rockfish bycatch data. All rockfish caught on operations in 2A are retained and marked externally with a Floy T-bar anchor tag and the tag number is recorded with the set and skate of capture (since 2006) information. All marked fish are retained so state biologists can collect additional data shore-side. Marketable fish are sold. The IPHC then provides each agency with the effort information collected as part of the normal survey data collection.

Area 2B
In 2012, IPHC will continue to work with the Department of Fisheries and Oceans Canada (DFO) to provide a third biologist on IPHC survey vessels to collect hook-by-hook occupancy information for all species. Otoliths, maturities, round weights, and lengths were collected for all rockfish except thornyheads. This is the ninth year of this cooperative program and continued collaboration is anticipated.

Area 2C and eastern 3A
Collection of whole-haul catch data for yelloweye rockfish capture is expected to continue in 2012, at the request of the Alaska Department of Fish and Game (ADFG), for survey vessels operating in the Fairweather, Sitka, Ommaney, and Ketchikan charter regions. This project built upon cooperative work started with ADFG in 2007 and future collaboration is anticipated.

Area 4
Length frequency data on incidentally-caught Pacific cod were collected in 2011 in the 4A Edge and 4D Edge charter regions. This project was initiated at the request of NMFS/AFSC Pacific cod assessment team and is part of a developing effort to collect bycatch information on Pacific cod in the western regions of our survey, where it makes up the largest component of our survey bycatch. The work was discontinued in 2010 at NMFS' request but resumed in 2011 and is anticipated to continue in 2012. We are also collecting lamprey scarring records on Pacific cod in these regions as well as on halibut in Washington and Oregon.

All Areas
This coming year will be the second of a two year (2011-2012) effort to collect size and gender data from spiny dogfish bycatch on the assessment survey. This project began as a request from NMFS/AFSC and has been expanded coastwide to enhance the project. Sampling entails obtaining length and sex data on the first five spiny dogfish at all survey stations coastwide, with the exception of B.C., where the first three dogfish are sampled, and in the Bering Sea survey regions, where all dogfish are sampled.

4. Electronic reporting project for commercial landings in Alaska

IPHC, ADF&G, and NMFS staffs have continued to refine the web-based Interagency Electronic Reporting System (IERS). For halibut, the system reduces duplicative reporting resulting from the current requirements of completing ADF&G fish tickets and NMFS/RAM quota share reports, and has been operational since May 2006. The application (eLandings) records data elements required by regulations, prints fish tickets, and connects with the NMFS quota share database. The appropriate data from IERS is being sent to the agencies for their internal databases. The application is continuously being modified, including the incorporation of additional fisheries and tender landings. Agency staffs attend annual workshops and provide training to processors. Costs represent system maintenance costs, software purchase and development, steering committee meetings, and travel costs.

5. Electronic logbooks

In 2011, no funds were spent but the staff provided feedback to NMFS on the electronic logbook program under development for Alaska. The current NMFS logbook program is for a small portion of the fleet and is expected to be available in 2012/2013. The staff will continue to explore options and collaborate with other agencies to determine the feasibility of an electronic logbook in other areas.

6. Electronic data capture

In 2012, further work will be done developing pilot level data acquisition systems for both our port and sea sampling collection efforts. A scoping document has been developed and basic groundwork is now being put in place to launch this effort.

Northwest Fisheries Science Center
National Marine Fisheries Service

NOAA Fisheries

Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2012

Review of Agency Groundfish Research, Assessments, and Management

A. Agency Overview

The Northwest Fisheries Science Center (NWFSC) provides scientific and technical support to the National Marine Fisheries Service (NMFS) for management and conservation of the Northwest region's marine and anadromous resources. The Center conducts research in cooperation with other federal and state agencies and academic institutions. Five divisions, Conservation Biology, Environmental Conservation, Fish Ecology, Resource Enhancement and Utilization Technologies, and Fishery Resource Analysis and Monitoring, conduct applied research to resolve problems that threaten marine resources or that deter their use. At the current time, the Environmental Conservation and Resource Enhancement and Utilization Technologies Divisions are being restructured to form a single new division. The Center's main facility and laboratories are located in Seattle. Other Center research facilities are located in Pasco, Big Beef Creek, Mukilteo, and Manchester, Washington; Newport, Hammond, and Clatskanie, Oregon; and Kodiak, Alaska.

The Fishery Resource Analysis and Monitoring Division (FRAMD) is the source for most of the research reported by the NWFSC to the Technical Subcommittee of the Canada-US Groundfish Committee. The FRAMD works in partnership with state and federal resource agencies, universities, and the groundfish industry to achieve a coordinated groundfish program for the West Coast.

FRAMD consists of a multi-disciplinary team with expertise in fishery biology, stock assessment, economics, mathematical modeling, statistics, computer science, and field sampling techniques. Members of this program are stationed at the NWFSC facilities in Seattle and in Newport, Oregon, with some Observer Program staff located in California. Together, they work to develop and provide scientific information necessary for managing West Coast marine fisheries and strive to provide useful and reliable stock assessment data with which fishery managers can set ecologically safe and economically valuable harvest levels. FRAM researchers develop models for managing multi-species fisheries; design programs to provide information on the extent and characteristics of bycatch in commercial fisheries as they look at methods to reduce fisheries bycatch; characterize essential habitats for key groundfish species; and employ advanced technologies for new assessments.

During 2011, FRAMD continued to: implement a West Coast observer program; conduct a coast wide survey program that includes West Coast groundfish acoustic and trawl surveys; develop new technologies for surveying fish populations, particularly in untrawlable areas; and expand its stock assessment, economics, and habitat research. Significant progress continues in all programs.

For more information on FRAMD and groundfish investigations, contact the Division Director, Dr. Michelle McClure at Michelle.McClure@noaa.gov, (206) 860-3381.

Other Divisions at the NWFSC are:

The Conservation Biology Division is responsible for characterizing the major components of biodiversity in living marine resources, using the latest genetic and quantitative methods. It also has responsibility for identifying factors that pose risks to these components and the mechanisms that limit natural productivity. The Division's multi-disciplinary approach draws on expertise in the fields of population genetics, population dynamics, and ecology.

The Environmental Conservation Division (ECD) conducts nationwide research on the effects of chemical pollution and harmful algal blooms on habitat quality and fisheries resources. ECD is also a leader in NMFS' National Marine Mammal Health and Stranding Response Program's bio-monitoring and quality assurances projects.

The Fish Ecology Division's role is to understand the complex ecological linkages among important marine and anadromous fishery resources in the Pacific Northwest and their habitats. The Division particularly places emphasis on investigating the myriad biotic and abiotic factors that control growth, distribution, and survival of important species and on the processes driving population fluctuations.

The Resource Enhancement and Utilization Technologies Division draws together multi-disciplinary groups to address existing and developing challenges of captive rearing of salmon and other marine fish, improved hatchery practices, smolt quality, disease control, and developing technologies for full utilization of bycatch and fish processing waste.

For more information on Northwest Fisheries Science Center programs, contact the Center Director, Dr. John Stein at John.Stein@noaa.gov, (206) 860-3200.

B. Groundfish Studies

1. Research

a) Quantitative video analysis of flatfish herding behavior and effective area swept of a survey trawl

Investigators: K.L. Bosley, D. Bryan, A. Hicks, W.W. Wakefield and M. Haltuch

Density calculations from fishery-independent bottom trawl surveys can be scaled up to provide relative abundance estimates and population trends that are used for stock assessments. The Northwest Fisheries Science Center uses an Aberdeen bottom trawl net with sweeps outfitted with mud gear during its annual trawl survey. In situ video was used to quantify flatfish responses to the sweeps of this trawl in order to determine effective area swept and to improve survey accuracy. A total of 632 flatfish were observed and their behavior recorded from video collected during four tows. Fish were not randomly oriented with respect to the trawl sweeps; over 90% had a heading between 90 and 270° away from the mud gear, an indication of herding. The effect of fish size on the herding response was not significant and only 1.3% of fish were observed escaping over or under the mud gear. The mean distance that a stationary fish reacted to the gear was 36.6 cm (± 2.0 SE) and 50% of the observed fish that reacted to the mud gear did so at a distance of 73.76 cm (± 3.4 SE). The mean fish lengths estimated during video analysis was significantly smaller than the actual lengths of fish measured in the catch from 2 of 3 tows. Although 10 cm fish were commonly recorded during video analysis, 10 cm fish were almost completely absent from the catch. Flatfish herding is occurring along the mud gear of the Aberdeen bottom trawl net used in this study. Therefore, area swept calculations for the purpose of providing relative abundance estimates for stock assessments would ideally include some portion of the area swept by the mud gear. However, additional work will be necessary in order to determine the extent of herding along the entire length of the sweeps.

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b) Can trip limits and time-area closures keep commercial catches of longnose skate and spiny dogfish shark below their harvest limits?

Investigators: D. Erickson, J. Cope and C. Niles

Commercial catches of spiny dogfish shark (*Squalus suckleyi*) and longnose skate (*Raja rhina*) off the U.S. west coast have recently reached levels that would exceed their annual harvest specifications. In general, both are incidentally caught in commercial trawl and fixed gear fisheries targeting other groundfish species. Limited commercial markets exist for these species, so targeting may occur, especially for dogfish shark. Life history characteristics of both species limit their resilience to overfishing. For example, dogfish sharks may not reach sexual maturity until approximately 35 years old, and may produce only 2-16 pups per litter over an 18-22 month gestation period. Such slow dynamics would translate into long recovery times if harvest were to reduce these populations to low levels. Setting appropriate harvest levels is therefore of high importance for these species. The most common management measures used to control fishing mortality for West Coast commercial groundfish fisheries are landing ("trip") limits and time-area closures. Such measures may have limited effectiveness for spiny dogfish shark and longnose skate. The geographic distribution of each is broad, extending along the entire U.S. west coast at depths from < 50 fathoms to > 600 fathoms. In addition, both species are often discarded at sea due to their limited marketability.

We examined the potential use of trip limits and time-area closures to control the fishing mortality of longnose skate and spiny dogfish shark off Washington, Oregon, and California. We evaluated the potential efficacy of these management measures through analysis of logbook, fish ticket, and at-sea observer data, and also discussed the potential impacts such management measures may have on commercial fisheries and coastal communities.

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c) Temporal and spatial summer groundfish assemblages in trawlable habitat off the U.S. West Coast: 1977 to 2009

Investigators: J. Cope and M. Haltuch

Multispecies interactions are increasingly being considered by U.S. management councils during decision making, highlighting the need for the identification of fish assemblages across varying spatial and temporal resolutions. On the U.S. West Coast, previous groundfish assemblage analyses have focused either on particular species groups (i.e., *Sebastes*) or over limited time frames and/or geographic regions within the groundfish fishery. This work expands those previous studies to identify groundfish assemblages across the full spatial extent of the West Coast groundfish fishery from 1977-2009 by using two fishery-independent trawl surveys. Species assemblages were identified using two clustering methods (partitioning analysis and hierarchical analysis) and two realizations of the data (presence-absence and log+1 transformed CPUE). The analysis using presence-absence data provides information on species that co-occur while the CPUE data provides information on species that occur at similar magnitudes. Temporally and spatially persistent assemblages were detected by both clustering methods through most years. Assemblages identified using CPUE were often subsets of those identified using presence-absence, indicating that the members of an assemblage may occur together, but not necessarily at the same magnitude, a result that should be considered when choosing the clustering metric. Identification of species assemblages is applicable to bycatch models and informative when evaluating the implementation of spatial management measures, thus germane to current challenges faced by marine resource managers.

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d) Feeding ecology of juvenile rockfishes off Oregon and Washington, based on stomach-content and stable-isotope analyses

Investigators: K. Bosley, T. Miller, R.D. Brodeur, K.M. Bosley, A. Van Gaest and A. Elz

The feeding habits of pelagic, juvenile rockfishes (*Sebastes* spp.) collected off Oregon and Washington during 2000, 2002, and 2006, were examined using stomach-content and stable-isotope analyses. The predominant species were darkblotched (*S. crameri*), canary (*S. pinniger*), yellowtail (*S. flavidus*), and widow (*S. entomelas*) rockfishes. Stomach-content analysis revealed that darkblotched rockfish had highly variable diets, and canary, yellowtail, and widow rockfishes exhibited a high degree of overlap. Multivariate analysis revealed significant differences in diet based on distance from shore, fish size, and species. Stable-isotope analysis showed all species were feeding at about the same trophic level within each year, with a 1.5‰ difference in δ15N between years. Depleted δ13C values were indicative of diets based on primary production from a more offshore origin. Comprehensively, these results add to our understanding of some of the important environmental factors that affect young-of-the-year rockfish during their pelagic phase.

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e) Relating groundfish biomass, species richness and community structure to the presence of corals and sponges using NWFSC bottom trawl survey data

Investigators: K.L. Bosley, K.M. Bosley, C.E. Whitmire and A.A. Keller

Some cold-water corals and sponges occur in such dense aggregations that they provide structurally complex habitats which support a diverse assemblage of associated invertebrates and fish. In many cases, marine fishes have been linked to the presence of epibenthic invertebrates, although the specific nature of this relationship is often unknown. The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey has collected approximately 250 coral specimens per year since 2006, and has identified, on average, 200 sites (of 750) per year where sponges are present. For this study, we investigated the relationship between these two groups of epibenthic invertebrates and their associations with demersal fish using trawl survey data from 2003-2010, when the survey covered continental shelf and slope waters from Cape Flattery, Wash., to the Mexican border. Regression models were used to correlate fish biomass and species richness with coral and sponge densities. Fish biomass was correlated with sponge density, but the relationship was not precise ($P<0.0001$, $R^2=0.043$). No other significant correlations were uncovered among these variables. Multivariate analyses were used to assess fish community structure in relation to coral and sponge densities, and to environmental parameters including depth, latitude and bottom temperature. There were strong correlations between species composition and both depth and bottom temperature, but no strong correlations with coral or sponge densities. Indicator species analysis was done to determine species that were associated with four levels of sponge and coral densities (high, medium, low and zero). Shortspine thornyhead, rosethorn rockfish and greenspotted rockfish were associated with high sponge catches, while flatfishes were typically associated with the absence of sponges. Shortspine thornyhead, Dover sole, longspine thornyhead, aurora rockfish and darkblotched rockfish were associated with high coral catches, and rex sole, English sole, and greenstriped rockfish with the absence of corals. These results provide information about broad-scale associations between corals, sponges and demersal fish that may be useful for developing studies that are specifically focused on the function of corals and sponges as habitats for fish, and the role they may play in their life-histories.

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f) A stable isotope-based perspective on the contribution of prey to Humboldt squid (*Dosidicus gigas*) in the northern California Current

Investigators: T.W. Miller, K.L. Bosley, J. Shibata, R.D. Brodeur, K. Omori and R. Emmett

Diet studies have shown Humboldt squid (*Dosidicus gigas*) to be aggressive opportunistic predators, yet this approach has yielded only a limited and potentially biased view of their trophic feeding behavior. As an alternative we measured δ13C and δ15N of *D. gigas* and their prey from the northern California Current ecosystem, and applied a stable isotope Bayesian mixing model to assess the proportional contributions of prey groups to their diet. Cluster analysis of prey taxa by their respective δ13C and δ15N values was first applied to consolidate prey into groups, which were then incorporated into a stable isotope mixing model (SIAR) as source groups to the diet mixture. Model results showed lower trophic-level feeding by *D. gigas* relative to previous diet-based studies, with greatest contributions from macrozooplankton and ichthyoplankton (median 50% credibility interval contribution = 0.26-0.43), and nekton of yearling-juvenile rockfish, market squid, sand lance, and juvenile hake (0.22). Prey groupings composed of myctophids and other deep water benthic-pelegic species, yearling-adult hake, other squid species, sardine and anchovy, juvenile salmonids and other nekton displayed negligible contributions (≤ 0.01). Sensitivity analyses of the SIAR model based on varying isotopic fractionation factors of δ13C (0, 0.39, 0.8, and 1.2‰) and δ15N (2.6, 3.0, and 3.4‰) showed that proportional contributions of prey to squid diets were fairly resilient to change. Analyses of size-specific shifts in δ13C and δ15N showed weak but significant relationships with increasing mantle length.

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g) Co-occurrence of demersal fish species in the US west coast bottom trawl fishery.

Investigators: E. Heery and J. Cope

This study presents a comprehensive and current view of species co-occurrence onboard commercial vessels in the bottom trawl fishery using data from a mandatory at-sea observer program conducted yearly from 2002. Three major questions were explored: (1) Are there identifiable associations between species caught in the bottom trawl fishery? (2) Do overfished species cluster with certain target groups in a consistent and predictable way? (3) Do overfished species cluster at particular spatial scales or are relationships spatially consistent across the whole data set? Results indicate two particularly significant assemblages when evaluating data from the entire geographic range of the fishery: a deepwater/slope group that included Dover sole, sablefish, and shortspine thornyhead, and a shallower shelf group dominated by English sole and petrale sole. Results also indicate that our ability to predict bycatch events of rare overfished species based on the catch of target species is extremely limited. Associations between overfished rockfish and other groundfish species simply are not evident over large spatial scales.

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h) Variation is age and growth of greenstriped rockfish (*Sebastes elongatus*) along the U.S. West Coast (Washington to California)

Investigators: A.A. Keller, K. Molton, A.C. Hicks, M. Haltuch and C. Wetzel

Greenstriped rockfish, *Sebastes elongatus,* are a common commercial and recreational species often taken as by catch in commercial West Coast fisheries. We evaluated weight-length relationships and size-at-age using von Bertalanffy growth models for greenstriped rockfish sampled along the U.S. West Coast from 2003 to 2008. Based on regression analyses, populations were subdivided into two depth strata (55 -122 m and 122 - 450 m) and four geographic regions (48°10'N – 48°28'N, 40°26'N – 48°10'N, 34°27'N – 40°26'N and 32°30'N

– 34°27’N) and differences in length, age and growth examined by gender. Strong evidence of variation in weight-length relationships was found north and south of Cape Mendocino (40°26’N) but little variation was noted for depth or gender. In contrast, variations in von Bertalanffy growth models were highly dimorphic between sexes with consistent patterns across depth and geographic regions. Females grew more slowly and reached larger asymptotic sizes (L_∞, cm) relative to males in all regions examined. Asymptotic size for both males and females tended to increase at higher latitude and increased depth; however the smallest asymptotic sizes occurred in the region from Pt. Conception to Cape Mendocino, CA (34°27’N – 40°26’N), rather than lower latitudes south of Pt. Conception (32°30’N – 34°27’N). Greenstriped rockfish growth rates (k, yr^{-1}) exhibited a more complex pattern. Higher growth rates were associated with regions within the northern California Current system characterized by high productivity.

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i) Variations in Eastern North Pacific demersal fish biomass based on the U.S. West Coast groundfish bottom trawl survey (2003–2010)

Investigators: A.A. Keller, J. Wallace, B. Horness, O. Hamel and I. Stewart

In response to declining biomass of Northeast Pacific groundfish in the late 1990s and to improve the scientific basis for management of the fishery, the Northwest Fisheries Science Center standardized and enhanced their annual bottom trawl survey in 2003. The survey was expanded to include the entire area along the U.S. West Coast at depths of 55–1280 m. Coast-wide biomass and species richness significantly decreased during the first eight years (2003–2010) of this fishery-independent survey. We observed an overall tendency towards declining biomass for 62 dominant taxa combined (fishery target and non-target species) and four of seven subgroups (including cartilaginous fish, flatfishes, shelf rockfishes, and other shelf species), despite increasing or variable biomass trends in individual species. These decreases occurred during a period of reduced catch for groundfish along the shelf and upper slope regions relative to historical rates. We utilized information from multiple stock assessments to aggregate species into three groups: with or without large recruitment in 1999 or unknown recruitment level. For each group, we evaluated if declining biomass was primarily related to depletion (using year as a proxy) or environmental factors (i.e., variation in the Pacific Decadal Oscillation). Based on Akaike’s Information Criterion, changes in aggregate biomass for species with strong recruitment were more closely related to year while those with no strong recruitment were more closely related to climate. The significant decline in biomass for species without strong recruitment confirms that factors other than depletion of the exceptional 1999 year class may be responsible for the observed decrease in biomass along the U.S. West Coast.

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j) Preliminary life history variability of longnose skate (*Raja rhina*) across two large marine ecosystems: Gulf of Alaska and California Current System

Investigators: C. Gburski, T. Helser, V.V. Gertseva, J.R. King and D.A. Ebert

The longnose skate, *Raja rhina*, is common in the eastern North Pacific Ocean ranging from the Bering Sea to Baja California and occurs from close inshore to a maximum of 1000 m depth. In the Gulf of Alaska (GOA), it has a maximum total length and age of 145 cm and 25 years, respectively. A directed fishery for *Raja* spp. off Kodiak Island, Alaska was initiated in 2003, ending in 2005. An experimental fishery in Prince William Sound, Alaska was reinstated in 2009. The vulnerability of elasmobranchs to over exploitation from commercial fishing, either from bycatch or a directed fishery, is well- documented. This inter-agency and institutional (AFSC, NWFSC, DFO and MLML/PSRC) collaborative study quantitatively compares growth and age/size at sexual maturity of the longnose skate across two large marine ecosystems, the GOA and California Current Ecosystem (CCE), on a spatial and temporal scale. Potential environmental (e.g., bottom water temperature) and oceanographic influences on life history traits between the GOA and CCE are also examined. Vertebrae (n=500) for this study were collected off the GOA, British Columbia (BC) 'current break' and U.S. West Coast states between 2001 and 2009 from research surveys and via port sampling. Ages were estimated from vertebrae prepared with the standard (unstained) thin sectioning technique in this preliminary study. A new histological (stained) method will be applied to archival vertebrae in the future. Age estimates from the standard technique and a new histological method will be compared to validated ages from a longnose skate 14C study. The methods estimated ages that best fit the validated ages will be used to standardize ageing criteria among agencies therefore optimizing age determination for use in stock assessment and management.

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k) Recent increase in *Nybelinia surmenicola* prevalence and intensity in Pacific hake (*Merluccius productus*) off the United States west coast

Investigators: D. Bryan, K. Jacobson and J. Buchanan

A larval marine cestode was found in 82.0% of 834 Pacific hake (*Merluccius productus*) stomachs collected from 341 trawl stations along the United States West Coast during the summers of 2008 and 2009. Morphology and DNA sequencing were used to identify the cestode as *Nybelinia surmenicola*. In an examination of 131 Pacific hake stomachs collected from the same region in 1999, *N. surmenicola* prevalence was 35.1%. The results from a general linear model suggested that their prevalence is influenced by year and latitude, Pacific hake size, and sex. Mean intensity of *N. surmenicola* in 2008–2009 was 20.22 (±1.13 SE) and was positively related to Pacific hake length and the latitude of collection. Year-1 Pacific hake (<27 cm length) had significantly lower prevalence and intensity of *N. surmenicola* compared to older and larger fish. Pacific hake collected south of Point Conception, California (32.5 to 35ºN) had lower prevalence and intensity of *N. surmenicola* compared to those collected in northern latitudes (35.1 to 48.4ºN). Higher *N. surmenicola* prevalence in Pacific hake in recent years suggests food-web fluctuations in the northern California current ecosystem caused by changes in ocean transport of zooplankton or pelagic fish distributions and warrants future monitoring as a metric for ecosystem change.

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l) Light availability during bottom trawls affects catchability of Eastern Pacific groundfish species

Fisheries assessments depend on fisheries-independent surveys to provide relative indices of biomass and abundance. Trawl survey catch rates vary across gradients of environmental variables. We tested the effect of near-bottom light levels on catch rates and catch probability for four common groundfish: arrowtooth flounder (*Atheresthes stomias*), greenstriped rockfish (*Sebastes elongatus*), longnose skate (*Raja rhina*), and Pacific hake (*Merluccius productus*). Downward irradiance was measured with net-mounted archival tag during annual West Coast trawl surveys in 2009 and 2010. Near-bottom light levels were recorded for 822 hauls completed at <400 m water depth. For all four species, there was a significant linear relationship between the catch per swept area (CPUE) and near-bottom irradiance ($p<0.05$). CPUE of Pacific hake decreased 17% for every unit increase in log 10 photon flux ($\mu E\ m^{-2}\ s^{-1}$), conditioning for depth and latitude. Irradiance, depth, and latitude explained 17% of the variance in CPUE. CPUE of arrowtooth flounder decreased 23% for every unit increase in log 10 photon flux ($\mu E\ m^{-2}\ s^{-1}$), conditioning for depth and latitude. Irradiance, depth, depth^2, and latitude explained 48% of the variance in CPUE. CPUE of longnose skate decreased 19% for every unit increase in log 10 photon flux ($\mu E\ m^{-2}\ s^{-1}$), conditioning for depth and latitude. Irradiance, depth, depth^2, and latitude explained 22% of the variance in CPUE. CPUE of greenstriped rockfish increased 37% for every unit increase in log 10 photon flux ($\mu E\ m^{-2}\ s^{-1}$), conditioning for depth and latitude. Irradiance, depth, depth^2, and latitude explained 27% of the variance in CPUE. The probability of catch for all four species was affected by near-bottom irradiance. At 100 m depth, the probability of catch decreased as irradiance increased for all fish. For arrowtooth flounder, greenstriped rockfish, and longnose skate there was an interaction between irradiance and depth. The relationship between near-bottom irradiance, CPUE, and availability of these groundfish can explain the variability in catch rates for bottom trawl surveys.

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m) Fine-scale analysis of arrowtooth flounder (*Atherestes stomias*) catch-per-unit-effort reveals spatial trends in abundance and diet

Investigators: S. Zador, K. Aydin and J.M. Cope

Multiple lines of evidence suggest that changes in the marine climate in the eastern Bering Sea are leading to numerical and distributional shifts in fish populations that may affect the balance of predator−prey relationships. A rapidly increasing arrowtooth flounder *Atheresthes stomias* population has prompted concern about the growing threat of arrowtooth flounder predation on economically valuable walleye pollock *Theragra chalcogramma*. The goal of this study was to investigate the overall increasing trend of arrowtooth flounder at a finer spatial resolution to better understand the potential spatial variability in their predatory impact under a changing climate. The specific objectives were to determine whether arrowtooth flounder were increasing equally throughout the eastern Bering Sea and, if not, (1) identify areas with dissimilar abundance trends and (2) explore physical and biological habitat characteristics that may be contributing to these differences. Clustering arrowtooth survey catch per unit effort revealed 4 distinct spatial groups showing stable, increasing, and variable trends. Increasing bottom water temperature and depth were associated with higher proportions of trawls containing arrowtooth and higher catch rates. Age-1 and -2 pollock were the predominant prey in all areas, but higher rates of non-empty stomachs in the northwest region indicated that current predatory impacts on pollock may be higher there. Favorable physical habitat (deep and warm) and diet trends (full stomachs) suggest that arrowtooth flounder in the northwest region of the eastern Bering Sea have the potential to increase further, perhaps to the abundance levels seen in the high-density area where they may have reached carrying capacity.

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n) Identifying potential habitats from multibeam echosounder imagery to estimate abundance of groundfish: a case study at Heceta Bank, OR, USA

Investigators: J.E.R. Getsiv-Clemons, W.W. Wakefield, C.E. Whitmire and I.J. Stewart

The Habitat and Conservation Engineering group contributed a case study (Getsiv-Clemons et al. 2012) to the recently published "Seafloor Geomorphology as Benthic Habitat: GeoHab Atlas of Seafloor Geomorphic Features and Benthic Habitats" (P.T. Harris and E.K. Baker, eds., Elsevier, Amsterdam, 2011). The Atlas provides an integrated look at seafloor lithologies and marine benthic habitats including background information on the concepts of taking a geohabitat approach to habitat science, including habitat classification schemes, techniques for mapping benthic habitats, and the importance of habitat science to resource management. The volume includes fifty-six case studies from around the world. The NWFSC's contribution is for Heceta Bank, Oregon.

Heceta Bank is one of the largest banks off the western coast of North America, extending 55 km from north to south and rising above the continental shelf to 67 m water depth. Due to heterogeneous substrate of varying relief, the bank supports a diverse assemblage of demersal fishes and is an important fishing ground off the coast of Oregon, USA. The top of the bank is comprised of boulders and cobbles eroded from outcrops of sedimentary rocks, while layers of finer grain size material cover the lower-relief flanks. Using observations of fish-substrate associations from 19 remotely operated vehicle dives, we identified 57 distinct substrate types and 9 habitat types. In a separate exercise, we overlaid observations of substrate types onto high-resolution multibeam imagery to delineate 4 potential habitat classes. Using this map of potential habitats, we estimated bank-wide abundance and variance values for a select group of resident fishes.

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o) A relative index of age-1 Pacific hake (*Merluccius productus*) abundance off the West Coast of North America, 2003-2011

Investigators: J.E.R. Getsiv-Clemons, R.E. Thomas and I.J. Stewart

Pacific hake (*Merluccius productus*) are an ecologically and commercially important groundfish species in the California Current ecosystem. The relative abundance and distribution of the adult (age-2+) portion of the Pacific hake stock is monitored through a biennial acoustic survey conducted jointly by the U.S. and Canada. The survey covers the North American coast from 50-1500 m water depth and 35°-55° north latitude, with systematic transects generally oriented perpendicular to the coastline and spaced 10-20 nm apart. Mid-water and bottom trawls are deployed to sample the species composition of observed acoustic backscatter and to collect biological information for hake including size, age, weight, and sex. Although more difficult to survey than the adult stock, acoustic and trawl data are also collected for age-1 hake. We investigated these data with regard to the schooling behavior of age-1 hake, as well as the observed spatial distributions across latitude and depth. We calculated a relative index of age-1 hake abundance for each survey year from 2003-2011. We then compared this index with recent stock assessment results to investigate its use as a predictive tool for the strength of future incoming year classes. This analysis may eventually be helpful to both the stock assessment and joint international hake fishery management in reducing the large uncertainty in strong recruitment events prior to the observation of these year-classes in other data sources.

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p) Five-year review of essential fish habitat for Pacific Coast groundfish

The current designations of EFH for Pacific Coast groundfish, as described in Amendment 19 to the Pacific Coast Groundfish FMP, were approved by NMFS in May 2006. Initial EFH designations were based on the best available data that were assimilated and developed from 2002 to 2005. Beginning in 2010, the Pacific Fisheries Management Council, NW and SW Fisheries Science Centers, and the NMFS Regional Offices initiated the first mandatory 5-year review for EFH provisions of the groundfish fishery management plan, and in this context, the Council formed an ad hoc EFH Review Committee. The groundfish EFH review is a three-phase process. Phase I includes the evaluation of published scientific literature and unpublished scientific reports; solicitation of information from interested parties; and the review of previously unavailable or inaccessible data. Information will be updated on the distribution and extent of seafloor maps of bathymetry and interpreted groundfish habitat types; the distribution and extent of groundfish fishing effort; the distribution of biogenic habitat; spatial management boundaries; prey species for groundfishes; known or potential anthropogenic impacts to habitats (including groundfish prey); and habitat associations for 91 groundfish species. At the end of Phase I, the new information will be presented to the Council, its advisory bodies, and the public, and the Council will solicit proposals to modify EFH and Habitat Areas of Particular Concern (September 2012). The 5-year review represents a major update of the groundfish habitat assessment for the California Current and will have research and management applications well beyond satisfying the regulatory guidelines of Magnuson-Stevens Fishery Conservation and Management Reauthorization Act.

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q) NOAA Habitat Blueprint: A framework to improve habitat for fisheries, marine life, and coastal communities

NOAA is developing and implementing new habitat-based solutions to support healthy and productive ecosystems – the Habitat Blueprint. To this end, NOAA will expand our partnerships, prioritize its activities, and direct its focus to better understand, protect, and restore habitat for the benefit of our living marine resources and coastal communities. The Habitat Blueprint consists of a four-pronged approach: 1) Implementing regional initiatives, 2) Establishing geographic priorities, 3) Implementing a systematic and strategic approach to habitat science, and 4) Strengthening policy and legislation. While the NOAA Habitat Blueprint starts with increasing efficiencies within NOAA and across its programs and offices, it is also designed to foster collaboration across federal, state, and local levels.

A part of NOAA's Habitat Blueprint will be the implementation of regional habitat initiatives to explore new collaborative approaches to habitat science and conservation. These initiatives will preserve or improve habitat conditions within a defined geographic area to address specific challenges to living marine and coastal resources. There are two initiatives for the Pacific Coast. The initiative for the Northwest will focus on Puget Sound. The State of Washington has lost more than 70 percent of its estuarine wetlands and 50 percent of its riparian habitat, with losses continuing to mount. To address these losses and the impacts on threatened Chinook salmon in the Puget Sound, NOAA Fisheries will work with federal, state, tribal, and local partners to develop new strategies to conserve salmon habitat. NOAA will integrate scientific modeling and monitoring with regulatory and restoration programs. Actions include reconnecting floodplains and restoring ecosystem functions through dike removal and levee setbacks, leading to restoration of more than 500 hundred acres in the Nooksack, Skagit, Puyallup/White, and Snohomish watersheds. While efforts will focus on habitat restoration in the near-term, NOAA will provide a critical scientific framework for long-term recovery.

In the Southwest, the initiative will focus on the Southern California Bight. The Bight is rich with important fisheries and other marine life, including endangered white abalone, deep-sea corals, and sponges. To address impacts caused by fishing and non-fishing activities, NOAA Fisheries will assess and monitor deep-water ecosystems. NOAA will use a variety of advanced survey tools and approaches to improve our assessments of living marine resources and their habitats in water depths 20 to 900 meters off southern California. These assessments and enhanced delivery of information to managers will improve conservation recommendations for Pacific Coast groundfish. We will also evaluate the effectiveness of protected areas as a tool for resource conservation along the West Coast, particularly for rockfish and deep-sea corals.

For more information, go to: http://www.habitat.noaa.gov/blueprint/

r) Demersal fish species composition and biomass in relation to low oxygen conditions along the U.S. West Coast

Investigators: A. A. Keller, V. Simon, K. Bosley. M. Bradburn, D. Kamikawa, J. Buchanan, W.W. Wakefield, J.A. Barth and S. Pierce

Understanding the relationship between environmental variables and fish distribution and abundance has long been a goal of fisheries biologists. Since 2002, hypoxic conditions have been observed on the continental shelf off the coast of the Pacific Northwest in a region not previously characterized by low oxygen conditions. In addition, major declines in dissolved oxygen have been observed in the oxygen minimum zone (OMZ) within the California Current as well as a shoaling of the OMZ. Despite these recent increases in frequency, duration, and spatial extent of hypoxia and the recognition of hypoxia as a threat to worldwide fish production, little is known about its effects on upper trophic levels. In 2007, the Northwest Fisheries Science Center (NWFSC) initiated studies on the extent of hypoxic conditions on the continental shelf and slope along the West Coast and the influence of hypoxia on demersal fishes and invertebrates, including commercially important groundfish. This project was developed as an extension of the NWFSC West Coast Groundfish Bottom Trawl Survey.

In 2011, we sampled a range of oxygen conditions extending from the upper to the lower limit of the OMZ as well as across the boundaries of the OMZ. We collected data on the composition, distribution, and biomass of demersal groundfish species in relation to bottom oxygen concentration within the Eastern North Pacific oxygen minimum zone (OMZ) along the U.S. West Coast from May 16 – July 26, 2011 (pass 1) and August 15 – Oct. 25, 2011 (pass 2). The 2011 catch data have not yet been analyzed but results for 2009 – 2010 are included below. We measured bottom oxygen concentrations on 360 successful tows conducted during the 2009 West Coast Groundfish Bottom Trawl Survey and 621 successful tows conducted during the 2010 survey. Our results indicate that DO ranged from 0.08 to 4.25 ml l^{-1} in 2009 with 240 stations experiencing hypoxic conditions (DO < 1.43 ml l^{-1}). In 2010, near bottom DO ranged from 0.02 to 3.97 ml l^{-1} with 376 stations located in hypoxic waters. Throughout this project, the NWFSC Center has collaborated with a group of physical oceanographers at Oregon State University to develop procedures and protocols for integrating the collection of oceanographic quality temperature, salinity, and dissolved oxygen data into the West Coast Groundfish Bottom Trawl Survey.

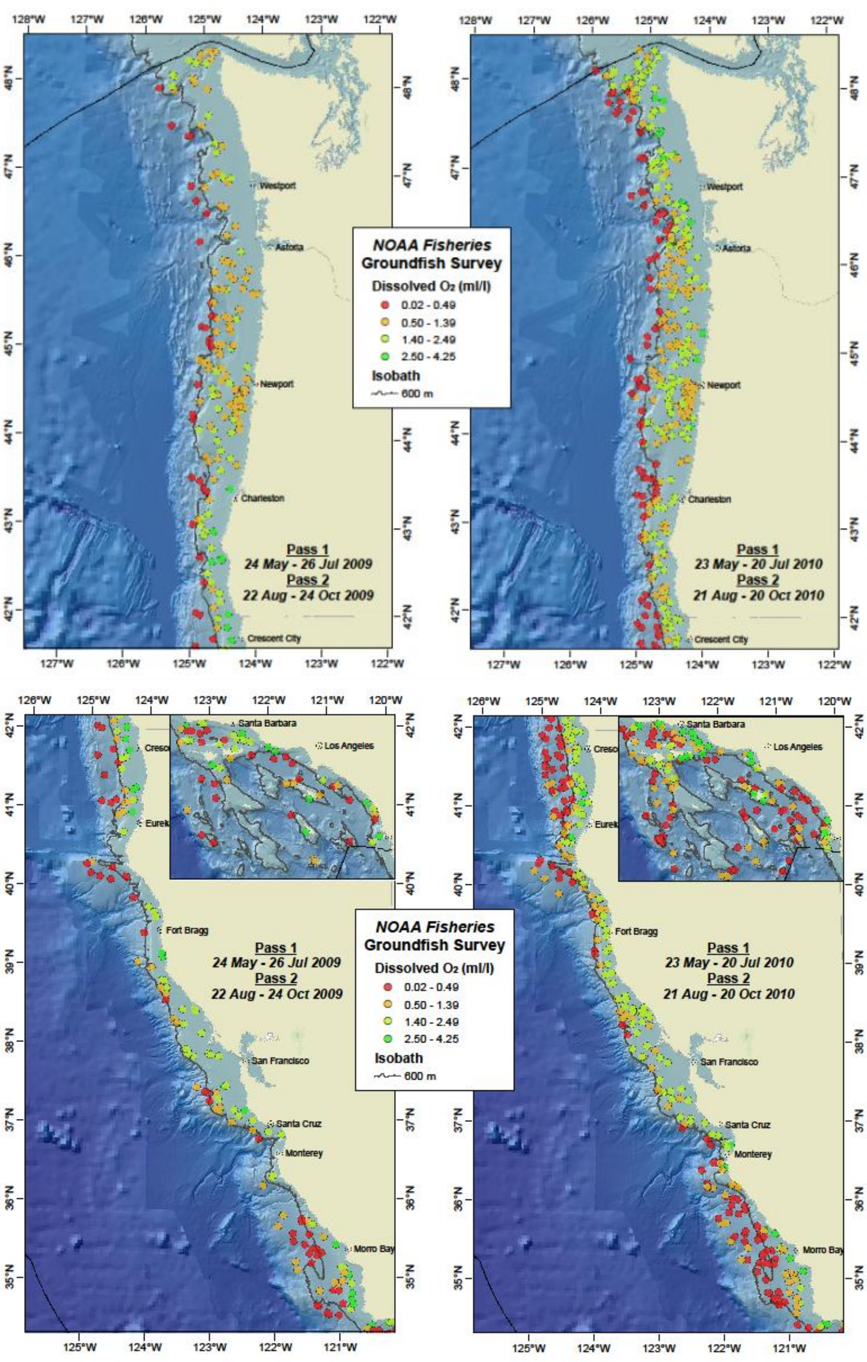

Figure 1 demonstrates the distribution of near bottom oxygen concentration during Pass 1 and Pass 2 of the 2009 and 2010 surveys. Sampling during the groundfish surveys indicates low DO in deep water within the OMZ during both passes of the survey. Low DO appeared to move shoreward as the summer progressed and later in the season occurred in shallower water offshore of both Washington and Oregon. In the southern California Current, low DO was more widespread in July (pass 1) than Oct. (pass 2) with the geographic distribution of low DO waters variable between passes.

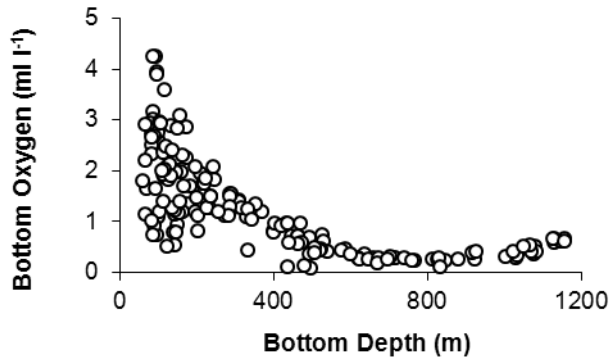

Figure 2 demonstrates the relationship observed between near bottom oxygen concentration and tow depth during the 2009 survey and clearly demonstrates the presence of low oxygen at greater depths.

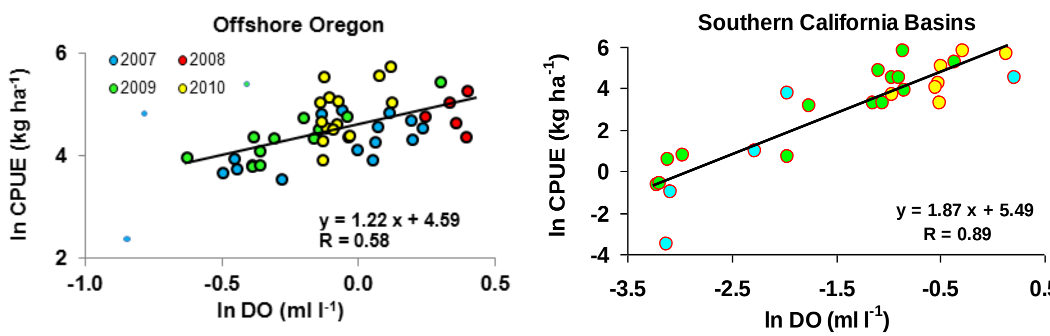

Figure 3 demonstrates the significant relationships between demersal organisms (catch per unit effort, CPUE, ln kg ha^{-1}) and near bottom oxygen concentrations (ln ml l^{-1}) during 2007 – 2010 in an hypoxic area offshore of Oregon (three outliers shown are smaller symbols) and during 2008, when 39 bottom trawls were made in the vicinity of the Santa Barbara Basin (SBB, n=19, green), the Santa Monica Basin (SMB, n=9, blue) and adjacent areas (ADJ, n=11, yellow). Results were similar, although less variable, to those seen offshore Oregon, with significant positive relationships between CPUE and near-bottom oxygen for tows within hypoxic waters (n=26).

Results from coast-wide hypoxic stations in 2009 – 2010 (Figure 4) were similar to those observed in 2007 – 2010 off Oregon and 2008 off California. CPUE (fish plus invertebrates) was significantly (P<0.0001) and positively related to near-bottom oxygen concentrations within hypoxic areas. Further analysis, using stepwise regression, confirmed the importance of depth in the relationship between CPUE and near bottom DO. Both variables were retained in the relationship with an overall r^2=0.29 when all data in hypoxic waters, DO<1.4 ml l^{-1} (2007 – 2010) were included in the analysis.

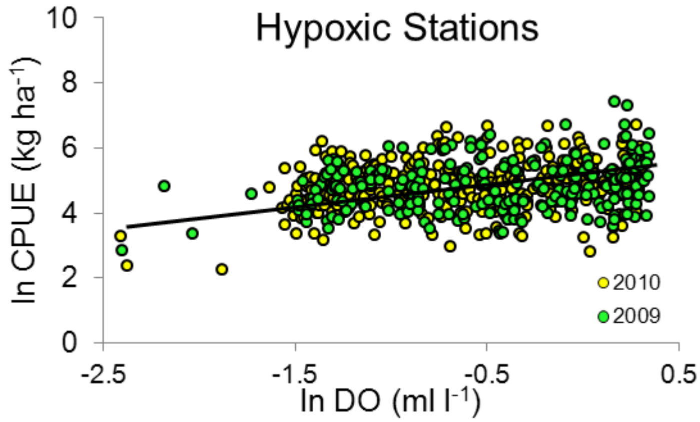

Figure 4, average near-bottom DO along the tow tracks are shown for the 616 hypoxic tows sampled coast wide in 2009 – 2010, using a Sea-Bird SBE 19*plus* attached to the net.

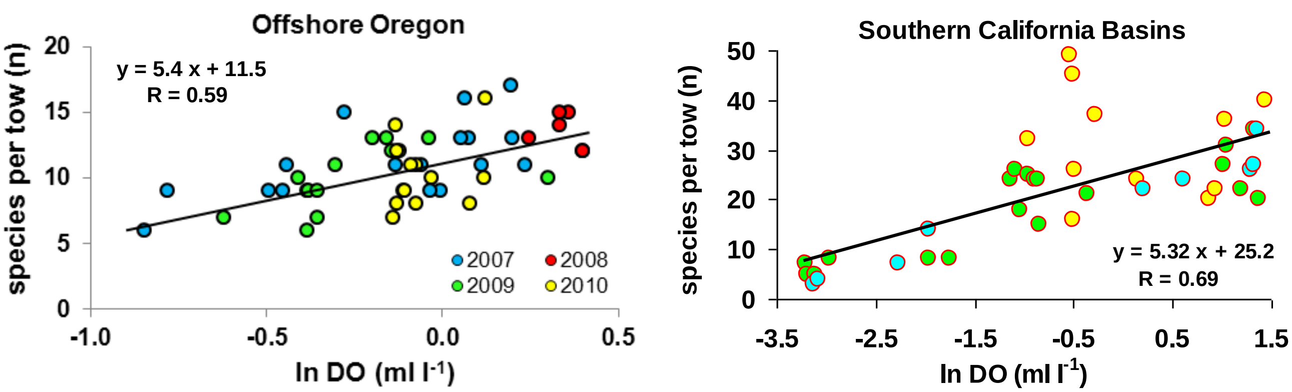

Figure 5 demonstrates that species richness (demersal fish and benthic invertebrates) varied significantly and positively with bottom oxygen concentration both offshore Oregon and within the hypoxic area of the southern California basins (green: Santa Barbara Basin; blue: Santa Monica Basin; yellow: adjacent areas). This relationship was not significant when examined using all data (coast wide and all depths) suggesting that both depth and/or geographic areas may influence the relationship.

Figure 6 shows the probability of occurrence of four selected species (spotted ratfish, Petrale sole, greenstriped rockfish and Dover sole) from the 2008 – 2010 surveys in relation to bottom depth (m) and near bottom dissolved oxygen (DO, ml l^{-1}). Probability values are estimated from a binomial Generalized Additive Model fit to the presence/absence data of the 2008 – 2010 NWFSC West Coast Groundfish Bottom Trawl Survey. For each examined species, in addition to the interaction term between depth and DO the species models also included terms for: position (longitude and latitude), time of the day, day of the year, salinity and near-bottom water temperature. In each plot, the grey dots indicate the actual sample values of DO and depth. The R^2 values indicate the amount of variance explained by the full model (including all terms). N = number of sampled stations.

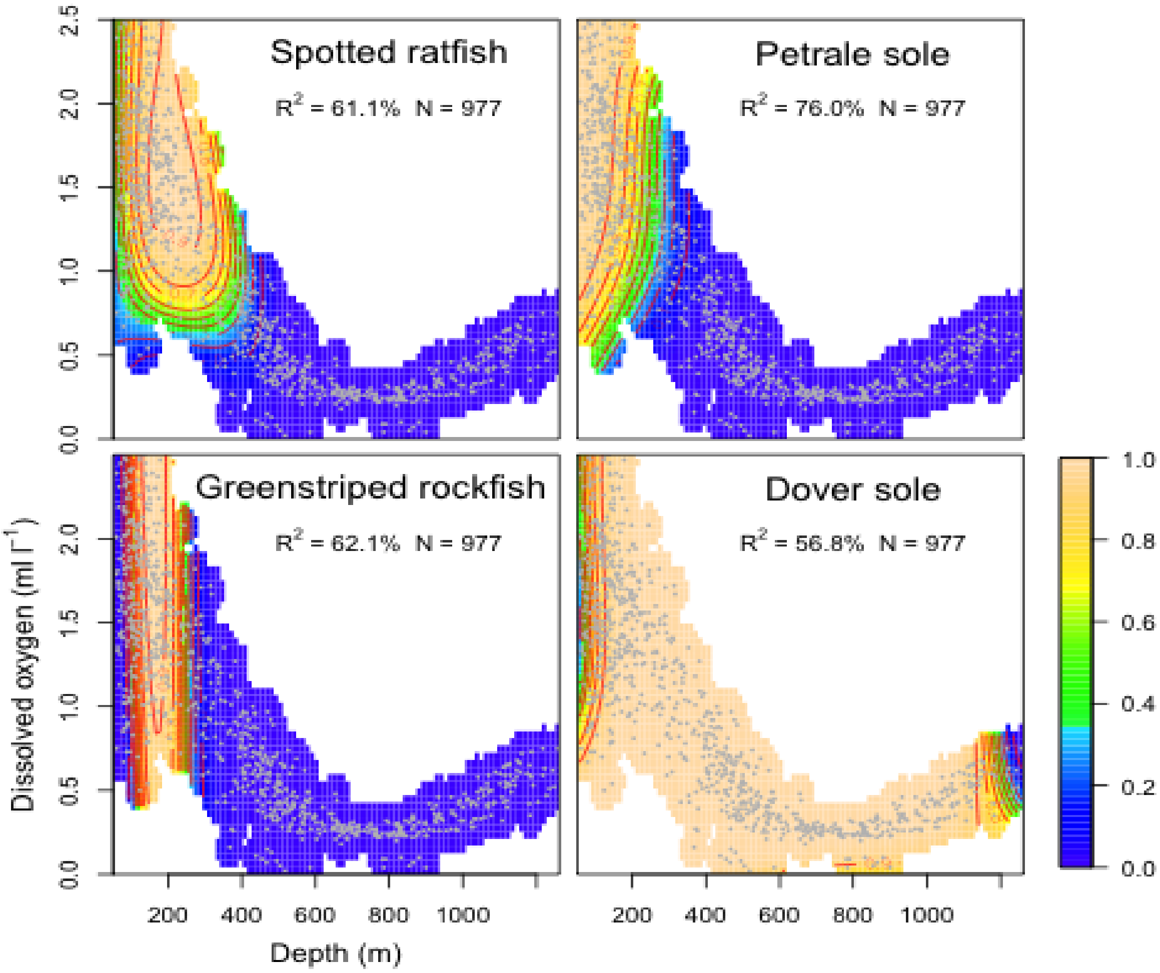

Figure 6. The probability of occurrence of four selected species (spotted ratfish, Petrale sole, greenstriped rockfish and Dover sole) from the 2008 – 2010 surveys in relation to bottom depth (m) and near bottom dissolved oxygen (DO, ml l^{-1}).

Results indicate that spotted ratfish and petrale sole (top two plots) are most sensitive to changes in near bottom DO, while greenstriped rockfish and Dover sole show no changes in probability of occurrence in relation to changes in DO. The probability of occurrence for spotted ratfish decreases sharply once DO goes below 1 ml l^{-1}. Greenstriped rockfish, petrale sole and spotted ratfish are mostly found in the upper slope region (depth <400 m) while the probability of catching Dover sole increases in the deeper slope areas (depth > 200 m), even when DO values are < 0.5 ml l^{-1}.

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2. Stock Assessment

a) Stock assessment model development

Stock Synthesis (SS) is an assessment model in the class termed integrated analysis and is the basis for West Coast groundfish assessments and many other assessments around the world. SS is built with a population sub-model that simulates a stock's growth and mortality processes, an observation sub-model to estimate expected values for various types of data, and a statistical sub-model to characterize the data's goodness of fit and to obtain best-fitting parameters with associated variance. It includes a rich feature set including age- and size-based population dynamics and the ability to specify observational phenomena, such as ageing imprecision. Model parameters can vary over time or be specified as functions of environmental data. SS includes routines to estimate MSY and exploitation levels that correspond to various standard fishery management targets. It supports assessments spanning several geographic areas and can use tag-recapture data. A customizable harvest policy is used to conduct a forecast in the final phase of running the model. The model is coded in ADMB (www.admb-project.org). SS is included in the NOAA Fisheries Assessment Toolbox (http://nft.nefsc.noaa.gov/) incorporating a graphical user interface developed by Alan Seaver (NEFSC). It is now at version 3.23b as of November 2011).

In 2011, Stock Synthesis was featured in the following non NWFSC publications as well as numerous publications reported below in section 10:

Piner, K.R., Lee, H-H., Maunder, M.N. 2011. A simulation-based method to determine model misspecification: examples using natural mortality and population dynamics models. Mar. Coast. Fish. 3(1): 336-343.

Maunder, M.N., Wong, R.A. 2011. Approaches for estimating natural mortality: Application to summer flounder (*Paralichthys dentatus*) in the U.S. mid-Atlantic. Fisheries Research 111, 92– 99.

Wetzel, C.R., Punt, A.E. 2011. Performance of a fisheries catch-at-age model (stock synthesis) in data-limited situations. Mar. Freshwat. Res. 62:927-936.

He, X., Ralston, S., MacCall, A.D. 2011. Interactions of age-dependent mortality and selectivity functions in age-based stock assessment models. Fish. Bull. 109:198–216.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

b) Estimating natural mortality within a fisheries stock assessment model: an evaluation using simulation analysis based on twelve stock assessments

Investigators: H-H. Lee, M.N. Maunder, K.R. Piner and R.D. Methot

Natural mortality (*M*) is one of the most influential and difficult to estimate number of losses in fisheries stock assessment and management. Typically, natural mortality is estimated using indirect methods, such as correlation with measurable life history factors and rarely relies on direct data such as tagging studies. In contemporary stock assessments, natural mortality may be estimated within the model by integrating different types of data into the analysis. We evaluated the estimability of *M* using simulation analyses based on 12 groundfish stock assessments conducted using Stock Synthesis. The advantages of utilizing this set of peer-reviewed assessment models were that various types of data were used over a wide range of model parameterization. Our results suggest that, in many cases, *M* is estimable with appropriate data. Profile likelihood analyses suggested that informative length or age composition data is needed to reliably estimate *M*.

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c) Adjusting for bias due to variability of estimated recruitments in fishery assessment models

Investigators: R. Methot and I. Taylor

Integrated analysis models provide a tool to estimate fish abundance, recruitment, and fishing mortality from a wide variety of data. The flexibility of integrated analysis models allows them to be applied over extended time periods spanning historical decades with little information from which to estimate the annual signal of recruitment variability to modern periods in which more information about recruitment variability exists. Across this range of data availability, the estimation process must assure that the estimated log-normally distributed recruitments are mean unbiased to assure mean unbiased biomass estimates. We examined how the estimation method implemented in the integrated analysis model, Stock Synthesis, achieves this unbiased characteristic in a penalized likelihood approach that is comparable to the results from Markov chain Monte Carlo. The total variability in recruitment was decomposed into variability among annual recruitment estimates based on information in the data and a residual variability. Because data are never perfectly informative, we demonstrated that estimated recruitment variability will always be less than the true variability among recruitments and that the method implemented here can be used to iteratively estimate the true variability among recruitments.

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d) Performance of a fisheries catch-at-age model (stock synthesis) in data-limited situations

Investigators: C.R. Wetzel and A.E. Punt

Limited data are a common challenge posed to fisheries stock assessment. A simulation framework was applied to examine the impact of limited data and data type on the performance of a widely used catch-at-age stock-assessment method (Stock Synthesis). The estimation method provided negatively biased estimates of current spawning-stock biomass (*SSB*) relative to the unfished level (final depletion) when only recent survey indices were available. Estimation of quantities of management interest (unfished *SSB*, virgin recruitment, target fishing mortality and final depletion) improved substantially even when only minimal-length-composition data from the survey were available. However, the estimates of some quantities (final depletion and unfished *SSB*) remained biased (either positively or negatively) even in the scenarios with the most data (length compositions, age compositions and survey indices). The probability of overestimating yield at the target *SSB* relative to the true such yield was ~50%, a risk-neutral result, for all the scenarios that included length-composition data. Our results highlight the importance of length-composition data for the performance of an age-structured assessment model, and are encouraging for the assessment of data-limited stocks.

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e) Can data collected from marine protected areas improve estimates of life-history parameters?

Investigators: T.M. Garrison, O.S. Hamel and A.E. Punt

One of the argued research-related benefits of marine protected areas (MPAs) to fisheries management is that because there is no fishing inside of an MPA, it may be possible to precisely estimate the rate of natural mortality and better determine growth and maturity rates, parameters that are often prespecified in stock assessments. This study assessed the degree to which having an MPA increased the ability to estimate these parameters in an integrated stock assessment model, Stock Synthesis; how long it would take for these benefits to be reflected in improved estimates of management quantities; and the extent to which these improvements will be reduced or lost if there is movement of adults (i.e., spillover) from the MPA to the fished area. A two-area, age- and length-structured simulation model was used to examine these benefits on estimation performance for Stock Synthesis. Given the data and process assumptions explored here, the extent of improvement in estimation of growth and maturity parameters with data collected from MPAs was small, but estimation of natural mortality was substantially improved compared with directly estimating these parameters using fishery data. The extent of this improvement depends on the degree of spillover and the complexity of the assessment model.

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f) Summary of stock status for assessed Pacific Coast groundfish species

Investigators: J. Hastie, S. Miller and J. Cope

Over the past decade, an increasing number of species have been assessed using methods that allow stock status to be estimated. Some stocks have been found to be in need of rebuilding, and they have had a substantial impact on the management of all sectors of the groundfish fishery. Of these rebuilding stocks, those which have not yet reached rebuilding targets have exhibited continuing growth throughout this period (to the extent that the available data are adequate to discern a trend). A high percentage of the other assessed species, as of their most recent assessments, are either near or above their target levels of spawning potential. We summarized trends in the status of assessed Pacific coast groundfish stocks over the last half-century, with particular focus on the recent rebuilding period. We also highlighted data, research, and methods that are needed to improve the number and quality of stock-status determinations that are available to inform future management.

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g) Fisheries science and management of U.S. West Coast groundfishes in resource-limited situations

New management mandates require catch limits for every managed fish stock in U.S. waters. This necessitates improved data analysis and assessment methods that inform management despite limited resources. Not anticipating a windfall of resources available to assess every managed stock each biennial assessment cycle required a creative approach. This is the story of the Pacific Fishery Management Council's attempt to manage 90+ species in the Groundfish Fishery Management Plan, only a third of which have been formally assessed. The Council advisory bodies' establishment of a framework to categorize species by assessment type, data availability, and uncertainty was examined. From there, alternative ways of devising science-informed catch limits were developed to provide overfishing limit estimates for stocks lacking assessments. The application of vulnerability analyses to help prioritize stocks for future assessment, provide guidance for data collection, and help formulate stock complexes for stocks without assessments was described. The ultimate goal is to both inform the management of species lacking assessments while attempting to develop the information needed to move those stocks toward formal assessment of their populations. Using otolith weights to obtain ages rather than reading annuli was discussed as an approach to move towards that final goal by greatly reducing the resources needed to access age data, a particularly important data type for stock assessment.

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h) Investigating rapid age determination methods using otolith morphometrics for four groundfish species

Investigators: J. Cope, P. McDonald, O. Rodriguez and K. Munk

Age-at-length information is one of the most informative types of data available for stock assessment modeling. Ageing structures, typically otoliths, record individual fish age by growing with the fish through time. Counting of incremental rings laid annually is the most widely recognized otolith characteristic used to define fish age. But while this approach has proven very useful, the application of this method requires a mix of both skill and art. Even with highly trained age readers, ageing error can remain significant. In addition, the technique can be time intensive. The Northwest Fisheries Science Center Groundfish Trawl survey has collected thousands of otoliths, many of which remain to be aged. The need to collect age data from these structures for stock assessment is a high priority, but resource limitation reduces the numbers obtainable. Previous studies in other fishes have explored the potential of alternative measures of otolith morphometrics such as weight, length, width, and thickness to more rapidly age fish. Attributes of these methods should include faster ageing with no reduction in accuracy, but a possible increase in precision, thus decreasing subjective analysis. Four species with very different otolith morphologies (Pacific hake, petrale sole, sablefish, and splitnose rockfish) were chosen to demonstrate how useful these measures may be as predicators of fish age. Samples sizes of 100-125 previously aged otoliths per sex per species were analyzed. The preliminary results demonstrated how useful otolith weight is as a predicator of age.

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i) Rags to Fishes II: Quantitative comparison of data-poor methods for fisheries management

Investigators: K. Honey, A. Apel, J. Cope, E.J. Dick, A. MacCall and R. Fujita

There is great need for reliable ways to assess the status of fish stocks when data sources are limited. We compared characteristics of three data-poor methods: Depletion-Corrected Average Catch, Depletion-Based Stock Reduction Analysis, and Length-Based Reference Point. We applied these peer-reviewed data-poor methods using common sets of data and input assumptions. These methods were compared to each other, as well as to the most current data-rich stock assessment to determine whether a method meets minimum federal requirements for setting the annual catch limit and how well the method performed relative to the stock assessment and the other data-poor methods. To summarize results, we estimated the relative degree of accuracy, precaution, and risk associated with the reference points derived from each data-poor method. All three data-poor methods produced sustainable yield estimates comparable, although somewhat lower and more risk-averse, to those generated from the most current stock assessment for stocks in relatively healthy conditions. These methods, however, performed least well for overfished and rebuilding stocks. Because of their simplicity, limited data requirements, and relative ease of use, data-poor methods may lend themselves to collaborative research efforts by fishermen and scientists. We concluded with management recommendations, caveats, and suggestions for on-going work to improve the management of data-poor species.

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j) Analysis of fishery-independent hook and line-based data for use in the stock assessment of bocaccio rockfish (*Sebastes paucispinis*)

Investigators: J.R. Wallace, J.H. Harms and I.J. Stewart

Fishery-independent surveys are an important source of information for stock assessment and management worldwide. Research surveys often use trawl gear to capture commercially valuable species and calculate indices of relative abundance or density. However, many species of interest do not occur in direct contact with the bottom, or occur in areas where high-relief habitat precludes trawl operation. This paper introduces a standardized hook and line survey for rockfish conducted by NOAA Fisheries' Northwest Fisheries Science Center in the Southern California Bight. The survey uses fishing gear similar to that used in many recreational fisheries to sample approximately 120 locations covering a wide range of depths and habitats. To provide an example of how these data can be analyzed for direct inclusion in stock assessments, we standardize catch rates of bocaccio rockfish from 2004–2008 using a Bayesian Generalized Linear Model to account for site, fishing time, survey vessel, angler, and other statistically significant effects. Results indicate that the bocaccio stock vulnerable to this survey in the Southern California Bight has shown a relatively flat trend over recent years. Length frequency distributions indicate the presence of several strong cohorts that should be detectable in future stock assessments of bocaccio for use in U.S. West Coast groundfish management. This survey is the only available tuning index for the adult portion of the bocaccio population in recent years as historically used recreational catch per unit effort indices have been compromised due to changes in bag limits and other management restrictions.

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k) Distribution and life history characteristics for vermilion rockfish (*Sebastes miniatus*) and sunset rockfish (*S. crocotulus*) in Southern California

Investigators: J.H. Harms, J. Hempelmann, O. Rodriguez, M. Head, R.M. Barnhart, P. McDonald, J.A. Benante and A.A. Keller

Recent genetic research by Hyde et al. (2008) at NOAA Fisheries' Southwest Fisheries Science Center identified a cryptic pair of the vermilion rockfish from specimens collected along the U.S. West Coast and suggested some depth and biogeographic partitioning between the two species. Using specimens and catch data collected during the hook and line survey, NWFSC researchers analyzed depth and latitudinal differences and similarities between vermilion and sunset rockfish and developed unique life history characteristics for the two species. These include age at length, annual growth estimates, length-weight relationships, and age at maturity. This information can be combined with the unique indices of abundance outlined in the previous paper to support separate stock assessments for vermilion and sunset rockfish.

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l) A fishery-independent multi-species examination of recent population trends for key species of shelf rockfish (Genus: *Sebastes*) in Southern California

Investigators: J.R. Wallace, I.J. Stewart and J.H. Harms

Fishery-independent surveys are an important source of information for stock assessment and management worldwide. Research surveys often use trawl gear to capture commercially valuable species and calculate indices of relative abundance or density. However, many species of interest do not occur in direct contact with the bottom, or occur in areas where high-relief habitat precludes trawl operation. This research was undertaken during a standardized hook and line survey for rockfish conducted by NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) in the Southern California Bight. The survey uses fishing gear similar to that used in many recreational fisheries to sample approximately 120 locations covering a wide range of depths and habitats. The methods described in Harms et al. (2010) were applied to hook and line survey data for six important species of shelf rockfish to generate fishery-independent abundance indices, including the first unique indices for vermilion rockfish (*S. miniatus*) and its cryptic pair, sunset rockfish (*S. crocotulus*). This survey is the only available ongoing tuning index for the adult portion of many structure-associated shelf rockfish species in the region, as historically-used recreational catch per unit effort indices have been compromised due to changes in bag limits and other management restrictions.

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m) Change we can perceive in: Using the concepts of "status", "scale", and "productivity" to interpret changes in management quantities across stock assessments as applied to U.S. west coast groundfishes

Investigators: J. Cope, O. Hamel, C. Niles, J. DeVore, E.J. Dick, J. Grebel and R. Jones

Fisheries stock assessments provide the scientific information used to calculate management quantities (e.g., maximum sustainable yield, the overfishing level, and time to rebuild) for application in precautionary fisheries management. Uncertainty in data inputs and model specification, though, can change our perception of a stock's population dynamics from assessment to assessment, and thus the resultant management quantities. These changes can be complex and technical in nature, sometimes resulting in what may seem to be contradictory outcomes. For instance, a new assessment may demonstrate that an overfished stock is more depleted than previously determined, yet able to support higher forecasted catches. Changes in assessment results like these have been particularly consequential to the Pacific Fishery Management Council's efforts to rebuild overfished stocks. We examined three general stock assessment concepts that help reconcile such apparent management contradictions: (1) "Status" refers to what proportion of a stock's abundance remains since fishing began; (2) "Scale" describes the absolute level of biomass; and (3) "Productivity" is the internal capacity of a population to grow. We represent these three dimensions using simple metrics and demonstrate how changes in these metrics from assessment to assessment can explain directional changes in the management quantities. We apply this method to six groundfishes currently under the Pacific Fishery Management Council's rebuilding plans. This approach allows one to anticipate and interpret changes in important management quantities without requiring a detailed understanding of the technical complexities involved in modeling past, current, and future trends in stock status and abundance.

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n) Evaluating the law and policy of rebuilding overfished groundfish at the Pacific Fishery Management Council

Investigators: C. Niles, J. Budrick, J.M. Cope, E.J. Dick, D.L. Erickson, J. Grebel, R. Jones, R.A. Kosaka, L. Mattes, H.J. Reed and E.C. Waters

The Pacific Fishery Management Council (PFMC) manages eight groundfish stocks under rebuilding plans, all but one being rockfishes of the genus *Sebastes*. The Magnuson Stevens Fishery Conservation and Management Act (MSA) requires the rebuilding to be "as short as possible" (i.e. by closing the fishery) unless delay is justifiable based on specific factors, with "the needs of the fishing communities" being the most prominent. The MSA limits delay to 10 years for stocks able to rebuild that quickly, yet is ambiguous on the outer time limit for stocks that cannot.

The rebuilding rockfishes present extreme circumstances for these MSA rebuilding provisions. Even absent fishing, some would not be expected to rebuild for decades. The incidental catch allowed in support of commercial and recreational targeting of other groundfish extends the expected rebuilding timeline decades longer for some species. These long rebuilding times have attracted 10 years of litigation. The courts have overturned individual rebuilding plans on two occasions, most recently in April 2010. On both occasions, the courts' main finding was that the long rebuilding times place disproportionate emphasis on short-term economic concerns.

The rebuilding plans are of consuming focus at the PFMC. We focused on key aspects of the courts' analysis while providing context for two related PFMC's rebuilding experience. We evaluated the courts' treatment of rebuilding against the principles of fisheries science and management and described how the lines between law, science, and policy have blurred. We paid particular attention to the assumption about overemphasis of short-term economics; described how this assumption has gone untested, and then argued for analysis of the MSA's rebuilding provisions based on long-term conservation tradeoffs.

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o) Recent Developments: Southern California Shelf Rockfish Hook and Line Survey

Investigators: R.M. Barnhart, J.H. Harms and J.A. Benante

The Fisheries Resource and Analysis and Monitoring Division of the Northwest Fisheries Science Center conducts an annual hook and line survey for shelf rockfish (Genus: *Sebastes*) in the Southern California Bight. The project, which began in 2002, targets demersal rockfish species associated with rocky, untrawlable habitats that are generally not sampled well by the division's other groundfish monitoring cruises. The hook and line survey is a collaborative effort with Pacific States Marine Fisheries Commission and the sportfishing industry in southern California. The 2011 field season was the eighth year in a time series of catch-per-unit-effort data and other biological parameters that are used to calculate an index of relative abundance for several important rockfish species including bocaccio, vermilion rockfish, greenspotted rockfish, and speckled rockfish. Bocaccio and vermilion rockfish, two primary species of interest, have been encountered at over 65% of survey sites in every year of the survey. Survey personnel are currently working with the NWFSC Genetics & Evolution Program to develop separate indices of abundance for vermilion and sunset rockfish by analyzing the finclips collected from each of the vermilion rockfish complex specimens collected during sampling.

Recent efforts include expanding the collection of environmental and oceanographic data during sampling including the acquisition of seawater temperature, dissolved oxygen, salinity, and turbidity information at depth from survey sites. These data may provide informative covariates reducing uncertainty associated with the model used to estimate indices of abundance and may also be useful in tracking shifts in oceanographic regimes in the region. In addition, the past two years work has been conducted to estimate size at maturity for the vermilion, sunset, and bocaccio rockfish. Efforts to collect video habitat information and further develop genetic biopsy hooks continue to move forward. The survey is improved by its collaboration with the sportfishing industry and has strengthened the working relationship between NOAA Fisheries and stakeholders in the region.

p) Reconciling uncertain and conflicting trends in petrale sole abundance

Investigators: M.A. Haltuch, J.D. Hastie, A. Hicks and C.E. Whitmire

Petrale sole are a commercially important flatfish that migrate seasonally between feeding and spawning grounds, and have recently been declared overfished. The summer trawl survey shows a decline in petrale sole abundance since 2005 similar to the unstandardized summer catch per unit of effort (CPUE) from the fishery. However, many stakeholders disagree that petrale sole abundance has been declining, instead choosing to focus on the unstandardized winter CPUE that shows a strong increase beginning in 2000. The assessment attributes the increasing trend in winter CPUE to management actions that forced the fleet to: 1) increase fishing effort during the winter; and 2) conduct winter fishing in locations with high historical catch rates. Standardized fishery CPUE was not used in the assessment due to changing management regulations beginning in the late 1990s and the high likelihood of a winter CPUE index showing hyper-stability due to the fishery focusing on the aggregated spawning stock. Given the potential discrepancy between the assessment results and the experience of the groundfish fleet, particularly during the winter fishing season, and the limited conclusions that can be drawn from unstandardized CPUE, this work explores the utility of the summer and winter fishery CPUE series as indices of abundance for the petrale sole stock assessment.

While the 2011 CPUE analysis attempted to account for the impact of management measures on the fishery, it is unable to account for changes in fishing behavior, or changes in spawning aggregation dynamics in the winter. Changes in the CPUE indices from approximately the years 2000-2003 forward could be due to management measures, fishing behavior, and spawning aggregation dynamics (winter only) that have not been captured in this analysis. For example, industry reports that the 2003 vessel buyback removed some of the more productive vessels in the fleet, but there is not information on the skippers that fished those vessels, many of which may have switched to fishing on different vessels. This CPUE analysis is also unable to capture changes in fishing behavior and targeting strategies for petrale sole and the dover-thornyhead-sablefish deep water fishery, which likely increased, as rockfish fishing opportunities became increasingly limited between the late 1990s and present. In the summer, the spatial management restrictions have changed on an annual basis and are captured only at a gross level in this analysis. In the winter, the spatial areas that have remained open to fishing since 2003 have been more stable, however, little is known about petrale sole spawning aggregation dynamics and how these spawning aggregation dynamics change as the stock increases from historical low levels in the 1990s to higher levels in the mid-2000s. There is some ancillary evidence that the timing of spawning (historically December - February) has shifted to be later in the winter season. This issue may have been captured by limiting the data used in the analysis to January-February. However little is known about how the timing of peak spawning, the duration of the spawning season, size of spawning aggregations, and density of spawning aggregations change with changes in the size of the spawning stock. It is not possible to capture these dynamics in the

CPUE analysis competed for the 2011 stock assessment as there is a lack of understanding between how changes in catch rates and changes in the true population are related.

The pre-STAR review draft of the 2011 stock assessment included the main effects commercial summer CPUE indices for each state as a sensitivity model run and excluded the winter CPUE indices due to the issues discussed above. Discussions during the STAR panel lead to the removal of the summer CPUE as a viable index for the model due to the annual changes in spatial management. While the summer CPUE indices were removed from the assessment, the general trends in the commercial summer CPUE are the same as the trend from the NWFSC fishery independent survey during the period of overlap. In the summer fishery, CPUE generally increased from 1987 through the middle of the past decade, but has decreased in the last few years for all three states. STAR panel discussions lead to the inclusion of the winter main effects CPUE indices due to the more consistent management during the winter, regardless of the possible issues with spawning aggregation dynamics. The winter fishery CPUE begins to increase about the year 2000, compared with the early part of the time series. While the California and Oregon CPUE indices continue to increase in the last few years, Washington (which has the largest data set of the three states) has declined since 2005. The winter commercial CPUE index from Washington shows a similar trend to the NWFSC summer fishery independent survey index. These winter CPUE indices were included in the 2011 base model of the petrale sole stock assessment.

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

C. By Species, by Agency

The PFMC currently operates under a biennial schedule for the development of stock assessments and management guidance. For all groundfish species except Pacific hake, stock assessments are scheduled for review only during odd-numbered years. A schedule for Stock Assessment Review (STAR) panels for full assessments of species conducted in 2011, along with the update review meeting and the 2012 Hake Scientific Review Group meeting, is shown in Table 1.

Table 1. 2011 Review Schedule for Full Groundfish Assessments.

STAR PANEL	STOCK	AUTHOR(S)	REVIEW PANEL DATES	STAR PANEL LOCATION
1	Data Poor Methods/ Examples	Jason Cope	April 25-29, 2011	Santa Cruz, CA
Updates	Bocaccio Canary Cowcod Darkblotched Yelloweye	John Field John Wallace E.J. Dick Andi Stevens Ian Taylor	June 6, 2011	Spokane, WA
2	Pacific Ocean Perch Petrale sole	Owen Hamel Melissa Haltuch	June 20-24, 2011	Seattle, WA
3	Widow Spiny dogfish	Xi He Vlada Gertseva	July 11 – 15, 2011	Seattle, WA
4	Sablefish Dover sole	Ian Stewart Allan Hicks Chantel Wetzel	July 25 -29, 2011	Hatfield Marine Science Center Barry Fisher Bldg., Room 101, 2032 SE Oregon State University Drive, Newport, OR 97365
5	Greenspotted Blackgill	John Field E.J. Dick	August 8-12, 2011	Southwest Fisheries Science Center 110 Shaffer Road Santa Cruz, CA 95060
Hake	Pacific hake/ whiting	Ian Stewart Robin Forrest Nathan Taylor Chris Grandin Allan Hicks	February 21-24, 2012	Seattle, WA

1. Shelf Rockfish - West Coast

a) Stock assessments

Full assessments of greenspotted rockfish and widow rockfish were conducted in 2011. Updates of the bocaccio rockfish, canary rockfish, and yelloweye rockfish assessments, and a status report for cowcod rockfish were also conducted in 2011.

Greenspotted rockfish

The complete version of: "Status of Greenspotted Rockfish, *Sebastes chlorostictus,* in U.S. Waters off California" can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/

Widow rockfish

The complete version of: "Status of the Widow Rockfish Resource in 2011" can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/

Bocaccio rockfish

The complete version of: "Status of bocaccio, *Sebastes paucispinis,* in the Conception, Monterey and Eureka INPFC areas as Updated for 2011" and "Rebuilding Analysis for Bocaccio, Based on the 2011 Stock Assessment" can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/

Canary rockfish

This updated assessment reports the status of the canary rockfish (*Sebastes pinniger*) resource off the coast of the United States from southern California to the U.S.-Canadian border using data through 2010. As in 2007 and 2009, the resource is modeled as a single stock. Historical (pre-1981) catches of canary rockfish catch were reconstructed for the 2009 assessment and resulted in substantial reductions compared to what was used in the 2007 assessment. Since the 2009 assessment, Oregon's commercial landings prior to 1986 have been reconstructed and those data are included in this updated assessment. The revised Oregon landings are higher in most of the years between 1941 and 1986. The net result of this revision is that the total estimated catch, from 1916 to 1986, is 36.5% higher than in 2009, and only 4.3% lower than in 2007.

Recent canary rockfish catches were revised based on current total mortality estimates (2002-2009) and the GMT scorecard (2010). In cases where only aggregated catches were available, they were pro-rated to modeled fleets as was done in the 2007 and 2009 assessments. The model data sources are unchanged, including updated catch, length- and age-frequency data from 11 fishing fleets. Biological data is derived from both port and on-board observer sampling programs. The National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC) bottom trawl survey's relative biomass indices and biological sampling provide updated fishery independent information on relative trend and demographics of the canary rockfish stock. The Southwest Fisheries Science Center (SWFSC)/NWFSC/Pacific Whiting Conservation Cooperative (PWCC) coast-wide pre-recruit survey provides an updated indicator of recent recruitment strength. The use of time-varying selectivity (for commercial fisheries) and catchability (Triennial bottom trawl survey) is unchanged from the 2007 and 2009 assessments.

As in 2007 and 2009, the base-case assessment model includes parameter uncertainty from a variety of sources but underestimates the considerable uncertainty in recent trend and current stock status. For this reason, in addition to asymptotic confidence intervals (based upon the model's analytical estimate of the variance near the converged solution), two alternate states of nature regarding stock productivity (expressed via the steepness parameter of the stock-recruitment relationship) are presented. The base-case model (steepness = 0.51) is considered to be twice as likely as the two alternate states (steepness = 0.35, 0.72), based on the results of a 2007 meta-analysis of west coast rockfish (M. Dorn, personal communication). In order to best capture this source of uncertainty, all three states of nature will again be used as probability-weighted input to the rebuilding analysis.

Based on the revised catch series, canary rockfish were very lightly exploited until the early 1940's, when catches increased and a decline in biomass began. The spawning biomass experienced an accelerated rate of decline during the late 1970s, and finally reached a minimum (10.8% of unexploited, below the estimate of 12% from the 2009 assessment) in the mid-1990s. Current depletion is estimated to have increased by over 50% since 2002. The canary rockfish spawning stock biomass is estimated to have been gradually increasing since that time, in response to reductions in harvest and above average recruitment in the preceding decade. However, this trend is very uncertain.

The degree to which canary rockfish recruitment declined over the last 50 years is closely related to the level of productivity (stock-recruit steepness) modeled for the stock. High steepness values imply little relationship between spawning stock and recruitment, while low steepness values indicate a strong positive correlation. After a period of above-average recruitments, recent year-class strengths (1997-2010) have generally been low, with only 2 of the 10 years (2001 and 2007) producing large estimated recruitments (the 2011 recruitment is based only on the stock-recruit function). The strength of the 2007 year-class is subject to greater uncertainty than other strong recruitment events in the last 30 years because of the limited number of years in which it has been observed. As the larger recruitments from the late 1980s and early 1990s move through the population in future projections, the effects of recent poor recruitment may tend to slow the rate of recovery.

Unfished spawning stock biomass, in the base-case model, was estimated to be 27,846 mt (7% higher than the 2009 estimate of 25,993, and 14.5% lower then the 2007 estimate of 32,561 mt). The target stock size ($SB_{40\%}$) is therefore 11,138 mt and the overfished threshold ($SB_{25\%}$) is 6,962 mt. Maximum sustained yield (MSY) applying current fishery selectivity and allocations (a 'bycatch-only' scenario) was estimated in the assessment model to occur at a spawning stock biomass of 10,464 mt and produce an MSY catch of 803 mt (down from the 960 mt estimate in the 2009 update). This sustainable yield is achieved at an SPR of 52.5%, nearly identical to the estimate from the 2007 assessment (52.9%). This is nearly identical to the yield, 801 mt, generated by the SPR (54.0%) that stabilizes the stock at the $SB_{40\%}$ target. The fishing mortality target/overfishing level (SPR = 50.0%) generates a yield of 799 mt at a stock size of 9,545 mt.

The abundance of canary rockfish was estimated to have dropped below the $SB_{40\%}$ management target in 1983 and the overfished threshold in 1990. In hindsight, the spawning stock biomass passed through the target and threshold levels at a time when the annual catch was averaging more than twice the current estimate of the MSY. The stock remains slightly below the overfished threshold (unlike the 2007 estimate), although the spawning stock biomass still appears to have been steadily increasing since 1999. The degree of increase is very sensitive to the value for steepness (which is included in the decision table as a state of nature), and is projected to slow as recent, and largely below average recruitments, begin to contribute to the spawning biomass. Fishing mortality rates in excess of the current F-target for rockfish of $SPR_{50\%}$ are estimated to have begun in the late 1970s and persisted through 1999. Recent management actions appear to have curtailed the rate of removal such that overfishing has not occurred since before 1999, and relative exploitation rates (catch/biomass of age-5 and older fish) are estimated to have been less than 1% since 2001. These patterns are largely insensitive to the three states of nature. Following the 1999 declaration that the canary rockfish stock was overfished, the canary OY was reduced by over 70% in 2000 and by the same margin again over the next three years. Managers employed several tools in an effort to constrain catches to these dramatically lower targets including reductions in trip/bag limits for canary and co-occurring species, implementing spatial closures, and new gear restrictions intended to reduce trawling in rocky shelf habitats and the coincident catch of rockfish in shelf flatfish trawls.

As in the 2007 and 2009 assessments, parameter uncertainty is explicitly captured in the asymptotic confidence intervals reported throughout this assessment for key parameters and management quantities. These intervals reflect the uncertainty in the model fit to the data sources included in the assessment, but do not include uncertainty associated with alternative model configurations, weighting of data sources (a combination of input sample sizes and relative weighting of likelihood components), or fixed parameters. Specifically, there appears to be conflicting information between the length- and age-frequency data regarding the degree of stock decline, making the model results sensitive to the relative weighting of each. This issue was not revisited as part of the update. The relationship between the degree of domed shape in the selectivity curves and the increase in female natural mortality with age remains a source of uncertainty that is included in model results, as it has been in previous assessments for canary rockfish. Uncertainty in the steepness parameter of the stock-recruitment relationship is significant and will likely persist in future assessments; this uncertainty is included in the assessment and rebuilding projections through explicit consideration of the three states of nature. Given the change in this update caused by the revised historical Oregon catch estimates, future assessments are likely to be sensitive to additional revised estimates from ongoing efforts in Washington state should they prove appreciably different from the time-series used here.

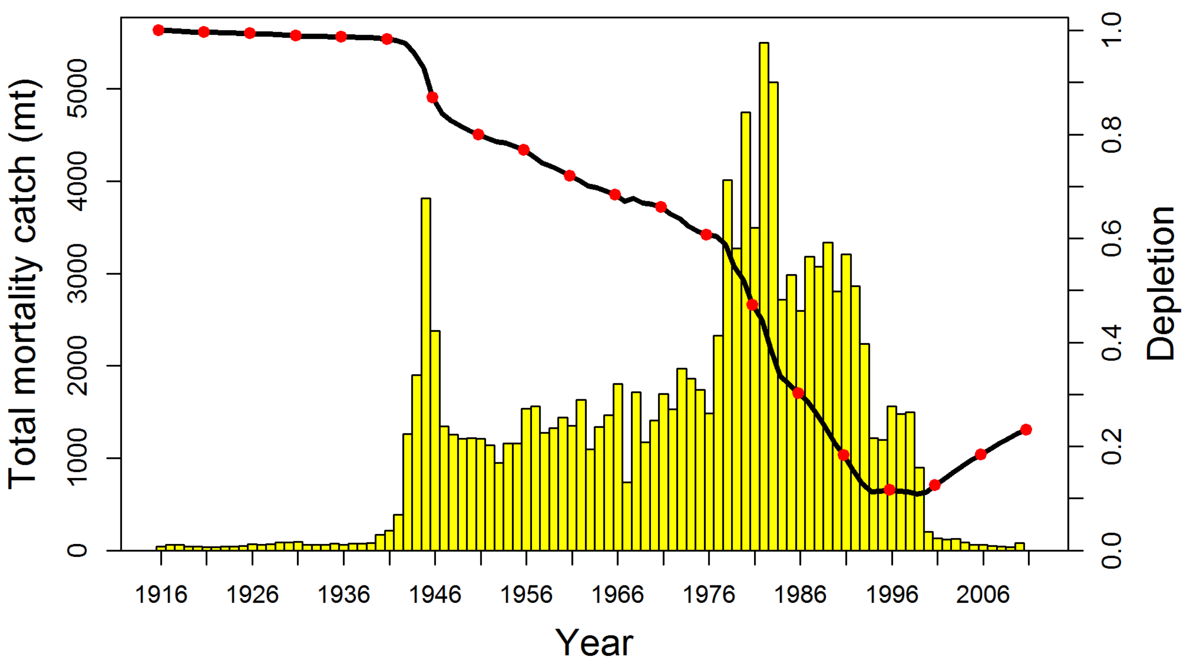

Figure 7. Level of estimated depletion (line) and total catch (bars) for canary rockfish, 1916-2011.

The complete versions of: "Status update of the U.S. canary rockfish resource in 2011" and "Rebuilding analysis for canary rockfish based on the 2011 updated stock assessment" can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information on the canary rockfish assessment please contact John Wallace at John.Wallace@noaa.gov

Yelloweye rockfish
The 2011 updated assessment reports the status of the yelloweye rockfish (*Sebastes ruberrimus*) resource off the coast of the United States from southern California to the U.S.-Canadian border using data through 2010. As in 2009, the resource was modeled as a single stock, but with three explicit spatial areas: Washington, Oregon and California. Each area was modeled simultaneously with its own unique catch history and fishing fleets (recreational and commercial) but the dynamics follow the current understanding of yelloweye stock structure: large stocks linked via a common stock-recruit relationship with negligible adult movement among areas.

Yelloweye rockfish catches were estimated from a variety of sources, including a new reconstruction of historical catch in Oregon for the years 1916-1986. Catches remain uncertain due to the relatively small contribution of yelloweye to rockfish market categories (prior to sorting requirements) and the relatively large scale of recreational removals (average 60% of the total in the past 10 years). The accuracy of estimates of rebuilding rates will therefore depend in part on the accuracy of the recreational catch data. Catches include estimates of discarding after 2001 when management restrictions resulted in nearly all yelloweye caught by recreational and commercial fishermen being discarded at sea. Recent catches were based on current total mortality estimates (2002-2009) and the GMT scorecard (2010). Estimated catches increased gradually throughout the first half of the 20^{th} century, with the exception of a brief period of higher removals around World War II. Catches peaked in 1982 at 463 mt, an estimate that was slightly higher than the previous assessment due to the inclusion of a new catch reconstruction for Oregon. Removals were estimated as remaining in excess of 200 mt for all years between 1977 and 1997. Uncertainty in catches was treated explicitly throughout this analysis.

As in the 2009 assessment, uncertainty from two sources was reported through alternate states of nature bracketing the base case results and included explicitly in the decision table. The magnitude of the estimated catch time-series was found to have a large influence on the perception of current stock size and the estimate of steepness of the stock-recruit relationship was closely linked to the projected recovery rates. Alternate values of each were selected to bracket the best estimates with marginal probabilities one-half as likely. For historical catch these values, 75% and 150% of the estimated catch series prior to 2000, were subjective, but reflect both the lack of a comprehensive catch reconstruction in Washington and the change in likelihood of the fit to data sources over a reasonable range of catch levels. For steepness, the 12.5th and 87.5th percentiles were calculated from the likelihood profile as a proxy for the probability distribution about this point estimate. The most optimistic and pessimistic of the nine combinations from these two axes (weighted 6.25% each relative to 25% for the best estimate on each dimension) are reported in this document and all combinations used to provide a more realistic degree of uncertainty for future projections, decision tables and rebuilding analyses.

A fecundity relationship is used for yelloweye specifying that spawning output per unit weight increases with fish weight; therefore all references to spawning output were in terms of eggs produced, instead of spawning biomass. Yelloweye rockfish were estimated to have been lightly exploited until the mid-1970's, when catches increased and a rapid decline in biomass and spawning output began. Spawning output is estimated to have reached a minimum in 2000, at 15.7% of unexploited levels (very similar to the 15.8% from the 2009 assessment). Yelloweye rockfish spawning output was estimated to have been gradually increasing since that time, in response to large reductions in harvest. Although the relative trend in spawning output is quite robust to uncertainty in the estimated removals, the absolute scale of the time series is very sensitive global shifts in removals. The estimated relative depletion level in 2009 is 20.2% (very similar to the estimate of 20.3% from the 2009 assessment) and 21.4% in 2011, corresponding to 219 million eggs. The range over states of nature indicates less uncertainty in level of depletion (18.9-24.0%) than in the absolute scale of the estimated spawning output: 146-371 million eggs in 2011. The portions of the total spawning output within each of the three states differs, with California and Oregon having very similar estimates of spawning output at unexploited equilibrium, with Washington considerably lower. Oregon was estimated to have the largest 2011 spawning output, followed by California, then Washington. Relative depletion also varies by state, with California estimated to be at 17.3% of unexploited conditions, Oregon, 23.9%, and Washington, 27.2%.

The coast-wide abundance of yelloweye rockfish was estimated to have dropped below the $SB_{40\%}$ management target in 1988 and the overfished threshold in 1994. In hindsight, the spawning output passed through the target and threshold levels with annual catch averaging almost five times the current estimate of the *MSY*. The coast-wide stock remains below the overfished threshold, although the spawning output was estimated to have been increased by 36% since 2000 (from 161 to 219 million eggs), in response to reductions in harvest. The degree of increase is largely insensitive to the magnitude of historical catch and only moderately sensitive to the value of steepness, but the absolute scale of the population reflects alternate removal series very closely. Fishing mortality rates were estimated to have been in excess of the current *F*-target for rockfish of $SPR_{50\%}$ from 1976 through 1999. Relative exploitation rates (catch/biomass of age-8 and older fish) are estimated to have peaked at 12.7% in 1992, but have been at or less than 1.1% after 2001. The alternate states of nature result in estimated exploitation rates ranging from less than 0.9% to less than 1.7% of the period 2002-2010.

Data for yelloweye rockfish are sparse and relatively uninformative, especially regarding current trend. Historical catches are very uncertain, as yelloweye comprise a small percentage of overall rockfish removals and actual species-composition samples are infrequently available for historical analyses. Currently available fishery-independent indices of abundance are imprecise and not highly informative. It was unclear whether increased rates of recovery (or lack thereof) will be detectable without more precise survey methods applied over broad portions of the coast. Fishery data are also unlikely to produce conclusive information about the stock for the foreseeable future, due to lack of retention and active avoidance of yelloweye among all fleets.

For these reasons, it was unlikely that the major uncertainties in this assessment will soon be resolved.

Current medium-term forecasts predict increases in coast-wide abundance under the SPR=71.9% rebuilding strategy, however these increases are largely driven by the California and Oregon portions of the stock. In fact, the Washington portion was projected to remain at current levels under recent allocation of catch; however, this result was likely to be sensitive to future revision of the estimated Washington historical catch series. The estimated ACL values for 2013 and 2014 are only slightly larger (17.7, 18.0) than the 17.0 value set for 2011 and 2012 and less that that predicted from the 2009 rebuilding analysis (21.0, 20.5), which was based on a higher fishing mortality associated with a 71.9% SPR.

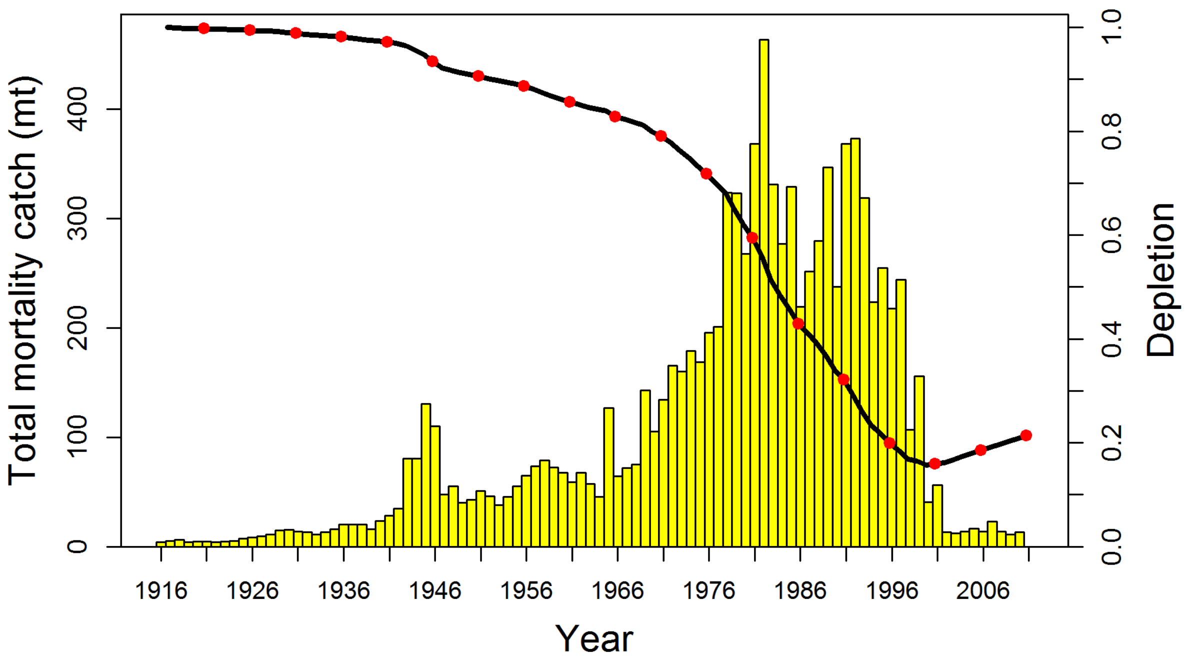

Figure 8. Level of estimated depletion (line) and total catch (bars) for yelloweye rockfish, 1916-2009.

The complete versions of: "Status of the U.S. yelloweye rockfish resource in 2011 (Update of 2009 assessment model)" and "Rebuilding analysis for yelloweye rockfish based on the 2011 update stock assessment" can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information on the yelloweye rockfish assessment, please contact Ian Taylor at Ian.Taylor@noaa.gov

Cowcod rockfish
The complete version of: "Cowcod status report" can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/by-species/

2. Slope Rockfish

a) Stock assessments

Full assessments of Pacific ocean perch rockfish and blackgill rockfish and an update of the darkblotched rockfish assessment were conducted in 2011.

Pacific ocean perch

This assessment applies to the Pacific ocean perch (*Sebastes alutus*) (POP) species of rockfish off of the U.S. West Coast from Northern California to the Canadian Border. Measurable harvest of Pacific ocean perch off of the northern half of the U.S. West Coast first occurred in 1940 and ramped up rapidly from under 300 mt in 1948 to over 2,000 in 1952. Estimated landings averaged 2,200 mt from 1952 to 1960, and then increased to between 5,000 and 20,000 mt during the mid-1960s. The largest removals in 1966-1968 were largely the result of harvest by foreign vessels. The fishery proceeded with more moderate removals of between 1,000 and 3,000 metric tons per year from 1969 through 1980, with the foreign fishery ending in 1977, and between 1,000 and 2,000 mt per year from 1981 through 1994. Management measures further reduced landings which fell steadily thereafter until reaching between 60 and 150 metric tons per year from 2002 through 2010, with total yearly catch, including discard, estimated to have been between 75 and 210 metric tons during those years.

This is the first full assessment of Pacific ocean perch since 2003 and the first one conducted in Stock Synthesis (SS, version 3.21d, R. Methot) since those conducted in the original version of Synthesis in the 1990s. The resultant SS model treats the data somewhat differently than the stand-alone forward-projection statistical catch-at-age model (Ianelli et al. 2000; Hamel et al. 2003; Hamel 2005, 2007, 2009). In addition, nearly all of the sources of data for Pacific ocean perch have been re-evaluated for 2011. Changes of varying degrees have occurred in the data from those used in previous assessments. These current data represent the best available scientific information. The landings history has been updated and extended back to 1940, since records indicate that harvest was negligible before that year. Survey data from the Alaska and Northwest Fisheries Science Centers have been used to construct series of indices using a GLMM model (J. Wallace, pers. comm) as well as length, age and conditional age-at length compositions consistent with the stratifications used for constructing the indices.

The assessment uses landings data and discard-fraction estimates; catch-per-unit-of-effort (CPUE) and survey indices; length or age composition data for each year and fishery or survey (with conditional age at length compositional data and mean-length at age data used in preliminary models); information on weight-at-age, maturity-at-age, and fecundity-at-age; priors on natural mortality (by sex) and the steepness of the Beverton-Holt stock-recruitment relationship (for preliminary models and sensitivities); estimates of ageing error; and (iteratively) sigma-r (representing the variability of the recruitments about the stock-recruitment curve) as inputs to the forward projection age structured model (SS). Recruitment at “equilibrium biomass”, length-based selectivity of the fishery and surveys, retention of the fishery, catchability of the surveys, the time series of biomass, age and size structure, and current and projected future stock status are outputs of the model. Growth, natural mortality and steepness were fixed in the final model after being estimated in preliminary models. This was done to simplify the models and due to relatively flat likelihood surfaces, such that fixing parameters and then varying them was deemed the best way to characterize uncertainty.

A number of sources of uncertainty are explicitly included in this assessment. For example, allowance is made for uncertainty in survey catchability coefficients. Furthermore, this assessment, unlike previous assessments, includes gender differences in growth and survival, a non-linear relationship between individual spawner biomass and effective spawning output, and a more complicated relationship between age and maturity, based upon published information. As is always the case, overall uncertainty is greater than that predicted by a single model specification. Among other sources of uncertainty that are not included in the current model are the degree of connectivity between the stocks of Pacific Ocean perch off of Vancouver Island, British Columbia and those in PFMC waters, and the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of Pacific ocean perch.

A reference case was selected which adequately captures the central tendency for those sources of uncertainty considered in the model. For West Coast rockfish, a stock is considered overfished when it is below 25% of virgin spawning biomass. Currently, the spawning stock is believed to be near 20% of the unfished level; roughly 40% higher than the low of 14% reached in 1999. POP is not expected to reach the rebuilding target (40% of the unfished level) for more than 30 years. This is in contrast to the 2009 and other recent assessments which indicated a higher depletion level (near 30%) and a shorter rebuilding time. This is due to the increase in the estimated virgin biomass (B_0) in the current assessment rather than a change in current estimated biomass (which is nearly the same). POP has not been subject to overfishing since 2000. Although catches were generally near or below harvest guidelines during the 1990s, the current assessment suggests that exploitation rates throughout most of the 1980s and 1990s were higher than those identified in more recent assessments as sustainable. POP are essentially managed on a regional basis, as they occur almost exclusively off of Oregon and Washington for the West Coast. Management and assessment of stock status might be improved through greater cooperation with British Columbia, as the stock extends northward into Canadian waters. Recent catch and levels of depletion are presented in Figure 9.

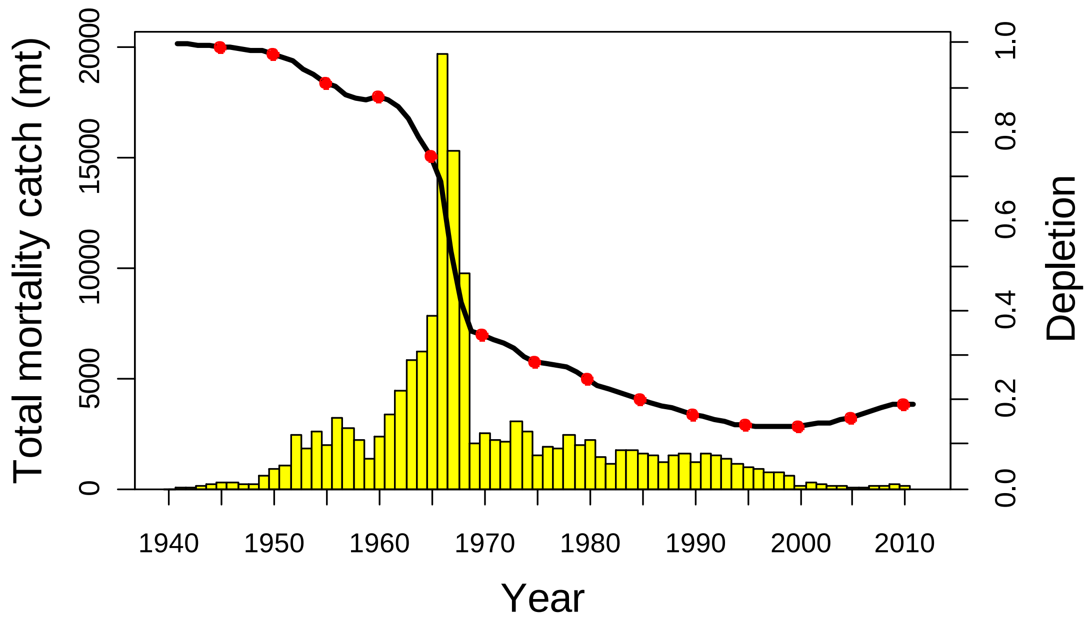

Figure 9. **Level of catch (bars) and depletion (line) for Pacific ocean perch, 1940-2011.**

The complete versions of: "Stock of Pacific Ocean Perch in Waters off of the U.S. West Coast in 2011" and "Rebuilding Analysis for Pacific Ocean Perch in 2011" can be viewed at : http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information on this assessment, contact Owen Hamel at: Owen.Hamel@noaa.gov.

Darkblotched rockfish

This assessment applies to the darkblotched rockfish (*Sebastes crameri*) for the combined U.S. Vancouver, Columbia, Eureka and Monterey INPFC areas. The largest landings (removals between 2,300 and 4,200 metric tons) of darkblotched were taken from 1966-1968, primarily by foreign vessels. From 1969 to 1981, the fishery proceeded with more moderate landings of between 200 and 1,000 mt per year, with the foreign fishery ending in 1977. A second peak in landings occurred between 1982 and 1993, with landings exceeding 1,100 mt in 10 of 12 years, reaching over 2,400 mt in 1987. Management measures reduced landings to below 950 mt since 1994, below 400 mt since 1999, and below 200 mt in recent years. This update used the SS model, version 3.03a and data through 2008. Based on this assessment, darkblotched rockfish on the West Coast remain below the overfished threshold, but the spawning biomass appears to have increased steadily over the past 7 or 8 years to 27.5% of the unfished level. Since 2001, overfishing occurred only once, with estimated catch exceeding the ABC by 2 mt (0.8%) in 2004.

A number of sources of uncertainty were explicitly included in this assessment. For example, allowance was made for uncertainty in natural mortality and the parameters of the stock-recruitment relationship. There were also other sources of uncertainty that were not included in the current model, including the degree of connection between the stocks of darkblotched rockfish off British Columbia and those in PFMC waters; the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of darkblotched rockfish; and gender-based differences in survival. With the stock extending northwards into Canadian waters, management and assessment of stock status might be improved through greater cooperation with British Columbia.

The recruitment pattern for darkblotched rockfish is similar to that of many rockfish species, with highly variable recruitment from year to year. With a few exceptions, the 1980s and 1990s provided rather poor year-classes compared with average historical recruitment levels. Although the 1999 and 2000 year-classes appear to be among the largest year-classes since 1975, they are only now reaching the age of 50% maturity, and will not be fully mature for another decade (when their fecundity will also be over 3 times what it is now). As a result, the full impact of these recruits will not be felt for years to come. 2008 saw another large year-class whose impact will not be evident for years. The exploitation rate (percent of biomass taken) on fully-selected animals peaked historically near 14% in the intensive foreign fishery of the mid-1960's. The exploitation rate dropped by the late 1960's, but increased slowly and steadily from the late 1970's to 1987, at roughly 15%, and stayed high until 1998, with the continuing decline in exploitable biomass. Over the past 10 years the exploitation rate has fallen from a peak of 16% in 1998 to under 3%. This stock is no longer overfished, however spawning biomass remains below the management target of 40% of unfished spawning biomass, and a rebuilding analysis was conducted in conjunction with the 2011 update assessment. The history of recruitment and levels of depletion in the fishery are presented in Figure 4.

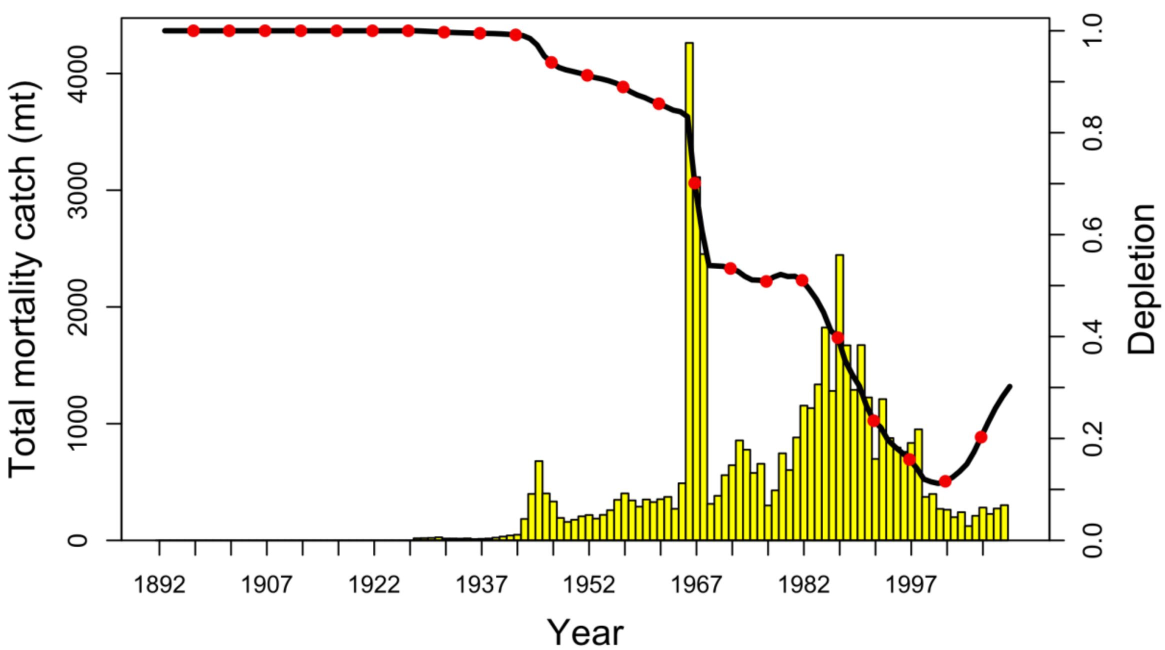

Figure 10. **Level of depletion (line) and total catch (bars) for darkblotched rockfish, 1892-2011.**
The complete versions of: "Status and Future Prospects for the Darkblotched Rockfish Resource in Waters off Washington, Oregon, and California as Updated in 2011" and " Rebuilding analysis for darkblotched rockfish in 2011" can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information on this assessment, contact Andi Stephens: Andi.Stephens@noaa.gov

3. Thornyheads

a) Stock assessment

No thornyhead assessments were conducted during 2011.

4. Sablefish

a) Stock assessment

A full sablefish assessment was conducted in 2011.

Sablefish
This assessment reports the status of the sablefish (*Anoplopoma fimbria*, or 'black cod') resource off the coast of the United States from southern California to the U.S.-Canadian border. Sablefish landings were small (< 5,000 mt), and were primarily harvested by hook-and-line fisheries until the end of the 1960s. A very large catch by foreign vessels fishing pot gear in 1976 resulted in the largest single-year removal of over 25,000 mt from the stock. This was followed by a rapid rise in domestic pot and trawl landings, such that over 240,000 mt of sablefish were landed between 1975 and 1990. Annual landings have remained below 10,000 mt in subsequent years, divided approximately 44% from hook-and-line, 14% from pot and 43% from trawl gear during the most recent decade. Model estimates of discarding result in total dead catches that are an average of 7.8% larger than reported landings over the last decade. The data sources for this stock assessment include: landings, length- and age-frequency data from both the retained and, in recent years the discarded portion of the commercial catch. Discard rates as well as mean observed individual body weight in the discards are also included. The National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC) shelf-slope trawl survey relative biomass index is the primary source of stock trend information, updated to cover the period 2003-2010 and including depths from 55-1,280 m. Other (discontinued) survey indices contributing information on trend and sablefish demographics include: the NWFSC slope survey conducted from 1998-2002, the AFSC slope survey (1997-2001), and the AFSC/NWFSC triennial shelf trawl survey (1980-2004). Environmental time-series including both sea-surface height (used in previous sablefish assessments) and zooplankton abundance were also investigated.

All externally estimated model parameters, including those defining the weight-length relationship, maturity schedule, and fecundity relationships, have been revisited and, in some cases, revised from the values used in previous assessments. The assessment explicitly estimates parameters describing dimorphic growth and mortality differences between male and female sablefish. Recruitment uncertainty is included via a full time-series of estimated deviations from the stock-recruit curve. Uncertainty in leading parameters such as natural mortality, the unexploited equilibrium level of the stock-recruit function and catchability coefficients of the survey indices are explicitly included in the model results. The available data for sablefish are largely uninformative about the absolute size and productivity of the stock. This is due to the 'one-way-trip' nature of the historical series: a slow and steady decline in spawning biomass consistent with a larger less productive stock, a smaller more productive stock, or many combinations in between. Historical catches provide some information about the minimum stock size needed to have supported the observed time-series but little information about the upper bounds for the stock size. Likelihood profiles, parameter estimates and general model behavior illustrate that small changes in many parameters can result in differing point estimates for management reference points, however the uncertainty about these estimates remains large unless leading model parameters, such as natural mortality, survey catchability, as well as historical recruitments, are fixed at arbitrarily selected values. This assessment includes the uncertainty for these unknown quantities, with the exception of steepness. This uncertainty will remain until a more informative time-series and better quality demographic and biological information is accumulated for the stock.

Sablefish are estimated to have been exploited at a modest level through the first half of the 20th century. Following a period of recruitments estimated to have been above average, but highly uncertain, the spawning stock biomass rebounded to nearly unexploited levels in the late 1970s. Large harvests during those years, and throughout the 1980s, are estimated to have caused the stock to decline nearly monotonically to the present. The coast-wide abundance of sablefish was estimated to have dropped below the $SB_{40\%}$ management target in 2009 and is currently declining steeply. The cause of this trend appears to be primarily due to relatively poor recruitments, as the fishing intensity remained below relative SPR target rates between 1988 and 2008. The relative spawning biomass is estimated to be at only 33% of unexploited levels in 2011; however this value is highly uncertain (~95% intervals range from 18-49%). It appears that large 1999 and 2000 year classes briefly slowed the rate of stock decline between 2002 and 2005. An above-average 2008 cohort is currently moving through the population, however it has yet to mature, and therefore is not currently contributing to the trend in spawning biomass. Since 2001, the total estimated dead catch has been only 79% of the sum of the OFLs (ABCs at the time) and 87% of the ACLs (OYs at the time). In only one year of the last 10, 2008, did the estimated dead catch exceed the ACL (and OFL) by 5% (3%). In retrospect, both relative SPR and exploitation fraction are estimated to be increasing rapidly over the last four years. This assessment estimates that the 2010 SPR is 104% of the SPR=45% management target. Recent catch and levels of depletion are presented in Figure 11.

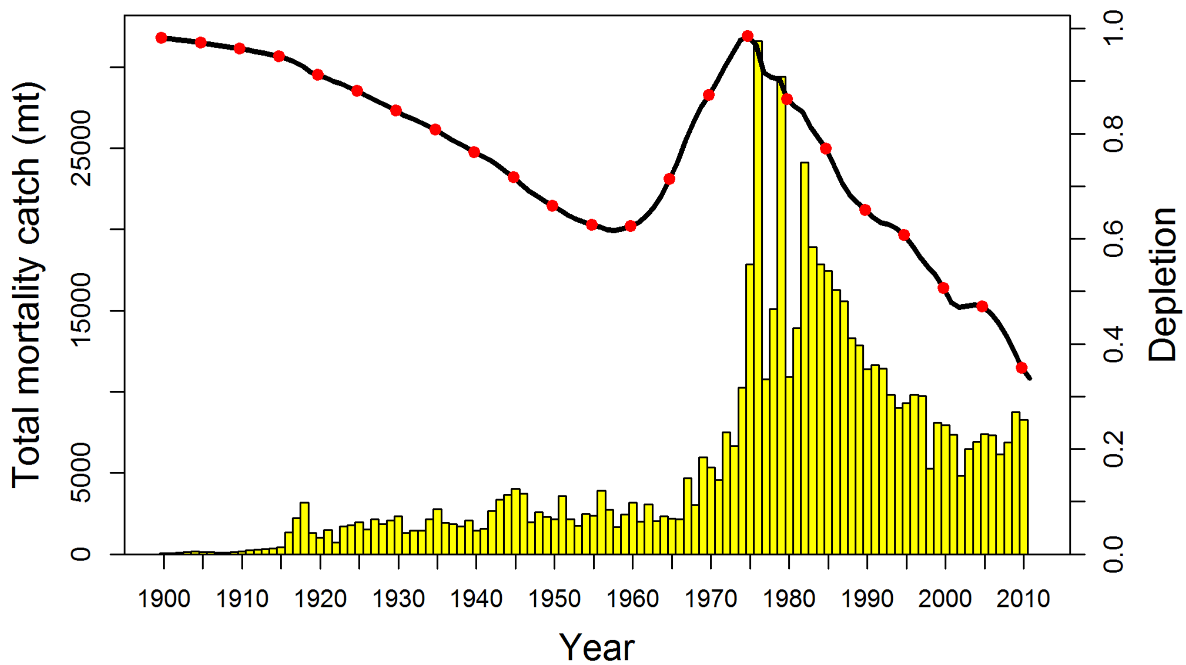

Figure 11. **Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for sablefish, 1900-2011.**

The complete document: *Status of the U.S. sablefish resource in 2011* can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-year/gf2011/.

For more information on the sablefish assessment, please contact Ian Stewart at Ian.Stewart@noaa.gov.

5. Flatfish

a) Stock assessment

Full assessments were conducted for Dover sole and Petrale sole in 2011.

Dover sole
This was an assessment of Dover sole (*Microstomus pacificus*) that reside in the waters off California, Oregon and Washington from the U.S./Canadian border in the north to the U.S./Mexico border in the south. Dover sole are also harvested from the waters off British Columbia and in the Gulf of Alaska, and although those catches were not included in this assessment, it is not certain if those populations contribute to the biomass of Dover sole off of the U.S. West Coast.

Dover sole were first landed in California in the early part of the 20^{th} century and the fishery began increasing landings in Oregon and Washington in the 1940's. Landings remained relatively constant throughout the 1950's and 1960's before increasing rapidly into the early

1990's. Subsequently, the landings declined (mostly in California) until 2007 when harvest guidelines increased the allowable catch. Groundfish trawl fisheries land the majority of Dover sole while fixed gears, shrimp trawls, and recreational fisheries make up a very small amount of fishing mortality. Some discarding of Dover sole occurs in the fisheries, and appears to have different patterns based on location. These discards were estimated in the model and total catches are reported, as opposed to landings.

The estimated spawning biomass has shown a slight decline over the entire time series with two periods of more significant decline (the early 1960's and the 1980's). Even though catches continued to increase in the 1970's, the spawning biomass also increased because of larger than average recruitment in the early 1960's. A period of smaller than average recruitments in the late 1970's and early 1980's along with the highest catches on record caused a decline in spawning biomass throughout the 1980's. More recently, spawning biomass has been increasing, although a recent increase in catch and low estimated recruitment in the early 2000's seem to be resulting in a slight downturn in spawning biomass.

Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high. Sensitivities showed that this uncertainty can be largely attributed to uncertainty in natural mortality. The estimates of spawning biomass from the 2005 assessment are contained within the intervals estimated from this assessment, but the average spawning biomass from this assessment is approximately 40% larger. The 95% confidence interval of estimated depletion (67–100%) is well above the target of 25% of unfished spawning biomass.

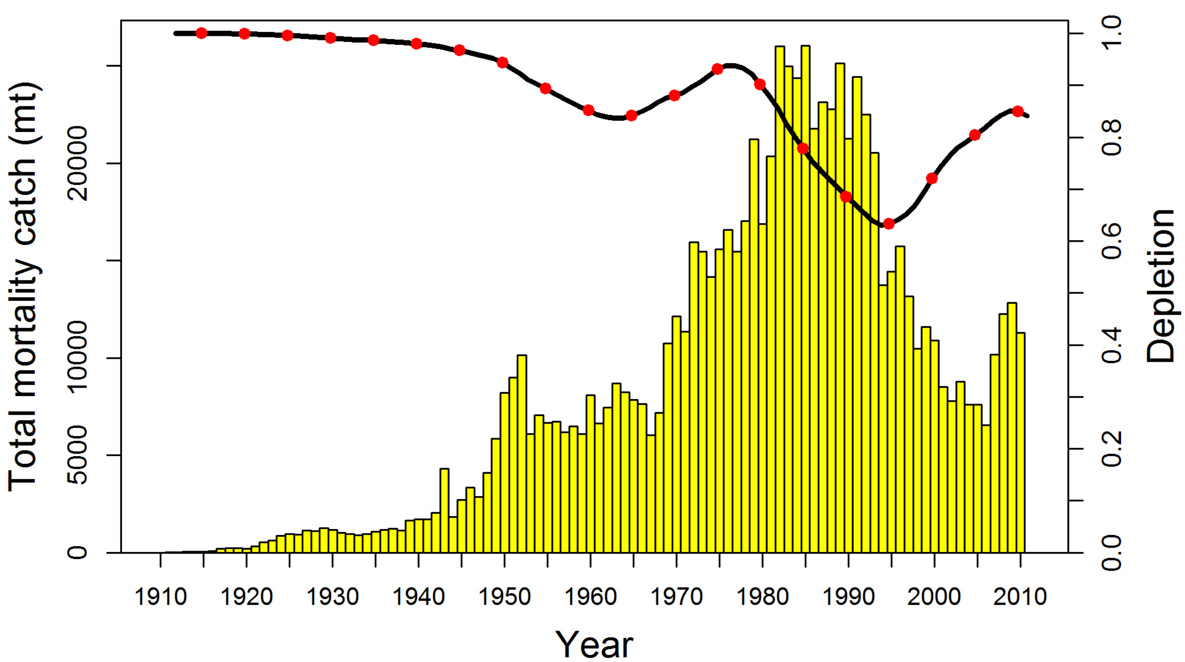

Figure 12. The time-series of total removals (bars) and estimated depletion (line) for Dover sole, 1910–2011.

The complete version of “The Status of Dover Sole (*Microstomus pacificus*) along the U.S. West Coast in 2011” can be found online at:
http://www.pcouncil.org/groundfish/stock-assessments/

For more information on the Dover sole assessment, please contact Allan Hicks at Allan.Hicks@noaa.gov.

Petrale sole
This assessment reports the status of the petrale sole (*Eopsetta jordani*) resource off the coast of California, Oregon, and Washington using data through 2010. While petrale sole are modeled as a single stock, the spatial aspects of the coast-wide population are addressed through geographic separation of data sources/fleets where possible and consideration of residual patterns that may be a result of inherent stock structure. There is currently no genetic evidence suggesting distinct biological stocks of petrale sole off the U.S. coast. The limited tagging data available to describe adult movement suggests that petrale sole may have some homing ability for deepwater spawning sites but also have the ability to move long distances between spawning sites and seasonally.

The earliest catches of petrale sole are reported in 1876 in California and 1884 in Oregon. Recent annual catches during 1981–2010 range between 701-3,056 mt (Figure 13). Petrale sole are almost exclusively caught by trawl fleets. Non-trawl gears contribute less than 2% of the catches. Based on the 2005 assessment, subsequent ACLs were reduced to 2499 mt. Following the 2009 assessment /ACLs were further reduced to 976 mt for 2011. From the inception of the fishery through the war years, the vast majority of catches occurred between March and October (the summer fishery), when the stock is dispersed over the continental shelf. The post-World War II period witnessed a steady decline in the amount and proportion of annual catches occurring during the summer months (March-October). Conversely, petrale catch during the winter season (November–February), when the fishery targets spawning aggregations, has exhibited a steadily increasing trend since the 1940’s. Since the mid-1980s, catches during the winter months have been roughly equivalent to or exceeded catches throughout the remainder of the year. In 2009 catches of petrale sole began to be restricted due to declining stock size.

Petrale sole were lightly exploited during the early 1900s but by the 1950s, the fishery was well developed and showing clear signs of depletion and declines in catches and biomass (Figure 13). The rate of decline in spawning biomass accelerated through the 1930s–1970s reaching minimums generally around or below 10% of the unexploited levels during the 1980s and 1990s (Figure 13). The petrale sole spawning stock biomass is estimated to have increased slightly from the late 1990s, peaking in 2005, in response to above average recruitment (Figure 13). However, this increasing trend reversed between 2005 and 2010 and the stock has been declining, most likely due to strong year classes having passed through the fishery. Since 2010 the total biomass of the stock has increased slightly as a large 2007 recruitment appears to be moving into the population. Note that these fish are not yet fully mature so this increase is not strongly reflected in the spawning biomass. The estimated relative depletion level in 2011 is 18% (~95% asymptotic interval: ±3.6%, ~ 75% interval based on the range of states of nature: 15.1-21.4%), corresponding to 4,720 mt (~95% asymptotic interval: ±493 mt, states of nature interval: 4,440-5,052 mt) of female spawning biomass in the base model. The base model indicates that the spawning biomass has been below 25% of the unfished level since 1956.

Unfished spawning stock biomass was estimated to be 26,278 mt in the base case model. The target stock size ($SB_{25\%}$) is therefore 6,570 mt which gives a catch of 2,578 mt. Model estimates of spawning biomass at MSY and MSY yield are slightly lower than those specified under the current harvest control rule. Maximum sustained yield (MSY) applying recent fishery selectivity and allocations was estimated in the assessment model at 2,588 mt, occurring at a spawning stock biomass of 5,805 mt (SPR = 0.25). Pacific coast flatfish, including Petrale sole, are considered overfished when the stock falls below 12.5% of unfished spawning biomass and rebuilt when it reaches 25% of unfished spawning biomass.

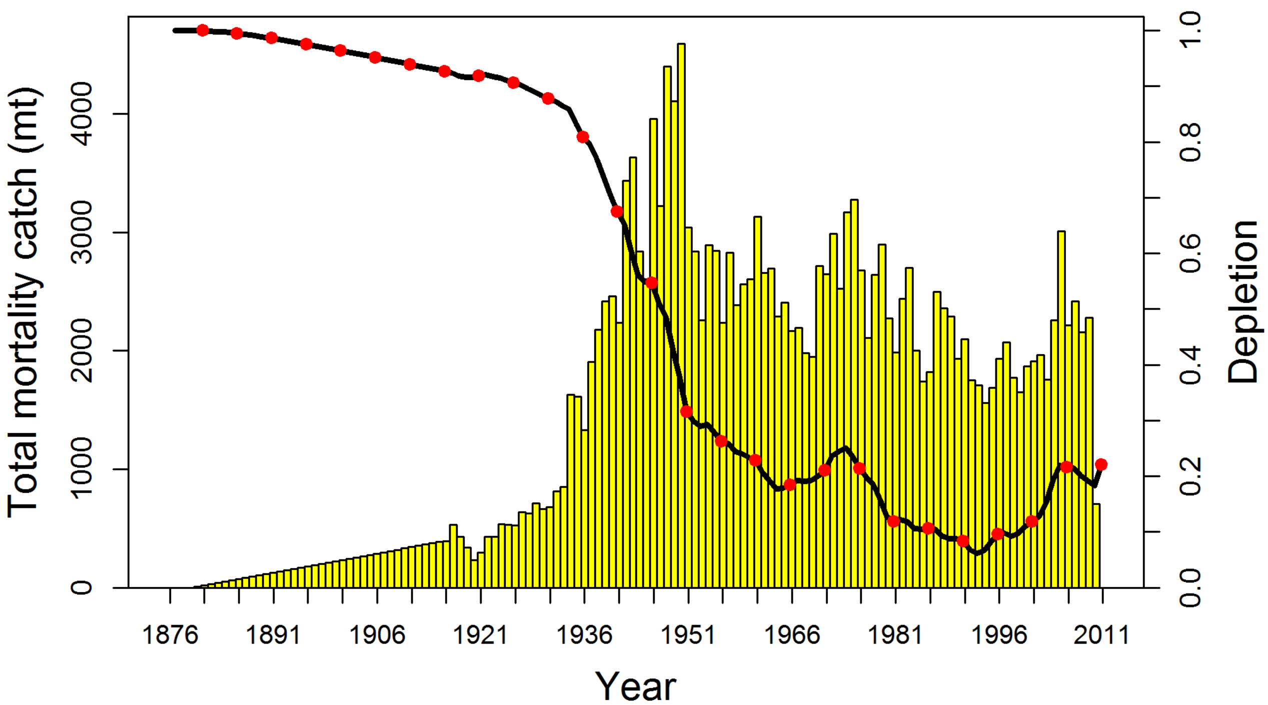

Figure 13. Time series of spawning biomass and catch for petrale sole.

The complete versions of: “Status of the U.S. petrale sole resource in 2010” and “Rebuilding analysis for petrale sole” can be viewed online at:
http://www.pcouncil.org/groundfish/gfstocks.html

For more information on the petrale sole assessment, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

6. Pacific hake

This stock assessment reports the collaborative efforts of the official U.S. and Canadian JTC members, as well as one previous assessment participant, contributing to the first analysis conducted according to the Agreement between the government of the United States and the Government of Canada on Pacific hake/whiting, signed at Seattle, Washington, on November 21, 2003, and formally established in 2011. The assessment reports the status of the coastal Pacific hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the United States and Canada. Coast-wide fishery landings of Pacific hake averaged 222 thousand mt from 1966 to 2011, with a low of 90 thousand mt in 1980 and a peak of 363 thousand mt in 2005. Prior to 1966, the total removals were negligible relative to the modern fishery. Recent coast-wide landings from 2007-2011 have been above the long term average, at 261 thousand mt. Landings between 2001 and 2008 were predominantly comprised of fish from the very large 1999 year class, with the cumulative removal from that cohort exceeding 1.2 million mt. In 2011, U.S. fisheries caught mostly 3-year old fish from the 2008 year class, while the Canadian fisheries encountered older fish from the 2005 and 2006 year classes more frequently than the U.S. fisheries. The current treaty between the United States and Canada, establishes U.S. and Canadian shares of the coast-wide TAC at 73.88% and 26.12%.

Following the 2010 assessment, nearly all of the data sources available for Pacific hake were reconstructed and thoroughly re-evaluated for 2011 from the original observations using consistent, and in some cases improved methods. These improved data streams have been updated for 2012 with the addition of new age distributions from the 2011 fishery and acoustic survey, as well as the 2011 acoustic survey biomass index. The assessment depends primarily upon the acoustic survey biomass index (1995, 1998, 2001, 2003, 2005, 2007, 2009 and 2011) for information on the scale of the current hake stock. The 2011 index value is the lowest in the time-series. The aggregate fishery age-composition data (1975-2011) and the age-composition data from the acoustic survey contribute to the assessment model's ability to resolve strong and weak cohorts. Both sources show a strong 2008 cohort, but differ somewhat in the relative magnitude of the weaker 2005 and 2006 cohorts. The assessment is fully Bayesian, with the base-case model incorporating prior information on two key parameters (natural mortality, M, and steepness of the stock-recruit relationship, h) and integrating over estimation and parameter uncertainty to provide results that can be probabilistically interpreted. Although the Bayesian results presented include estimation uncertainty, this within-model uncertainty is likely a gross underestimate of the true uncertainty in current stock status and future projections, since it does not include structural modeling choices, data-weighting uncertainty and scientific uncertainty in selection of prior probability distributions. Pacific hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts, and a biennial rather than annual fishery-independent acoustic survey, will continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Currently, uncertainty in this assessment is largely a function of the disparate survey indices in 2009 and 2011 coupled with the large, but uncertain 2008 year-class. The vast uncertainty in current status and future trends will likely persist as long as the acoustic survey is conducted only every other year, since the dynamics of Pacific hake are elastic enough for the assessment model to respond dramatically to each new biennial survey observation.

The base-case stock assessment model indicates that the Pacific hake female spawning biomass was well below the average unfished equilibrium in the 1960s and 1970s. The stock is estimated to have increased rapidly after two or more large recruitments in the early 1980s, and then declined rapidly after a peak in the mid- to late 1980s to a low in 2000. This long period of decline was followed by a brief increase to a peak in 2003 as the exceptionally large 1999 year class matured. The stock is then estimated to have declined with the aging 1999 year class to a time-series low in 2009. The current median posterior spawning biomass is estimated to be 32.6% of the average unfished equilibrium level. However, this estimate is quite uncertain, with 95% posterior credibility intervals ranging from historical lows to above the average unfished equilibrium levels. Estimates of historical Pacific hake recruitment indicate very large year classes in 1980, 1984, 1999, and 2008. The U.S. fishery and acoustic age compositions both show the 2008 year class comprised a very large proportion of the observations in 2010 and 2011. Uncertainty in estimated recruitments is substantial, especially for 2008, as indicated by the broad posterior intervals. The fishing intensity on the Pacific hake stock is estimated to have been below the $F_{40\%}$ target until 2007. Although the official catch targets adopted by the U.S. and Canada have been exceeded only once in the last decade (2002), in retrospect the fishing intensity is estimated to have exceeded the target rate in four of the last five years. Recent catch and levels of depletion are presented in figure 14.

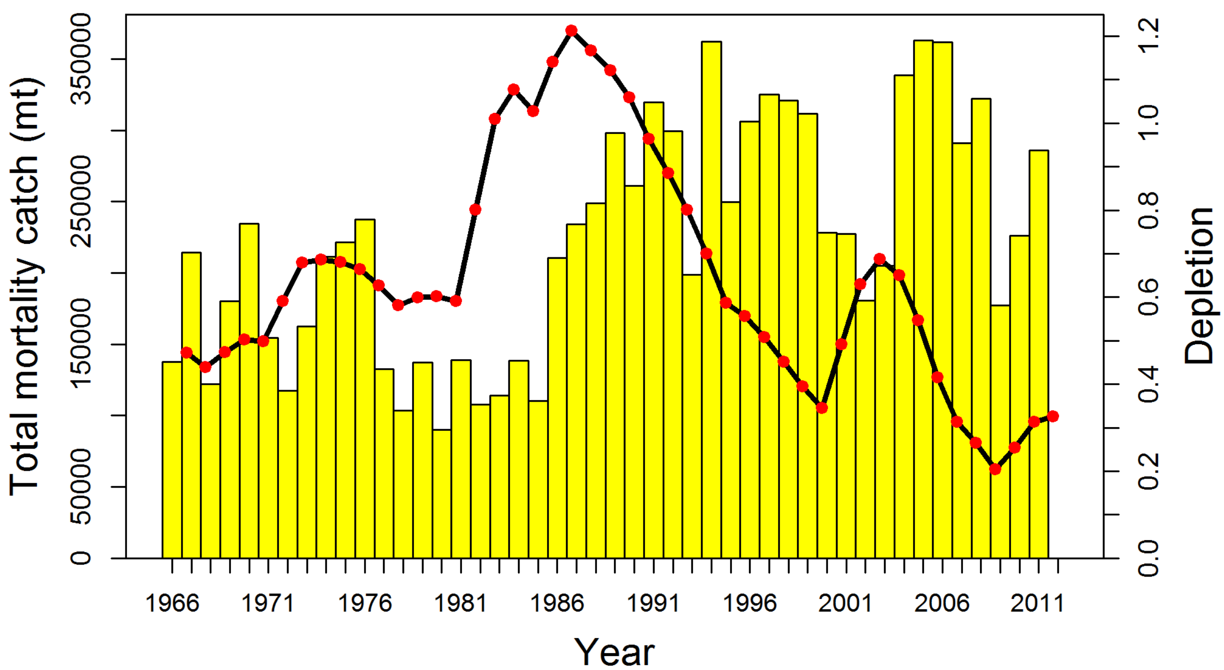

Figure 14. **Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2012.**

The complete document: "Status of the Pacific hake (Whiting) stock in U.S. and Canadian Waters in 2012" can be viewed online at:
http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Whiting-Management/Treaty-docs.cfm.

For more information on the Pacific hake assessment, please contact Ian Stewart at Ian.Stewart@noaa.gov.

7. Other species

a) Stock assessments

A full assessment for spiny dogfish was conducted in 2011.

Spiny dogfish

Spiny dogfish (*Squalus suckleyi*) in the Northeast Pacific Ocean occur from the Gulf of Alaska, with isolated individuals found in the Bering Sea, southward to San Martin Island, in southern Baja California. They are extremely abundant in waters off British Columbia and Washington, but decline in abundance southward along the Oregon and California coasts. This assessment focuses on a portion of a population that occurs in coastal waters of the western United States, off Washington, Oregon and California, the area bounded by the U.S.-Canada border on the north and U.S.-Mexico border on the south. The assessment area does not include Puget Sound or any other inland waters. The population within this area is treated as a single coast-wide stock, given the migratory nature of the species and the lack of data suggesting the presence of multiple stocks.

The spiny dogfish stock included in this assessment likely has interaction and overlap with dogfish observed off British Columbia. A spatial population dynamics model, which included data from several tagging studies in the Northeast Pacific Ocean, estimated movement rates of about 5% per year between the U.S. coastal sub-population of dogfish and that found along the west coast of Vancouver Island in Canada. Given this relatively low estimated rate of exchange, it was considered appropriate to proceed with the assessment for the limited area of species range, recognizing that the scope of this assessment does not capture all of the removals and dynamics which likely bear on the status and trends of the larger, transboundary population.

In the coastal waters of the U.S. West Coast, spiny dogfish has been utilized since early 20th century. The history of dogfish utilization included a brief but intense fishery in the 1940s, which started soon after it was discovered that livers of spiny dogfish contain high level of vitamin A. During the vitamin A fishery, removals averaged around 6,821mt per year reaching their peak of 16,876 mt in 1944. The fishery ended in 1950 with the advent of synthetic vitamins. In the mid-1970s, a food fish market developed for dogfish when the species was harvested and exported to other counties, primarily Great Britain. This fishery existed until very recently and the landings averaged around 450 mt per year. For the last 10 years landings ranged between 164 and 876 mt.

Even though spiny dogfish was heavily harvested in the 1940s, in general, this species is not highly prized and is mostly taken as bycatch in other commercially important fisheries. It is often discarded when bycaught. It has been taken by three major gear groups, including trawl, hook-and-line and a variety of nets. Since 2002, the discard rates in the trawl fishery were on average 85% of all encountered dogfish catch and in the hook-and-line fishery 52%. The vast majority of commercial catch (more than 90%) has been landed in Washington. A small portion of the catch is taken recreationally.

The assessment shows that the stock of spiny dogfish off the continental U.S. Pacific Coast is currently at 63% of its unexploited level and, therefore, not overfished. Historically, the spawning output of spiny dogfish showed a relatively sharp decline in the 1940s, during the time of the intense dogfish fishery for vitamin A. During a 10-year period (between 1940 and 1950), the spawning output dropped from 99% to under 70% of its unfished level. Between 1950 and 1974, the catches of spiny dogfish were minimal, and the spawning output started to increase (mostly as a result of maturation of younger dogfish that were not selected by the vitamin A fishery). For the last thirty five years, spawning output of spiny dogfish has been slowly but steadily declining due to fishery removals (an export food fish fishery developed in the mid-1970s) and low productivity of the stock. The time-series of total mortality catch (landings plus discards) and estimated depletion for spiny dogfish since 1940 are presented in Figure 15.

The assessment model captures some uncertainty in estimated size and status of the stock through asymptotic confidence intervals estimated within the model. Also, uncertainty from two sources, natural mortality and catch time series, is reported via alternate states of nature in the decision table bracketing the base model results. The estimate of natural mortality was found to have a relatively large influence on the perception of current stock size. The estimated catch time series were included in the decision table to account for lack of historical records on dogfish discard even though sensitivity analysis showed little model sensitivity to alternative historical discard assumptions.

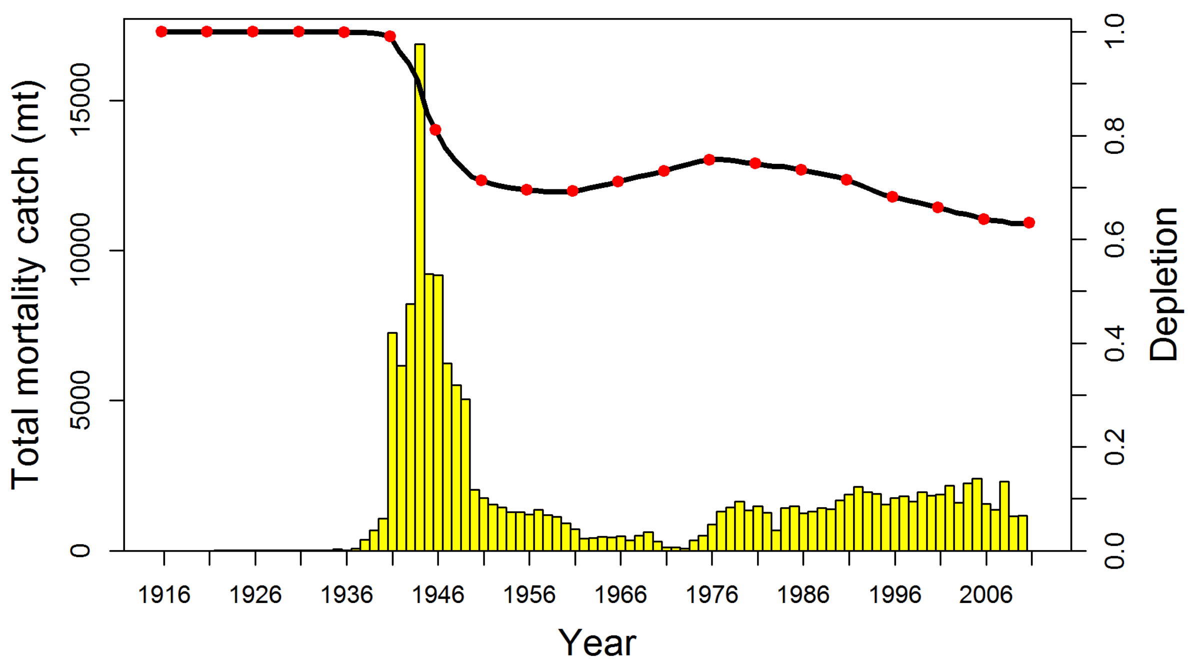

Figure 15. The time-series of recent total mortality catch (bars) and estimated depletion (line) for spiny dogfish, 1940-2010.

The complete version of "Status of the spiny dogfish shark resource off the continental U.S. Pacific Coast in 2011" can be found online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information on the spiny dogfish assessment, contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

D. Other Related Studies

1. The PaCOOS, West Coast habitat data portal

The PaCOOS West Coast Habitat Data Portal and associated server, were conceived in 2005 as a Local Data Access Center (LDAC) of the Integrated Ocean Observing System (IOOS). Funding for its development was provided by the NOAA IOOS Program through the FRAM Division of the Northwest Fisheries Science Center. The database and GIS system had its origin the data collected together for the West Coast Essential Fish Habitat Environmental Impact Statement, which was completed in 2005/2006. Maintained jointly by FRAM and Oregon State University, College of Oceanic and Atmospheric Sciences Seafloor Mapping Laboratory and in collaboration with PSMFC, the portal provides access to data (search, connection, and download), a visualization environment, and integrated navigation tools. The data portal houses an ever expanding array of information including but not limited to geological and geophysical data, benthic habitat maps, fisheries survey datasets, and ocean climatologies. Data access, which includes data searching and metadata harvesting, is provided through IOOS Data Management and Communications (DMAC) compliant pathways such as OPeNDAP, OGC WMS, and ESRI ArcIMS map services. The portal's centerpiece is its unique map viewer environment (http://pacoos.coas.oregonstate.edu/), an online application that provides a map interface to data holdings with custom tools for data downloads and queries. There is a growing user base that includes local, state, and federal agencies within the California Current Large Marine Ecosystem.

The functionality of the PaCOOS data portal is continually being improved and new data sets are being added. During the latter part of 2011 and continuing into 2012, the Active Tectonics and Seafloor Mapping Lab will transition the PaCOOS server from ESRI ArcIMS Internet Map Server software to the current ESRI ArcGIS Server software, and upgrade the application underlying the West Coast Habitat server. Datasets and metadata developed as part of the current Pacific Coast groundfish EFH 5-year review will be placed on the PaCOOS West Coast Habitat Server.

For more information, contact Waldo Wakefield at waldo.wakefield@noaa.gov or Chris Goldfinger at gold@coas.oregonstate.edu

2. Bycatch Reduction Research

In 2011, the West Coast limited entry groundfish trawl fishery began management under a Groundfish Trawl Rationalization Catch Share Program (Pacific Fisheries Management Plan Amendments 20 and 21). This new program establishes annual catch limits and individual fishing quotas along with individual bycatch quotas. These complex fishery management measures have created increased demand for bycatch solutions in the groundfish trawl fishery. Currently, bycatch of overfished species in the west coast groundfish trawl fishery constrains the fishery such that a substantial portion of available harvest is left in the ocean. The NWFSC's Habitat and Conservation Engineering team, working in collaboration with the Pacific States Marine Fisheries Commission, has continued work on a wide range of research projects and outreach to reduce bycatch in Pacific coast fisheries, and recently, to respond to industry needs resulting from the Catch Share Program.

Reducing Chinook Salmon and Rockfish Bycatch in the Pacific hake Fishery

Since 2009, the NWFSC has iteratively developed and tested an open escape window bycatch reduction device (BRD) to reduce Chinook salmon and overfished or rebuilding rockfish species (e.g., darkblotched, canary, and widow) bycatch in the Pacific hake fishery (e.g., Lomeli and Wakefield 2012). In 2011, this BRD was tested using a recapture net to quantify fish escapement rates under normal commercial fishing operations (Figures 16 - 20). Of particular interest was the gear's performance under high volume catches of Pacific hake. Results from this study showed reductions in Chinook salmon, yellowtail rockfish, and widow rockfish bycatch by 21.4, 8.3, and 8.3%, respectively. Escapement of Pacific hake, the target species, was 1.2%. Earlier studies conducted on the same BRD employed artificial illumination, whereas, escapement rates measured with the recapture net were made in the absence of artificial illumination (Lomeli and Wakefield 2012).

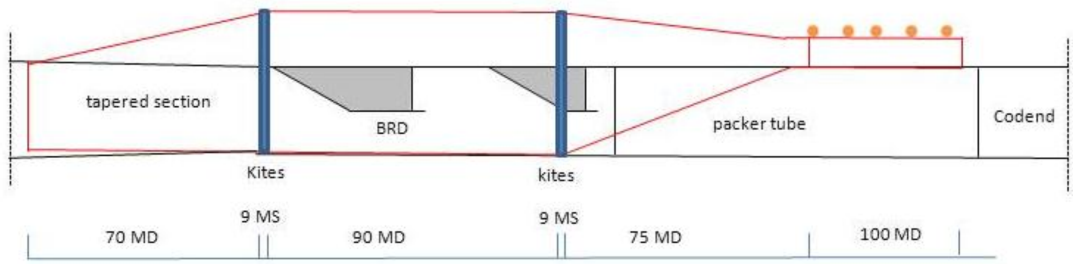

Figure 16. Schematic design of the recapture net incorporated into the open escape window bycatch reduction device used during the current study.

Figure 17. Recapture net under construction and integration with bycatch reduction device in a net loft in Newport, Oregon.

Figure 18. Bycatch Reduction Device and recapture net being deployed aboard a commercial fishing vessel off Washington during July 2011.

Figure 19. Bycatch Reduction Device and recapture net being deployed aboard a commercial fishing vessel off Washington during July 2011. Blue objects encircling recapture net are kites used to hydrodynamically open the net.

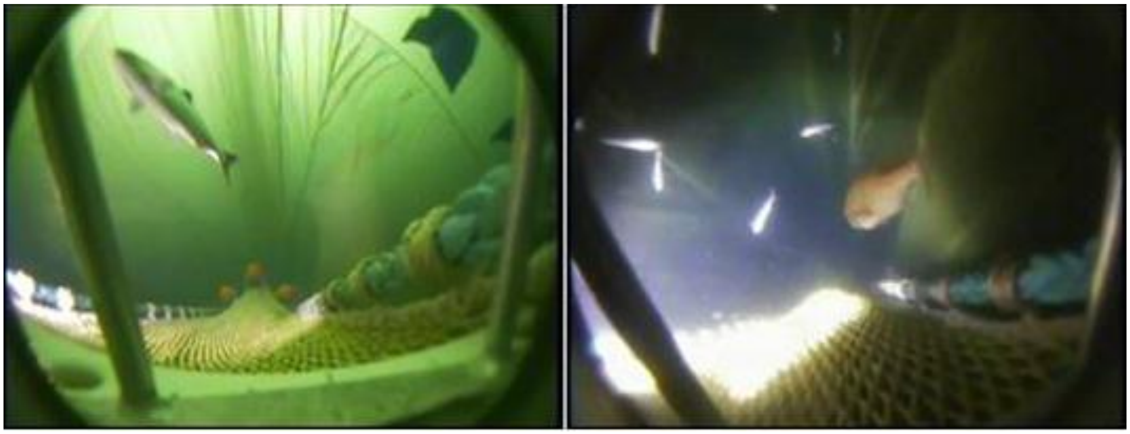

Figure 20. **Video frame grabs showing Chinook salmon (left image), and widow rockfish with Pacific hake (right image) swimming inside the recapture net surrounding the BRD.**

Reducing Pacific Halibut Bycatch in Bottom Trawl Fisheries

In a second project and in response to fishermen's concern about Pacific halibut bycatch, the NWFSC's Habitat and Conservation Engineering Team, working with the Pacific States Marine Fisheries Commission (PSMFC) and the fishing industry, tested the efficacy of a flexible sorting grate bycatch reduction device (BRD) designed to reduce Pacific halibut bycatch. The BRD is built around a four-seam tube of netting that is inserted between the trawl's intermediate and codend and includes two vertical panels (7.5" mesh) and an exit ramp (5.5" mesh) constructed of AQUAPEX® (cross-linked polyethylene tubing). The flexible grate sorts fish by size as they move towards the codend (Figure 21 – bottom left photo). The concept of design is that fish smaller than the sorting grate openings will be retained, whereas fish greater than the sorting grate openings will be excluded from the trawl via the exit ramp (Figure 22 – bottom right photo).

For this project, a recapture net was used to quantify the escapement rates of target and non-target species. Results showed Pacific halibut bycatch reduced numerically by 57% and gravimetrically by 62%. A significant difference in the mean total length was also noted between Pacific halibut caught in the trawl codend and the recapture net codend; with larger fish occurring in the recapture net. Target species loss ranged from 9% to 22%.

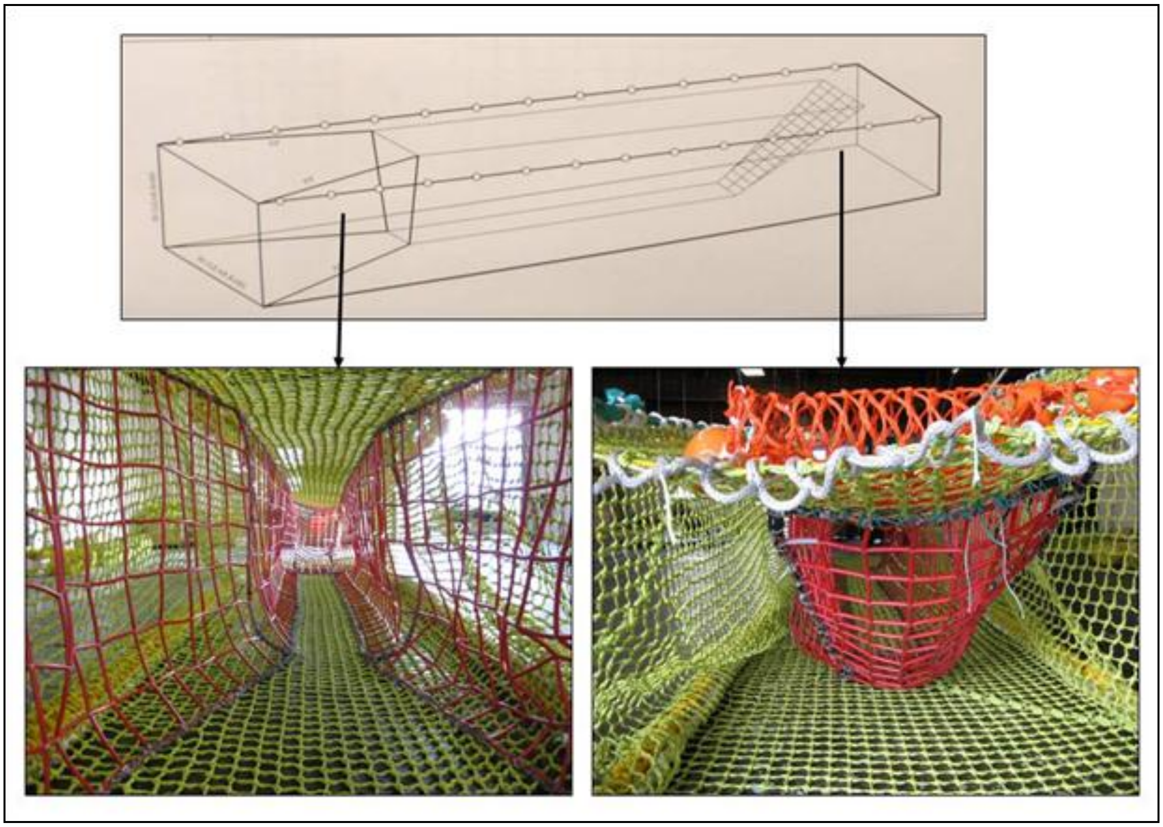

Figure 21. Schematic 3D view of a Pacific halibut flexible sorting grate excluder (top); aft-looking view of the forward portion of the excluder where fish enter and encounter the device (bottom left); forward view of the aft end of the excluder where fish larger than the sorting grate openings would be guided and excluded from the trawl out an exit ramp (bottom right). Image and design is courtesy of Dantrawl, Inc., Seattle, WA.

Figure 22. Comparison of fish caught between the trawl codend and recapture codend during one tow.

Providing Direct Observation Video Camera Systems to Fishermen for Use in Evaluating Industry-Designed Approaches to Reducing Bycatch and Impacts to Benthic Habitats

In 2010, the Northwest Fisheries Science Center (NWFSC) received funding from the NMFS National Bycatch Reduction Engineering Program to build and deploy two video imaging systems and make these systems available to commercial fishers and other sectors of the industry for their use in evaluating industry-designed bycatch reduction devices. In 2011, the NWFSC added three additional video systems to the pool (Figures 23-24) and has successfully operated the loaner program for one year. These camera systems have been used over 20 times across the Pacific hake midwater trawl fishery, groundfish bottom trawl fishery, and the pink shrimp trawl fishery.

Figure 23. One of five autonomous direct observation video camera systems developed at the NWFSC.

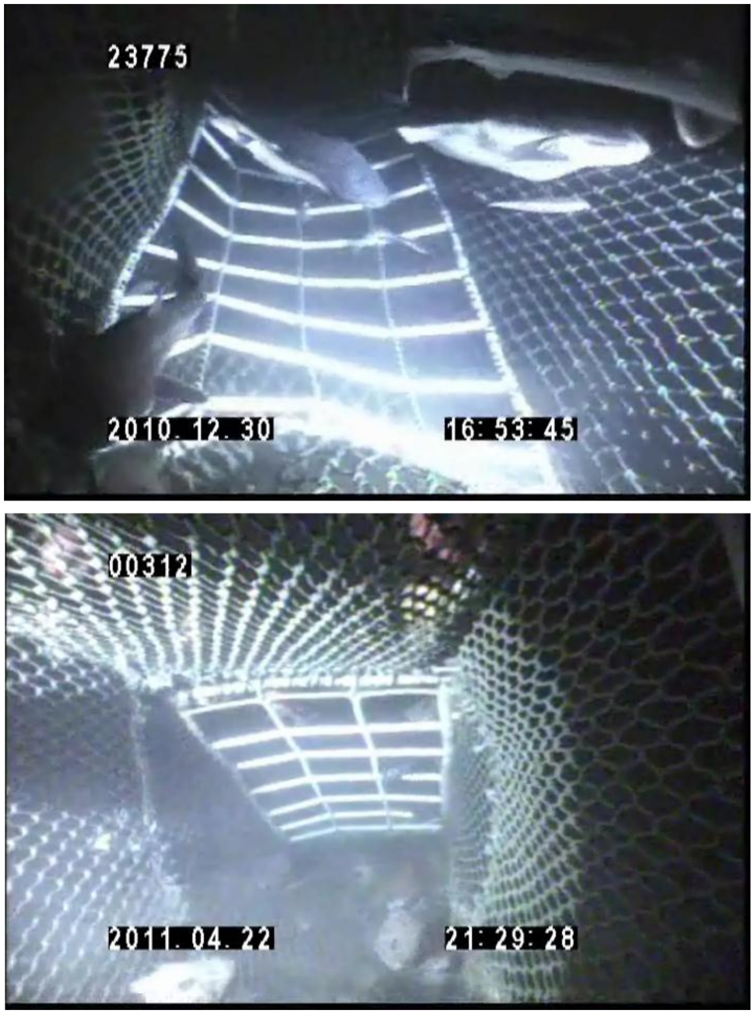

Figure 24. Video frame grabs showing flexible sorting grates developed by the fishing industry to reduce Pacific halibut bycatch in the groundfish bottom trawl fishery. Information gained from the videos was used to improve the performance of the grates.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or visit http://www.nwfsc.noaa.gov/research/divisions/fram/habitat.cfm

3. Cooperative Ageing Unit

The Cooperative Ageing Project (CAP) operates under a grant from the Northwest Fisheries Science Center to Pacific States Marine Fisheries Commission, and provides direct support for U.S. West Coast groundfish stock assessments by providing fish ages derived primarily from otoliths. In 2011, CAP finished ageing the following species for inclusion in assessments: Dover sole, petrale sole, canary rockfish, Pacific ocean perch, darkblotched rockfish, Pacific hake, and sablefish. CAP also began routinely recording otolith weights prior to breaking and burning, in support of research into alternative methods of age determination.

For more information, please contact Jim Hastie at Jim.Hastie@noaa.gov

4. Resource Surveys

a) U.S. West Coast Groundfish Bottom Trawl Survey

The NWFSC conducted its fourteenth annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2011 survey was to provide information on the distribution and relative abundance of demersal species within this region at depths from 30 to 700 fathoms. Other biological information necessary to assess the status of groundfish stocks (e.g. length, weight, sex and age structures) was collected throughout the survey period.

The NWFSC chartered commercial fishing vessels to conduct independent, replicate surveys using standardized trawl gear. Fishing vessels *Ms. Julie, Excalibur, Noah's Ark* and *Raven* were contracted to survey the area from Cape Flattery, WA to the Mexican border in Southern California, beginning in the later part of May and continuing through October. Each vessel was chartered for 11-12 weeks with the *Ms Julie* and *Noah's Ark* surveying the coast during the initial survey period from May to July. The *Excalibur*, and *Raven* operating in tandem, surveyed the coast during a second pass from mid-August to late October. The survey area was partitioned into ~12,000 adjacent cells of equal area (1.5 nm long. by 2.0 nm lat., Albers Equal Area projection) with each vessel assigned a primary subset of 188 randomly selected cells to sample. An Aberdeen-style net with a small mesh (1 1/2" stretch) liner in the codend was used for sampling. The survey followed a stratified random sampling scheme with 15-minute tows within 2 geographic strata (80% N of Pt. Conception, CA and 20% S) and 3 depth strata. The depth strata were: shallow (30-100 fms), middle (100-300 fms), and deep (300-700 fms). The sample design consisted of 752 sampling locations, with a minimum of 30 tows per strata.

In 2011, we also continued to utilize the FSCS data collection system with updated software applications, and wireless networking. Established NOAA national bottom trawl protocols were used throughout the survey. As in prior years, a series of special research projects were undertaken in cooperation with other NOAA groups and various universities.

Additional data were collected during the trawl survey for collaborative research projects with several NMFS/academic colleagues: 1) Maternal effects on larval quality in rockfishes - Southwest Fisheries Science Center; 2) Maturity investigations for blackgill rockfish (*Sebastes melanostomus*) - Southwest Fisheries Science Center; 3) Collection of *Solaster exigus* from northern and southern extremes of range - AFSC; 4) Record all sightings of basking sharks - Moss Landing Marine Laboratories; 5) Collections of sandpaper skate, *Bathyraja kincaidii* - Moss Landing Marine Laboratories; 6) Collection of any Pacific black dogfish, *Centroscyllium* nigrum - Moss Landing Marine Laboratories; 7) Collection of all unusual or unidentifiable skates, deepsea skate, *Bathyraja abyssicola*, Pacific white skate, *Bathyraja spinossisima*, fine-spined skate, *Bathyraja microtrachys*, Aleutian skate, *Bathyraja aleutica*, and broad skate, *Amblyraja badia*, - Moss Landing Marine Laboratories; 8) Collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* - Moss Landing Marine Laboratories; 9) Collection of any chimaera that is not *Hydrolagus colliei*, including: *Harriotta raleighana*, *Hydrolagus* spp. and *Hydrolagus trolli* - Moss Landing Marine

Laboratories; 10) Collection of voucher specimens for multiple fish species – Northwest Fisheries Science Center .

Several other research initiatives were undertaken by the Survey Team including: 1) Use of stable isotopes and feeding habits to examine the feeding ecology of rockfish (genus *Sebastes*); 2) Fin clip collection for various shelf rockfish species; 3) Collection of stomachs for various rockfish species and Pacific hake; 4) Collection and identification of cold water corals; 5) Fish distribution in relation to bottom dissolved oxygen concentration in the oxygen minimum zone; 6) Fish distribution in relation to bottom dissolved oxygen concentrations in a known hypoxic area off OR; 7) Composition and abundance of benthic marine debris collected during the 2011 West Coast Groundfish Trawl Survey from May to October 2011; and 8) Collection of ovaries from shortspine thornyheads and canary rockfish to assess maturity.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov.

b) Southern California shelf rockfish hook-and-line survey

In early Fall 2011, FRAM personnel conducted the eighth hook and line survey for shelf rockfish in the Southern California Bight (SCB). This project is a cooperative effort with Pacific States Marine Fisheries Commission (PSMFC) and the southern California sportfishing industry aimed at developing an annual index of relative abundance and time series of other biological information for structure-associated species of rockfish (genus *Sebastes*) such as bocaccio (*S. paucispinis*), greenspotted rockfish (*S. chlorostictus*), and the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) within the SCB.

The F/V *Aggressor* (Newport Beach, CA) and F/V *Mirage* (Port Hueneme, CA) were each chartered for 11 days of at-sea research, with nine biologists participating during the course of the survey. The two vessels sampled a total of 111 sites ranging from Point Arguello in the north to 9 Mile Bank and the US-Mexico EEZ boundary in the south. Approximately 3,247 lengths, 3,252 weights, 3,156 fin clips, and 2,862 otolith pairs were taken during the course of the entire survey representing 31 different species of fish and one invertebrate species.

Several ancillary projects were also conducted during the course of the survey. Ovaries were collected from key species to develop maturity curves. Several dozen individual fish were retained for use in species identification training for West Coast groundfish observers and for a genetic voucher program conducted by the University of Washington. Researchers are also constructing a new underwater video sled to capture visual observations for habitat analysis, species composition, and fish behavior studies. Work with a patented non-lethal biopsy hook to capture genetic information *in situ* is ongoing.

For more information, please contact John Harms at John.Harms@noaa.gov.

c) 2011 Joint U.S.-Canada hake acoustic survey and the processing of the collected data

The Joint U.S./Canada Integrated acoustic and trawl survey was conducted in U.S. waters from June 26 to Aug. 12, 2011 by the U.S. Team (NWFSC/FRAMD) on the NOAA ship Bell M. Shimada. In Canadian waters, the survey ran from August 17 to September 9, 2011 with the Canadian Team (DFO/PBS) on the CCGS W.E. Ricker. The Ricker and Shimada worked jointly in Canadian waters from August 23 to August 30, 2012. The data collected during the survey were processed to provide an estimate of the abundance and spatial distribution of the coastal Pacific hake stock shared by both countries. The survey covered the slope and shelf of the Pacific Coast from 35.2°N to 54.9°N with acoustic transects spaced 10-20 nm apart. Data were collected on 18-, 38-, 70-, 120-, and 200-kHz EK60 echo sounder on the Shimada, and 38 and 120 kHz EK60 echosounder on the Ricker. The survey resulted in 126 transects with 4,123 nautical miles of acoustical transect. Aggregations of Pacific hake were detected along the continental shelf break from just south of Morro Bay to the southern Haida Gwaii Islands. The highest concentrations of Pacific hake were observed off Cape Mendocino. Closed-net midwater trawls equipped with a camera system, along with a bottom trawl, were conducted to verify size distribution and species composition and to obtain biological information (i.e., age composition, sex). A total of 80 successful trawls (49 by U.S.) resulted in a total hake catch of 11,508 kg (9,686 kg from U.S.). The coastal Pacific hake stock surveyed in 2011 was dominated by age 3 hake. The data analysis was completed by 20 Feb to provide necessary information to the hake stock assessment group. The estimated total biomass of Pacific hake was 0.521 million metric tons (0.480 million metric tons from U.S.). Pacific hake numbers off the west coast, especially Canada, were low relative to previous years.

Also on the joint U.S./Canadian survey, the NWFSC Video Plankton Recorder (VPR) was used aboard Shimada to give a complete picture of the plankton community, including gelatinous zooplankton not identifiable from net tows. The goal of this work is to identify plankton that affects acoustic backscatter during hake surveys.

For more information, contact Larry Hufnagle at lawrence.c.hufnagle@noaa.gov

d) Preliminary results from the 2010 inter-vessel comparison (IVC) of the EK60 scientific echosounder between two NOAA ships, the *Miller Freeman* and *Bell M. Shimada*

The FRAM Acoustics Team conducted an inter-vessel comparison (IVC) of the EK60 scientific echosounder using two NOAA ships, the *Miller Freeman* and *Bell M. Shimada* in June-July 2010. The *Miller Freeman* has previously been used by FRAM for the Joint US/Canada Integrated Acoustic and Trawl Hake Survey and was compared to the *Bell M. Shimada,* a noise-reduced vessel. The IVC was conducted to examine if results from FRAM's ongoing acoustic survey onboard the *Miller Freeman* are comparable to results obtained using NOAA's new noise-reduced fisheries survey vessels (FSV), the *Bell M. Shimada,* and/or to document any differences due to either the vessels' equipment or to fish behavior in response to noise-reduction. The IVC consisted of both vessels surveying an area in tandem, running either follow-the-leader or parallel transects with random selection of the lead, or north/south, vessel.

Most vessel operations were identical to the normal FRAM hake acoustic survey operations, with additional time devoted to the follow-the-leader transects.

The 2010 Inter-Vessel Calibration (IVC) between the NOAA Ships *Miller Freeman* and *Bell M. Shimada* for the Pacific hake (*Merluccius productus*) acoustic survey was completed on July 26, 2010. The original plan was to conduct a hake IVC and to study the acoustic signatures of Humboldt squid (*Dosidicus gigas*). Since Humboldt squids were not sighted or collected during the IVC, effort focused solely on hake. During the IVC, four sets of 50 nm mini-grids were completed using both ships, with 1 to 1.5 nm spacing between transects. For the IVC, there were two operating modes: follow-the-leader (FL) and side-by-side (SS). I n the follow-the-leader mode, one ship followed the other along the same transect separated by about 0.5 nm. In the side-by-side mode, the two ships were horizontally separated by 0.5 - 1.0 nm. For mini-grid IVC operations, two sets were follow-the-leader mode (*Bell M. Shimada* led once and the *Miller Freeman* led once), and two sets were side-by-side mode.

The preliminary results from the IVC are summarized in Figures 25 and 26 for FL and SS modes, respectively. During the FL comparison, the *Miller Freeman* consistently saw 5% more hake than the *Bell M. Shimada*. For the SS comparison, the *Bell M. Shimada* saw more hake for the B-transects but results were mixed for the C-transects. Overall, the *Bell M. Shimada* detected 13% more hake than the *Miller Freeman*. The standard deviations for the FL and SS are 0.12 and 0.31, respectively. Such results are expected since the comparison with the FL mode is based on the assumption that both vessels see the same hake aggregations and are highly correlated. The comparison with the SS mode is based on the assumption that both vessels see hake aggregations that are uncorrelated or loosely correlated, hence, more measurements of hake aggregations are required.

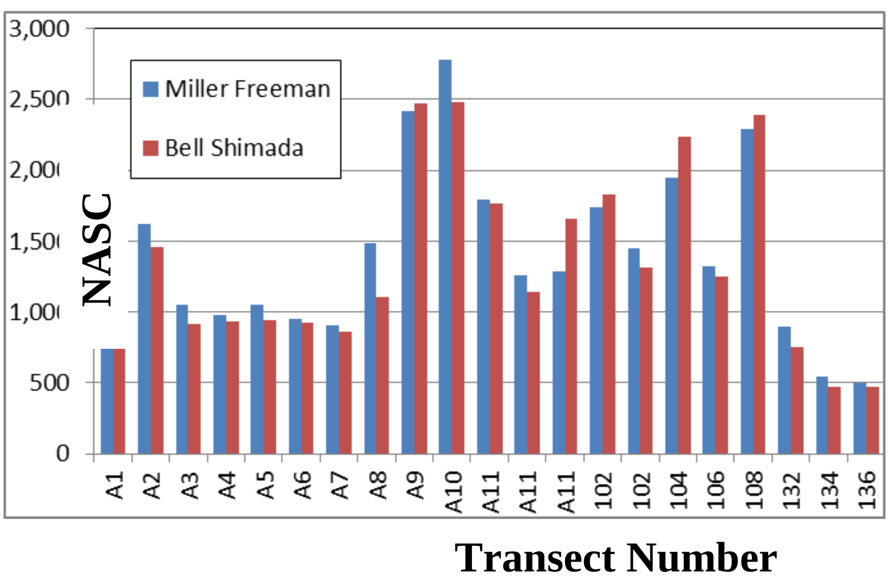

Figure 25. Comparison of the NASC values from the NOAA Ships *Miller Freeman* and Bell Shimada in follow-the-leader (FL) mode.

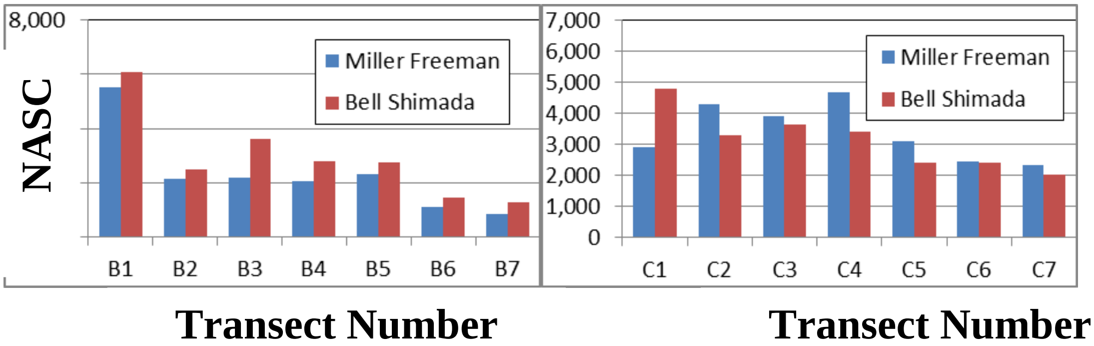

Figure 26. Comparison of the NASC values from the NOAA Ships *Miller Freeman* and Bell Shimada in side-by-side (SS) mode: (a) Mini-grid B-transects; (b) mini-grid C-transects.

The preliminary results indicate the differences between the two vessels range from 5% to 13%, however, additional IVC work is required to obtain more conclusive results.

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e) Joint NWFSC-SWFSC hake pre-recruit survey

A joint Fish Ecology Division and Fisheries Resource Analysis and Monitoring Division pre-recruit survey was conducted in 2011 to determine the spatial distribution and abundance of young-of-year (YOY) Pacific hake and rockfish along the U.S. West Coast. The survey occurred in May-June 2011 using the chartered fishing vessel *Excalibur*. A minimum of 5 trawl stations were sampled on transects located at 30 nm intervals with stations located over waters between approximately 50 m and 1200 m depth. The survey was conducted using the research gear and survey protocol developed by the NMFS Santa Cruz laboratory for surveys of juvenile rockfish (*Sebastes* spp.). Trawling was done at night at a speed of 2.7 kt for 15 minutes duration at target depth. A modified-Cobb midwater trawl with a 26 m (86') headrope and a 9.5 mm (3/8") codend liner was used. Target headrope depth was 30 m except in areas with shallow bottom depths, in which case the target headrope depth was 10 m. All fish and invertebrates captured were identified to the lowest taxonomic level and enumerated. All hake caught were counted and measured and data summarized and transferred to the NWFSC within 3 months of the end of the survey. Rockfish collected were bagged, labeled, frozen and delivered to the NWFSC for identification.

All planned transect lines were sampled, with an extra night of sampling on Heceta Head. Additionally, an opportunistic night of gear comparisons were made between this survey and the SAIP survey off of Columbia River, resulting in 18 transects. A total of 102 mid-water trawls were completed between Cape Mendocino, CA to Cape Flattery, WA. During some nights, poor weather prevented sampling some stations due to increased transit time, but on average, 5.3 stations were sampled per night.

Young-of-the-year (YOY) of commercially-important species have been sorted, measured, and tentatively identified (some species require genetic testing to confirm or determine identification). YOY rockfish and Pacific hake densities appear to be much lower than in past years, as referenced from the similar NWFSC FE Stock Assessment Improvement Program (SAIP) survey. Flatfish were highly diverse and appeared to be very abundant in 2011. However, these surveys are not directly comparable, so the differences could be due to other factors such as gear used and time of sampling.

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5. NOAA Program: Fisheries And The Environment (FATE)

Project Title: Modeling Pacific hake (*Merluccius productus*) summer distribution

Investigators: M. Haltuch, C. Holt, E.C. Clarke and A.E. Punt

Funding obtained via the NOAA Fisheries and the Environment (FATE) Program as well as funding via the Department of Fisheries and Oceans (DFO) Canada, International Governance Strategy Funds during 2010-2011 lead to a joint project between the Northwest Fisheries Science Center (NWFSC) and DFO, Nanaimo focusing on building a model to describe hake distribution during the summer migratory season, with the long term goal of being able to both hind-cast and forecast hake distribution. The motivation for this work is that Pacific hake exhibits strong environmentally-driven inter-annual variation during the stock's annual summer northerly migration that impact monitoring, assessment, and management of hake. Being able to describe and forecast hake distribution could impact management via optimized survey design and planning, resulting in improved estimates of hake distribution and density. Specifically, survey effort could be distributed to minimize (expected) variance given the ability to predict hake distribution and density prior to a survey, resulting in more precise estimates of abundance that form the basis for stock assessment and management advice. Hind-casting hake distribution could also be useful for investigating hake selectivity and availability in the stock assessment model. Essentially, the ability to model hake selectivity as a function of a covariate(s) would reduce the number of parameters in the stock assessment model. Finally, understanding and forecasting of hake distribution during migration is important for both short-term management decisions and long-term planning under future climate scenarios.

This project is using the depth aggregated hake acoustics survey data (1992-2007) to investigate space (latitude and longitude), population age composition, and environmental drivers of the north-south and cross-shelf distribution of hake along the west coast of North America. A set of hypotheses have been proposed in order to investigate potential mechanisms underlying the hake summertime distribution. The null hypothesis is that the north-south summertime distribution of hake is determined by latitude and the population age structure; and that the cross-shelf distribution of hake is determined by bathymetry. Three hypotheses have been developed that address possible climate mechanisms forcing hake summer distribution. Hypothesis 1 proposes that the intensity and location of the poleward undercurrent impacts the period of active migration, with stronger poleward flow leading to the population moving farther north. Hypothesis 2 suggests that formation and distribution of mesoscale structure in the CCE, e.g. eddies, is different between warm and cool years, impacting the distribution of hake's main prey resource, euphausiids. The hake distribution then tracks the changes in the distribution of euphausiids. Hypothesis 3 concerns the timing of the spring transition and in turn the intensification of upwelling, which impacts the timing and distribution of euphausiid availability and therefore hake distribution. A suite of environmental data from both satellite data on surface ocean conditions (e.g. SST) and regional ocean model (ROMS) outputs (e.g. poleward flow) are being used to test these hypotheses.

A delta general additive modeling (GAM) approach is used to predict hake backscatter. This is a two-step hurdle model consisting of a presence-absence model and a positive data model (all zeroes excluded) and is often used for zero-inflated data. GAMs are extensions of generalized linear models that apply semi-parametric smoothing functions to each independent variable and additively calculate the component response. Zero-inflation is often found in ecological data and needs to be accounted for when modeling abundance data. The hurdle model also has the advantage that it is possible to model different variables for the binary and the positive abundance response, as they can be driven by different processes. In the first step, a binomial GAM is used to model the occurrence (presence-absence) of hake backscatter. In the second step lognormal GAMs and variable coefficient GAMs are fit to the positive backscatter (presence data). The variable coefficient GAM allows for the testing of a variable spatial effect of the covariates on hake distribution in the California Current. The two models are merged by multiplying the predictions from both steps, resulting in the final model. Model fits are evaluated using residual plots, deviance explained by the model, and AIC is used for model selection. A runs test for randomness is used to test for problems with autocorrelation in model residuals, to avoid inflating the statistical significance of model results and to decrease the likelihood of type 1 errors (false positives).

The null model is explored by examining the spatial pattern of hake biomass-at-age composition data by applying two spatial indicators, center of gravity (spatial mean location) and the associated inertia (spatial variance). The population age structure is clearly contributing to both within and between year differences in hake distribution. The centers of gravity for young ages were found at more southerly locations than those of older ages. In warm years and years when there are proportionally more old fish in the population (e.g. 1998), the population is distributed further north. In cold years and years when there are proportionally fewer old fish in the population (e.g. 2001), the population is distributed further south. Based on the exploration of the hake biomass-at-age-and-latitude data and information on hake maturity, the hake age data are classified into juvenile (age 3) and adult categories (age 3+) for further modeling.

Each hake acoustic line transect is treated as the sampling unit for the GAM modeling described above, yielding a model that has hake backscatter summed for each transect and an average spatial scale of 50 to 100 kilometers. GAM model results show that the population age structure, satellite SST and ROMS temperature at depth and pole-ward velocity are drivers of hake distribution, supporting both the null and alternative hypotheses. Model fits are generally good, explaining between 35%-40% of the variability in the data, and runs tests indicate a lack of autocorrelation in the model residuals. Comparisons between the observed and predicted also indicate that the model fits the data well but generally under predicts the level of backscatter observed. Forecasts, in which one year of data are removed from the model and a forecast is made without those data, are reasonable. The final sets of alterative models are being finalized and a peer review publication is in preparation.

The funding for this project ended during September 2011 and alternative funds have not been identified to support further investigations at this time.

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6. Ecosystem Studies

a) Fish Ecology Division Summary Report

The Fish Ecology Division completed five monthly field surveys in 2011 for larval fishes using plankton nets and juvenile fishes using trawls. Field surveys are used to assess spawning success of a variety of groundfish species in relation to oceanographic conditions and climate variability, with the intent of establishing recruitment success indices to enhance stock assessment. All five cruises were done aboard the chartered fishing vessel *Miss Sue*. All larval and juvenile fish have been sorted and identified for 2011. Preliminary results have shown a substantial decrease in the abundance of rockfishes in our plankton nets and trawls in the past year as opposed to the last couple of years were they were a dominant species caught. However, there have been moderate increases in flatfish larvae/juveniles of several commercially important species. We have been examining diets of four of the most common rockfish species using direct stomach and stable isotope analysis and have recently submitted a manuscript on this. We are also continuing to look at the species composition of rockfish based on genetics.

Products:

- Oral presentation at the ICES Annual Meeting in Gdansk Poland entitled, "Larval and juvenile recruitment dynamics of rockfishes in the Northern California Current." R.D. Brodeur, T.D. Auth, E.A. Daly, T.A. Britt, M.C.C. Litz, and R.L. Emmett.
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- Litz, M.N.C., A.J. Phillips, R.D. Brodeur, and R.L. Emmett. 2011. Occurrences of Humboldt squid (*Dosidicus gigas*) in the northern California Current. CalCOFI Rep.52:97-108.
- Bjorkstedt, E.P., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson, B. Emmett, R. Brodeur, and 21 other authors. 2011. State of the California Current 2010-2011: Regionally variable responses to a strong (but fleeting?) La Niña. CalCOFI Rep.52:36-58.

- Bosley, K.L, T.W. Miller, R.D. Brodeur, K. Bosley, A. Van Gaest and A. Elz. MS. Feeding ecology of juvenile rockfishes off Oregon and Washington: insights into life history patterns based on stomach content and stable isotope analyses. Submitted to *Mar. Biol.*
- Miller, T.W., K. L. Bosley, J. Shibata, R.D. Brodeur, K. Omori and R.L. Emmett. MS. A stable isotope-based perspective on the contribution of prey to Humboldt squid (*Dosidicus gigas*) in the northern California Current. Submitted to Mar. Ecol. Prog. Ser.
- Oral presentation at the 2011 Salmon Ocean Ecology Meeting in Seattle, WA (March 2011) entitled, "Winter ichthyoplankton biomass: predictor of summer prey fields and ultimate survival of juvenile salmon?" Elizabeth A. Daly, Richard D. Brodeur, Toby D. Auth, William T. Peterson, and Edmundo Casillas.
- Oral presentation at the 2011 Annual Larval Fish Conference in Wilmington, NC (May 2011) entitled, "Anomalous ichthyoplankton distributions and concentrations in the northern California Current resulting from the 2010 El Niño and La Niña events." Toby D. Auth.

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b) Integrated Ecosystem Assessment of the California Current: Ecosystem health, Salmon, Groundfish and Green Sturgeon

Editors: Phil Levin and Frank Schwing

An Integrated Ecosystem Assessment (IEA) is a formal synthesis and quantitative analysis of information on relevant natural and socio-economic factors in relation to specified ecosystem management goals. In this first iteration of the California Current IEA, we focus on a series of ecosystem components and ecosystem pressures that are of keen interest to resource managers, policy makers and the public: ecosystem health, salmon, groundfish and green sturgeon. The goal is to provide the technical underpinnings of future IEA documents that will target stakeholders and managers. We report on: 1) a process to develop a limited set of scientifically credible indicators; and 2) the status and trends of these indicators. We then develop a new method for conducting ecosystem risk assessment, and report on pilot evaluations of management scenarios. This report is the first in a series of efforts to complete a full IEA of the California Current. The next iteration of the IEA will improve analytical techniques and models, fill data gaps, will include more ecosystem components and pressures.

A 30-page summary of IEA findings, as well as the full Technical Memorandum, will be available this spring at http://www.nwfsc.noaa.gov/publications/scientificpubs.cfm

For more information, please contact Phil Levin at Phil.Levin@noaa.gov

c) Screening California Current Fishery Management Scenarios Using the Atlantis End-to-End Ecosystem Model

Investigators: I.C. Kaplan, P.J. Horne and P.S. Levin

End-to-end marine ecosystem models link climate and oceanography to the food web and human activities. These models can be used as forecasting tools, to strategically evaluate management options and to support ecosystem-based management. Here, we report the results of such forecasts in the California Current, using an Atlantis end-to-end model. We worked collaboratively with fishery managers at NOAA's regional offices and staff at the National Marine Sanctuaries (NMS) to explore the impact of fishery policies on management objectives at different spatial scales, from single Marine Sanctuaries to the entire Northern California Current. In addition to examining status quo management, we explored the consequences of several gear switching and spatial management scenarios. Of the scenarios that involved large scale management changes, no single scenario maximized all performance metrics. Any policy choice would involve trade-offs between stakeholder groups and policy goals. For example, a coast-wide 25% gear shift from trawl to pot or longline appeared to be one possible compromise between an increase in spatial management (which sacrificed revenue) and scenarios such as the one consolidating bottom impacts to deeper areas (which did not perform substantially differently from Status Quo). Judged on a coast-wide scale, most of the scenarios that involved minor or local management changes (e.g., within Monterey Bay NMS only) yielded results similar to Status Quo. When impacts did occur in these cases, they often involved local interactions that were difficult to predict a priori based solely on fishing patterns. However, judged on the local scale, deviation from Status Quo did emerge, particularly for metrics related to stationary species or variables (i.e., habitat and local metrics of landed value or bycatch). We also found that isolated management actions within Monterey Bay NMS would cause local fishers to pay a cost for conservation, in terms of reductions in landed value. However, this cost was minimal when local conservation actions were part of a concerted coast-wide plan. The simulations demonstrate the utility of using the Atlantis end-to-end ecosystem model within NOAA's Integrated Ecosystem Assessment, by illustrating an end-to-end modeling tool that allows consideration of multiple management alternatives that are relevant to numerous state, federal and private interests.

For more information, please contact Isaac Kaplan at Isaac.Kaplan@noaa.gov

d) From krill to convenience stores: forecasting the economic and ecological effects of fisheries

Investigators: I.C. Kaplan and J. Leonard

There is a need to better understand the linkages between marine ecosystems and the human communities and economies that depend on these systems. Here, those linkages are drawn for the California Current on the US West Coast by combining a fishery ecosystem model (Atlantis) with an economic model (IO-PAC) that traces how changes in seafood landings impact the broader economy. The potential effects of broad fisheries management options are explored, including status quo management, switching effort from trawl to other gears, and spatial management scenarios. Relative to Status Quo, the other scenarios here involved short-term ex-vessel revenue losses, primarily to the bottom trawl fleet. Other fleets, particularly the fixed gear fleet that uses pots and demersal longlines, gained revenue in some scenarios, though spatial closures of Rockfish Conservation Areas reduced revenue to fixed gear fleets. Processor and wholesaler revenue tracked trends in the bottom trawl fleet, which accounted for 58% of total landings by value. Income impacts (employee compensation and earnings of business owners) on the broader economy mirrored the revenue trends. The long-term forecast (15 years) from the Atlantis ecosystem model predicted substantial stock rebuilding and increases in fleet catch. The 15-year projection of Status Quo suggested an additional ~$27 million in revenue for the fisheries sectors, and an additional $23 million in income and 385 jobs in the broader economy, roughly a 25% increase. Linking the ecological and economic models here has allowed evaluation of fishery management policies using multiple criteria, and comparison of potential economic and conservation trade-offs that stem from management actions.

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e) Modeling growth and reproduction of chilipepper rockfish under variable environmental conditions

Investigators: C.J. Harvey, J.C. Field, S.G. Beyer and S.M. Sogard

Chilipepper rockfish (*Sebastes goodei*), a long-lived, highly fecund commercial species in the California Current ecosystem, contend with a variable environment on several time scales. Using a bioenergetics model, we simulated alternate strategies of energy allocation by female chilipeppers under variable conditions, and examined resulting patterns in age-dependent size and fecundity. Variable conditions consisted of single climate events (one anomalous year, one 4-year regime shift, or one 10-year regime shift) that occurred at different points over the lifespan of the fish and were either “poor” or “good” relative to baseline conditions. Poor years or regimes reduced growth and fecundity, while good years or regimes increased growth and fecundity. Fecundity losses during poor conditions could be mitigated by partially or fully reallocating energy from gonadal production into somatic growth, thereby increasing potential fecundity in future years. However, when mortality was incorporated, those energetic re-routing strategies only increased lifetime reproductive output if we assumed that old (≥age 8) females produce more viable larvae than young females, and if the event occurred prior to age 8. Young females also increased output of larvae beyond age 8 if they skipped spawning or reallocated reproductive energy during good conditions, instead investing the surplus energy into additional somatic growth and enhancing future fecundity. Our results are consistent with recent estimates of growth rate variability in the chilipepper population, and with observations of young females of other rockfish species skipping spawning during poor conditions. Models like this may help improve stock assessment parameters and biological reference points for species with environmentally driven variability in size at age.

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f) Climate forcing and the California Current ecosystem

Investigators: J.R. King, V.N. Agostini, C.J. Harvey, G.A. McFarlane, M.G.G. Foreman, J.E. Overland, E. Di Lorenzo, N.A. Bond and K.Y. Aydin

The Climate Forcing and Marine Ecosystem (CFAME) Task Team of the North Pacific Marine Science Organization (PICES) was formed to address climate forcing impacts on ecosystem structure and productivity of marine species. For the California Current system, the Task Team described the physical processes, built an overview of species across trophic levels, and described how the population dynamics of these species have changed over time. Focal groundfish included Dover sole (*Microstomus pacificus*), Pacific hake (*Merluccius productus*), sablefish (*Anoplopoma fimbria*), and rockfish (*Sebastes* spp.). Based on the synthesis work, conceptual models were developed describing the potential pathways linking climate forcing, oceanography, and species' responses. The resultant empirical data scenarios draw on ecosystem histories to provide a synopsis of expected change given global climate change. The multidisciplinary team faced challenges and limitations in their attempt to draw connections between the outputs from global climate models (GCMs), the physical processes, and the subsequent impacts on species via the identified pathways. To some degree, there was a mismatch of variables that fishery scientists identified as important in determining species' response to climate and physical forcing and the variables that current GCMs can now resolve at the regional level. These gaps will be important for researchers to consider as they begin to develop higher resolution climate and regional oceanographic models for forecasting changes in species' productivity.

For more information, please contact Chris Harvey at Chris.Harvey@noaa.gov

g) Comparison of fine-scale acoustic monitoring systems using home range size of lingcod

Investigators: K.S. Andrews, N. Tolimieri, G.D. Williams, J.F. Samhouri, C.J. Harvey and P.S. Levin

We compared the results from fixed acoustic transmitters and transmitters implanted in lingcod *Ophiodon elongatus* provided by two fine-scale passive acoustic monitoring systems: the older Vemco© Radio Acoustic Positioning (VRAP) system and the newer VR2W Positioning System (VPS) with either three or four receivers. The four-receiver VPS method calculated five times more positions of lingcod than VRAP and more than twice as many as the three-receiver VPS. Calculated positions of fixed transmitters were less precise with VRAP than either VPS approach. Measurements of home range for lingcod were similar between the four-receiver VPS and VRAP, which were both greater than the three-receiver VPS. Comparisons varied when lingcod were in/near complex habitats. As new technology develops, it is important to understand how new methods compare to previous methods. This may be important when describing patterns of movement or habitat use in the context of changes in habitat or management efforts.

For more information, please contact Kelly Andrews at Kelly.Andrews@noaa.gov

h) Combining fishing and acoustic monitoring data to evaluate the distribution and movements of spotted ratfish *Hydrolagus colliei*

Investigators: K.S. Andrews and T.P. Quinn

Direct and indirect methods have been used to describe patterns of movement of fishes, but few studies have compared these methods simultaneously. We used 20 years of trawl survey data and one year of acoustic telemetry data to evaluate the vertical and horizontal movement patterns of spotted ratfish *Hydrolagus colliei* in Puget Sound, WA, USA. Densities of large ratfish (≥ 30 cm) were higher at the deepest depths trawled (70 m) during daylight hours, whereas densities were similar across depth zones (to 10 m) at night. Acoustic tracking of ratfish showed distinct diel patterns of movement and activity level; ratfish moved into shallow, nearshore habitats at night from deeper, offshore habitats during the day and made ~3 times more moves at night than day in shallow habitats. Broader spatial patterns depended on where ratfish were tagged: one tag group remained in one general location with few excursions, whereas a second tag group moved within a 20-km band with some individuals moving > 90 km. These data will help inform food web models' abilities to quantify interspecific interactions between ratfish and other components of their community.

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i) Ecosystem-level consequences of movement: the predatory impact of spiny dogfish in Puget Sound.

Investigators: K.S. Andrews and C.J. Harvey

The impact of predators in an ecosystem is directly related to how much time they spend in specific habitats and the manner in which they move throughout the environment. In order to investigate the predatory impact of spiny dogfish in Puget Sound, we combined acoustic telemetry with bioenergetics modeling. We used large-scale arrays of passive acoustic receivers in Puget Sound and along the US West Coast to monitor the movement patterns of 17 spiny dogfish *Squalus suckleyi* for up to four years. Spiny dogfish consistently entered Puget Sound in early summer, remained until late autumn, migrated through the Strait of Juan de Fuca and inhabited coastal waters (as far south as Long Beach, CA) the remainder of the year before returning to Puget Sound the subsequent summer. Individuals returning to Puget Sound showed remarkable consistency in the timing of movements into and out of Puget Sound across years. However, individuals varied in the duration of months spent in Puget Sound (2-7 months) and the ultimate destination within Puget Sound (50 - >120km southward). We then constructed a bioenergetics model to calculate predatory impact based on consumption rates of the spiny dogfish population in each month of the year in Puget Sound. We compared models with and without the patterns of movement detected by acoustic monitoring. When patterns of movement are included, the annual predatory impact of spiny dogfish in Puget Sound was 53% lower than when movement is excluded. The strength of interspecific interactions is ultimately determined by the amount of time species interact and this analysis shows the importance of including movement patterns into any effort to quantify food web interactions.

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j) Scale and pattern of broadnose sevengill shark *Notorhyncus cepedianus* movement in estuarine embayments.

Investigators: G.D. Williams, K.S. Andrews, S.L. Katz, M.L. Moser, N. Tolimieri, D.A. Farrar and P.S. Levin.

The detailed movements of 32 acoustically tagged broadnose sevengill shark *Notorynchus cepedianus* were documented in and around north-east Pacific Ocean estuarine embayments from 2005 to 2007. Arrangements of passive acoustic receivers allowed analysis of movement at several spatial scales, with sex and size examined as possible factors influencing the pattern and timing of these movements. *N. cepedianus* exhibited a distinctly seasonal pattern of estuary use over three consecutive years, entering Willapa Bay in the spring, residing therein for extended periods of time during the summer and dispersing into nearshore coastal habitats and over the continental shelf during the autumn. *N. cepedianus* within Willapa Bay showed spatio-temporal patterns of segregation by size and sex, with males and small females using peripheral southern estuary channels early in the season before joining large females, who remained concentrated in central estuary channels for the entire season. Individuals displayed a high degree of fidelity not only to Willapa Bay (63% were documented returning over three consecutive seasons), but also to specific areas within the estuary, showing consistent patterns of site use from year to year. Cross-estuary movement was common during the summer, with most fish also moving into an adjacent estuarine embayment for some extent of time. Most winter and autumn coastal detections of *N. cepedianus* were made over the continental shelf near Oregon and Washington, U.S.A., but there were also examples of individuals moving into nearshore coastal habitats further south into California, suggesting the feasibility of broad-scale coastal movements to known birthing and nursery grounds for the species. These findings contribute to a better understanding of *N. cepedianus* movement ecology, which can be used to improve the holistic management of this highly mobile apex predator in regional ecosystems.

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k) How does the definition of ‘home range’ affect predictions of the efficacy of marine reserves?

Investigators: N. Tolimieri, K.S. Andrews and P.S. Levin.

Understanding how animals use space is fundamental to the employment of spatial management tools like marine protected areas (MPAs). A commonly used metric of space use is home range—defined as the area in which an individual spends 95% of its time and often calculated as 95% of the utilization distribution (UD), which is a probabilistic map describing space use. Since home range represents only 95% of an animal’s time, it is important to understand whether the other 5% matters to the design of MPAs. We developed an MPA-population model for lingcod *Ophiodon elongatus* that examined the population recovery under six characterizations of space use ranging from one mean home range to nine real lingcod UDs. Mean home range and similar estimates (based on the area in which a fish spent 95% of its time) predicted higher biomass and numbers relative to the more complete analysis of space use like the UD (which represented 99.99% of a fish's time) and underestimated the size of reserves necessary to achieve the same level of recovery of biomass. Our results suggest failing to account for the full extent of a fish's time overestimates the effectiveness of marine reserves.

For more information, please contact Nick Tolimieri at Nick.Tolimieri@noaa.gov

l) Precipitous decline in exploited predators causes ecosystem reorganization in the California Current

Investigators: N. Tolimieri, J.F. Samhouri, B.E. Feist and P.S. Levin

Indicators are an essential component of ecosystem-based management. For indicators to be useful, they need to be rigorously linked to changes in structure and function of the ecosystems they track. Mean trophic level (MTL) of fisheries catch measures the relative abundance of exploited species across a spectrum of trophic levels. The ubiquity and causes of a general decline in catch MTL through time have engendered much attention and debate. However, the consequences of this pattern for broader ecosystem structure and function, inclusive of unexploited species, remain virtually unexplored. Here, we use a fisheries-independent data set to document a pronounced decline in the MTL of the groundfish community along the Pacific U.S. Coast from 2003-2010 caused by decrease in biomass of higher trophic level fishes. Using a food web model, we illustrate how these shifts in ecosystem structure may have resulted in short-term positive responses by many lower trophic level species. In the longer-term, our model predicts that initial patterns of prey release may be tempered in part by lagged responses of non-groundfish, higher trophic level species, such as seals and seabirds. Importantly, the model suggests that aggregate ecosystem functions should change little following the initial reorganization of biomass from groundfish to other components of the food web. Our findings imply that efforts to manage and conserve marine ecosystems will benefit from a fuller consideration of the information content contained within, and implied by, fisheries-independent trophic level indicators.

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m) Atlantis ecosystem model summary

Editor: H.N. Morzaria Luna

This short document describes the basic structure and capabilities of the Atlantis ecosystem model, and presents groundfish case studies from the US and Mexico. The document is intended for scientific and fisheries management audiences, rather than modelers.

The document is available from the NWFSC website, at:
http://www.nwfsc.noaa.gov/publications/documents/atlantis_ecosystem_model.pdf

For more information, please contact Phil Levin at Phil.Levin@noaa.gov

n) Potential effects of ocean acidification on larval growth and otolith development in China rockfish

Investigators: S. Norberg, S. Busch and P. McElhany

The effects of CO_2-driven changes in ocean carbon chemistry, or ocean acidification (OA), on shell-building organisms have received much attention, but information regarding the effects of OA on fish is limited. High levels of pCO_2 in vertebrates can lead to lethal or sub-lethal hypercapnia-induced acidification of body fluids. Fish can tolerate brief exposures to high pCO_2, although it is energetically costly. Larval fish, which must meet the added daily energy requirements for growth and development, may not have enough energy to contend with the extra energetic expense of increased ion transport needed to maintain acid-base equilibrium. China rockfish (*Sebastes nebulosa*) larvae were reared in 3 different pH treatments, pH 7.70, 8.05, or 8.10. These conditions approximate past (280 ppm), present (400 ppm), and future (1000 ppm) global average atmospheric pCO_2 levels. Larvae exposed to future pCO_2 conditions had significantly lower survival over a 20-day period (21%) than larvae exposed to present pCO_2 conditions (70%). After two weeks of exposure to treatment conditions, larvae that survived in the future pCO_2 treatment were shorter than larvae that survived in the past and present pCO_2 treatments, though they had greater body depth than larvae in the present pCO_2 treatment. At the end of the experiment, larval size and shape were similar in all treatments. Otolith diameter relative to body size in the present (400 ppm) treatment was significantly larger than the past (280 ppm) and future (1000 ppm) treatments by 6.5 and 4.5%, respectively. From these results, we conclude that high CO_2 conditions can negatively impact the growth, development and survival of larval China rockfish.

o) Cryptic population structure near Point Conception, CA in the severely depleted cowcod, *Sebastes levis*

Investigators: J. Hess, P. Chittaro, A. Elz, L. Gilbert-Horvath, J. Carlos Garza and V. Simon

Cowcod (*Sebastes levis*) is a temperate rockfish species managed as a single homogenous population, yet there are a combination of factors that, in concert, may produce population structure. These factors include a geographical distribution separated by a putative biogeographic boundary, Point Conception; severe declines in abundance which may have reduced effective population sizes and led to divergence driven by genetic drift; and dependence on patchily distributed habitat (i.e. rocky outcrops). Since 2004, the National Marine Fisheries Service has considered cowcod a "species of concern" due to its dramatic decline in abundance (3.4% - 16.3% of historical biomass). We address two questions: 1) Is there population subdivision within the species, specifically, between two marine biogeographic regions separated by Point Conception, and 2) Have cowcod populations experienced loss of genetic variation due to a reduction in population size? A combination of genetic (24 microsatellite loci and mitochondrial d-loop sequencing) and otolith microchemistry (based on trace elements) analyses were used to test these objectives. Coarse-scale analysis of sequence and microchemistry data indicated regional differences of fish separated at Point Conception, however, fine-scale analysis of microsatellites revealed cryptic, divergent lineages (F_{ST}=0.148, $P<0.05$) which were in contact south of Point Conception. Regional differences for cowcod include relatively faster somatic growth rate, higher genetic diversity, and greater structuring in the southern versus northern region. In general, cowcod is one of the least genetically diverse among other evaluated rockfishes. However, neither cowcod population appears to have suffered detectable loss in genetic variation, despite declines in abundance.

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7. Acoustic Modeling and Research

a) Refinement of the EchoPro software package with inclusion of a geo-statistical technique (kriging) to process the 2011 Integrated Acoustic and Trawl Survey (IATS) data for hake biomass estimate

EchoPro software package developed in FY11 has been refined to increase the flexibility and reduce the complexity of the program. It reads the Nautical Area Scattering Coefficient exported from the EchoView (Myriax) and can provide length, age, and sex structured biomass estimate in a few minutes. The data processing is totally independent of Oracle database and the processing cycle is much shorter. In addition, the 2011 hake biomass estimate was obtained based on kriging, hence the coefficient of variance (CV) was provided at the same time. Kriging is a geostatistical method and a local estimator used to interpolate a spatially distributed quantity in an unobserved location and was considered to be suitable to estimate fish abundance and precision by an ICES Study Group. In addition, sensitivity analysis of the biomass estimates in terms of the stratification scheme and the kriging parameters was performed, indicating that the biomass estimate was robust.

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b) Development of an age-1 hake index and analysis of historical data.

An age-1 index for Pacific hake is under development, with the preliminary analysis of 2003 to 2011 data concluded February 2011. This analysis included an overall index of abundance as well as a spatial component of age-1 echosign. This index of abundance was joined to the 1995-2001 historic AFSC data set of age-1 abundance. Initial results indicate that the age-1 index was consistent with major recruitment events; however, more years of data and a full spatial analysis are needed. Currently, work is proceeding on converting historic 1995-2001 echogram data, with hopes to get a full spatial component similar to that in spatial years. Also, as the current adult hake biomass estimate is currently calculated using kriging methods, but the age-1 index is calculated using simple linear interpolation, the age-1 index will also eventually move in the direction of kriging.

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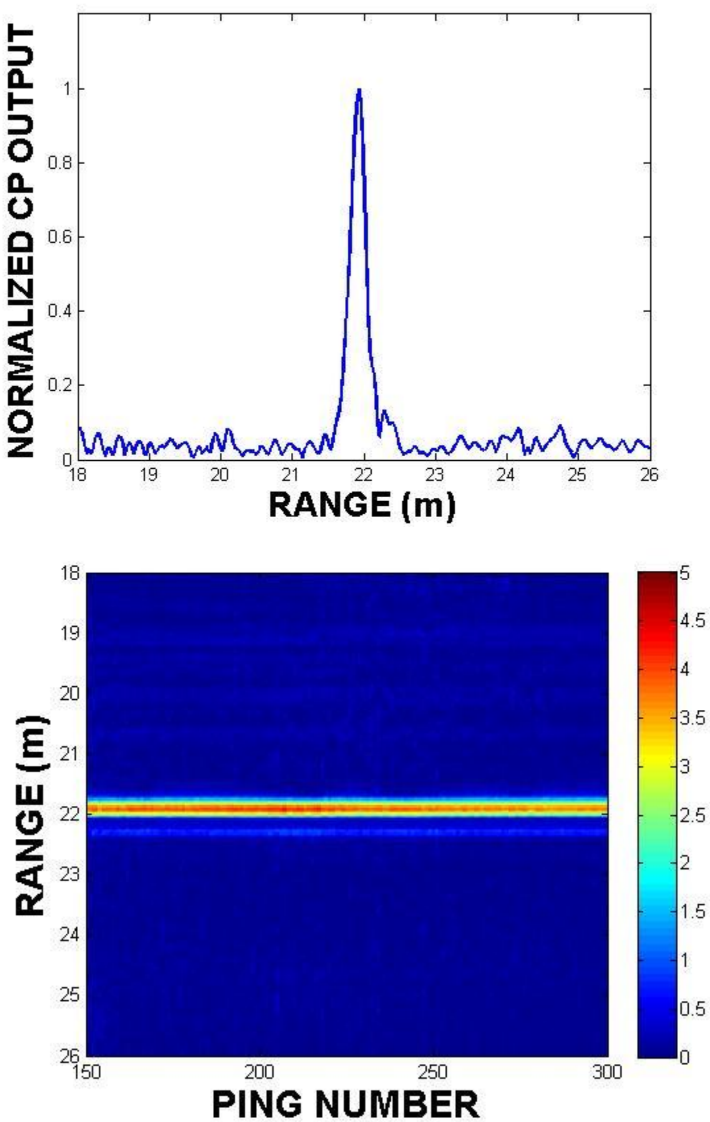
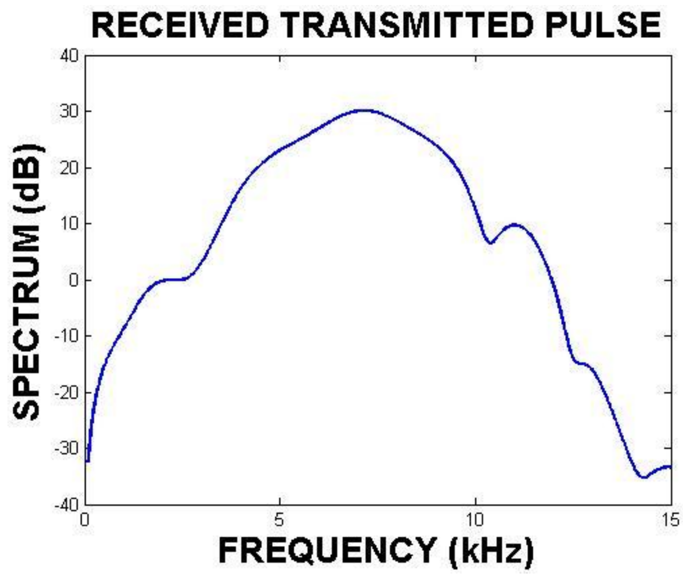
c) Application of low frequency broadband technology to fish characterization acoustically

The goal of the proposed research is to develop a technology capable of discriminating Pacific hake from other marine species using a commercially available broadband echosounder system (EdgeTech XSTAR 512i (500 Hz to 12 kHz). The broadband system can provide much improved signal-to-noise ratio (SNR) and range resolution with pulse compression technique (Figure 27). Most importantly, it can provide a wide spectrum that covers a large range of acoustic resonance frequency for adult hake, a swimbladder-bearing fish species.



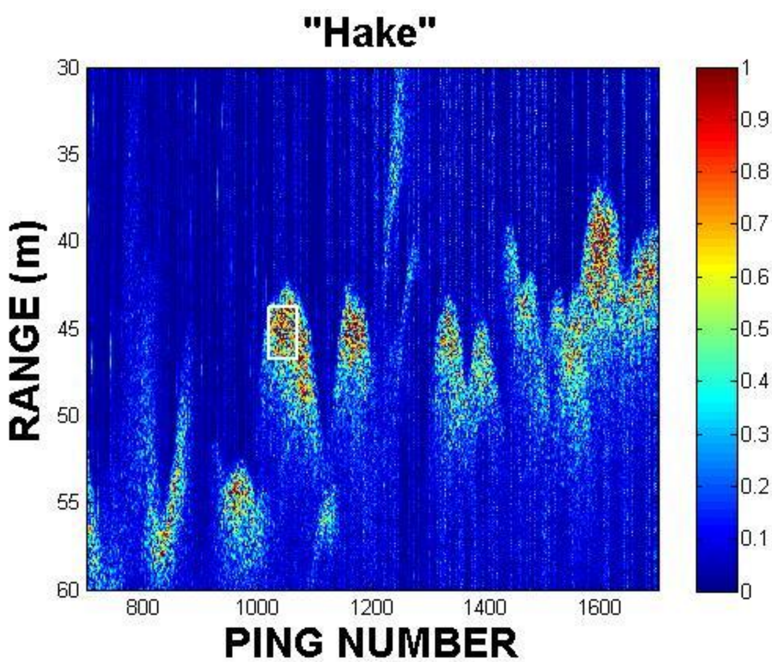
(a)

(b)

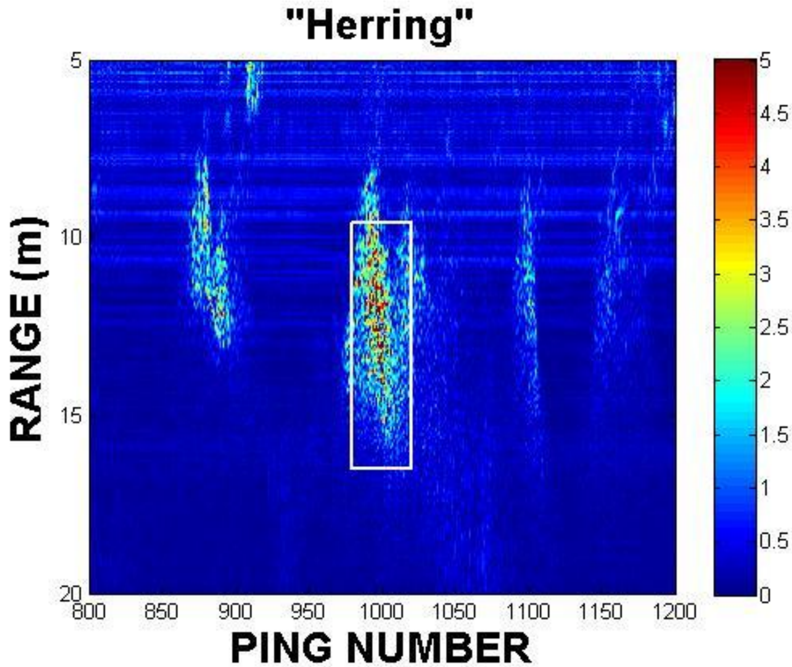


(c)

Figure 27. Calibration outputs of a 30-cm aluminum sphere (AL300): a) echogram of the compressed pulse (CP, or matched filtered) output (top); b) time series of the CP output of the received echo from the calibration sphere (mid); c) averaged spectrum of the received



(a)



(b)

Figure 28. Examples of the Pulse-Compressed (PC) or match-filtered echograms recorded with the EdgeTech SB 512i broadband towed system for "hake" (a) and "herring" (b). The data within the white rectangular boxes were used for spectral analysis.

Due to the time constraint during the 2011 Integrated Acoustic and Trawl Survey (IATS), only one successful deployment and a system calibration were conducted off the NOAA Ship *Bell M. Shimada*. The classification of "hake" and "herring" was based on the experience and knowledge (Figure 28). The schools classified as "hake" was aggregated between 40 and 60 m from the towfish. The EdgeTech broadband system was towed at about 50 m at 2.5 knots, i.e., fish schools were at about 100 m depth. Echoes from the fish aggregations classified as "herring" were recorded during the calibration conducted on August 31, 2011 in Elliott Bay, WA. The fish aggregations were at about 15 to 20 meters from the surface.

The frequency response of S_v of the "hake" and "herring" aggregations are shown in Figure 29. Note that the frequencies corresponding to "peaks" of S_v for "hake" and "herring" are different, at 1.6 kHz and 2.05 kHz, respectively. The fact that the S_v spectra have peaks at lower frequency ($ka < 1$, where k is the acoustic wave number and a is the equivalent spherical radius of the swimbladder) and are peaked at different frequencies indicates that the two aggregations are swimbladdered fish with different (swimbladder) size. By taking into account the depth (pressure) difference between two fish, the average length of "hake" should be twice as that of 'herring", assuming they both have the similar body-to-swim bladder length ratio ($a_{esr} \propto \sqrt{1+0.1z} / f_{resonace}$, where a_{esr} is the equivalent spherical radius, z is the depth, and $f_{resonace}$ is the resonance frequency, Medwin & Clay, *Fundamentals of Acoustical Oceanography*, 1998, p294). This is a very important result, confirming the usefulness of a broadband acoustic system in classifying fish with different swim bladder sizes.

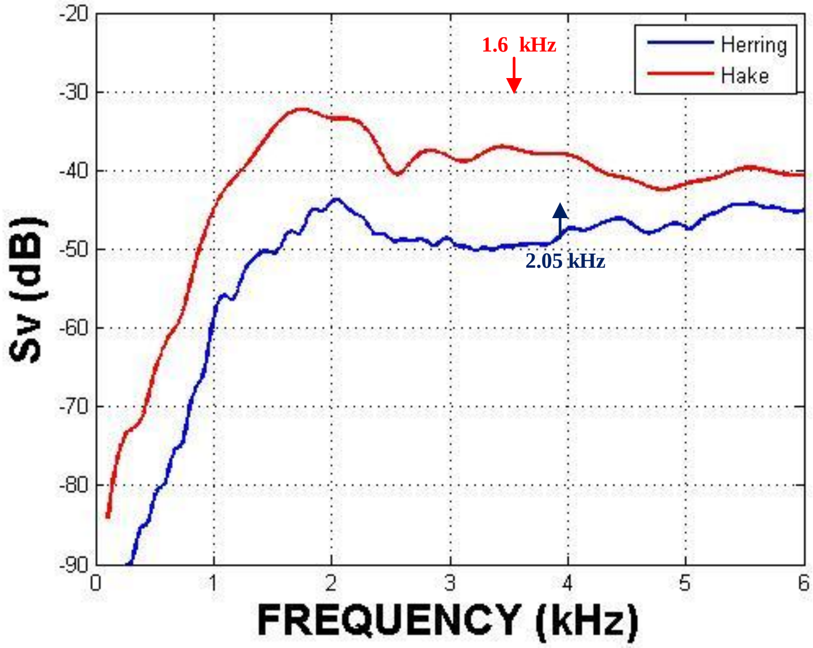


Figure 29. The Average Volume Backscattering Strength (Sv) as a function of frequency for "hake" and "herring". Note that resonance frequencies corresponding to the peaks of S_v for "hake" and "herring" are different, at 1.6 kHz and 2.05 kHz, respectively.

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8. Advance Technologies

a) Advance technologies for monitoring fish and their habitat on the U.S. West Coast

Investigators: M.E. Clarke, E. Fruh, C.E. Whitmire and H. Singh

The Northwest and Pacific Islands Fisheries Science Centers have worked with researchers at Woods Hole Oceanographic Institution (WHOI) to redesign the Seabed AUV to overcome the difficulty of monitoring fish populations and habitat in rocky areas. Traditional fish monitoring techniques such as bottom trawl surveys have some limitations for assessing groundfish populations and their habitat throughout their range because of the abundance of rugged terrain. Hover-capable bottom tracking AUVs, on the other hand, offer a unique tool that is appropriate for work in such areas. In addition, this group is collaborating with other researchers to gather information to assess multiple technologies in a variety of habitats.

In 2011, the NWFSC conducted Autonomous Underwater Vehicle (AUV) operations funded by NOAA's Deep Sea Coral Program. In August 2011, scientists from the Northwest Fisheries Science Center and Cordell Bank National Marine Sanctuary a survey on the Sanctuary Vessel *Fulmar* at selected sites in Bodega Canyon off California. The scientists used an autonomous underwater vehicle (AUV) to take still photos to assess the abundance, distribution, and habitat associations of deep-sea corals and sponges, as well as associated fish and invertebrates. From these dives, it was apparent that the Canyon habitat is primarily mud-draped rock with scattered outcrops of sedimentary rock. This primarily mud-draped area supported only a few Primnoid (likely *Plumarella longispina*) corals and scattered sponges. These data have been used to refine habitat maps of the region.

In September - October 2011, a collaborative study with the SWFSC was conducted to begin to assess the capability and efficiency of existing technologies to perform surveys of groundfish species in areas and habitats of the West Coast not surveyed adequately by bottom trawls. Underwater surveys of demersal fishes and habitats were conducted on two rocky seamounts off southern California using acoustics, the Nuytco *Dual DeepWorker* submersible, a SeaBED type AUV operated by the SWFSC, and a ROV operated by the SWFSC. The study site was located offshore of Santa Cruz Island, and includes two seamounts: the Piggy Bank and the Footprint Bank. The objectives were to collect data on counts and sizes for several rockfish species and estimate densities, total abundance and biomass for these species. Analyses of the data are underway.

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b) Developing the SeaBED AUV to monitor West Coast groundfish and their habitat

Investigators: M.E. Clarke, E. Fruh and C.E. Whitmire

Many of the commercially important species of demersal fish off the U.S. West Coast inhabit rocky habitats of varying relief that are not accessible with traditional survey gears such as bottom trawls. Due to the number and geographic extent of these habitats, and the number of fish stocks that must be assessed on a regular basis, there is a need for cost-effective tools to survey these areas. Over the past several years, we have been developing a SeaBED type AUV (Autonomous Underwater Vehicle) to survey various benthic habitats for fish and biogenic structure-forming invertebrates (e.g., deep-sea corals, sponges). The SeaBED AUV, developed by Hanumant Singh's lab at Woods Hole Oceanographic Institution, is a bottom tracking AUV that collects high-resolution digital still images of the seafloor and associated fauna. This AUV can be deployed from a variety of vessels ranging from fishing boats to larger oceanographic research vessels. The AUV is primarily an imaging platform that can provide high-resolution georeferenced images as well as associated oceanographic information such as temperature and salinity. We have configured the AUV with both orthogonal (vertical) and oblique (forward) perspective cameras to provide multiple views to aid in the identification of fish and invertebrates. Utilizing its very precise inertial navigation system, we have also employed the AUV to validate habitat information interpreted from high-resolution multibeam sonar imagery. Results from initial surveys show that many fish species can be identified from the images and that associations between fish and emergent fauna (e.g., deep-sea corals) can be quantified. The ability to collect precisely positioned still images has also facilitated photo-mosaicing techniques that show a broader view of the relationships between fauna and habitat than by individual images alone. Some limitations of this AUV relative to ROVs and manned submersibles are that samples cannot be collected and that there is more limited navigational control of the AUV during missions. This limits opportunistic adjustments while surveying, but also minimizes operator chosen diversions from the survey track. In general, AUVs have the advantage of being untethered. This can allow the support vessel to conduct other operations in the vicinity thereby maximizing the data that can be collected per sea day. Furthermore, the complexity of operatingthe SeaBED AUV in relatively deep depths up to 1500 meters is generally less than those for tethered devices.

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c) Report of the National Marine Fisheries Service automated image processing workshop, September 2010, Seattle, WA

Investigators: K. Williams, C.N. Rooper and J.H. Harms

This report is a summary of presentations and discussions from a workshop on automated image processing conducted in Seattle, Washington from September 4-7, 2010. The objective of the workshop was to examine current and future applications of automated image processing for fisheries and marine ecology research. The workshop provided a platform for representatives from all six NOAA centers to present image–based sampling systems that are being used and developed for a wide range of purposes, including essential fish habitat research, target identification for acoustic biomass surveys, verifying commercial fisheries catches through video observing systems, and fish behavior studies.

Experts in the field of image processing presented their past and current projects that incorporate automated processing in various stages, showing what can be achieved through automation and where the challenges lie. The majority of the projects presented by computer vision experts dealt with marine ecology or fisheries applications, even though the analytical methodology is general to the field of computer vision. Their examples illustrate the possibilities for future collaborations as automated processing solutions for image-based sampling programs continue to expand. We hope this publication will serve as a networking tool for biologists and computer vision experts and provide concrete examples of working projects, as well as guidance for developing future automated image processing projects.

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9. Observer Data Collection and Analysis

The FRAM Observer Program continued collecting fishery-dependent data during 2011 on groundfish fleets along the entire U.S. West Coast. On January 11, 2011, the West Coast Trawl Catch Share program was implemented. Simply stated, this program divides the total allowable catch in the groundfish trawl fishery into shares controlled by individual fishermen or into cooperatives. A key component of the catch share program is 100% mandatory monitoring of catch at-sea since all catch (not just retained catch) is counted towards quota attainment. The observer program was restructured and enlarged to successfully meet this data collection requirement.

a) Catch Shares

There are three sectors in the Catch Share program: shore-based, motherships (includes motherships and mothership catcher-vessels), and catcher-processors. All vessels participating in the shorebased sector or acting as mothership catcher-vessels (MSCV's) must carry one observer on all trips. Motherships and catcher-processors carry two observers each trip. The shorebased sector is managed through Individual Fishing Quotas (IFQ's) and includes all vessels that land catch at shoreside processors. Catch shares regulations allow the shorebased sector to use trawl, longline, or pots to harvest IFQ species. The mothership and catcher-processor sectors target Pacific hake using trawl gear and process it entirely at-sea. Motherships and catcher-processors have formed cooperatives to ensure sectors can attain Pacific hake quota without exceeding bycatch caps for overfished species or salmon.

In response to additional data needs under the new catch share program, observer sampling/data collection protocols were updated and expanded as necessary. Since the end of 2010 and through 2011, the program conducted 7 observer trainings, an increase of around 70% over previous years. The number of observer sea days increased dramatically in this sector between 2011 and 2010, with 9574 observed sea days in 2011, compared to 3418 in 2010. The table below provides further information on observer coverage in the catch share fishery.

Table 2. Summary of observer coverage in the catch share fishery

Description	SS IFQ Trawl	SS IFQ Fixed Gear	SS Hake	MSCV	A-SHOP
Number of vessels	72	26	27	18	14
Number of trips	1164	320	927	49	47
Number of hauls	9406	2182	1716	1256	1315

SS IFQ trawl: vessels targeting non-hake groundfish with trawl gear and landing at shorebased processors.
SS IFQ Fixed Gear: vessels targeting non-hake groundfish using longlines or pots and landing at shorebased processors.
SS Hake: vessels targeting hake using trawl gear and landing at shorebased processors.
MSCV: mothership catcher-vessel targeting hake with trawl gear
A-SHOP: motherships and catcher-processors targeting hake using trawl gear

b) Non-catch shares

The observer program continued to collect data in other West Coast fisheries that are not part of the catch share program. The program observed 10 distinct fishery sectors in 2011, including state-managed nearshore and pink shrimp fisheries and federally managed fixed gear fisheries. The program had 2102 sea days in the non-catch share fisheries in 2011 aboard vessels ranging in size from skiffs to larger fixed gear vessels and depths ranging from less than 20 fm to more than 300 fm.

Due to its unique data collection circumstances in both the catch shares and non-catch shares fisheries, the program continues to stress safety and data quality.

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

c) Data and analytical reports

The data collected by observers is used to improve total catch estimates, primarily for fish discarded at-sea. The data are used in assessing a variety of groundfish species, by fisheries managers, and by other fishery, protected resource, and other scientists.

Summaries of data collected on observed trips are routinely published on the NWFSC web site. Several fleet-specific reports, which are detailed below, were completed during 2011 - 2012. All reports can be obtained through the links included in the report descriptions.

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

Table 3. Recent summaries of data collected on observed trips

Jannot, J., Bellman, M.A., Majewski, J. 2011. Pacific halibut bycatch in the groundfish fishery (2002-2010). http://www.pcouncil.org/wp-content/uploads/I2b_SUP_NWFSC_PWRPT_SEPT2011BB.pdf

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All reports can be obtained at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm.

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

d) Implementation of West Coast groundfish trawl catch hares program

The NOAA NMFS Northwest Fisheries Science Center is responsible for at-sea monitoring under the trawl catch share program. In 2010, the observer program, in conjunction with the NOAA Northwest Regional Office, the Pacific Fisheries Management Council, NOAA Office of Law Enforcement, and NOAA General Counsel, completed the necessary regulation to implement the program in 2011.

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

e) Multivariate analyses to predict and avoid bycatch events

Investigators: J.E. Jannot and D. Holland

Fisheries managers need to find effective and efficient approaches to managing bycatch of unmarketable fish species. Bycatch of unmarketable species occurs because target species and bycatch species overlap in time and space. Thus, the best management response depends on a number of factors including understanding the interacting physical, ecological, environmental, and temporal factors that influence bycatch. However, bycatch can be highly variable in space and time and therefore difficult for managers and fishers to predict. Abnormally large bycatch events, although rare, do occur, often account for a large proportion of annual species bycatch, and can have serious negative impacts on both the bycatch species population and the fishery. Rare events, such as abnormally large bycatch events, require special modeling techniques. To date, few studies have compared the efficacy of alternative modeling methods for predicting rare bycatch events. The goal of this study is to compare the ability of three models (logistic regression, zero-inflated models, and choice-based sampling models) to predict the probability of bycatch events using multiple spatial, temporal and environmental variables. To facilitate this comparison, analyses were presented of the relationship between environmental variability and bycatch variability of rebuilding fish species in the U.S. Pacific limited entry trawl groundfish fishery. Utilizing data collected by the West Coast Groundfish Observer Program, this work will provide insight into the predictability and rarity of bycatch distribution and events, inform management tools for reducing bycatch, and provide a basis for understanding preferred modeling approaches for rare bycatch events.

For more information, please contact Jason Jannot at Jason.Jannot@noaa.gov

f) Discarding and total fishing mortality trends in the U.S. Pacific west coast groundfish demersal trawl fishery

Investigators: M. Bellman and E. Heery

Discarded catch is a major concern in mixed-stock fisheries and enumeration of discard has been a challenge in marine fishery management. We provide estimates of discarded and total catch in the U.S. Pacific West Coast groundfish demersal trawl fishery from 2002 through 2009, under trip limit management. Discarded-catch data from the West Coast Groundfish Observer Program (WCGOP) were expanded to the fleet-level using a ratio estimator. Total estimated discard in the fishery declined by 54% across the study period and represented 33% of the annual average groundfish catch. Fishing effort (landings and tow hours) with a high proportion of discard was observed at the beginning of the study period, and then fishing effort subsequently increased but overall discard decreased. The largest components of discard (by weight) were Pacific hake (*Merluccius productus*), arrowtooth flounder (*Atheresthes stomias*), skates (*Rajidae* sp.) and spiny dogfish (*Squalus suckleyi*). For species managed under rebuilding plans, total catch estimates fluctuated but the discarded proportion of catch increased (39%). For non-rebuilding groundfish species, the discarded proportion of catch decreased (21%). This study provides the first reference of total mortality trends in the west coast demersal trawl fishery and will serve as a baseline for future comparisons as the fishery shifts from trip limit management to an Individual Transferable Quota (ITQ) program in 2011.

For more information, please contact Marlene Bellman at Marlene.Bellman@noaa.gov

g) Observed and estimated bycatch of green sturgeon and Pacific eulachon in U.S. West Coast fisheries (2002-2010)

Investigators: A. Al-Humaidhi and M.A. Bellman.

The West Coast Groundfish Observer Program (WCGOP) is tasked with quantifying bycatch estimates in U.S. West Coast groundfish fisheries as prescribed under the Magnuson-Stevens Act. This also includes providing bycatch estimates of non-salmonid fish species protected under the Endangered Species Act (ESA) in observed U.S. West Coast fisheries. WCGOP provides important information to fisheries managers regarding rates and estimates of protected species encounters in these fisheries. We present observer bycatch ratios and estimated bycatch for two species listed as threatened under the ESA: green sturgeon (*Acipenser medirostris*) and Pacific eulachon (*Thaleichthys pacificus*). Bycatch estimates were provided for 2002 through 2010 for all fishery sectors observed by the WCGOP. The coast-wide green sturgeon bycatch estimate for 2010 was the lowest estimate of all observed years. The largest estimates of green sturgeon bycatch were in the limited entry sector of the California halibut trawl fishery. Overall, green sturgeon bycatch estimates from 2003 through 2006 were higher, in contrast with bycatch estimates from 2007 through 2010, with the exception of 2009. The Pacific eulachon bycatch estimates for 2009 and 2010 were the highest estimates of all observed years. The pink shrimp (*Pandalus jordani*) trawl fishery constituted the largest source of eulachon bycatch coast-wide. Observer coverage of the pink shrimp fishery increased in 2010 with increased coverage in California and the initiation of coverage in Washington. Protected species bycatch estimates produced by the WCGOP inform managers regarding the level of risk and impact of the various fisheries, allowing for well-informed and focused efforts to preserve protected species.

For more information, please contact Alia Al-Humaidhi at Alia.Al-Humaidhi@noaa.gov

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NMFS Southwest Fisheries Science Center

Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2012

Edited by Xi He and John Field

With contributions from E.J. Dick, John Hyde,
Janet Mason, Andrew Thompson, Cindy Thomson, and Mary Yoklavich

A. Agency Review

The Southwest Fisheries Science Center (SWFSC) conducts fisheries and marine mammal research at three laboratories in California. Activities are primarily in support of the Pacific Fishery Management Council, the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), as well as a number of international fisheries commissions and conventions. The Director is Dr. Francisco Werner and the Deputy Director is Kristen Koch. All three SWFSC laboratories have supported the essential needs of the NMFS and the Pacific Fishery Management Council (PFMC) for groundfish, including as active members of the PFMC's Scientific and Statistical Committee (SSC), the Groundfish Management Team, and other management teams and advisory bodies.

The Center is headquartered in La Jolla, which hosts three divisions that conduct research on a wide range of Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats; the Antarctic Ecosystem Research Division (led by Dr. George Watters), the Protected Resources Division (led by Dr. Lisa Ballance), and the Fisheries Resources Division (led by Dr. Russ Vetter). The Fisheries Resources Division (FRD) conducts research on groundfish, large pelagic fishes (tunas, billfish and sharks), and small coastal pelagic fishes (anchovy, sardine and mackerel), and is the only source of groundfish research at the La Jolla facility. The La Jolla laboratory is also the primary source of federal support for the California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys that have taken place along much of the California coast since 1951. Researchers at the La Jolla lab have primary responsibility for ichthyoplankton collections, studies of species abundance and distribution (including responses to climate variability), systematics, and the application of early life history information to stock assessments.

The Fisheries Ecology Division (FED), located in Santa Cruz and directed by Dr. Steve Lindley, comprises two research branches. The Fisheries Branch (led by Michael Mohr) conducts research and stock assessments in salmon population analysis, economics, groundfish, and fishery oceanography of salmonids and groundfish. The Ecology branch (led by Dr. Susan Sogard) conducts research on the early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. Specific objectives of the FED groundfish programs include: (1) collecting and developing information useful in assessing and managing groundfish stocks; (2) conducting stock assessments and improving upon stock assessment methods to provide a basis for harvest management decisions at the PFMC; (3) characterizing and mapping biotic and abiotic components of groundfish habitats, including structure-forming invertebrates; (4) disseminating information, research findings and advice to the fishery management and scientific communities; and (5) providing professional services (many of which fall into the above categories) at all levels, including inter-agency, state, national and international working groups. An FED economist represents the SWFSC on the Pacific Council's Groundfish Management Team.

The Environmental Research Division (ERD) is led by Acting Director Dr. Steven Bograd and is located at the Pacific Fisheries Environmental Laboratory (PFEL) in Pacific Grove. The ERD is a primary source of environmental information to fisheries researchers and managers along the west coast, and provides science-based analyses, products, and information on environmental variability to meet the agency's research and management needs. The objectives of ERD are to: (1) provide appropriate science-based environmental analyses, products, and knowledge to the SWFSC and its fishery scientists and managers; (2) enhance the stewardship of marine populations in the California Current ecosystem, and other relevant marine ecosystems, by understanding and describing environmental variability, the processes driving this variability, and its effects on the production of living marine resources, ecosystem structure, and ecosystem function; and (3) provide science-based environmental data and products for fisheries research and management to a diverse customer base of researchers, decision-makers, and the public. The ERD also contributes oceanographic expertise to the groundfish programs within the SWFSC, including planning surveys and sampling strategies, conducting analyses of oceanographic data, and cooperating in the development and testing of environmental and biological indices that can be useful in preparing stock assessments.

B. Multispecies Studies

1. Research

Genetic research on larval rockfish at the SWFSC

In 2011, the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division collaborated on a study to better discern the spatial distribution of spawning locations of different rockfish species within and around the Southern California Bight. To achieve this goal, we anlayzed ichthyoplankton samples collected in February 2005 (0502 JD) within a grid of stations that stretched north to Point Conception and south to within the Cowcod Conservation Area. Because it is often difficult to discern to species larval rockfishes based on morphology, samples were preserved in ethanol to enable identification using genetic sequencing.

We sorted 5,022 rockfish larvae from the 95 0502JD stations and sequenced ~600 bp of mitochondrial *cytochrome b* from 2592 individual larvae of uncertain identity. We compared these sequences to rockfish species of known identity (Hyde and Vetter 2007) and found larvae from 34 rockfish species. Numerically, the assemblage was by far dominated by four small species (*Sebsates jordani*, *S. hopkinsi*, *S. wilsoni*, and *S. ensifer*) that were historically not targeted by fishers. However, there were also over 100 larvae of each of three targeted rockfishes (*S. rufus*, *S. paucispinis*, and *S. mystinus*; Figure B1, Panel A-C), thus providing information on spawning distribution of these species. Notably, we found 28 *S. levis* larvae (Figure B1, Panel D) and hence identified essential fish habitat for this commercially important species. In addition to single-species analysis, evaluation of rockfish diversity patterns provided insight on the biogeographic patterns of rockfish assemblages in the oceanographically variable Southern California Bight (Figure B2). At present, we are completing a small number of additional genetic identifications in stations where larva were initially subsampled and conducting statistical analyses. We anticipate completing and submitting a manuscript based on the 0502JD rockfish assemblage data by October 2012.

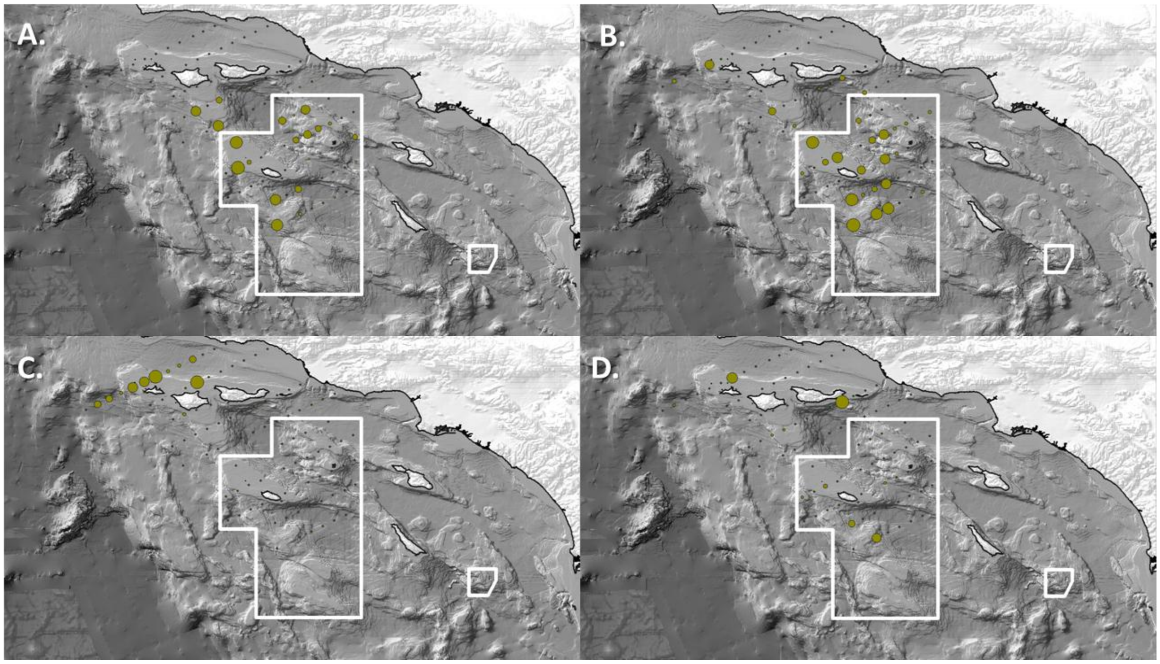

Figure B1. Distribution and abundance of A. *S. rufus* (range: 0 – 29 per stations), B. *S. paucispinis* (range: 0 - 14), C. *S. mystinus* (range: 0 – 23), and D. *S. levis* (range: 0 - 8) larvae from the 0502JD cruise.

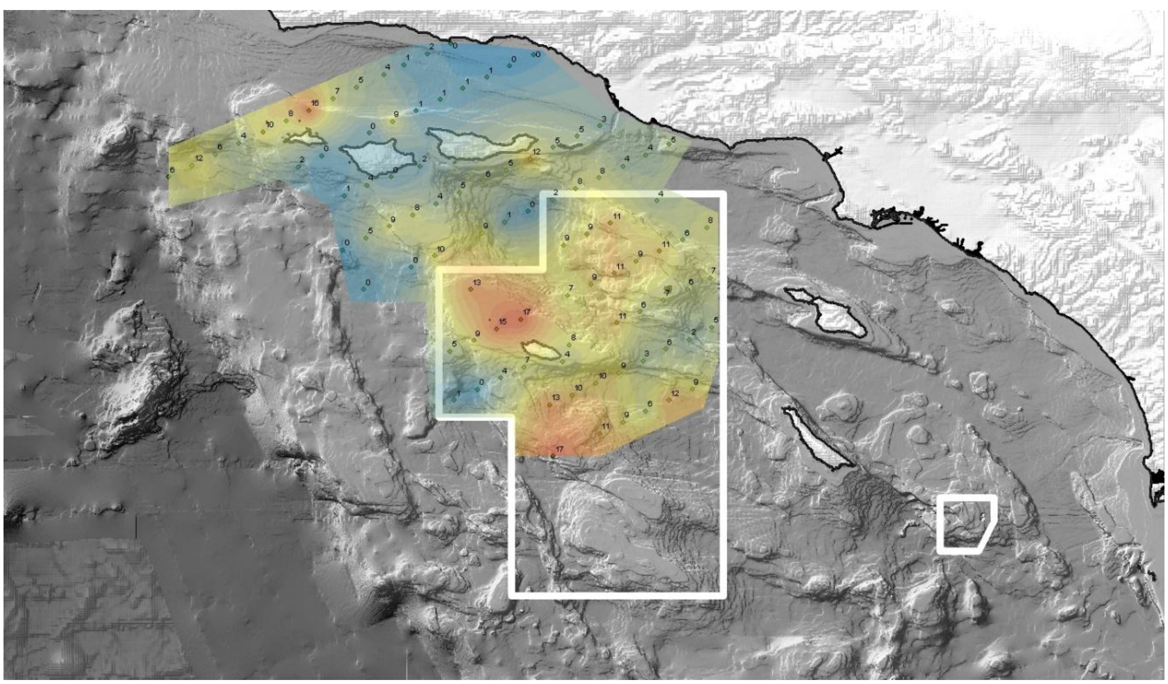

Figure B2. Rockfish species richness (no. species per station) from the 0502JD cruise. Labels depict the total number of species at a station and colors are krig-based image plots where red depicts high, and blue low, values.

In addition to the 0502JD data, we completed sorting 41 of 46 ethanol-preserved samples from the 0501NH CalCOFI cruise. Our goal is to eventually build a rockfish larval time-series from ethanol-preserved CalCOFI samples (1998-present). Initially, however, to evaluate CalCOFI rockfish sampling efficacy, we will conduct genetic identification on the 0501NH sample and compare patterns of rockfish distribution and abundance to the fine-grained 0502JD samples. Preliminary results for this study should be available in 2012.

Juvenile Surveys

The Groundfish Analysis Team at FED has conducted an annual midwater trawl survey for juvenile rockfish and other pelagic nekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile rockfish for fisheries oceanography studies and for developing indices of year class strength for stock assessments, although many other commercially and ecologically important species are captured and enumerated as well. The results here summarize trends in the core area since 1990, as not all species were consistently identified in earlier years. From 1983 through 2008, cruises took place on the NOAA ship David Starr Jordan, but since 2009, a series of different ships has been utilized; in 2011 the cruise took place onboard the F/V Excalibur and had limited temporal and spatial coverage relative to the post-2003 period. The data for the 2011 survey presented here are preliminary, and the analysis does not account for potential differences in catchability among vessels (although see Sakuma et al. 2006). Although this survey has sampled a greater spatial area from 2004 onward (roughly Cape Mendocino to the U.S./Mexico border), the results presented here focus on the core survey area (corresponding to the region just south of Monterey Bay to just north of Point Reyes, CA) as the length of the time series leads to more informative insights. Results from the expanded survey area will be developed for future reports. A spatial analysis of the distribution of key taxa for the core area is also in development (Santora *et al*., in prep) and should be published during 2012.

The standardized anomalies from the log of mean catch rates are shown by year for six key forage species and assemblages that are sampled in this survey (Figure B3). Most are considered to be well sampled, although the survey was not designed to accurately sample either krill or coastal pelagic species which have variable depth distributions, and those numbers should be considered with caution. Trends in 2010 and 2011 were of increasing abundance for the species and assemblages that tend to do better with cool and productive conditions, including juvenile rockfish, juvenile Pacific hake, market squid and krill. In 2011, juvenile rockfish, market squid, and other groundfish (such as Pacific hake, shown, and Pacific sanddabs, not shown) were at their highest levels since the early 2000s. By contrast, the coastal pelagic forage species (adult northern anchovy and Pacific sardine) were at low levels in 2009 and 2010, although this is likely a greater reflection of their local availability and ocean conditions rather than their coastwide or regional abundance. As with past reports (e.g., Bjorkstedt *et al*. 2010), the trends observed in these six indicators are consistent with trends across a broader suite of taxa within this region, with the first and second components (of a principle components analysis) explaining 39% and 14% of the variance in the data respectively (representing strong covariance among young-of-the-year groundfish, cephalopods and euphausiids, which in turn tend to be negatively correlated with coastal pelagic and mesopelagic fishes). As with the 2010 results, the 2011 survey continued to indicate a return to conditions similar to those seen in the early 1990s and early 2000s. The groundfish analysis team is also in the process of finalizing a manuscript that characterizes the relationship between juvenile rockfish abundance and environmental factors (particularly relative sea level height) from the period 1983 through 2010 (Ralston *et al*, in prep).

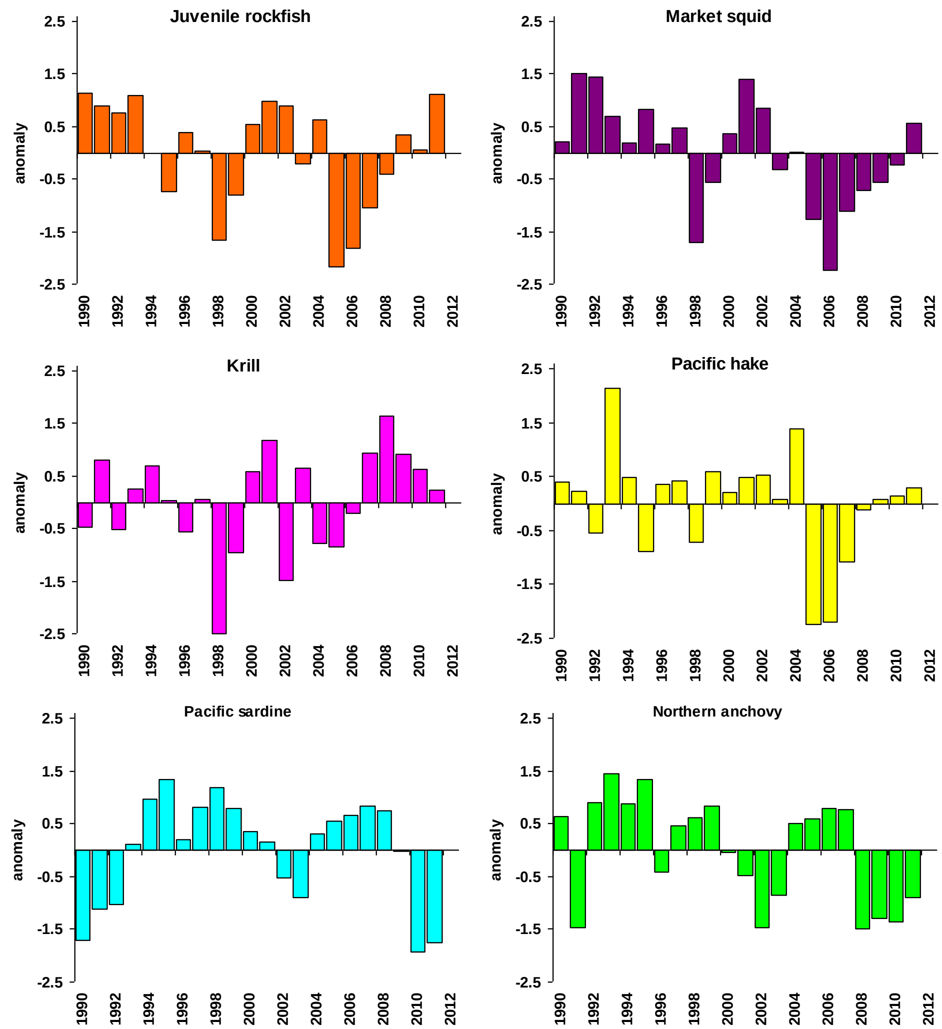

Figure B3: Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from the central California rockfish recruitment survey in the core region (1990-2011 period only, not all taxa were recorded from 1983-1989).

Adult Surveys

Pilot Survey for Nearshore Groundfish

Stock assessments of West Coast groundfish rely on size and age data from fishery-independent surveys to estimate the relative strength of cohorts and individual growth rates, two essential factors for determining stock productivity. Fishery-independent trawl surveys on the U.S. West Coast are designed to sample species associated with low-relief shelf and slope habitats. Many nearshore groundfish species are not available to the trawl survey due to depth and habitat restrictions, but are primary targets of both recreational and commercial (e.g., live fish) fisheries. FED scientists aim to fill a gap in fishery-independent sampling of west coast groundfish by evaluating a collaborative, fishery-independent trap survey design for species associated with nearshore and untrawlable habitats. The project was funded through the NMFS FY12 Cooperative Research Internal RFP process, and we are in the process of soliciting bids and acquiring necessary permits.

C. By Species, By Agency

3. Shelf Rockfish

i. Research

Two recent publications (Buonaccorsi *et al*. 2011 & 2012) deal with a range-wide genetic study of *Sebastes paucispinis* using both anonymous and gene-associated microsatellite markers. Despite an increase in sample size and marker coverage there was no significant signal for genetic stock structure. In collaboration with researchers at USC, UCM, and Juniata College, we have been work working to sequence the genomes and transcriptomes of *S. rubrivinctus* and *S. nigrocinctus*. SWFSC (FRD) is acting in a sample support and advising role on this project while the other collaborators do the majority of the sequencing and annotation.

The SWFSC FRD genetics and physiology group has begun a study of post release mortality, health, and behavior of rockfish species suffering from barotrauma injuries and released using descending devices. Animals were captured primarily from depths between 140-180 m, externally tagged with Vemco V9AP acoustic tags, and descended to depths between 40-70 m for release. In total, 48 animals were tagged and released (*12 S. paucispinis, 12, S. rufus, 12 S. crocotulus, 9 S. levis, 3 S. constellatus*). External injury was assessed prior to tagging and behavior at release was recorded for subsequent analyses. Tag data is being collected over the course of 6 months and these data will be used to assess levels of immediate and delayed mortality as well as monitor shifts in behavior (horizontal and vertical movement, gross activity) over the course of the study. In addition to the tagging data, samples (heart, rete mirable, head kidney) were taken from 4 species (*S. paucispinis, S. crocotulus, S. rufus, and S. constellatus*) to examine histologically for barotrauma injury. Planned work includes examining gene expression and health of fish subjected to simulated capture and release using a hyperbaric chamber.

ii. Assessments

Full stock assessments were conducted for widow rockfish (*Sebastes entomelas*, He *et al*. 2012), greenspotted rockfish (*Sebastes chlorostictus*, Dick *et al*. 2012), and blackgill rockfish (Field and Pearson 2012, see Slope Rockfish section). An update assessment and rebuilding analysis were conducted for bocaccio (*Sebastes paucispinis*, Field 2012a and 2012b). A status report for cowcod stock was also conducted in 2011 (Dick 2011).

In the 2011 widow rockfish stock assessment, all data and model structures were reanalyzed and reexamined and the assessment was reviewed by a STAR panel in July 2011. A revised version of the assessment was again reviewed by the Mop-up panel in October 2011. The assessment results from the Mop-up panel indicated that the stock was rebuilt in 2011, with stock depletion at 51.1% of unfished level. However, great uncertainties existed in the assessment, especially in the area of estimating stock-recruitment relationship because of insufficient data.

Greenspotted rockfish in California waters was fully assessed for the first time in 2011. The stock was modeled as two separate stocks (north and south of Point Conception). Data from commercial and recreational fisheries as well fishery-independent surveys were used in the assessment. Both assessment models are single sexed, since no evidence of sexual dimorphism in growth was found. The assessment models estimated that the stock is at 37% of unexploited level south of Point of Conception, and at 31% of its unexploited level north of Point Conception. Sustainable yield estimates for Oregon and Washington were calculated using MacCall's Depletion-Corrected Average Catch method.

Update assessment for bocaccio used the 2009 stock assessment model but included new data from 2009 and 2011. The model suggested an unprecedented strong recruitment in 2010, which has an overly strong influence on the model results. Based on this result and the guidance provided by the SSC, an alternative assessment model was developed. The stock was estimated to be at 26% of unfished level in 2011. Rebuilding analysis for bocaccio provided range of reference points for management considerations.

FED scientists are also actively working on developing methods of assessing data-poor stocks and will present their findings to a Methodological Review Panel in June 2012. Included in the review are: a review of methods to generate prior probability distributions for parameters used in several models (e.g., natural mortality, FMSY/M, BMSY/B0, and current stock status). Improvements to model specifications used for depletion-based stock reduction analysis (DB-SRA), Bayesian extensions to DB-SRA, including an age-structured model with a generalized stock-recruitment relationship. The review is intended to provide a comprehensive evaluation of approaches for assessment of data-moderate (tier 2) stocks in the PFMC’s Groundfish FMP. Assessments using an extended DB-SRA approach have the potential to raise the tier level of stocks to data-moderate. Status determinations of data moderate stocks are considered more certain than those of data-poor stocks, which under the Council’s current ABC control rule will allow an increase in ABC due to a reduction in scientific uncertainty. In addition to methodological developments, FED scientists are developing indices of relative abundance from existing recreational data to help inform these new data-poor methods. Data from dockside surveys have been formatted into a relational database that facilitates development of CPUE indices for stocks important to recreational fisheries. Data are available at a county-level resolution, and a standardized indices will be developed for three regions (Southern California Bight, Central California, Northern California / Oregon).

FED scientists are also exploring surplus production functions which incorporate different time lags for recruited biomass and natural mortality. This project is a collaboration with E. Aalto, a Ph.D. Candidate from the University of California at Davis. Lagged production models often assume (implicitly) that all factors affecting net production (recruitment, deaths, etc.) depend on biomass a fixed number of years before the current time step. In many applications, it is preferable to specify one lag for recruitment (e.g., age at maturity), but to define replacement biomass in terms of more recent population size. A potential bias in yield estimates is introduced by ignoring differences in lag times between recruitment and mortality. An ongoing study aims to quantify the magnitude of this bias under a variety of assumptions about life history characteristics, fishing intensity, and stock status.

4. Slope Rockfish

i. Research

We are conducting a focused study of maturity patterns for blackgill rockfish (*Sebastes melanostomus*) to better inform future stock assessments. Analysis of existing data has suggested unusual patterns of maturity stages throughout the spawning season that are consistent with observations of "prolonged adolescence" in other species of deepwater Sebastes. Specifically, we found unusually high numbers of stage 2 females (stage 2 equates to unfertilized oocytes) throughout, and following, the "typical" spawning (parturition) period that ranges from January through April, when one would expect those fish to move through fertilization, eyed larvae, and then spent stages. To further evaluate these findings, ovarian samples collected in collaboration with The Nature Conservancy (TNC) and fishermen in Morro Bay from 2010 through 212 have been macroscopically staged, with a subset processed for histological analyses. Histological analysis from an initial subset of 75 blackgill rockfish ovarian tissue samples collected between June 2010 and April 2011 indicate that the high proportion of stage 2 females collected year round is likely a result both of errors in macroscopic staging and anomalous ovarian development. The most frequent discrepancy between macroscopic and histological staging was with spent or resting ovaries being macroscopically identified as being in early stages of development. Through histological examination, atretic oocytes, which might appear with the naked eye to be developing, were visible, as were microscopic structures indicative of oocyte ovulation (post-ovulatory follicles). Comparison of fresh, preserved, and histologically processed ovaries may help provide indicators of atresia that could be detected macroscopically. Additionally, ovaries from 3 females appeared to be undergoing abortive maturation, with 30-80% of the developing oocytes being resorbed. All three females were smaller than the estimated L95 (42.4 cm), and two were around the L50 (33 cm), suggesting these females were in an adolescent phase. Histological examination from more individuals will help to determine the prevalence of these abortive maturation events and their effect on production of the population.

ii. Assessments

The Fisheries Ecology Division completed a full assessment of the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas, using data from 1950 through 2010. The resource is modeled as a single stock. Landings peaked in the mid-1980s at just over 1000 tons, but have declined to a value of approximately 100 to 150 tons in recent years. The base case model assumes a steepness of 0.76 and a natural mortality rate of 0.063 (females) and 0.065 (males), with model results highly sensitive to the assumed value for M. Due to the very slow growth, relative scarcity of age data, and high degree of ageing error, annual recruitments were not estimated for this assessment, rather recruitment is assumed to be deterministic. Results indicate that the spawning output of blackgill rockfish was at high levels in the mid-1970s; began to decline steeply in the late 1970s through the 1980s (consistent with the rapid development and growth of the targeted fishery); and reached a low of approximately

18% of the unfished level in the mid- 1990s. Since that time, catches have declined and spawning output has increased such that the current estimated larval production is 30% of the unfished level. The base model estimates recent SPR rates variable but very close to the target levels (e.g. 0.62 in 2008, approximately 0.46 in 2009, and 2010). Exploitation rates are estimated to have ranged from 1.2 to 2.3% over recent years. Age estimates are highly uncertain, and this species has proven very difficult to age. Conducting cross reads with other laboratories, as well as consideration of alternative age validation and bias evaluation methods, are important factors for future efforts. Similarly, historical catches remain uncertain for this stock due to the likely spatial patterns of fishery development for this species (a deeply distributed species generally encountered in offshore waters). Efforts to analyze spatially explicit historical catch data are ongoing.

D. Other Related Studies

D.1. SWFSC FED Current Habitat Activities

The SWFSC/FED Habitat Ecology Team conducts research in response to the mandates of the Magnuson-Stevens Reauthorization Act of 2006, with a focus on deep-water California demersal communities. Our goal is to provide sound scientific information to ensure the sustainability of marine fisheries and the effective management of marine ecosystems, with objectives to: (1) improve stock assessments, especially of overfished rockfish species in complex habitats; (2) characterize fish and habitat associations to improve EFH identification and conservation; (3) contribute to MPA design & monitoring and to Coastal and Marine Spatial Planning; and (4) understand the significance of deep-sea coral as groundfish habitat. The habitat team uses a variety of survey tools and approaches to improve assessments of demersal fishes, macro-invertebrates (including members of deep-water coral communities), and associated seafloor habitats in water depths from 20 to 900 meters off central and southern California. Habitat-specific distribution and densities of juvenile and adult life stages of numerous Pacific Coast demersal species have been determined from non-extractive, visual surveys conducted with remotely operated vehicles (ROV), manned submersibles, scuba, and towed cameras, coupled with seafloor maps of the continental shelf and upper slope off California. These surveys have resulted in habitat-specific assemblage analyses on multiple spatial scales; fishery-independent stock assessments; baseline monitoring of MPAs; documentation of marine debris on the seafloor; and predictive models of the distribution and abundance of deepsea coral communities.

Underwater Technologies to Survey West Coast Groundfishes

The FED Habitat Ecology Team recently completed a survey of demersal fishes in southern California using Nuytco's occupied *Dual Deepworker* submersible (Figure D1). This survey is part of a "calibration study" to understand the capabilities of various technologies and methods to assess West Coast groundfishes. All data from this survey are being analyzed to estimate abundance, size composition, biomass, and species diversity of demersal fish assemblages in untrawlable rocky habitats. Our results will be compared with those from two other studies conducted with an autonomous underwater vehicle (AUV; NWFSC) and a remotely operated vehicle (ROV) coupled with hydroacoustics (SWFSC). The results of this comparison will assist in our selection of survey tools to improve assessments of those species residing in high relief untrawlable habitats **(**for more details, see http://swfsc.noaa.gov/HabitatEcology/**).**

Figure D1. Two-person submersible *Dual Deepworker* being launched off the F/V *Velero* during a survey of demersal fishes and habitats on the Footprint seamount in the Southern California Bight.

Development of Predictive Models to Relate Population Abundance of Rockfishes and Habitats

FED Habitat Ecology Team members are developing statistical models that predict densities and biomass of demersal fish species in untrawlable areas, and are coupling these models with broad-scale seafloor habitat maps in a geographical-information-systems (GIS) environment to spatially predict fish densities/biomass on a regional basis. We are basing these models on fish data (identification, counts, sizes) collected during visual surveys conducted from manned submersibles off central California (Figure D2), and on a number of associated habitat variables (e.g., depth, substratum type, patch size and configuration). Spatial data sets are being compiled and the most up-to-date multibeam sonar data sets are being synthesized to provide a bathymetric base layer to support the spatially predictive models. These results will provide managers, policy makers, and the public with information that can be used in the conservation and management of sustainable marine resources (both the fisheries and associated habitats). Development of models of co-occurring species and associated habitats will have application to ecosystem-based management, providing information needed to manage a more complete demersal fish community. By including measures of spatial variability, this work will advance our understanding of the ecological processes that influence demersal fish distribution and abundance.

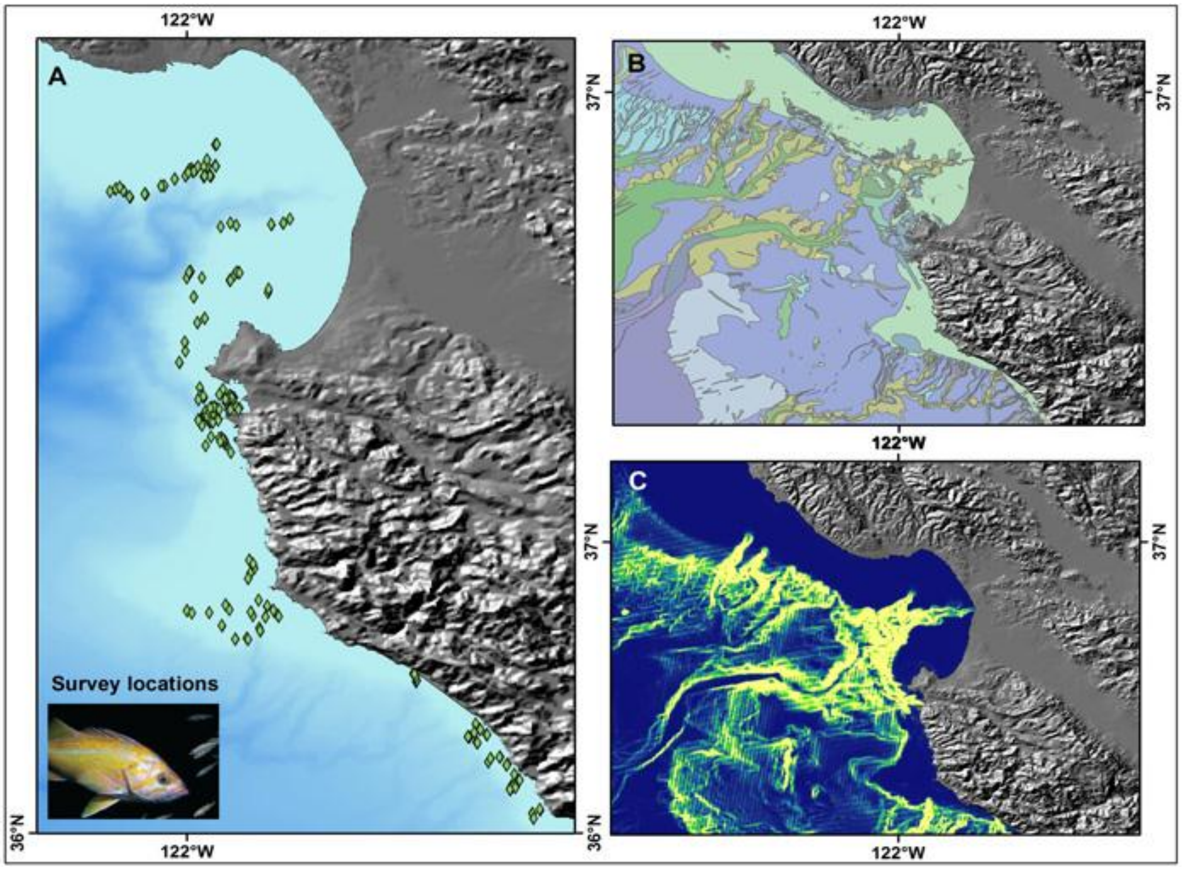

Figure D2. Spatial data sets compiled to support predictive modeling, including (A) map of submersible survey locations, (B) benthic habitat map, and (C) multibeam-derived product (e.g., habitat complexity, or rugosity).

Predicting Distribution of Benthic Macro-invertebrates

As part of the California Seafloor Mapping Project (CSMP), the FED Habitat Ecology team continues to collaborate with USGS and others to create a suite of maps detailing seafloor morphology and geology and characterizing potential benthic habitats derived from high-resolution multibeam sonar data. These efforts are being conducted coastwide, from the Oregon-California border to Mexico. We are using a towed camera sled to groundtruth these data and to survey biological components of the habitats. From presence/absence of macro-invertebrates associated with specific sediment types, depth, and latitude, we have developed multivariate models using logistic regression to predict the distribution of various species. Coupling these results with spatial information on bottom type and depth, we have created maps of probability of occurrence of these important components of seafloor communities (Krigsman *et al*. 2012). These maps will provide managers, policy makers, and the public with information that can be used in the conservation and management of sustainable marine resources.

Deep-Sea Coral Communities and Fisheries Habitats off California

The FED Habitat Ecology Team has developed a research program to assess deep-sea coral communities associated with fisheries habitats off California. An underwater survey of corals, sponges, and associated habitats and fishes was conducted on Piggy Bank Seamount in Southern California using direct observations from a remotely operated vehicle (ROV; Yoklavich *et al*. 2011), From this survey, we found that this underwater mountain supports very high densities and a remarkable diversity of deep-sea corals and sponges. At least 26 different taxa of corals and 26 different taxa of sponges occur on rocky, mixed, and soft sediment at depths from 275 to 900 m. The high densities and diversity of these corals and sponges could reflect the wide range of habitats and depths of our survey. Whatever the reason, these communities occur inside a new Marine Reserve and will continue to receive protection from any type of fishing that impacts the seafloor. With such protection, the Piggy Bank seamount very likely will serve as a source of young corals and sponges that may repopulate surrounding rocky banks. Our characterization provides the baseline for future monitoring of change to this community and for evaluation of the effectiveness of the new MPA. In Fall of 2012, we will survey corals off northern California and southern Oregon at depths up to 1000 meters in areas of high coral bycatch from the commercial trawl fishery. This study will be conducted using an ROV (depth capability to 1,000 m) and the Seabed AUV (depth cabability to 2,000 m). Our research on deepsea corals will assist in (1) understanding those factors that influence settlement and distribution of corals in the deep sea; (2) informing the Pacific Council's management of Essential Fish Habitat; (3) addressing petitions for conservation; and (4) NOAA's Coastal and Marine Spatial Planning processes.

NMFS Southwest Regional Habitat Initiative in the Southern California Bight

As part of NMFS' new Habitat Blueprint to improve habitat for fisheries, marine life, and coastal communities, the SWFSC and SW Region have initiated a 5-year plan to evaluate change in biodiversity, abundance, and size composition of demersal fish stocks and in their habitat following the closure of selected areas of the Southern California Bight to bottom-contact fishing gear. This study will significantly enhance our understanding of the effectiveness of habitat conservation measures on rebuilding commercially valuable fish stocks and on the demersal communities of which they are a part. This information will help NMFS to tailor management measures that meet its conservation mandates more efficiently and with less economic impact.

D.2. SWFSC FED Economics Team Activities

A paper co-authored by members of FED's Economics Team was accepted for publication in Marine Policy (Mason et al., in press). The paper compares the spatial distribution of groundfish trawl effort in California before and after establishment of the Rockfish Conservation Area. Results indicate some concentration of effort along parts of the closed area boundaries, suggesting the "fishing the line" behavior noted in the marine reserve literature. However, other possible explanations also exist for this behavior, including the effects of coincident changes in other regulations and changing bioeconomic conditions.

The FED's Economics Team is hosting a workshop on "Productivity Change under Catch Shares" on June 11-13, 2012 in Santa Cruz. The workshop will include presentations by academic and government economists on methods of measuring productivity change. The workshop is funded by NMFS Economics and Social Analysis Division in Silver Spring, which is also providing funding for an economist from each Science Center to attend the workshop. Workshop proceedings will be published in late 2012.

The FED's Economics Team provided input into the design of a nationwide economic survey of marine recreational anglers sponsored by NMFS. The survey, which was completed in 2011, provides data that will be used to estimate the impacts of marine recreational fishing (including groundfish) on employment and income in California and other states.

D.3 Environmental Research Division (ERD) Trawl intensity mapping

The Environmental Research Division (ERD) completed maps showing the intensity of bottom trawling off California. Data from California trawl logbooks from 1997 to 2009 was summarized into periods before and after the development in 2003 of the Rockfish Conservation Areas (RCAs) that closed specific depths to trawling. These maps are being used in the Pacific Council's review of Essential Fish Habitat areas in California. Maps of species density from California commercial trawling landings for aggregated years are being developed from the same data source.

The Environmental Research Division (ERD) collaborated with the Fisheries Economics Team to analyze the effects of the Rockfish Conservation Areas (RCAs) on California's groundfish trawl fleet using 1997-2009 trawl logbook data and landings receipts. They grouped California groundfish trawlers by their level of effort within the closed area prior to the closure in order to compare effort changes between groups before and after the closure. Results suggest that the RCA may have a small effect on the level of fishing effort in California's trawl fishery. Spatial distribution of effort before and after RCA implementation suggests some concentration of effort along parts of the closed area boundaries. This pattern suggests the "fishing the line" behavior noted in the marine reserve literature, but other possible explanations exist, including the effects of coincident changes in other regulations and changing bioeconomic conditions. Effort changes around a marine reserve: the case of the California Rockfish Conservation Area (in Press 2012) Marine Policy.

D.4 FED Historical Catch Reconstruction

Currently, spatially explicit catch data exists for many California commercial landings as recorded in the California Department of Fish and Game (CDFG) blocks (10' latitude x 10' longitude grid resolution), and comparable historical catch records were recently recovered from microfiche and paper records with support from the (now defunct) NOAA Climate Data Modernization Program. These data were used to help aid in the first round of catch reconstruction efforts for California groundfish (Ralston et al. 2010), and since early 2011, we have initialized efforts to error check, refine and analyze these data in a spatial context, which is allowing us to utilize these important data to their full potential. Our initial efforts have focused on groundfish landings in California waters, particularly rockfish and sablefish landings in the

Southern California Bight due to the unique biogeography of the region and our perception of the spatial expansion of the southern California fishery based on anecdotal accounts. Moreover, this is a region that is facing considerably complex and controversial issues regarding the consequences of large-scale area closures (rockfish conservation areas, cowcod conservation areas) on the ability to conduct stock assessments of overfished rockfish populations (e.g., cowcod, bocaccio). By stratifying habitat areas by depths at which fisheries for different groundfish target species have taken place (e.g,. 0 to 600 meters for rockfish, 100 to 1200 meters for sablefish) we have been able to develop preliminary results that include estimates of legacy groundfish landings as a function of available habitat, a suite of geostatistical analyses, and evaluation of the spatial pattern of fisheries development (Figure D3). These results are consistent with the expectation that the distance between catch locations and ports has increased through time, and that both distance from port and depth are critical in explaining fishery development patterns.

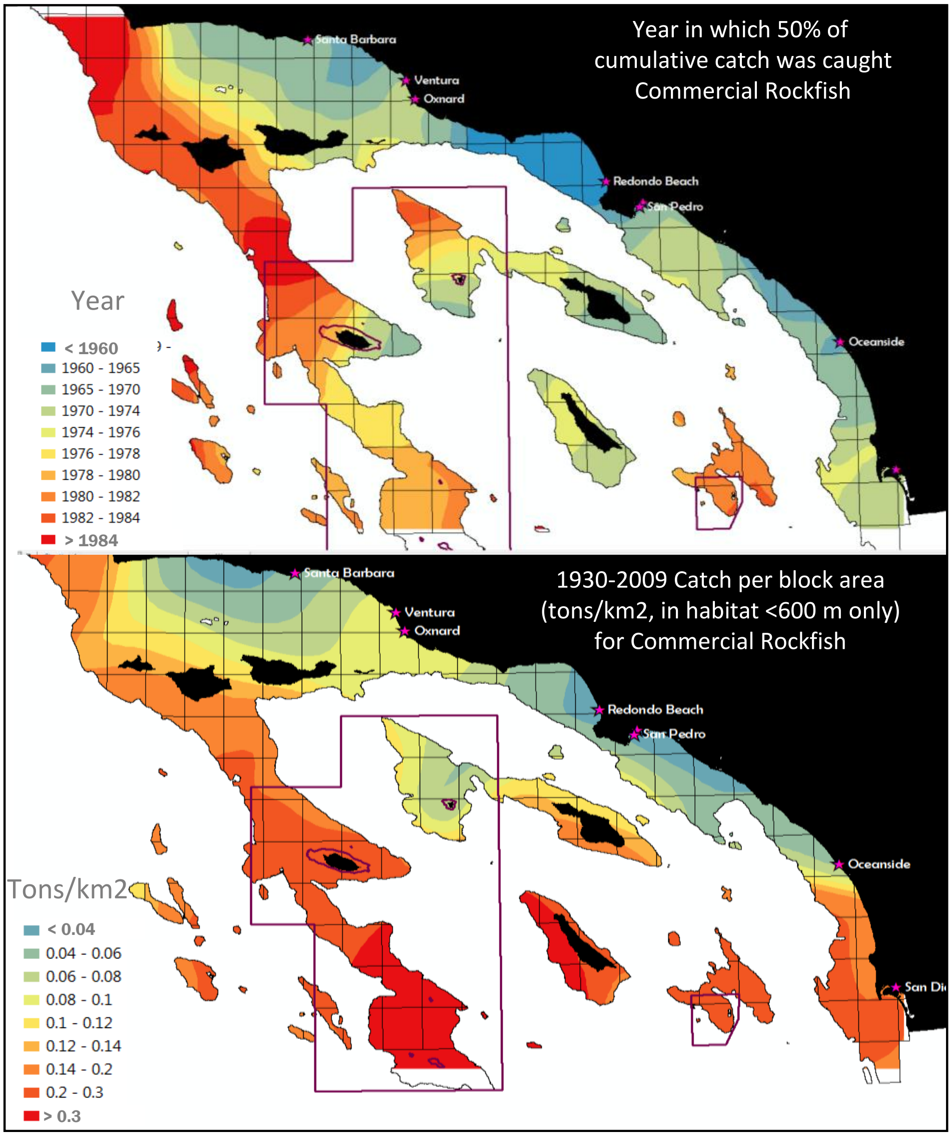

Figure D3: Preliminary results for rockfish (all *Sebastes* spp.) historical commercial landings in the southern California Bight, showing the year in which 50% of the total cumulative catch was caught (top) and the total cumulative catch per unit of habitat area (bottom). The Cowcod Conservation Areas (areas in which fishing is prohibited and bottom-contact survey data do not exist) is denoted in magenta.

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STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2011

Prepared for the Fifty-second Annual Meeting of the Technical Subcommittee
of the Canada-United States Groundfish Committee

With new contributions from:
Mike Byerly, Bob Chadwick, Heather Fitch, Barbi Failor, Dr. Ken Goldman, Kristen Green, Lee Hulbert, Mike Jaenicke, Scott Meyer, Kristen Munk, Elisa Russ, Nick Sagalkin, Gail Smith, Trent Hartill, Charles Trowbridge and Carrie Worton

April 2012

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION of COMMERCIAL FISHERIES & DIVISION of SPORT FISH
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STATE OF ALASKA GROUNDFISH FISHERIES AND ASSOCIATED INVESTIGATIONS IN 2011

AGENDA ITEM VII -- REVIEW OF AGENCY GROUNDFISH RESEARCH, STOCK ASSESSMENT, AND MANAGEMENT

A. Agency Overview

1. Description of the State of Alaska commercial groundfish fishery program:

The Alaska Department of Fish and Game (ADF&G) has jurisdiction over all commercial groundfish fisheries within the internal waters of the state and to three miles offshore along the outer coast. A provision in the federal, Gulf of Alaska (GOA) Groundfish Fishery Management Plan (FMP) gives the State of Alaska limited management authority for demersal shelf rockfish (DSR) in federal waters east of 140^{o} W. longitude. The North Pacific Fisheries Management Council (NPFMC) took action in 1997 to remove black and blue rockfish from the GOA FMP. In 2007 the dark rockfish was removed from both the GOA and the Bering Sea and Aleutian Islands (BSAI) FMP. Thus in these areas, the state manages these species in both state and federal waters. The state also manages the lingcod resource in both state and federal waters of Alaska. The State of Alaska manages some groundfish fisheries occurring in Alaska waters in parallel with NOAA fisheries, adopting federal seasons and in some cases allowable gear types as specified by NOAA. The information related in this report is from the state-managed groundfish fisheries only.

The State of Alaska is divided into three maritime regions for marine commercial fisheries management. The Southeast Region extends from the Exclusive Economic Zone (Equi-distant line) boundary in Dixon Entrance north and westward to 144^{o} W. longitude and includes all of Yakutat Bay (Appendix II). The Central Region includes the Inside and Outside Districts of Prince William Sound (PWS) and Cook Inlet including the North Gulf District off Kenai Peninsula. The Westward Region includes all territorial waters of the Gulf of Alaska south and west of Cape Douglas and includes North Pacific Ocean waters adjacent to Kodiak, and the Aleutian Islands as well as all U.S. territorial waters of the Bering, Beaufort, and Chukchi Seas.

a. Southeast Region

The **Southeast Region** Commercial Fisheries Groundfish Project is based in Sitka with the groundfish project leader, fisheries biologist, and one full-time fisheries technician located there. One full-time biologist, one full-time fisheries technician and one full time research analyst for this project are based in Douglas. Seasonal technicians and port samplers are employed in Petersburg, Ketchikan and Sitka. The project also receives biometrics assistance from the regional office in Douglas and from headquarters in Juneau.

The **Southeast Region's** groundfish project has responsibility for research and management of all commercial groundfish resources in the territorial waters of the Eastern Gulf of Alaska as well as in federal waters for demersal shelf rockfish (DSR), black, blue, and dark rockfishes, and lingcod. The project cooperates with the federal government for management of the waters of the adjacent EEZ. The project leader participates as a member of the NPFMC Gulf of Alaska Groundfish Plan Team and produces the annual stock assessment for DSR for consideration by the NPFMC. In 2011, as in 2010, the project leader also served as member of the NPFMC Plan Team Halibut Bycatch Working group. The goals of the working group are to determine a best method for extrapolating the catch of bycatch on the International Pacific Halibut Commission (IPHC) survey to the halibut fishery as a way to comply with Annual Catch Limit (ACL) requirements.

Project activities center around fisheries monitoring, resource assessment, and in-season management of the groundfish resources. In-season management decisions are based on data collected from the fisheries and resource assessment surveys. Primary tasks include fish ticket collection, editing, and data entry for both state and federally-managed fisheries; dockside sampling of sablefish, lingcod, Pacific cod, and rockfish landings; and logbook collection and data entry. Two resource assessment surveys were conducted during 2011. The Southeast Groundfish project is funded in part with NOAA Grant NA08NMF4070534. The R/V *Medeia*, home ported Juneau, conducts a variety of groundfish research activities in Southeast Region waters.

b. Central Region

Central Region groundfish staff is headquartered in Homer and is comprised of a regional groundfish management biologist, a regional groundfish/shellfish research project leader, a groundfish sampling coordinator, a groundfish fish ticket entry position, two marine research biologists, one GIS analyst, five to six seasonal technicians, and one seasonal commercial catch sampler. An assistant area management biologist and a seasonal commercial catch sampler are also located in Cordova and regional support is in Anchorage. The groundfish management biologist serves as a member of the North Pacific Fishery Management Council's (NPFMC) Gulf of Alaska Groundfish Plan Team and the research project leader serves on the NPFMC Non-Target Species Committee. The R/V *Pandalus*, home ported in Homer, and the R/V *Solstice,* in Cordova, conduct a variety of groundfish research activities in Central Region waters.

Groundfish responsibilities include research and management of groundfish species harvested in territorial waters of **Central Region**. Within Central Region, groundfish species of primary interest include sablefish, Pacific cod, pollock, lingcod, rockfishes, skates, sharks, and flatfishes. Data are collected through commercial catch sampling, fishermen interviews, logbooks, onboard observing, and through ADF&G trawl and remotely operated vehicle (ROV) surveys. Commercial harvest data (fish tickets) are processed in Homer for state and federal fisheries landings in Central Region ports. For some fisheries, logbook data are required and these are collected and entered to provide additional information including catch depth and harvest data.

c. Westward Region

The **Westward Region** Groundfish management and research staff is located in Kodiak and Dutch Harbor. Kodiak staff is comprised of a regional groundfish management biologist, an area groundfish management biologist, an assistant area groundfish management biologist, a groundfish research project leader, a groundfish research project assistant biologist, a groundfish dockside sampling coordinator, a trawl survey biologist, two seasonal fish ticket processing technicians, and several seasonal dockside samplers. A full-time area management biologist, an assistant area groundfish management biologist and a seasonal fish ticket processing technician are located in the Dutch Harbor office. Seasonal dockside sampling also occurs in Chignik, Sand Point, and King Cove. The R/V *Resolution*, R/V *K-Hi-C*, and R/V *Instar* hail from Kodiak and conduct a variety of groundfish related activities in the waters around Kodiak, the south side of the Alaska Peninsula, and in the eastern Aleutian Islands.

Major groundfish activities include: fish ticket editing and entry for approximately 11,000 tickets from both state and federal fisheries, analysis of data collected on an annual multi-species trawl survey encompassing the waters adjacent to the Kodiak archipelago, Alaska Peninsula and Eastern Aleutians, management of black rockfish, state-waters Pacific cod, lingcod, and Aleutian Island state-waters sablefish fisheries, conducting dockside interview and biological data collections from commercial groundfish landings, and a number of research projects. In addition, the Westward Region has a member on the NPFMC Bering Sea/Aleutian Island Groundfish Plan Team (Dave Barnard) and the Gulf of Alaska Groundfish Plan Team (Nick Sagalkin).

d. Headquarters

The 1996 Magnuson-Stevens Act called for developing regional fishery databases coordinated between state and federal agencies. The Alaska Fisheries Information Network (AKFIN), created in 1997, accomplishes this objective. The AKFIN program provides the essential fishery catch data needed to manage Alaska's groundfish and crab resources within the legislative requirements of the Act in Section 303(a)5. Alaska has diverse data collection needs that are similar to other states but the extensive geographic area and complexity of fisheries management tools used in Alaska have resulted in AKFIN becoming a cooperative structure that is responsive to the needs to improve data collection. The Pacific States Marine Fisheries Commission (PSMFC) manages the AKFIN grant with the funding shared by the ADF&G statewide AKFIN contract and the PSMFC sponsored AKFIN Support Center (AKFIN-SC) in Portland, Oregon. The ADF&G has primary responsibility for collecting, editing, maintenance, analysis, and dissemination of these data and performs this responsibility in a comprehensive program.

The overall goal of ADF&G's AKFIN program is to provide accurate and timely fishery data that is essential to management, pursuant to the biological conservation, economic and social, and research and management objectives of the fishery management plans for groundfish and crab. The specific objectives related to the groundfish fisheries are:

1) to collect groundfish fishery landing information, including catch and biological data, from Alaskan marine waters extending from Dixon Entrance to the BSAI;
2) to determine ages for groundfish samples using age structures (as otoliths, vertebrae, and spines) arising from statewide commercial catch and resource survey sampling conducted by ADF&G;
3) to provide the support mechanisms needed to collect, store, and report commercial groundfish harvest and production data in Alaska;

4) to integrate existing fishery research data into secure and well maintained databases with consistent structures and definitions;
5) to increase the quality and accuracy of fisheries data analysis and reporting to better meet the needs of ADF&G staff, AKFIN partner agencies, and the public, and to make more of this information available via web-access while maintaining the department's confidentiality standards;
6) to provide GIS services for AKFIN fishery information mapping to ADF&G Division of Commercial Fisheries staff and participate in GIS and fishery data analyses and collaboration with other AKFIN partner agencies;
7) to support economic analysis as needed prior to implementation of state and federal fishery regulations; and
8) to provide internal oversight of the AKFIN contract between the ADF&G and the Pacific States Marine Fisheries Commission (PSMFC).

Groundfish species include walleye pollock, Pacific cod, sablefish, skates, various flatfish, various rockfish, Atka mackerel, lingcod, sharks, and miscellaneous species.

The foundation of the state's AKFIN project is an extensive port sampling system for collection and editing of fish ticket data from virtually all of the major ports of landing from Ketchikan to Adak and the Pribilof Islands, with major emphasis on Sitka, Homer, Kodiak, and Dutch Harbor. The port sampling program includes collection of harvest data, such as catch and effort, and also the collection of biological data on the species landed, and age determination based on samples of age structures collected from landed catches. A dockside sampling program provides for collection of accurate biological data (e.g., size, weight, sex, maturity, and age) and verifies self-reported harvest information submitted on fish tickets from shoreside deliveries of groundfish throughout coastal Alaska. In addition, the Gulf of Alaska Groundfish FMP and the Bering Sea and Aleutian Islands Groundfish FMP require the collection of groundfish harvest data (fish tickets) in the north Pacific. The AKFIN program is necessary for management and for the analytical and reporting requirements of the FMPs.

The state's AKFIN program is supported by a strong commitment to development and maintenance of a computer database system designed for efficient storage and retrieval of the catch and production data on a wide area network and the internet. It supports the enhancement of the fish ticket information collection effort including; regional fishery monitoring and data management, GIS database development and fishery data analysis, catch and production database development and access, the Age Determination Unit laboratory, database management and administration, fisheries data collection and reporting, fisheries economic projects, and fisheries information services.

Local ADF&G personnel maintain close contact with fishers, processors and enforcement to maintain a high quality of accuracy in the submitted fish ticket records. Following processing, the data are electronically transferred to Headquarters. The research analyst working with this project works as part of a team to maintain a master statewide groundfish fish ticket database. Data feeds to Headquarters are merged to this master database. Data are routinely reviewed for accuracy with corrections applied as required. Within the confines of confidentiality agreements, raw data are distributed to the NMFS (both NMFS-ARO and NMFS-AFSC), the NPFMC, the

Commercial Fisheries Entry Commission (CFEC), the Pacific States Fisheries Information Network (PACFIN) and the AKFIN Support Center on a regularly scheduled basis. Summary groundfish catch information is also provided back to regional ADF&G offices as well as to the State of Alaska Board of Fisheries, NMFS, NPFMC and the AKFIN Support Center.

The fishery information collected by the AKFIN program is not only essential for managers and scientists who must set harvest levels and conserve the fisheries resources, but it is also valuable for the fishermen and processors directly involved in the fisheries, as well as the general public. To meet those needs, the department has designed, implemented, and continues to improve database systems to store and retrieve fishery data, and continues to develop improvements to fishery information systems to provide data to other agencies and to the public.

The department also conducts economic analyses of these data for use in the NPFMC arena. The need for an economic analysis component of the AKFIN program arises from jurisdictional obligations, pressing economic needs, and impacts of environmental regulations. The ADF&G is the management agency for state fisheries under its jurisdiction, and also a lead agency in policy making for federal fisheries of the region through its role in the NPFMC and the Pacific Salmon Commission (PSC). Economic analysis of seafood and fishery management policy is essential for the state to determine how proposed policies will impact the industry, Alaska regions, and coastal localities of the state. The role of state personnel is especially crucial under the rationalization plan currently being refined by the NPFMC, which will directly impact the state managed groundfish fisheries in the Gulf of Alaska.

Groundfish fishery milestones for this ongoing ADF&G AKFIN program are primarily the annual production of catch records and biological samples. In calendar year 2011, ADF&G AKFIN staff processed 19,690 groundfish fish tickets, collected 34,098 groundfish biological samples and measured 15,918 age structures (see tables below for regional breakdown). These basic measures of ongoing production in support of groundfish marine fisheries management by AKFIN funded ADF&G staff are representative of the level of annual productivity by the AKFIN program since its inception in 1997. (Contact: Lee Hulbert)

Groundfish Fish Tickets Processed -Calendar Year 2011

ADF&G Region	
1 - Southeast	3,239
2 - Central	2,751
4 - Westward; Kodiak, AK Pen.	12,160
4 - Westward; BSAI	1,540
Total	19,690

Groundfish Biological Data Collection - Calendar Year 2011

ADF&G Region	AWL Samples Collected	Age Structures Measured
1 - Southeast	7,018	7,141
2 - Central	9,249	4,852
4 – Westward	17,831	3,925
Total	34,098	15,918

Intergency Electronic Reporting System (contact Gail Smith)

ADF&G maintains a commercial harvest database, based on landing report receipts – fish tickets. These data are comprehensive for all commercial salmon, herring, shellfish, and groundfish from 1969 to present. Data are stored in an Oracle relational database and available to Headquarters and regional staff via the State of Alaska wide-area network.

Beginning in 2001, the agencies tasked with commercial fisheries management in Alaska (ADF&G, NMFS, IPHC) began development of a consolidated landing, production, and IFQ reporting from a sole source – the Interagency Electronic Reporting System (IERS). The goal is to move all fisheries dependant data to electronic reporting systems. The web-based reporting component of this system is ***eLandings.*** The desktop application for the at-sea catcher processor fleet is ***seaLandings***. Vessels using the seaLandings application email landing and production reports to the centralized database as an email attachment. ***tLandings*** was developed to address electronic reporting on-board salmon tender vessels. The application and the landings reports are stored on a portable hard drive and delivered to the shoreside processor for upload to the eLandings database. Fisheries management agencies use a separate application, the ***IERS Agency Interface***, to view and edit landing reports. The IERS management/development team are developing and implementing an electronic logbook application, ***eLogbook***, currently used by groundfish catcher processors. The ***eLogbook*** will be modified to accommodate groundfish and crab catcher vessels and implemented in the future. The IERS has been in successful operation in the groundfish and IFQ halibut/sablefish fisheries since July 2006.

Our approach, throughout this project, has been staged implementation which allows a small staff to successfully manage this ambitious project. We expect the IERS will be fully implemented with the salmon fishery by the end of the 2014 season. Statewide shellfish and herring fisheries will be addressed in 2015.

The IERS features include electronic landing and production reports, real time quota monitoring, immediate data validation, and printable (.pdf) fish ticket reports. The IERS provides processors with a web-based electronic catch and production data extraction using an XML output. ADF&G personnel, funded by AKFIN, Rationalized Crab Cost Recovery funds and IFQ Halibut/Sablefish Cost Recovery funds, participate in the IERS project on the development, implementation, and maintenance levels. During 2011, the IERS recorded more than 47,500 landing reports in crab, groundfish and salmon fisheries.

The IERS is extensively documented on a public and secure wiki at https://elandings.alaska.gov/confluence/

Local ADF&G personnel in six locations throughout the state of Alaska (Petersburg, Sitka, Juneau, Homer, Kodiak and Dutch Harbor) maintain close contact with groundfish fishers, processors and state/federal enforcement to maintain a high quality of accuracy in the submitted fish ticket records. The Interagency Electronic Reporting System – eLandings , seaLandings, tLandings and eLogbook applications, with immediate data validation and business rules, has improved data quality and allows personnel to function at a higher level. User support on a 24/7 basis is being provided by GCI, an Alaska based telecommunications company. IFQ reporting support is provided by the NMFS Data Technicians.

Landing and production data are submitted to a central database, currently hosted by the State of Alaska, validated and reviewed, and pulled to the individual agency databases. Landing data are available to agency personnel within seconds of submission of the report. Printable documentation of the landing report and the Individual Fishery Quota debit are created within the applications. Signed fish tickets continue to be submitted to local offices of ADF&G for additional review and comparison to other data collection documents. These documents include vessel/fisher logbooks, agency observer datasets, and dockside interviews with skippers.

Within the confines of confidentiality agreements, raw data are distributed to the State of Alaska Commercial Fisheries Entry Commission (CFEC) and to the National Marine Fishery Service NMFS-ARO and AKFIN Support Center on a monthly schedule. The CFEC merges the ADF&G fish ticket data with fisher permit and vessel permit data. This dataset is then provided to the AKFIN Support Center, which distributes the data to the professional staff of the North Pacific Fishery Management Council (NPFMC) and summarized data to the Pacific States Fisheries Information Network (PACFIN). Summary groundfish catch information is also posted on the ADF&G Commercial Fisheries website:
http://www.cf.adfg.state.ak.us/geninfo/finfish/grndfish/grndhome.php.
Summarized data are provided to the State of Alaska Board of Fisheries, the North Pacific Fisheries Management Council, and to the State of Alaska legislature as requested.

e. Gene Conservation Laboratory

In the past, the ADF&G Gene Conservation Laboratory collected genetic information on black rockfish, light and dark dusky rockfish, and pollock (a list of *Sebastes and* pollock tissue samples stored at ADF&G's Gene Conservation Laboratory can be found in Appendix III).

f. Age Determination Unit

The ADFG's centralized statewide age reading program at the Age Determination Unit (ADU; also known as the Otolith Lab or the Age Lab) in Juneau continued to provide age data to ADF&G regional managers in 2011. Age structures from 11,495 groundfish representing 18 species were received from statewide commercial and survey harvest sampling efforts. A total of 9,101 age data were released back to managers, which included data from samples received in previous years, but processed in 2011. Over 2,808 additional age data were produced through precision testing, and an additional 4,225 data were produced through training and calibration procedures. A total of 47,358 age structure measurement records were produced (representing over 26,346 specimens) were measured. The majority (>70%) of funding for this project is through AKFIN, and the remaining is from state funding. The ADU employed six people in 2011 for approximately 55 work months to age groundfish and invertebrate age structures and conduct associated work, for example, sample preparation, data entry, archiving of data and samples, age structure measurements, and project work.

Quality of age data is routinely assessed through second-reading of at least 15% of the sample, either by the initial reader or by a reader with equal or greater experience. Species-specific control limits are imposed to further guide release of age data; transgression of control limits direct reviewing of some or the entire sample.

In 2011, the ADU was in production status for all species received except for gadids from commercial fisheries. Aging of sablefish dominated the reading schedule. This is due to substantial increases in sampling of sablefish and the use of these data in age structured models. Effort continued toward increasing objective information (age structure measurements, age validation) to strengthen foundation of pattern interpretation for all species.

Substantial project work is conducted by the ADU and is in varying stages of implementation and completion. Notable projects include: bomb radiocarbon age validation, culture of walleye pollock for known otolith accretion, tagging and release of walleye pollock, and development of the seminal "ADU Data Filter". Most of the bomb radiocarbon age validation work is in the writing stages, although completion of reports is on hold due to other high priority work. Culture of walleye pollock to produce known otolith accretion values at age continued in 2011. These fish reached age-5 in April 2011, and have been under tank culture at the NMFS Auke Bay Marine Station, Juneau Alaska since their capture in 2006 at age-0. This project reached maturity in 2011 and it will conclude April 2012. An interim Regional Information Report was produced (Munk 2011); this report suggested that contemporary aging practice of walleye pollock should be revisited because the known otolith accretion from cultured pollock is suggesting that walleye pollock are currently being underaged. In 2011, ADU staff tagged and released 49 wild pollock in Auke Bay for a three year total of 2,699 tagged pollock. The longest distance for a recovery (of a tag which did not include the fish) was approximately 20 miles (north of Benjamin Island in Lynn Canal), and the longest time between tagging and recovery was approximately 1 year. Pollock and other fish tagging updates are available at http://tagotoweb.adfg.state.ak.us/ADU/Tagged.aspx. In 2011, ADU staff commenced development of the ADU Data Filter. This filter models age structure dimensions-at-age, and eventually will compare the established range to 100% of produced age data, highlighting specimens which are not within expected ranges. These "exceptions" will then be reviewed for possible age mis-assignment, data entry errors, etc. The phases of work conducted in development of the ADU Data Filter are: modeling age-at-age structure dimension (usually otolith weight) and creation of lookup tables of values; creation of a computer interface; testing and evaluating proof of concept; and development of protocols for implementation. The first species of application is sablefish, and will be followed by lingcod and yelloweye rockfish once the project components are established for sablefish. This project will evaluate the performance of the data filter for one year and report outcome, prior to full implementation in the ADU program.

The ADU Oracle database *AegIS*, Age Information System, was used for logging in samples, importing and exporting of data, importing field data, and direct entry of age structure measurements. We completed development of an online age structure invoicing system, *OASIS*, which was first deployed late 2010, and this system was fully utilized in 2011. All samples sent to the ADU are first invoiced online, which provide for standardization of sample information prior to receipt of the sample.

The ADU participated in the Canada-US Groundfish Committee's working group, Committee of Age Reading Experts (CARE). We participated in the biennial workshop, age structure exchanges, and committee work including developing narrative for an age reading manual. (Contact Kristen Munk)

2. Description of the State of Alaska recreational groundfish fishery program (Sport Fish Division)

ADF&G manages all recreational groundfish fisheries within the internal waters of the state, in coastal waters out to three miles offshore, and throughout the EEZ. The Alaska Board of Fisheries extended existing state regulations governing the sport fishery for all marine species into the waters of the EEZ off Alaska in 1998. This was done under provisions of the Magnuson-Stevens Fishery Conservation and Management Act, which stipulate that states may regulate fisheries that are not regulated under a federal fishery management plan or other applicable federal regulations. No recreational fisheries are included in the Gulf of Alaska Fishery Management Plan.

Most management and research efforts are directed at halibut, rockfish, and lingcod, the primary groundfish species targeted by the recreational fishery. Statewide data collection programs include an annual mail survey to estimate overall harvest (in number of fish) of halibut, rockfishes (all species combined), lingcod, Pacific cod, sablefish, and sharks (all species combined), and a mandatory logbook to assess harvest of selected species in the charter boat fishery. The statewide bottomfish coordinator (Scott Meyer) coordinates federal data requests and develops scientifically-based advice for assessment and management of halibut and groundfish.

Regional programs with varying objectives address estimation of recreational fishery statistics including harvest and release magnitude and biological characteristics such as species, age, size, and sex composition. Research was funded through state general funds and the Federal Aid in Sport Fish Restoration Act. There are essentially two maritime regions for marine sport fishery management in Alaska. The Southeast Region extends from the EEZ boundary in Dixon Entrance north and westward to Cape Suckling, at approximately 144^{o} W. longitude. The Southcentral Region includes state and federal waters from Cape Suckling to Cape Newenham, including Prince William Sound (PWS), Cook Inlet, Kodiak, the Alaska Peninsula, the Aleutian Islands, and Bristol Bay.

a. Southeast Region Sport Fish

Regional staff in Douglas coordinates a data collection program for halibut and groundfish in conjunction with a region wide Chinook salmon harvest studies project. The project leader, assistant project biologist for the northern southeast Alaska ports, the project biometrician, and the project research analyst are based in Juneau, while the assistant project biologist for the southern southeast Alaska ports is based out of Ketchikan. A total of 25 technicians worked at the major ports in the Southeast region, where they interviewed anglers and charter operators and collected data from sport harvests of halibut and groundfish while also collecting data on sport harvests of salmon. Data collected on groundfish were limited to species composition, lengths of harvested rockfish, halibut and lingcod, and sex of lingcod; no otoliths or other age structures were collected. Data were provided to the Alaska Board of Fisheries, other ADF&G staff, the public, and a variety of other agencies such as the NPFMC and the IPHC.

The Regional Management Coordinator and Area Management Biologists in Yakutat, Haines, Sitka, Juneau, Petersburg, Craig, and Ketchikan are responsible for groundfish management in those local areas. The demersal shelf rockfish and lingcod sport fisheries are managed under the direction of the Demersal Shelf Rockfish Delegation of Authority and Provisions for Management (5 AAC 47.065) and the Lingcod Delegation of Authority and Provisions for Management (5 AAC 47.060) for allocations set by the Alaska Board of Fish.

b. Southcentral Region Sport Fish

The **Southcentral Region** groundfish staff consisted of two Regional Management Biologists as well as Area Management Biologists and assistants for the following areas: (1) PWS and the North Gulf areas, (2) Lower Cook Inlet, and (3) Kodiak, Alaska Peninsula, and the Aleutian Islands. In addition, a region-wide harvest assessment project was based in the Homer office, consisting of a project leader, project assistant, and six technicians. The research project biometrician was located in Anchorage. Ongoing assessment of sport harvest and fishery characteristics at major ports throughout the region is the primary activity. Data were collected from harvested halibut, rockfishes, lingcod, and sharks, and anglers and charter boat operators were interviewed for fishery performance information. All age reading was done in Homer, and the staff members are active participants in the Committee of Age Reading Experts (CARE). Seasonal technicians collected data from the sport harvest at seven major ports in the region, and two of them read all rockfish and lingcod age structures. Halibut otoliths were collected from the harvest and will be forwarded to the IPHC for age reading.

Southcentral Region staff is responsible for management of groundfish fisheries in state and federal waters. For all species, the lack of stock assessment information has hindered development of abundance-based fishery objectives. As a result, management is based on building a conservative regulatory framework specifying bag and possession limits, seasons, and methods and means that are hoped to provide for sustained yield over the long term. Lack of stock assessment information coupled with increasing effort and harvest in several groundfish sport fisheries accentuate the need for a comprehensive management plan and harvest strategy.

Typical duties included providing sport halibut harvest statistics to IPHC and NPFMC, assisting in development and analysis of the statewide charter logbook program and statewide harvest survey, providing information to the Alaska Board of Fisheries, advisory committees, and local fishing groups, drafting and reviewing proposals for recreational groundfish regulations, and dissemination of information to the public.

B. By Species

Pacific cod

Catch rate and biological information is gathered from fish ticket records, port sampling programs, a tagging program, and during stock assessment surveys for other species. A mandatory logbook program was initiated in 1997 for the state waters of Southeast Alaska. Commercial landings in Southeast, Central Region and the Westward Region are sampled for length, weight, age, sex, and stage of maturity.

a. Research

The **Westward Region** has continued the cod-tagging program that was initiated in 1997 in the Central, Western, and Eastern Gulf of Alaska. Approximately 1,247 fish were tagged in 2011, bringing the total number of tags released to 18,670. By year's end, 62 tags had been recovered. Fish spent from 100 to 500 days at liberty; a few over 1,000 days. Recovery rates averaged 5.6% per year. While the vast majority of Pacific cod are recovered within 10-20 km of their tagging location, much longer recapture distances are possible. Several fish were recaptured more than 500 km from their tagging location. The relatively small number of long distance recaptures show movement of cod is occurring from the Shumagin Islands and Unlaska into the Bering Sea, the Alaska Peninsula to Kodiak waters, and several fish tagged in Kodiak waters were recovered in Cook Inlet and Southeast Alaska.

b. Stock Assessment

No stock assessment programs were active for Pacific cod during 2011.

c. Management

Regulations adopted by the Alaska Board of Fisheries during November 1993 established a guideline harvest range (GHR) of 340 to 567 mt for Pacific cod in the internal waters of **Southeast Alaska**. The internal waters of Southeast Alaska are comprised of two areas, the Northern Southeast Inside (NSEI) Subdistrict and the Southern Southeast Inside (SSEI) Subdistrict. The GHR was based on average historic harvest levels rather than on a biomass-based ABC estimate. This fishery has the most participation in the winter months, and in-season management actions such as small area closures are implemented to spread out the fleet and reduce the risk of localized depletions. Pacific cod in state waters along the outer coast are managed in conjunction with the Total Allowable Catch (TAC) levels set by the federal government for the adjacent EEZ.

In 1996, the Alaska Board of Fisheries (BOF) adopted Pacific cod Management Plans for fisheries in five groundfish areas, **Prince William Sound**, **Cook Inlet**, **Kodiak**, **Chignik** and **South Alaska Peninsula**. The plans did not restrict participation to vessels qualified under the federal moratorium program. Included within the plans were season, gear and harvest specifications. State-waters fishing seasons were set to begin seven days after the close of the initial federal season in all areas except Cook Inlet, which begins 24 hours after the closure and

Chignik, which has a regulatory opening date of March 1; however, in 2011, the BOF adjusted state-waters seasons in Prince William Sound (PWS) for pot gear and jig gear to open 24 hours following the closure of the initial federal season; and for longline gear in PWS to open seven days following the initial federal season closure or concurrent with the individual fishing quota (IFQ) halibut season opening date, whichever occurs later. The BOF restricted the state-waters fisheries to pot or jig gear in an effort to minimize halibut bycatch and avoid the need to require onboard observers in the fishery. However, in 2009, a new BOF regulation became effective permitting use of longline gear in PWS. This change was largely in response to the very low levels of effort and harvest and the high level of interest from the longline gear group. With the exception of longline gear in PWS, guideline harvest levels (GHL) are allocated by gear type; however, in 2011, the BOF adopted caps for PWS whereas longline gear will close when 85% of the GHL is reached and pot gear will close when 90% of the GHL is reached.

In October 2011, the BOF held a special meeting to coordinate state-managed Pacific cod fisheries with changes occurring in the federal fisheries due to the implementation of gear sector splits (differential allocations of the TAC by gear type), and adjust Pacific Cod Management Plans and related regulations accordingly. The BOF adopted regulatory changes to align the parallel seasons with the federal seasons for each legal gear type. In PWS, the parallel longline season was aligned with the federal catcher vessel less than 50 foot hook-and-line gear sector. Different parallel season closures by gear type resulted in different seasons for each gear type in the state-waters seasons, and the department considered these changes manageable. The annual GHLs are based on the estimate of acceptable biological catch (ABC) of Pacific cod as established by the NPFMC. Current GHLs are set at 25% of the Western Gulf ABC to be reserved for the South Alaska Peninsula Area, 25% of the Central Gulf ABC to be apportioned between the Kodiak, Chignik and Cook Inlet Areas and 25% of the Eastern Gulf ABC for the Prince William Sound Area. Action by the BOF in 2004 reduced the GHL in Prince William Sound to 10% of the Eastern Gulf ABC with a provision to increase subsequent GHLs to15% and then 25% if the GHL is achieved in a year; in 2011 the Prince William Sound GHL was set at the maximum level of 25% after achieving the GHL the two previous years, and in 2011, the BOF removed the step-up provision, as there was no mechanism to lower the GHL to previous levels

Additional regulations include a 58’ vessel size limit in the Chignik and South Alaska Peninsula Areas. For the Cook Inlet Area, the BOF also adopted a harvest cap for vessels >58’ that limited harvest to a maximum of 25% of the GHL. The fishery management plans also provided for removal after October 31 of restrictions on exclusive area registrations, vessel size, and gear limits to increase late season production to promote achievement of the GHL. In addition, observers are occasionally used on day-trips to document catches and at-sea discards in the nearshore pot fisheries.

In February of 2006, the Alaska Board of Fisheries adopted a Pacific cod Management Plan for a nonexclusive Aleutian Islands District, west of 170° W longitude, state-waters fishery. Included within the plan were season, gear and harvest specifications. The fishery GHL was set by regulation at three percent based on the estimate of acceptable biological catch (ABC) of Pacific cod as established by the NPFMC for the Bering Sea – Aleutian Islands area with a maximum of 70% of the GHL available before June 10. By regulation, the fishery opened on or after March

15, at the conclusion of the initial parallel catcher-vessel trawl fishery for Pacific cod in the federal BSAI Area. Non-pelagic trawl, longline, jig and pot gear were all permissible in the 2006 fishery.

In October of 2006, the Alaska Board of Fisheries amended the Pacific Cod Management Plan for the **Aleutian Islands**. Beginning in 2007, a new regulation set the opening date of the fishery at four days after the initial closure of the federal Bering Sea – Aleutian Islands catcher vessel trawl season. Additional regulations introduced new vessel size limits of 125' or less overall length for pot vessels, 100' or less overall length for trawl vessels and 58' or less overall length for longline and jig vessels. In 2009, vessels participating in the B season were restricted to under 60' overall length for all legal gear types. In 2010, this regulation was once again changed to allow pot vessels 125' or less to participate in the B season beginning August 1. Prior to August 1, during the B season, all vessels must still be less than 60'.

The NPFMC recently established sector allocations for the federal CGOA Pacific cod fisheries. The NPFMC's action established unique Pacific cod harvest allocations for pot, jig, trawl, and longline gear vessels. Beginning in 2012, the federal/parallel Pacific cod season for each federal gear sector will be prosecuted independently of other Pacific cod federal gear sectors, likely resulting in staggered federal season closure dates. Prior to federal sector allocations, all gear types competed for federal/parallel Pacific cod during a single derby-style fishery. In order to coordinate state-waters Pacific cod fisheries, a Board of Fisheries meeting was held in October 2011 to adopt or amend regulations anticipating these federal changes. In most cases, starting in 2012, state-waters fisheries opened independently for each gear type.

There is no bag, possession, or size limit for Pacific cod in the recreational fisheries in Alaska, and the season is open year-round. Recreational harvest of Pacific cod is estimated through the Statewide Harvest Survey (SWHS). Limited information is collected through the Sport Fish Division's Southcentral Region port sampling program. Specifically, numbers of cod kept and released by stat area is recorded by ADF&G groundfish staff for each vessel-trip interview. Size and age data are collected opportunistically. No information is collected in the Southeast Region creel survey program on the Pacific cod sport fishery.

d. Fisheries

Most of the Pacific cod harvested in **Southeast Alaska** are taken by longline gear in the NSEI Subdistrict during the winter months. Pots have been the dominant gear in **Cook Inlet** and longline gear the dominant gear in recent **Prince William Sound** fisheries. Overall, Pacific cod harvest from the Cook Inlet and PWS areas during the parallel season has declined in recent years. In the **Westward Region**, trawl gear takes over 60% of the harvest, with the remainder split between longline, jig, and pot gear. In the Aleutian Islands, trawl gear took 60% of the harvest, pot gear took 31%, and the remainder was split between longline and jig gear. Trawl gear was used primarily during the A season and pot gear in the B season.

Prior to 1993, much of the cod taken in the **Southeast** was utilized as bait in fisheries for other species. In recent years in Southeast Alaska, the Pacific cod harvest has been largely sold for human consumption. In 2011, 26% of the Pacific cod catch was recorded as being used for bait. In other areas of the state, Pacific cod are harvested in both state and federal waters and utilized primarily as food fish. Harvests of Pacific cod in the Southeast state-managed (internal waters) fishery during 2011 totaled 270 mt.

The 2011 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and Prince William Sound Areas of the **Central** Region were 2,018 mt and 651 mt, respectively. Harvest from the Cook Inlet Area state-waters Pacific cod fishery totaled 1,996 mt and the Prince William Sound Area harvest totaled 723 mt. In 2012, Cook Inlet will receive its maximum allocation of 3.8% of the CGOA ABC, which was increased to that level by the BOF in 2004, and the PWS allocation will receive its maximum allocation of 25.0% of the EGOA ABC. The Kodiak and South Alaska Peninsula Areas obtained their maximum GHL 'step up' provisions for 2000 and all subsequent years. The Kodiak Area will receive 12.5% of the Central Gulf ABC and the South Alaska Peninsula will receive 25% of the Western Gulf ABC in all future years. The Chignik Area achieved its maximum GHL 'step' up in 2003.

Estimates of the 2011 recreational harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2010 estimates were 9,291 fish in **Southeast** and 27,258 fish in **Southcentral Alaska**. The average estimated annual harvest for the most recent five-year period (2005-2010) was 9,761 fish in **Southeast** Alaska and 16,982 fish in **Southcentral** Alaska.

2. Rockfishes

Commercial rockfish fisheries are managed under three assemblages: demersal shelf (DSR), pelagic shelf (PSR), and slope rockfish. DSR include the following species: yelloweye, quillback, china, copper, rosethorn, canary, and tiger. PSR include black, blue, dusky, dark, yellowtail, and widow. Slope rockfish contain all other *Sebastes* species, except *Sebastolobus*, which are defined separately.

a. Research

In the **Southeast Region,** port sampling effort for rockfish expanded in 2008 to include the sampling of DSR caught as bycatch in the IFQ halibut fishery. The sampling of the halibut fishery was started in part to obtain more samples in years that the directed fisheries was not opened. The mandatory logbook program for all groundfish fisheries continued. The logbook program is designed to furnish detailed catch and effort information, and to obtain more detailed information regarding specific harvest location. The port-sampling program collects biological samples. In 2011, the directed fishery for DSR opened in the Southern Southeast Outside (SSEO) area of the Southeast Outside District (SEO). Length, weight and age structures were collected from 249 yelloweye rockfish caught in the directed fishery. The remaining areas of SEO, the East Yakutat (EYKT), Central Southeast Outside (CSEO) and Northern Southeast Outside (NSEO) Sections, did not open to directed fishing because the portion of the TAC allocated to those areas was not large enough to support an orderly fishery. The directed fishery for DSR opened in internal waters. Landings were minimal in NSEI, but the full SSEI quota was harvested. No biological samples of yelloweye rockfish were collected from the internal waters fishery. An additional 1,173 yelloweye rockfish biological samples were collected from the commercial halibut fishery in SEO.

Rockfish habitat mapping projects continue in the **Southeast Region**. The objective of this project is to continue to collect and evaluate data in the Eastern Gulf of Alaska for the purpose of identifying potential habitats in this important fishing ground. To date, ADF&G has mapped approximately 2,238 km^2 of seafloor. This represents over 7% of the total habitat inside the 100-fm contour along the outer coast of Southeast. More importantly, over 1118 km^2 of rocky habitat has been mapped, approximately 37% of what is estimated to occur. No habitat mapping occurred in 2011. (Contact Kristen Green). Work is also in progress on an age-structured assessment model for yelloweye rockfish. (Contact Dave Carlile).

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2011 occurred in Homer, Seward, Whittier, Anchorage and Cordova. Efforts throughout the year were directed at the sampling of rockfish delivered as bycatch to other groundfish and halibut fisheries, primarily slope and demersal shelf species. The directed jig fishery in the Cook Inlet Area that targets pelagic rockfish begins July 1 and historically had been the focus of rockfish sampling during the last half of the year. However, very limited fishing effort had drastically reduced sampling opportunities from 2006 to 2009 until an increase in effort in 2010 and 2011 resulted in additional sampling opportunity. In 2011, harvest of pelagic shelf rockfish was twice the amount in 2010 and back to the same level as 2005. This resulted in the sampling goal (n=510) for the directed jig fishery being achieved for the first time since 2004. Sample data collected included date and location of harvest, species, length, weight, sex, and gonad condition. Otoliths were collected from most sampled fish. Homer staff determined ages of 1,090 pelagic and demersal shelf rockfish otoliths. Otoliths from all other rockfish species were sent to the Age Determination Unit. Additional sampling occurred during the Cook Inlet and PWS trawl surveys. (Contact Elisa Russ).

Development continued on a marine habitat GIS in **Central Region**. A final bathymetry grid for the 2009 Chugach Islands multibeam survey was completed. The area mapped was 102 km^2 and represents import recreational fishing grounds for DSR in Lower Cook Inlet. A new effort was initiated to re-compile all existing xyz bathymetry data for Central Region. This task had been completed in 2006 and a regional 50 m mosaic was produced. This early mosaic has proved very useful in preliminary characterization of hard and soft seafloor features for the region. More accurate and precise methods of interpolating the wide mixture of bathymetry resolutions are available and will be used for this new effort. All NOAA xyz data sets have been acquired and organized by buffered nautical chart areas. Mosaics will be created for each chart area which will make future GIS work easier and more manageable. Margaret Spahn was coordinating this project but has recently retired. Mike Byerly is currently overseeing this work until this position is filled. (Contact Mike Byerly or Dr. Ken Goldman).

The **Westward Region** continued its port sampling of the commercial rockfish and Pacific cod harvests in 2011. Rockfish sampling consisted mainly of black rockfish with opportunistic sampling of duskys, darks, and other miscellaneous *Sebastes* species. Skippers were interviewed for information on effort, location, and bycatch. Length, weight, gonadal maturity, and otolith samples were collected (Contact Sonya El Mejjati).

Staff from the Kodiak office has completed aging black rockfish otoliths through the 2011 season while a number of Pacific cod otoliths remain to be read.

The **Westward Region** also continued several studies on Western Gulf of Alaska black and dark rockfish. Daily and seasonal movement data were collected from 85 black rockfish and 55 dark rockfish tags that were released off the east side of Spruce Island, just north of the port of Kodiak. The acoustic tagging of black rockfish and dark rockfish ended in 2010 and is currently being analyzed. In addition, hydroacoustic surveys of black and dark rockfish were conducted in 2011 in the Northeast, Southeast, Southwest, Westside, and Mainland District of the Kodiak Management Area and the South Peninsula Management Area in an effort to generate biomass estimates for both black and dark rockfish; data is currently being analyzed. Surveying of the Northeast District in the Kodiak Management Area will continue in 2012 (Contact Carrie Worton).

The **Division of Sport Fish—Southeast Region** continued to collect catch and harvest data from rockfish as part of a marine harvest onsite survey program with rockfish harvests tabulated back to 1978 in some selected ports. Rockfish objectives included estimation of 1) species composition, 2) weight and length composition, and 3) the geographic distribution of harvest by the fleets by port. Primary species harvested in Southeast Alaska included yelloweye, black, copper, and quillback rockfish. Approximately 6,198 rockfish were sampled from the sport harvests at Ketchikan, Craig, Klawock, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2011 (Contact Mike Jaenicke).

The **Division of Sport Fish—Southcentral Region** continued collection of harvest and fishery information on rockfish as part of the harvest assessment program. Rockfish objectives included estimation of: 1) species composition, 2) age, sex, and length composition, and 3) the geographic distribution of harvest by the fleets by port. Approximately 3,588 rockfish were sampled from the sport harvests at Seward, Valdez, Whittier, Kodiak, and Homer in 2011 (Contact Barbi Failor).

The Division of Sport Fish published a paper on the effectiveness of deepwater release at improving the discard survival of yelloweye rockfish. This project used mark-recapture to generate a maximum likelihood estimate of the 17-day survival probability of yelloweye rockfish (n = 182) caught by hook-and-line (depth range = 18 – 72 m) and subsequently released at depth. The average survival probability for yelloweye released at depth was remarkably high (0.988, 95% CI = 0.426 – 0.999) and positively correlated with individual total length. Survival probability was not significantly influenced by capture depth or exposure to barotrauma and other capture stressors. Submergence success of yelloweye rockfish released at the water's surface was 0.221 (95% CI = 0.149 – 0.315) and suggests that the maximum survival potential of individuals released at the surface is low. The results of this study indicate that the average survival of discarded yelloweye rockfish can be substantially improved with the use of deepwater release (Contact Sam Hochhalter).

b. Stock Assessment

The **Southeast Region** conducts a multi-year stock assessment survey for DSR in the Southeast District. Biomass is estimated by management area as the product of yelloweye rockfish density determined from line transect surveys, the area of rocky habitat within the 100 fm contour, and the yelloweye rockfish average weight. Yelloweye rockfish density for the stock assessment is based on the most recent estimate by management area. Yelloweye rockfish densities for each area are multiplied by the current year's average commercial fishery weight of yelloweye rockfish specific to that management area. During the last submersible survey in 2009, density surveys were conducted in EYKT. The SSEO area was last surveyed in 2005, CSEO was last surveyed in 2007 and NSEO was surveyed in 2001. The most recent density estimates by area range from 1,068 to 3,557 yelloweye rockfish per km^2. Allowable biological catch for the SEO is set by multiplying the lower bound of the 90% confidence interval of total biomass for yelloweye rockfish by the natural mortality rate (0.02) and increasing the biomass estimate by 2–4.0% (depending on the current year's weight ratio of other species landed in the DSR assemblage). There is no stock assessment information available for NSEI and SSEI. New rockfish density surveys are planned for August 2012 in CSEO, however the Delta submersible we have used for all surveys since 1989 is no longer available for use. For 2012, we are planning on collaborating with the Central Region staff to utilize their expertise to conduct rockfish surveys with an ROV in lieu of a submersible. No surveys for non-DSR species, (e.g. black rockfish) have been conducted since 2002.

Central Region conducts ROV surveys along the north Gulf of Alaska coast from the Kenai Peninsula to Prince William Sound to monitor the local abundance of lingcod and DSR in selected index sites. These sites are on the order of 100's of sq km and tend to be relatively isolated rocky banks boarded by land masses, deep fjords, and / or expanses of deeper soft substrates. A rocky bank surrounding and extending to the south of outer Pye Island was mapped with multibeam during a department survey in 2008. A three nm no-transect zone has been in effect for Outer Pye Island since 1996 and encompasses this area acting as a de facto preserve. Additionally, there is a 10 nm fixed and trawl gear closure surrounding outer Pye Island. The seafloor features within the mapped area were delineated and an ROV survey to estimate DSR abundance and biomass was conducted there in May 2010. Yelloweye rockfish density was estimated at 2,836 fish / km^2 (cv = 0.23) for rocky / hard substrates and 2,042 fish / km^2 (cv = 0.25) for the survey area. These estimates were higher though not significantly (95% CI's) from Nuka Island which is located just west and is open to fishing. Population estimates from ROV surveys have not yet been used to set harvest limits or incorporated into a stock assessment. (Contact Mike Byerly or Dr. Ken Goldman).

In the **Westward Region,** hydroacoustic equipment was deployed in a preliminary effort at stock assessment of black and dark rockfish. Surveyed areas included the Westside District of the Kodiak Management Area and the Chignik Management Area (contact Carrie Worton).

c. Management

Management of DSR in the **Southeast Region** is based upon a combination of GHRs, seasons, gear restrictions, and trip limits. Directed commercial harvest of DSR is restricted to hook-and-line gear. Directed fishing quotas are set for the four outside water management areas (NSEO, CSEO, SSEO, and EYKT) vased on the stock assessment. Directed fishery quotas for the two internal water management areas (NSEI and SSEI) are set at 25 mt annually. Regulations adopted in 1994 include trip limits (within any 5 day period) of 6,000 pounds per vessel in all areas except for EYKT where the trip limit is 12,000 pounds, and added a requirement that logbook pages must be submitted with fish tickets for each fishing trip. At the Board of Fisheries meeting in early 2006, the season for the directed fishery of DSR in SEO was changed to occur in the winter only from January 5th until the day before the start of the commercial halibut IFQ season, or until the annual harvest limit is reached, whichever occurs first. At this meeting, the total allowable catch (TAC) for DSR was allocated 84% to the commercial sector and 16% to the sport sector. At the 2009 Board of Fisheries meeting, it was decided that the anticipated harvest of DSR in the subsistence fisheries would be deducted from the ABC before the split in allocation is made between commercial and sport fisheries. The 2012 ABC for DSR was 293 mt, which resulted in an allocation of 240 mt to commercial fisheries and 46 mt to sport fisheries (after a deduction of 7 mt for the subsistence fishery) (Green et al. 2011). A significant portion of the total commercial harvest is taken as bycatch mortality during the halibut fishery; each year this is estimated and decremented from the commercial TAC. Prior to the 2012 fishery, we had used IPHC survey data to determine bycatch rate by depth and apply this to the commercial catch to estimate DSR bycatch. In 2012, commercial landing data was used to calculate the commercial bycatch rate of DSR in the halibut fishery and this bycatch rate was applied to the current year's quota to estimate bycatch of DSR. This change in methodology was made since five years of full retention DSR landings are available for analysis, and we felt this was more accurate than using the IPHC survey bycatch rate to estimate mortality. Full retention of DSR has been in regulation in state waters since 2002 and in federal waters since 2005.

Sport fishery harvest estimates in the **Southeast Region** have been used since 2005 to add to our knowledge of what we determine to be the total harvest of DSR in other fisheries. (Contact Bob Chadwick).

Management of the commercial black rockfish fishery in the **Southeast Region** is based upon a combination of GHLs and gear restrictions. Directed fishery GHLs are set by management area, and range from 11 mt in EYKT and IBS to 57 mt in SSEOC, totaling 147 mt. A series of open and closed areas was also created so managers could better understand the effect a directed fishery has on black rockfish stocks. Halibut and groundfish fishermen are required to retain and report all black rockfish caught. The directed fishery for black rockfish continues to have very little participation and the total reported harvest for Southeast directed and commercial groundfish and salmon troll bycatch fisheries was 3.6 mt in 2011. Shortspine thornyhead, shortraker rockfish, rougheye rockfish and redbanded rockfish may be taken as bycatch only (no directed fishing). A total of 60 mt of slope rockfish were landed in NSEI and SSEI during 2011, a decrease from the 97 mt reported in 2010. (Contact Kristen Green).

Rockfish in **Central Region's** Cook Inlet and PWS Areas are managed under their respective regulatory Rockfish Management Plans. Plan elements include a fishery GHL of 68 mt for each area and 5-day trip limits of approximately 0.5 mt in the Cook Inlet District, 1.8 mt in the North Gulf District, and 1.4 mt in PWS. Rockfish regulations underwent significant change beginning in 1996 when the Alaska Board of Fisheries formalized the 68 mt GHL into a harvest cap for all rockfish species in Cook Inlet and PWS and adopted a 5% rockfish bycatch limit for jig gear during the state waters Pacific cod season. In 1998, the Board adopted a directed rockfish season opening date of July 1 for the Cook Inlet Area and restricted legal gear to jigs, primarily because the fishery typically targets pelagic shelf rockfish species. At the spring 2000 meeting, the Board closed directed rockfish fishing in the PWS area and established a bycatch-only fishery with mandatory full retention of all incidentally harvested rockfish. In November 2004, the Board also adopted a full retention requirement for rockfish in the Cook Inlet Area and restricted the directed harvest to pelagic shelf rockfish. Rockfish bycatch levels were also set at 20% during sablefish, 5% during the parallel Pacific cod season and 10% during other directed fisheries. Those rockfish bycatch levels have been maintained in PWS, however in 2010, the Board adjusted rockfish bycatch levels for Cook Inlet to 10% during halibut and directed groundfish, other than rockfish, and 20% nonpelagic rockfish during the directed pelagic shelf rockfish fishery. Proceeds from rockfish landed in excess of allowable bycatch levels are surrendered to the State of Alaska. (Contact Charles Trowbridge).

The **Westward Region** has conservatively managed black rockfish since 1997 when management control was relinquished to the State of Alaska. Area GHLs were set at 75% of the average production from 1978-1995 and sections were created to further distribute effort and thereby lessen the potential for localized depletion. Since 1997, section GHLs have been reduced in some areas that have received large amounts of effort.

In the Kodiak Area, vessels may not possess or land more than 5,000 pounds of black rockfish in a 5-day period. Additionally, vessel operators are required to register for a single groundfish fishery at a time. A registration requirement also exists for the Chignik Area; that area was also designated as super-exclusive for the black rockfish fishery beginning in 2003.

In 2011, 49 mt of black rockfish were harvested from five sections in the Kodiak Area. GHLs were attained in three sections. Harvest in the Chignik and South Alaska Peninsula Management areas remain confidential. In 2010, no vessels made directed black rockfish landings in the Aleutian Islands Area. Fishers are allowed to retain up to 5% of black rockfish by weight incidentally during other fisheries. The incidental harvest in the Aleutian Islands Area is confidential due to limited participation. A voluntary logbook program was initiated in 2000 in the hope of obtaining CPUE estimates as well as more detailed harvest locations; the logbook program was made mandatory in 2005. (Contact: Nick Sagalkin).

Statewide, the majority of sport caught rockfish is taken incidental to recreational fisheries for halibut or while trolling for salmon. Size limits have never been set for rockfish harvested in the sport fishery, although there has been a progression of bag and possession limit changes over the last 20 years.

For the 2011 season, the entire **Southeast Alaska** region's sport bag and possession limit for pelagic rockfish was five fish per day, 10 in possession. The non-pelagic rockfish regulations were set as follows:

Southeast Alaska Outside Waters: 1) resident bag limit was two fish, only one of which could be a yelloweye; four fish in possession, of which no more than two could be yelloweye; all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) nonresident bag limit was two fish, only one of which could be a yelloweye, four fish in possession, of which no more than one could be yelloweye; all non-pelagic rockfish caught must be retained until the bag limit is reached; and an annual limit of one yelloweye rockfish, which must be recorded in ink on the back of the sport fishing license or on a harvest record at the time of harvest.

Southeast Alaska Inside Waters: 1) resident bag limit was three fish, only one of which could be a yelloweye; six fish in possession, of which no more than two could be yelloweye; all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) nonresident bag limit was two fish, only one of which could be a yelloweye, four fish in possession, of which no more than two could be yelloweye; all non-pelagic rockfish caught must be retained until the bag limit is reached; and an annual limit of two yelloweye rockfish, which must be recorded in ink on the back of the sport fishing license or on a harvest record at the time of harvest;

For the entire Southeast Alaska region, charter operators and crewmembers could not retain rockfish while clients are on board the vessel (Contact Bob Chadwick).

As a result of the pervasive lack of quantitative stock assessment information, rockfish regulations in **Southcentral Alaska** have been designed to discourage targeting of rockfish yet allow for retention of incidental harvest. Bag limits are reduced for demersal and slope species because of their lower natural mortality rates. The bag limit in Cook Inlet was five rockfish daily, only one of which could be a non-pelagic species (DSR or slope species). The bag limit in Prince William Sound during the period May 1-September 15 was four rockfish, no more than two of which could be a non-pelagic species. During the period September 16-April 30, the bag limit was eight rockfish, of which no more than two could be non-pelagic species. During both periods, the first two non-pelagic rockfish caught were required to be retained. The bag limit in the North Gulf Coast area was four rockfish daily, including no more than one non-pelagic rockfish. The bag limit in the Kodiak and Alaska Peninsula areas was five rockfish, no more than two of which could be non-pelagic species, and no more than one of the non-pelagic species could be a yelloweye.

d. Fisheries

Directed fisheries for DSR and black rockfish occurred in **Southeast** in 2011. Effort in the directed black rockfish fishery was minimal with only three vessels participating. The directed DSR fishery in 2011 in outside waters was opened in SSEO only for a total harvest of 21.7 mt. There was also a directed DSR fishery in internal waters in 2011 (SSEI and NSEI); the total harvest in SSEI and NSEI combined was 21.9 mt.

The total amount of rockfish (all species) taken as bycatch in all commercial fisheries conducted east of 140^0 W Longitude in 2011 in state and federal water was 409 mt. DSR bycatch made in conjunction with the IFQ halibut fishery in outside as well as internal waters contributed 91 mt toward this total.

In the **Central Region**, total rockfish harvest in 2011 was 84 mt. The 2011 Cook Inlet Area directed rockfish fishery opened July 1 and closed December 31 with a harvest of 20 mt of pelagic shelf rockfish. Total rockfish harvest in the Cook Inlet Area including bycatch to longline, pot and jig fisheries was 30.1 mt. Total rockfish harvest for the PWS Area bycatch-only fishery was 53.9 mt. This included a 3.4 mt incidental catch of demersal and slope rockfish from the walleye pollock trawl fishery and a 48.9 mt incidental harvest of demersal and slope rockfish primarily from the sablefish, Pacific cod, and halibut longline fisheries.

Estimates of **sport harvest** are obtained by three methods – the Statewide Harvest Survey (SWHS), charter vessel logbooks, and, in major ports, creel survey dockside sampling. Harvest reporting areas for these programs are different than commercial reporting areas making direct comparisons difficult. Additionally, species-specific data are available only from creel surveys.

The SWHS reported harvest for the general category of "rockfish", and the charter vessel logbook recorded rockfish harvest in three categories - pelagic, yelloweye, and other non-pelagics. DSR are part of the "non-pelagic" category. Recreational rockfish harvest is typically estimated in numbers of fish. Estimates of the 2011 harvest are not yet available from the statewide harvest survey, but the 2010 estimates were 105,565 fish in Southeast and 118,476 fish in Southcentral Alaska. The average estimated annual harvest for the most recent five-year period (2006-2010) was 99,667 rockfish (all species) in Southeast Alaska and 106,378 fish in Southcentral Alaska.

3. Sablefish

a. Research

In 2011, sablefish longline surveys were conducted for both the NSEI and SSEI areas. These surveys are designed to measure trends in relative abundance and biological characteristics of the sablefish population. Biological data collected in these surveys include length, weight, sex and maturity stage. Otoliths are collected and sent to the ADF&G age determination unit in Juneau for age reading. The survey CPUE for NSEI was slightly up in 2011 (0.86 lb/hook).

The cost of these surveys is offset by the sale of the fish landed, but in 2011, six commercial fishermen that participated in the surveys were allowed to sell their share of PQS from the total testfish harvested in the survey, thus reducing the total testfish harvest impact on the quota by 54%.

In the SSEI longline survey, there has been a downward trend in CPUE since 2006. However, there was a slight increase in survey CPUE in 2011 (1.16 lb/hook) versus 0.75 lb/hook in 2010.

The on-going mandatory logbook program in the sablefish fisheries provides catch and effort data by date, location, and set. In the SSEI sablefish fishery, overall CPUE (adjusted for hook spacing) has been decreasing since 2005. However, in 2011 there was an increase in CPUE from 2010 (1.16 lb/hook in 2011 versus 0.75 lb/hook in 2010). In 2006, the SSEI CPUE was 1.41 lb/hook. In the NSEI fishery, the overall CPUE adjusted for hook spacing expressed in round lb/hook was 0.38 in 2011, up slightly from 0.33 lb/hook in 2010.

In 2011, ADF&G canceled the mark/recapture study in NSEI due to mechanical problems with the vessel. Typically, in this survey 5,000 to 7,000 tagged fish are distributed by area and depth in proportion to the harvested commercial catch using logbook data from the three previous years. In 2011, substantial staff time and funds were directed towards conducting the pot survey on a state vessel for the 2012 season, including purchasing pot gear and hauling equipment. A pot tagging survey is planned for May 2012. (contact Kristen Green).

Central Region ADF&G conducted longline surveys for sablefish from 1996 through 2006 in Prince William Sound. Longline survey effort was extended into the North Gulf District in 1999, 2000 and 2002. All longline surveys were discontinued due to funding issues, and with the goal of transitioning to a pot longline survey, particularly in PWS. Between 1999 and 2005, sablefish were opportunistically tagged in PWS on ADF&G trawl surveys. A sablefish tagging survey was conducted in PWS in 2011 using pot longline gear. There were 1,203 sablefish tagged and 161 recaptured from the commercial fishery in 2011. Seventy-nine percent of recaptured fish moved less than 10 nm and maximum straight line distance was 439 nm. Six fish (3.7%) were recaptured outside of PWS.

Long-term goals include garnering funding to pursue more sablefish tagging; working towards tag-recapture analysis potentially in combination with an age-structured model. (Contact Dr. Ken Goldman).

Skipper interviews and port sampling occurred in Whittier, Valdez, Cordova and Seward for the PWS Area commercial fishery and in Seward and Homer for the Cook Inlet Area fishery. Data obtained included date and location of harvest, length, weight, sex, and gonad condition. Otoliths were removed and sent to the Age Determination Unit. Logbooks are required for both fisheries and provide catch and effort data by date and location. (Contact Elisa Russ).

b. Stock Assessment

In **Southeast**, the department is using mark-recapture methods with external tags and fin clips to estimate abundance and exploitation rates for sablefish in the NSEI Subdistrict. Sablefish are captured with pot gear in May or June, marked with a tag and a fin clip then released. Tags are recovered from the fishery and fish are counted at the processing plants and observed for fin-clips. The allowable biological catch (ABC) for 2011 was based on the 2010 Petersen–estimated number of sablefish fish in NSEI. The forecast for 2011 was made by decrementing the 2010 estimate to account for natural mortality, and adding a number of age-4 recruits equal to that of 2010. Each age class was converted to biomass using the average weight of that age class from the 2010 commercial fishery. The forecast for 2011 was 16,284,116 round pounds of sablefish. An $F_{50\%}$ (=0.070) harvest rate was applied to the point estimate of the forecasted biomass to give a ABC of 1,046,873 round pounds. This represents a 16% decrease from the 2010 ABC (1,250,961 round pounds). In addition to the mark-recapture work, an annual longline survey is conducted in NSEI to provide biological data as well as relative abundance information. In SSEI, only an annual longline survey is conducted to provide biological data as well as relative abundance information. Unlike NSEI, the department does not currently estimate the absolute abundance of SSEI sablefish. There appears to be substantial movement of sablefish in and out of the SSEI area, which violates the assumption of a closed population, consequently, Peterson mark-recapture estimates of abundance or exploitation rates are not possible for this fishery. Instead, the SSEI sablefish population is managed based on relative abundance trends from survey and fishery CPUE data, as well as with survey and fishery biological data that are used to describe the age and size structure of the population and detect recruitment events. (Contact Kristen Green).

c. Management

There are three separate internal water areas in Alaska which have state-managed limited-entry commercial sablefish fisheries. The NSEI and SSEI (**Southeast Region**), and the Prince William Sound Inside District (**Central Region**) each have separate seasons and GHRs. In the Cook Inlet Area, there is an open access sablefish fishery.

In the **Southeast Region,** both the SSEI and NSEI sablefish fisheries have been managed under a license limitation program since 1984. In 1994, the BOF adopted regulations implementing an equal share quota system where the annual GHL was divided equally between permit holders and the season was extended to allow for a more orderly fishery. In 1997, the BOF adopted this equal share system as a permanent management measure for both the NSEI and SSEI sablefish fisheries. There are currently 79 permit holders eligible to fish in 2011 in NSEI and 23 permit holders eligible to fish in SSEI.

The SSEI quota was set at 265 mt for 2011, an 8% decrease from the 2010 quota. The quota reduction was based on declining survey CPUE since 2006, and declining survey CPUE from 2006-2009 (there was a slight increase in fishery CPUE in 2010).

During the February 2009 Board of Fisheries (BOF) meeting, the BOF made no changes affecting the regulation of commercial sablefish fisheries. The BOF did, however, establish bag and possession limits for sablefish in the sportfish fishery.

Commercial sablefish fisheries in outer coastal state waters (0-3 miles) have been managed in conjunction with the federal-managed fishery in the EEZ. There is no open-access sablefish fishery in the Southeast Outside District as there are limited areas that are deep enough to support sablefish populations inside state waters. In some areas of the Gulf, the state opens the fishery concurrent with the EEZ opening. These fisheries, which occur in Cook Inlet Area’s North Gulf District and the Aleutian Island District, are open access in state waters, as the state cannot legally implement IFQ management at this time. The fishery GHLs are based on historic catch averages and closed once these have been reached.

Within the **Central Region,** the Cook Inlet North Gulf District sablefish GHL is set using an historic baseline harvest level adjusted annually by the same relative change to the TAC in the Central Gulf Area. The 2011 fishery GHL was 25.6 mt. In 2004, the BOF adopted sablefish fishery-specific registration, a logbook requirement, and a 48-hour trip limit of 1.36 mt. in Cook Inlet. For PWS, a limited entry program that included gear restrictions and established vessel size classes was adopted in 1996. The fishery GHL is set at 110 mt, which is the midpoint of the harvest range set by a habitat-based estimate. Fishery management continued to develop through access limitation and in 2003 into a shared quota system wherein permit holders are allocated shares of the harvest guideline. Shares are equal within each of four vessel size classes, but differ between size classes. In 2009, the commissioner's permit requirement was removed by BOF action and regulations adopted which included a registration deadline, logbooks, and catch reporting requirements.

The GHL for the Aleutian Island District is set at 5% of the BSAI TAC. The state GHL can be adjusted according to recent state-waters harvest history when necessary. From 1995 to 2000, the fishery opened concurrently with the EEZ IFQ sablefish fishery. In 2001, the BOF changed the opening date of the state-waters fishery to May 15 so as to provide small vessel operators an opportunity to take advantage of potentially better weather conditions. From 1995 to 2000, all legal groundfish gear types were permissible during the fishery. Effective in 2001, longline, pot, jig and hand troll became the only legal gear types. Vessels participating in the fishery are required to fill out logbooks and processors are required to send the Department weekly processing reports.

The Southeast Alaska **sport fishery** for sablefish was regulated for the first time in 2009. Sport limits in 2011 were four fish per day, four in possession, with an annual limit of eight fish applied to nonresidents only. A small number of sablefish were sampled during creel surveys in Southeast Alaska, suggesting that recreational sablefish harvest at sampled ports was small relative to other species. The sablefish sport fishery in Southcentral Alaska was unregulated in 2011, with no bag, possession, or size limits. No port samplers in Southcentral Alaska encountered sablefish from the sport harvest, again suggesting relatively small harvests.

d.Fisheries

In the **Southeast Region,** the 2011 NSEI sablefish fishery opened August 15 and closed November 15. The 87 permit holders landed a total of 478 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 5.5 mt. The 2011 SSEI sablefish fishery opened June 1 and closed November 15. Twenty-six permit holders landed a total of 253 mt of sablefish, each with an equal quota share of 9.4 mt. In SSEI, 24 permits were designated to be fished with longline gear and the remaining three fished with pot gear. One of the longline permits did not fish in 2011. (Contact Kristen Green).

In the **Central Region,** the 2011 open access sablefish fishery in the Cook Inlet North Gulf District opened at noon July 15 and closed at noon August 15. Ten vessels harvested 26 mt. In 2009, new season dates adopted by the BOF for PWS sablefish were April 15 – August 31. The new season opening date, one month later than in previous years, was adopted to reduce the opportunity for orca depredation on hooked sablefish which predominately occurred prior to May 1. The 2011 PWS harvest totaled 100 mt (Contact Charles Trowbridge).

Within the **Westward Region**, only the Aleutian Islands have sufficient habitat to support mature sablefish populations of sufficient magnitude to permit commercial fishing. All other sections within the region are closed by regulation to avoid the potential for localized depletion from the small amounts of habitat within the jurisdiction of the state. Bycatch from the areas closed to directed fishing is limited to 1% for trawl gear only, no bycatch is allowed for all other gear types. The 2011 Aleutian Island fishery opened on May 15. Additional requirements for the fishery include registration and logbook requirements. The GHL was set at 237 mt for the state-managed fishery. The harvest from the 2011 Aleutian Islands sablefish fishery was 115 mt. The season remained open until the November 15 closure date (Contact Trent Hartill or Heather Fitch).

Sablefish recreational harvest estimates were available for the first time from the SWHS for 2010. The estimated harvest was 4,793 fish in Southeast Alaska and 3,992 fish in Southcentral Alaska. Charter operators reported (in logbooks) a guided sport harvest of about 3,927 sablefish in Southeast Alaska and 153 sablefish in Southcentral Alaska in 2010. (Contact Bob Chadwick).

4. Flatfish

a. Research

There was no research on flatfish during 2011.

b. Stock Assessment

There are no stock assessments for flatfish.

c. Management

Trawl fisheries for flatfish are allowed in four small areas in the internal waters of **Southeast Alaska** under a special permit issued by the department. The permits are generally issued for no more than a month at a time and specify the area fished and other requirements. Trawl gear is limited to beam trawls, and mandatory logbooks are required, observers can be required, and there is a 20,000 pound weekly trip limit.

Within **Central Region,** flatfish may be harvested in a targeted fishery only under the authority of a permit from the commissioner of ADF&G. The permit may stipulate fishing depth, seasons, areas, allowable sizes of harvested fish, gear, logbooks, and “other conditions” the commissioner deems necessary for conservation or management purposes.

There are no bag, possession, or size limits for flatfish (excluding Pacific halibut) in the recreational fisheries in Alaska. Harvest of flatfish besides Pacific halibut are not explicitly estimated by the SWHS and no information is collected in the creel surveys and port sampling of the recreational fisheries in Southcentral or Southeast Alaska. Flatfish are occasionally taken incidentally to other species and in small shore fisheries, but the recreational harvest is believed to be very small.

d. Fisheries

There has been almost no effort in the **Southeast** fishery for the past nine years, with no harvest reported for the 2009-2011 season. The Southeast flatfish trawl areas are also the sites of a shrimp beam trawl fishery. In the past, most of the Southeast harvest was starry flounder. NMFS manages the flatfish fishery and harvest in the state waters of **Westward Region**. No flatfish harvest permits were issued in **Central Region** during 2011.

5. Pollock

State-managed pollock is limited to the Central Region and Aleutian Islands

a. Research

Pollock continue to be a dominant species in the **Central Region** ecosystem. Skipper interviews and biological sampling of **Central Region** commercial pollock deliveries during 2011 occurred in Seward and Kodiak. Sample data collected included date and location of harvest, species, length, weight, sex, and gonad condition. Otoliths were collected from approximately half of sampled fish. Homer staff determined ages of 949 pollock otoliths (Contact Elisa Russ).

Beginning in 1998, spatial patterns of genetic variation were investigated in six populations of walleye pollock from three regions: North America – Gulf of Alaska; North America – Bering Sea; Asia – East Kamchatka. The annual stability of the genetic signal was measured in replicate samples from three of the North American populations. Allozyme and mtDNA markers provided concordant estimates of spatial and temporal genetic variation. These data show significant genetic variation between North American and Asian pollock as well as evidence that spawning aggregations in the Gulf of Alaska, such as Prince William Sound, are genetically distinct and may merit consideration as distinct stocks. These data also provide evidence of inter-annual genetic variation in two of three North American populations. Gene diversity values show this inter-annual variation is of similar magnitude to the spatial variation among North American populations, suggesting the rate and direction of gene flow among some spawning aggregations is highly variable. This study was published in 2002 in the Fishery Bulletin (Olsen et al. 2002). (Contact Bill Templin).

b. Stock Assessment

No stock assessment work was conducted on pollock in 2011 (Contact Dr. Ken Goldman).

c. Management

Prince William Sound pollock pelagic trawl fishery regulations were amended by BOF action and for 2009 included a January 13 registration deadline, logbooks, catch reporting, check-in and check-out provisions, and accommodation of a department observer upon request. Prior to 2009, these requirements were stipulated as terms of a commissioner’s permit. The Prince William Sound Inside District is divided into three ‘sections” for pollock management: Port Bainbridge, Knight Island, and Hinchinbrook, with the harvest from any section limited to a maximum of

60% of the GHL. Additionally, the fishery is managed under a 5% maximum bycatch allowance that is further divided into five species or species groups. For **Cook Inlet,** directed fishing for pollock is managed under a "Miscellaneous Groundfish" commissioner's permit. However, due to pelagic trawl closures associated with Steller sea lion conservation measures, no directed fishing has occurred in the Cook Inlet Area since 2000. (Contact Charlie Trowbridge).

d. Fisheries

The 2011 **Prince William Sound** fishery opened on January 20 with a GHL of 1,651 mt. The Hinchinbrook section closed by emergency order at 12:00 midnight February 1 while the Knight Island and Bainbridge sections closed by emergency order at 7:00 p.m. February 6. Total pollock harvest for all sections combined was 1,538 mt. Total bycatch was 10.2 mt, 0.4 percent of the GHL and was dominated by squid at 6.7 mt. (Contact Charlie Trowbridge).

6. Sharks

a. Research

In 2009, **Central Region** Commercial Fisheries Division began tagging all sharks with spaghetti-type external tags. A research project on the reproductive biology of salmon sharks was initiated in the summer of 2010 continues with the goal of providing an accurate and precise estimate of the timing of reproductive activity (annual vs. biennial) and length-at-maturity via the examination of blood hormone concentrations. (Contact Dr. Ken Goldman)

The **Division of Sport Fish—Southcentral Region** collected harvest and fishery information on sharks through the groundfish harvest assessment program although no specific research objectives were identified. Few samples were collected in 2011. Interviews also provided estimates of the numbers of salmon sharks and spiny dogfish kept and released by ADF&G statistical area. (Contact Barbi Failor).

b. Stock Assessment

There is no stock assessment work being conducted on sharks in Central Region. (Contact Dr. Ken Goldman).

c. Management

The Alaska Board of Fisheries prohibited all directed commercial fisheries for sharks in 1998. In 2000, the BOF increased the bycatch allowance in **Southeast Region** for dogfish taken while longlining for other species to 35% round weight of the target species and also allowed full retention of dogfish bycatch in the salmon setnet fishery in Yakutat. This action was an effort to minimize waste of dogfish in these two fisheries and to encourage sale of bycatch. In **Central Region**, bycatch is set by regulation at 20% of the round weight of the directed species on board. However in 2004, the BOF amended Cook Inlet Area regulations to provide for a directed fishery for spiny dogfish in the Cook Inlet area under terms of a permit issued by the commissioner.

Also in 2000, the BOF prohibited the practice of "finning", requiring that all sharks retained must be sold or utilized and have fins, head and tail attached at the time of landing. "Utilize" means use of the flesh of the shark for human consumption, for reduction to meal for production of food for animals or fish, for bait or for scientific, display, or educational purposes.

Recreational fishing for sharks is allowed under the statewide Sport Shark Fishery Management Plan adopted by the BOF in 1998. The plan recognizes the lack of stock assessment information, the potential for rapid growth of the fishery, and the potential for over harvest, and sets a statewide daily bag limit of one shark and a season limit of two sharks of any species except spiny dogfish which have a daily bag limit of five. Recreational demand for spiny dogfish remains low and they are widely considered a nuisance species. There is, however, a directed charter boat fishery for salmon sharks in Southcentral Alaska, primarily in Prince William Sound. Pacific sleeper sharks are occasionally caught but rarely retained.

d. Fisheries

No applications for permits to target spiny dogfish in Cook Inlet were received in 2011.

Estimates of recreational shark harvest in 2011 are not yet available from the SWHS, but in 2010, an estimated 17 sharks of all species were harvested in Southeast Alaska and 315 sharks were harvested in Southcentral Alaska. The precision of these estimates is low; the Southeast estimate has a CV of 100% and the Southcentral estimate has a CV of 30%. The statewide charter logbook program also required reporting of the number of salmon sharks kept and released in the charter fishery. Charter anglers are believed to account for the majority of the recreational salmon shark harvest. The 2010 reported charter harvest from logbooks was 8 salmon sharks in Southeast Alaska and 19 salmon sharks in Southcentral Alaska.

7. Lingcod

a. Research

Since 1996, 9,175 lingcod have been tagged and 463 fish recovered in Southeast Region. Opportunistic tagging of 17 lingcod in the vicinity of Sitka occurred during 2011. Length, sex and tagging location are recorded for all tagged fish. Dockside sampling of lingcod caught in the commercial fishery continued in 2011 in Sitka and Yakutat with over 1,740 fish sampled for biological data. Otoliths were sent to the ADU in Juneau for age determination. (Contact Kristen Green).

In the **Central Region**, skipper interviews and port sampling were conducted in Cordova, Whittier, Seward and Homer. Data obtained included date and location of harvest, length, weight, sex and age. There were 579 lingcod samples collected and 84% were from the Prince William Sound Area, as there was very little effort in the directed fishery in the Cook Inlet Area.

Otoliths were sent to the ADU in Juneau for age determination. Gonad condition was generally not determined as nearly all fish were delivered gutted (Contact Elisa Russ).

The Division of Sport Fish—Southeast Region continued to collect catch, harvest, and biological data from lingcod as part of a marine harvest survey program with lingcod harvests tabulated back to 1987 in some selected ports. Data collected in the program include statistics on effort, catch, and harvest of lingcod taken by Southeast Alaska sport anglers. Ports sampled in 2011 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,486 lingcod in 2011, primarily from the ports of Sitka, Ketchikan, Craig, Gustavus, Elfin Cove, and Yakutat. (Contact Mike Jaenicke).

The **Division of Sport Fish—Southcentral Region** continued collection of harvest and fishery information on lingcod through the groundfish harvest assessment program. Lingcod objectives include estimation of: 1) the age, sex, and length composition of lingcod harvests by ports and 2) the geographic distribution of harvest by each fleet. A total of 929 lingcod were sampled from sport harvest at Seward, Valdez, Whittier, Kodiak, and Homer in 2011. These ports accounted for the majority of recreational lingcod harvest in Southcentral Alaska (Contact Barbi Failor).

b. Stock Assessment

The **Southeast Region** is not currently able to reliably estimate lingcod biomass or abundance. Lacking abundance estimates, and given the complex life history and behavior of lingcod, impacts to lingcod populations from fishing are difficult to assess. Analysis of catch per unit effort data (CPUE) from fishery logbooks, in terms of fish per hook-hour for 1988–1998, showed that CPUE had declined between 21 to 62% in areas where a directed fishery and increased recreational catch had developed. Consequently, the quota for lingcod was reduced in all areas in 2000. Commercial logbook data for the period 2002–2009 shows CPUE in fish per hook hour trending up since 2000 in CSEO but down from 2008 to 2010. CSEO CPUE was up in 2011. There is not much fishery data available in NSEO or SSEOC. EYKT CPUE has been fairly stable since 2000 with a slight increase in the past few years. IBS has been fairly stable since 2004 with an increase in the past two years.

Central Region conducts ROV surveys along the north Gulf of Alaska coast from the Kenai Peninsula to Prince William Sound to monitor the local abundance of lingcod and DSR in selected index sites. These sites are on the order of 100's of sq km and tend to be relatively isolated rocky banks boarded by land masses, deep fjords, and / or expanses of deeper soft substrates. A rocky bank surrounding and extending to the south of outer Pye Island was mapped with multibeam during a department survey in 2008. A three nm no-transect zone has been in effect for Outer Pye Island since 1996 and encompasses this area acting as a de facto preserve. Additionally, there is a 10 nm fixed and trawl gear closure surrounding outer Pye Island. The seafloor features within the mapped area were delineated and an ROV survey to estimate lingcod abundance and biomass was conducted there in May 2010. Lingcod density was estimated at 3206 fish / km^2 (cv = 0.21) for rocky / hard substrates and 2159 fish / km^2 (cv = 0.22) for the survey area. These estimates were higher though not significantly (95% CI's) from Nuka Island which is located just west and is open to fishing. Population estimates from ROV surveys have not been incorporated into a stock assessment. (Contact Mike Byerly or Dr. Ken Goldman).

c. Management

Management of lingcod in **Southeast Alaska** is based upon a combination of GHRs, season and gear restrictions. Regulations include a winter closure for all users, except longliners, between December 1 and May 15 to protect nest-guarding males. GHLs were greatly reduced in 2000 in all areas and allocations made between directed commercial fishery, sport fishery, longline fisheries, and salmon troll fisheries. This was the first time sport catch was included in a quota allocation. The 27" minimum commercial size limit remains in effect and fishermen are requested to keep a portion of their lingcod with the head on, and proof of gender to facilitate biological sampling of the commercial catch. Vessel registration and trip limits are allowed when needed to stay within allocations. The directed fishery is limited to jig or dinglebar troll gear. In 2003, the Board of Fish (BOF) established a super-exclusive directed fishery registration for lingcod permit holders fishing in the IBS Subdistrict.

Regulations for the **Central Region commercial** lingcod fishery include open season dates of July 1 to December 31 and a minimum size limit of 35 inches (89 cm) overall or 28 inches (71 cm) from the front of the dorsal fin to the tip of the tail. In 1997, the BOF adopted a jig only gear requirement for the directed lingcod fishery in the Cook Inlet Area. Resurrection Bay, near Seward is closed to commercial harvest of lingcod. In 2009, a new BOF regulation permitted retention of lingcod in PWS waters following closure of the directed season.

In Southeast Alaska, the sport fishery for lingcod prior to 2000 had an open season of May 1 to November 30, and a region-wide bag and possession limit of two per day, four in possession, with no size limits. Area-specific exceptions to this included: 1) The Pinnacles area near Sitka has been closed to sport fishing year-round for all groundfish since 1997, and 2) the nonresident sport anglers bag and possession limit for the Sitka Sound LAMP area was one per day, two in possession during 1997-2000.

Beginning in 2000, the open season has been set at May 16 to November 30. Sport harvests of lingcod in Southeast Alaska as of the year 2000 have been incorporated into a region-wide lingcod management plan, which reduced GHLs for all fisheries (combined) in seven management areas, and allocated a portion of the GHL for each area to the sport fishery. Since 2000, harvest limits reductions, size limits, and mid-season closures have been implemented by emergency order in various management areas to ensure sport harvests do not exceed allocations.

In 2011, lingcod daily bag limits for all anglers were one fish per day, and two fish in possession for residents, and one fish in possession for nonresidents. There were no size limits for resident anglers. Throughout central outside and northern Southeast Alaska, nonresident anglers were allowed to keep only fish between 30 and 35 inches, or fish 55 inches or longer. In southern Southeast Alaska, nonresident anglers were allowed to keep only fish between 30 and 40 inches, or fish 55 inches or longer. In the Yakutat area, nonresidents were allowed to retain fish between 30 and 45 inches, or fish 55 inches or longer. Nonresidents were also constrained by a two fish annual limit. Seasons varied by area. (Contact Robert Chadwick).

Conservative harvest strategies were established in 1993 for recreational lingcod fisheries in **Southcentral Alaska** in light of the lack of quantitative stock assessment information. Resurrection Bay was closed to lingcod fishing year-round to rebuild the population, although no formal rebuilding plan was put in place. The season was closed region-wide from January 1 through June 30 to protect spawning and nest guarding lingcod. Daily bag limits in 2011 were 2 fish in all areas except the North Gulf, where the daily bag limit was one fish. All areas except Kodiak had a minimum size limit of 35 inches to protect spawning females. (Contact Matt Miller or Tom Vania).

d. Fisheries

Lingcod are the target of a "dinglebar" troll fishery in Southeast Alaska. Dinglebar troll gear is power troll gear modified to fish for groundfish. Additionally, lingcod are landed as significant bycatch in the DSR and halibut longline and salmon troll fisheries. At the 2009 Board of Fisheries meeting, a regulation was adopted that allowed Southeast management staff to adjust the lingcod bycatch levels in the halibut fishery to maximize the harvest of the lingcod longline allocations. For example, in years when the halibut catch limits are low the bycatch of lingcod can be set higher without the risk of going over the longline allocation. The directed fishery landed 132 mt of lingcod in 2011. An additional 63 mt was landed as bycatch in halibut and other groundfish fisheries and 10 mt in the salmon troll fishery).

Central Region commercial lingcod harvests have primarily occurred in the North Gulf District of Cook Inlet and PWS. In 2011, the Cook Inlet GHL was 24 mt and the PWS GHL was 16 mt. Lingcod harvests in 2011 totaled 4.2 mt in Cook Inlet and 20.1 mt in PWS. Approximately 19 percent of the lingcod harvest in Cook Inlet resulted from directed jig effort. In PWS, approximately 79 percent of lingcod harvest was from directed longline effort. In both areas, the remaining harvest resulted from bycatch to other directed (primarily halibut) longline fisheries. The Outside District of PWS closed at noon August 14 and the Inside District closed at noon October 6 when district GHLs were achieved. (Contact Charlie Trowbridge).

No directed effort occurred for lingcod in the **Westward Region** during 2011. A large jump in the amount of incidental harvest in the bottom trawl fisheries occurred in 2008. In response, ADF&G reduced bycatch limits in 2009 from 20% to 5%. Incidental harvest totaled 23 mt in 2007, 250 mt in 2008, 39 mt in 2009, and 31 mt in 2010. The majority of the harvest occurred in the Kodiak Area with a minor amount occurring in the Chignik Area.

Recreational lingcod harvest estimates for 2011 are not yet available from the statewide mail survey, but in 2010 an estimated 8,967 lingcod were harvested in Southeast Alaska while 23,251 lingcod were taken in Southcentral Alaska. The average estimated annual harvest for the most recent five-year period (2006-2010) was 12,549 fish in Southeast Alaska and 22,980 fish in Southcentral Alaska.

8. Other species

In 1997, the BOF based a new policy that would strictly limit the development of fisheries for other groundfish species in Southeast. Fishermen are required to apply for a “permit for miscellaneous groundfish” for all fisheries that do not already have specific regulations and permits do not have to be issued if there are management and conservation concerns. At this time, that includes all species except sablefish, rockfish, lingcod, flatfish, and Pacific cod. Most other groundfish species taken in state waters are taken as bycatch in fisheries for other groundfish and halibut. The state also has a regulation that requires that the bycatch rate of groundfish be set annually for each fishery by emergency order unless otherwise specified in regulation.

A commissioner’s permit is required before a directed fishery may be prosecuted for skates. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined by the commissioner to be necessary for conservation and management purposes. A commissioner’s permit is also required before any trawl fishery besides the existing beam trawl fishery for flatfish may be prosecuted in the Southeast District.

Skates may be harvested in a directed fishery within the **Central Region** only under the authority of commissioner’s permit. The permit may stipulate fishing depth, seasons, areas, allowable sizes of harvested fish, gear, logbooks, and “other conditions” the commissioner deems necessary for conservation or management purposes. A directed fishery in the Prince William Sound Area for big and longnose skates was prosecuted under this authority in 2009 and 2010, however, the fishery was deemed unsustainable and no permits were issued in 2011. Skates may also be retained as bycatch up to 20% during other directed fisheries for groundfish or halibut.

In the **Central Region**, skates may also be retained as bycatch up to 20% during other directed fisheries for groundfish or halibut. Bycatch harvest in 2011 of combined big and longnose skates in the **Prince William Sound Area** was 91.2 mt and 5.6 mt in the **Cook Inlet Area**.

In 2009, Central Region Commercial Fisheries Division began tagging all big, longnose and Aleutian skates greater than 70 cm total length with spaghetti-type tags. Starting in 2010, all skate species of all sizes were tagged on ADF&G surveys. In addition to 261 longnose skate, 34 big skate, 23 Aleutian skate, and 357 sandpaper skate tagged in PWS, six big skates were tagged with pop-off satellite transmitters as part of a collaborative project between Thomas Farrugia, a graduate student with the University of Alaska, Fairbanks and ADF&G. There were 20 longnose and 2 big skates tagging during Kachemak Bay the trawl survey. (Contact Dr. Ken Goldman)

The recreational halibut fishery is the focus of a statewide research and management effort. Data on the recreational fishery and harvest are collected through port sampling in Southeast and Southcentral Alaska. Harvest estimates are provided annually to the IPHC for use in an annual stock assessment, and to the NPFMC. The council’s Scientific and Statistical Committee has periodically reviewed the state’s estimation and projection methods, and the council incorporates the information in the design and analysis of regulations for the sport charter fishery (Contact Scott Meyer).

C. Other Related Studies

Staff in the **Central Region** continued the development of an Oracle database, currently named “Sedna”, for historical multi-species large-mesh and small mesh trawl survey data. Though these surveys originated as Tanner crab and shrimp surveys many groundfish species are captured and in fact compose most of the catches in recent years. They, therefore, represent a valuable tool for monitoring groundfish population trends and collecting biological data. The Sedna database project is currently in MS Access and is awaiting transition to Oracle by regional staff. Queries are complete for calculating cpue and biomass estimates from all trawl surveys and survey areas. All data are being additionally captured in a GIS for spatial analysis. The long-term goal is to have the database house all Central Region commercial fisheries survey and port sampling data in a GIS relational format.

The department manages state groundfish fisheries under regulations set triennially by the Board of Fisheries. The department announces the open and closed fishing periods consistent with the established regulations, and has authority to close fisheries at any time for justifiable conservation reasons. The department also cooperates with NMFS in regulating fisheries in the offshore waters.

1. Dixon Entrance Area

Total removals (including those from test fishing) from the Dixon Entrance area (Alaska statistical areas 325431, 315431, 325401, and 315401) has dropped since last year due to a decline in sablefish removals from that area. The table below lists the catch by species group from 1988 through 2011 rounded to the nearest mt.

Year	# Permits	# Landings	DSR	Other Rock	Sablefish	Other	Total
1988	20	25	3	3	82	3	91
1989	8	7	1	1	20	0	22
1990	16	17	3	5	182	1	191
1991	24	21	6	12	150	2	170
1992	19	19	3	5	150	1	159
1993	27	26	6	14	232	1	253
1994	27	26	1	20	216	2	239
1995	21	18	0	20	137	0	157
1996	16	14	1	12	83	0	96
1997	37	30	1	18	103	0	122
1998	26	23	1	8	95	0	104
1999	23	24	0	7	71	0	78
2000	27	22	0	14	49	0	63
2001	23	29	1	14	86	0	101
2002	30	46	1	11	106	0	118
2003	29	44	8	12	89	2	111
2004	23	33	5	9	114	2	130
2005	23	26	<1	9	138	<1	148
2006	43	32	1	12	167	1	181
2007	32	31	<1	19	165	1	184
2008	27	32	1	16	101	<1	118
2009	29	34	1	18	132	2	153
2010	34	35	2	17	107	2	128
2011	31	28	<1	16	112	2	130

2. Marine Reserves

In September of 1997, the ADF&G submitted proposals to both the BOF and the NPFMC requesting that they implement a small no-take marine reserve in **Southeast**. The purpose of these proposals was to permanently close a 3.2 sq. mile area off Cape Edgecumbe to all bottomfish and halibut fishing (including commercial, sport, charter, bycatch and subsistence) and anchoring to prevent over-fishing and to create a groundfish refuge. Two large volcanic pinnacles that have a diversity and density of fishes not seen in surrounding areas dominate the Edgecumbe Pinnacles Marine Reserve. The pinnacles rise abruptly from the seafloor and sit at the mouth of Sitka Sound where ocean currents and tidal rips create massive water flows over this habitat. These two pinnacles provide a very unique habitat of rock boulders, encrusted with *Metridium*, bryozoans and other fragile invertebrate communities, which attracts and shelters an extremely high density of juvenile rockfishes. The area is used seasonally by lingcod for spawning, nest-guarding, and post-nesting feeding. Yelloweye rockfish and pelagic rockfish species as well as large numbers of prowfish and Puget Sound rockfish also densely inhabit the pinnacles. This closure protects the fragile nature of this rare habitat, and prevents the harvest or bycatch of these species during critical portions of their life history. In February 1998, the BOF approved of the reserve and the NPFMC approved of the reserve at their June 1998 meeting. The NPFMC recommended to the BOF that they consider closure of the area to salmon trolling which would make the area a complete-no take zone. In February 2000, the BOF rejected closing the area to salmon trolling. The area is an important “turn-around” area for commercial trollers and the BOF did not believe there was sufficient conservation benefit to warrant closing the area to salmon fishing.

3. User Pay/ Test Fish Programs

The department receives receipt authority from the state legislature that allows us to conduct stock assessment surveys by recovering costs through sale of fish taken during the surveys. Receipt authority varies by region. In **Southeast Alaska,** several projects are funded through test fish funds (total receipt authority is approximately 600k), notably the sablefish longline assessments and mark-recapture work, the king crab survey, the herring fishery and some salmon assessments.

4. GIS

The ADF&G Division of Commercial Fisheries Headquarters Office is using ArcGIS 9.2 for general map production, project planning and spatial analysis. Basemaps are maintained in ArcGIS format. Statistical area charts have been updated using ArcGIS 9.0 and the NAD83 datum. All data and map requests are made in NAD83 (the State of Alaska standard) or will be converted into NAD83, if possible. Final output and all metadata will be in NAD83. Users in other divisional and area offices use ArcGIS 8, ArcView 3.x, and MapInfo 9.0 for their GIS work.

Hardcopy and digital groundfish and shellfish statistical area charts are available. Digital are available in Abode PDF and can be viewed or downloaded at http://www.cf.adfg.state.ak.us/geninfo/statmaps/charts.php . (Contact Mike Plotnick)

5. Logbooks

In 1997, logbooks became mandatory for all state-managed commercial fisheries in Southeast Alaska. Logbooks for rockfish and lingcod had been mandatory for a number of years. All usable longline and jig logbook data through 2011 has been entered.

Number of commercial fishery logbooks collected by fishery, target species, and year.

SE	Longline				Jig/dinglebar			
Year	DSR	Pacific cod	Slope Rock	Sablefish (includes pot gear)	Lingcod	Black rockfish	DSR	PSR
1986	21	1						
1987	25							
1988	20							
1989	19							
1990	50	1	2					
1991	232	8	1					
1992	259	7						
1993	190	8						
1994	197	9	3		108			
1995	140	13			215			
1996	261	8			252	31	6	
1997	204	98	4	466	177	64	8	1
1998	177	135	15	552	153	70	3	4
1999	165	223	9	405	89	21	1	1
2000	153	97	4	421	153	30		
2001	128	48	2	332	44	2	2	
2002	143	27	5	276	53	31	4	0
2003	115	53	closed	298	54	37	2	closed
2004	139	97	closed	283	40	23	3	closed
2005	17	53	closed	249	52	23	2	closed
2006	8	65	closed	241	97	8	0	closed
2007	2	83	closed	200	115	2	0	closed
2008	27	113	closed	190	91	2	0	closed
2009	37	87	closed	164	152	3	0	closed
2010	30	85	closed	170	104	5	0	closed
2011	25	78	closed	137	113	5	0	closed

Since 1998, marine recreational charter operators have been required to log port of landing, effort and harvest, and ADF&G statistical area for every charter trip made. In 2011, catch and harvest were reported for each individual angler, along with their name and fishing license number (if required). Other data collected for each vessel trip included port of landing, statistical area fished, effort for salmon and bottomfish, and harvest and/or release (in numbers) of Chinook, coho, sockeye, other salmon, halibut, pelagic rockfish, yelloweye rockfish, other rockfish, lingcod, sablefish, and salmon sharks. The Sport Fish Division conducted a three-year evaluation of logbook data, including comparisons to an independent end-of-season survey of anglers, to estimates from the statewide harvest survey, and to data from onsite interviews. This evaluation was presented to the North Pacific Fishery Management Council in October and December 2009.

Web Pages

ADF&G Home Page: http://www.adfg.alaska.gov
Commercial Fishing home page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingCommercial.main
News Releases: http://www.adfg.alaska.gov/index.cfm?adfg=newsreleases.main

Sport Fishing home page: http://www.adfg.alaska.gov/index.cfm?adfg=fishingSport.main
Age Determination Unit Home Page: http://tagotoweb.adfg.state.ak.us/
Region 1 Groundfish Home Page:

http://www.cf.adfg.state.ak.us/region1/finfish/grndfish/grndhom1.php
Region II Groundfish Home Page:

http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishareas

ADF&G Groundfish Overview Page:

http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.main

Commercial Fisheries Entry Commission: http://www.cfec.state.ak.us/
State of Alaska home page: http://www.alaska.gov
Gene Conservation Laboratory Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishinggeneconservationlab.main

Demersal shelf rockfish stock assessment document:
http://www.afsc.noaa.gov/refm/docs/2011/GOAdsr.pdf

Adobe PDF versions of groundfish charts can be viewed or downloaded at
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps

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APPENDIX I
ALASKA DEPARTMENT OF FISH AND GAME PERMANENT FULL-TIME GROUNDFISH STAFF DURING 2011.

COMMERCIAL FISHERIES DIVISION

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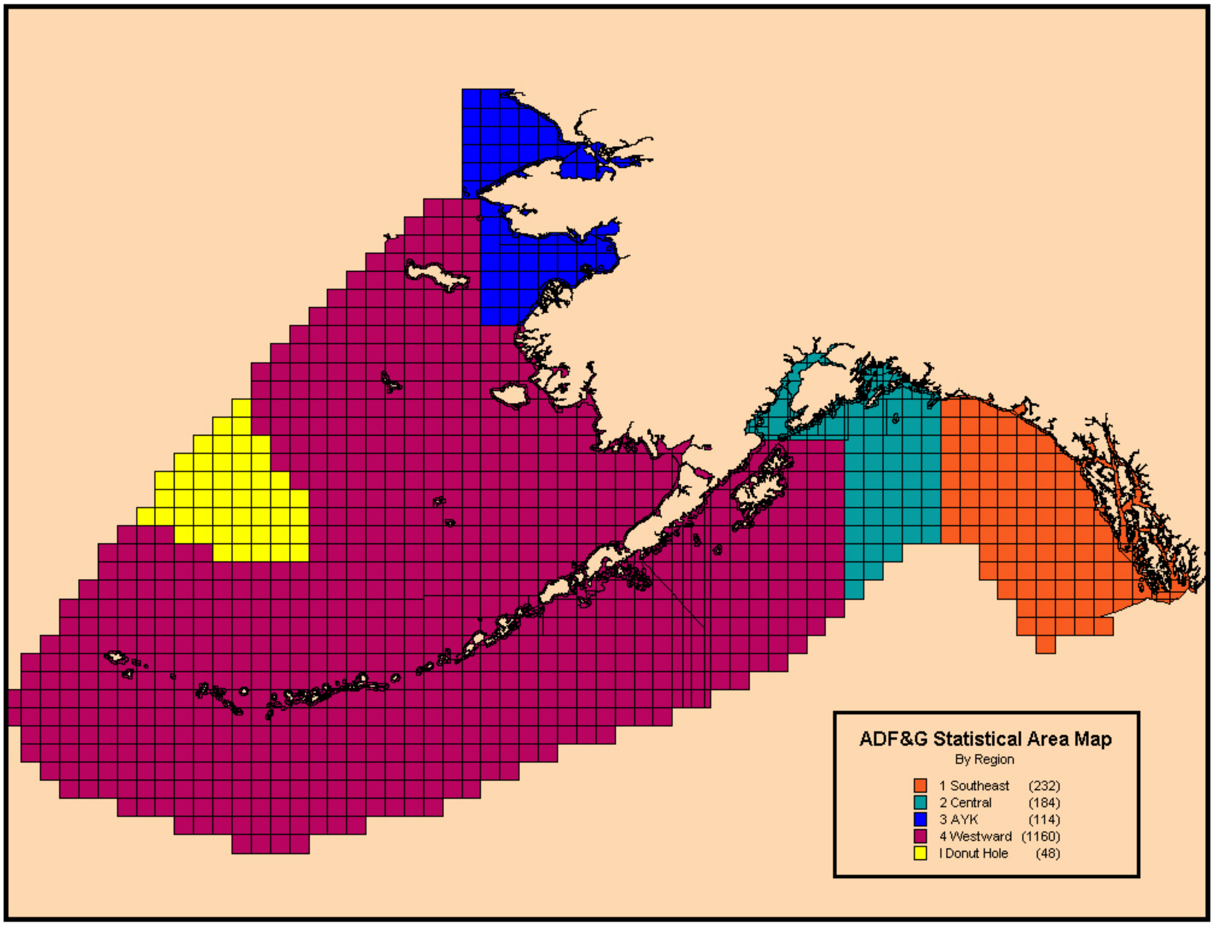

Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions

Appendix III

Tissue samples of Sebastes species and pollock collected for genetic analyses and stored at Alaska Department Fish and Game, Gene Conservation Laboratory, Anchorage. Species, sampling location year collected, sample size, and tissue type are given.

Species	Location	Year	Sample size	Tissues
Yelloweye rockfish *Sebastes ruberrimus*				
	Gravina,Danger,Herring	1991	27	muscle, liver, eye
	Knight Is./Naked Islands area	1998	100	fin
	Whittier	2000	97	fin
		2000	50	fin
	Kachemak Bay	1999	58	fin
	Kodiak Island	1999	115	fin
	Resurrection Bay	1999	100	fin
	Fairweather Grounds	1999	100	fin
	Flamingo Inlet	1998	46	fin, larvae
	Tasu Sound	1998	50	fin
	Topknot	1998	49	fin
	Triangle Island	1998	63	fin, larvae
	Sitka	1998	49	fin
	SE Stat Areas 355601, 365701 (CSEO)	1999	100	fin
Black rockfish *S. melanops*				
	Carpa Island	1998	40	fin
	Castle Rock near Sand Point	1999	60	fin
	Akutan	1999	100	fin
	Dutch Harbor	2000	6	fin
	Chignik	2000	100	fin
	Ugak Bay, Kodiak Island	1997	100	muscle,liver,heart,eye
	Eastside Kodiak Is.: Ugak and Chiniak Bays	1998	100	fin
	Southwest side Kodiak Island	1998	86	fin
	Westside Kodiak Island	1998	114	fin
	Kodiak Island	1996	2	muscle,liver,heart,eye
	North of Fox Island	1998	24	fin
	Resurrection Bay - South tip Hive Island	1997	82	muscle,liver,heart,eye,fin
	Yakutat Bay	2003	130	fin
	Valdez	2000	13	fin
		2001	50	fin
	Whittier	2000	16	fin
		2001	93	fin

Species	Location	Year	Sample size	Tissues
	Oregon - Pacific Northwest	1999	50	muscle, liver, heart
	Washington - Pacific Northwest	1998	20	fin
	Sitka	1998	50	fin
	SE Stat Areas 355631, 365701 (CSEO)	1999	83	fin
	Sitka Sound Tagging study	1999	200	fin
Dusky rockfish *S. ciliatus*				
	Sitka	2000	23	liver, fin
		2000	23	fin
	Sitka Black RF Tagging study	1999	15	muscle,liver,heart,eye
	Harris Bay - Outer Kenai Peninsula	2002	37	muscle
	North Gulf Coast - Outer Kenai Peninsula	2003	45	fin
	Resurrection Bay	1998	3	fin
	Eastside Kodiak Is.: Ugak, Chiniak, Ocean Bays	1998	100	muscle,liver,heart,eye
	Kodiak Island	1997	50	muscle,liver,heart,eye
Walleye pollock *Theragra chalcogramma*				
	Exact location unknown; see comments	1997	402	fin
	Bogoslof Island	1997	120	muscle,liver,heart
		1998	100	muscle
		2000	100	muscle,liver,heart
	Eastern Bering Sea	1998	40	muscle,liver,heart
	Middleton Island	1997	100	fin
		1998	100	muscle,liver,heart
		2000	100	muscle,liver,heart
	NE Montague/E Stockdale	1997	100	fin
	Orca Bay, PWS	1997	100	fin
	Prince William Sound	2000	100	muscle,liver,heart
	Port Bainbridge	1997	100	fin
		1998	100	muscle,liver,heart
	PWS Montague	1999	300	heart
	Eastern PWS	1999	94	heart
	Resurrection Bay	1998	120	fin
	Kronotsky Bay, E. Coast Kamtchatka	1999	96	muscle,liver,heart,eye,fin
	Avacha Bay	1999	100	
	Shelikof Strait	1997	104	muscle,liver,heart,eye,fin
		1998	100	muscle,liver,heart
		2000	100	muscle,liver,heart

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APPENDIX I. ALASKA DEPARTMENT OF FISH AND GAME PERMANENT FULL-TIME GROUNDFISH STAFF DURING 2010.

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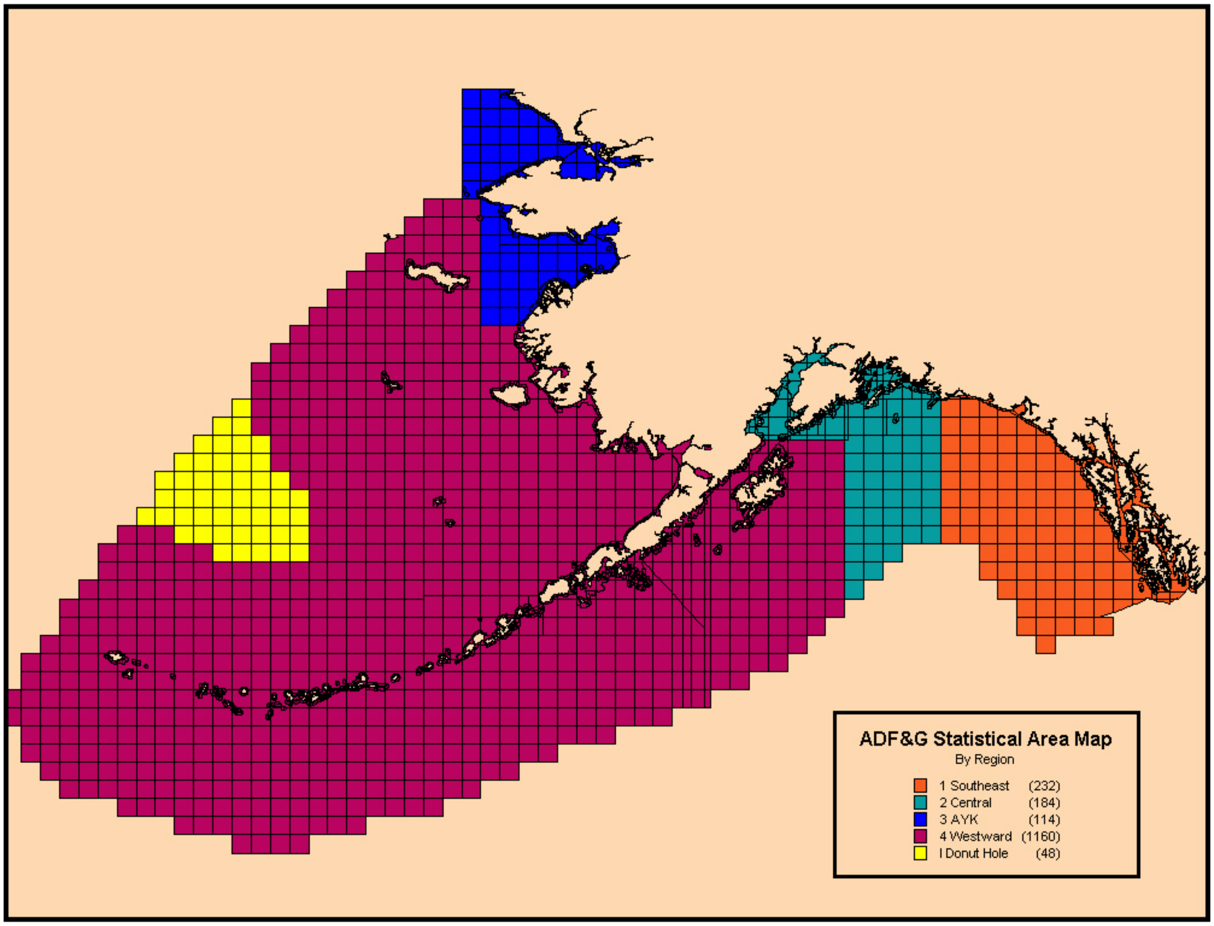
Appendix II
Map Depicting State of Alaska Commercial Fishery Management Regions.



Appendix III.

Tissue samples of *Sebastes* species and pollock collected for genetic analyses and stored at Alaska Department Fish and Game, Gene Conservation Laboratory, Anchorage. Species, sampling location year collected, sample size, and tissue type are given.

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		2000	50	fin
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	Resurrection Bay	1999	100	fin
	Fairweather Grounds	1999	100	fin
	Flamingo Inlet	1998	46	fin, larvae
	Tasu Sound	1998	50	fin
	Topknot	1998	49	fin
	Triangle Island	1998	63	fin, larvae
	Sitka	1998	49	fin
	SE Stat Areas 355601, 365701 (CSEO)	1999	100	fin
Black rockfish *S. melanops*				
	Carpa Island	1998	40	fin
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	Akutan	1999	100	fin
	Dutch Harbor	2000	6	fin
	Chignik	2000	100	fin
	Ugak Bay, Kodiak Island	1997	100	muscle,liver,heart,eye
	Eastside Kodiak Is.: Ugak and Chiniak Bays	1998	100	fin
	Southwest side Kodiak Island	1998	86	fin
	Westside Kodiak Island	1998	114	fin
	Kodiak Island	1996	2	muscle,liver,heart,eye
	North of Fox Island	1998	24	fin
	Resurrection Bay - South tip Hive Island	1997	82	muscle,liver,heart,eye,fin
	Yakutat Bay	2003	130	fin
	Valdez	2000	13	fin
		2001	50	fin
	Whittier	2000	16	fin

Species	Location	Year	Sample size	Tissues
		2001	93	fin
	Oregon - Pacific Northwest	1999	50	muscle, liver, heart
	Washington - Pacific Northwest	1998	20	fin
	Sitka	1998	50	fin
	SE Stat Areas 355631, 365701 (CSEO)	1999	83	fin
	Sitka Sound Tagging study	1999	200	fin
Dusky rockfish *S. ciliatus*				
	Sitka	2000	23	liver, fin
		2000	23	fin
	Sitka Black RF Tagging study	1999	15	muscle,liver,heart,eye
	Harris Bay - Outer Kenai Peninsula	2002	37	muscle
	North Gulf Coast - Outer Kenai Peninsula	2003	45	fin
	Resurrection Bay	1998	3	fin
	Eastside Kodiak Is.: Ugak, Chiniak, Ocean Bays	1998	100	muscle,liver,heart,eye
	Kodiak Island	1997	50	muscle,liver,heart,eye
Walleye pollock *Theragra chalcogramma*				
	Exact location unknown; see comments	1997	402	fin
	Bogoslof Island	1997	120	muscle,liver,heart
		1998	100	muscle
		2000	100	muscle,liver,heart
	Eastern Bering Sea	1998	40	muscle,liver,heart
	Middleton Island	1997	100	fin
		1998	100	muscle,liver,heart
		2000	100	muscle,liver,heart
	NE Montague/E Stockdale	1997	100	fin
	Orca Bay, PWS	1997	100	fin
	Prince William Sound	2000	100	muscle,liver,heart
	Port Bainbridge	1997	100	fin
		1998	100	muscle,liver,heart
	PWS Montague	1999	300	heart
	Eastern PWS	1999	94	heart
	Resurrection Bay	1998	120	fin
	Kronotsky Bay, E. Coast Kamtchatka	1999	96	muscle,liver,heart,eye,fin
	Avacha Bay	1999	100	
	Shelikof Strait	1997	104	muscle,liver,heart,eye,fin
		1998	100	muscle,liver,heart
		2000	100	muscle,liver,heart

California Department of Fish and Game Agency Report to the Technical Subcommittee of the Canada-United States Groundfish Committee

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A. AGENCY OVERVIEW

Within the California Department of Fish and Game (CDFG), the Marine Region is responsible for protecting and managing California's marine resources under the authority of laws and regulations created by the State Legislature, the California Fish and Game Commission (CFGC) and the Pacific Fishery Management Council (Council). The Marine Region is unique in the CDFG because of its dual responsibility for both policy and operational issues within the State's marine jurisdiction (0 – 3 miles). It was created to improve marine resources management by incorporating fisheries and habitat programs, environmental review and water quality monitoring into a single organizational unit. In addition, it was specifically designed to be more effective, inclusive, comprehensive and collaborative in marine management activities.

The Marine Region has adopted a management approach that takes a broad perspective relative to resource issues and problems. This ecosystem approach considers the values of entire biological communities and habitats, as well as the needs of the public, while ensuring a healthy marine environment. The Marine Region employs approximately 200 permanent and seasonal staff that provide technical expertise and policy recommendations to the CDFG, CFGC, Council, and other agencies or entities involved with the management, protection, and utilization of finfish, shellfish, invertebrates, and plants in California's ocean waters.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

B. MULTISPECIES STUDIES

1. Research and Monitoring

a. Commercial Fishery Monitoring

Statistical and biological data from landings are continually collected and routinely analyzed by CDFG staff to provide current information on groundfish fisheries and the status of the stocks. California's primary commercial landings database is housed in CDFG's Commercial Fisheries Information System. Outside funding also enables California fishery data to be routinely incorporated into regional databases such as Pacific Coast Fisheries Information Network (http://www.psmfc.org/pacfin).

Commercial sampling occurs at local fish markets where samplers determine species composition of the different market categories, measure and weigh fish and take otoliths for future ageing. Market categories listed on the landing receipt may be single species (e.g., bocaccio) or species groups (e.g., group slope rockfish). Samplers need to determine the species composition so that landings of market categories can be split into individual species for management purposes.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

Table 1. Commercial groundfish landings[1] and samples taken in 2011.

Common name	Metric tons	Len	Oto	Common name	Metric tons	Len	Oto
Flatfish:				Flatfish:			
Dover sole	2797	1529	349	Pacific sanddab	4	409	
Petrale sole	193	1570	27	Rock sole	2	27	
Arrowtooth flounder	105	750	84	Curlfin sole	0	4	
Rex sole	79	2361	77	Fantail sole	0	47	
Unidentified sanddab	45			Slender sole	0	1	
English sole	19	302	8	Deepsea sole	--	2	
Unidentified flatfish	19	13		Diamond turbot	--	2	
Sand sole	16	281		C-O turbot	--	1	
Starry flounder	10	230		Longfin sanddab	--	1	
Hornyhead turbot	6	93					
Rockfish:				Rockfish:			
Chilipepper rockfish	293	574		Starry rockfish	0	15	
Blackgill rockfish	162	1365	204	Canary rockfish	0	12	
Group slope rockfish	60			Flag rockfish	0	27	
Brown rockfish	35	244		Speckled rockfish	0		
Gopher rockfish	35	584	3	Greenblotched rockfish	0	1	
Black rockfish	30	349	44	Rosy rockfish	0		
Vermilion rockfish	21	238		Redbanded rockfish	0	374	247
Black-and-yellow rockfish	14	274		Greenstriped rockfish	0	26	1
Grass rockfish	14	242		Pacific ocean perch	0	81	34
Splitnose rockfish	10	436	17	Swordspine rockfish	0		
Blue rockfish	10	348	27	Group bolina rockfish	0		
Bocaccio rockfish	8	70	2	Honeycomb rockfish	0	35	
Bank rockfish	7	225	74	Rosethorn rockfish	0	5	
Copper rockfish	4	67		Group rosefish rockfish	0		
Darkblotched rockfish	4	882	330	Cowcod	0	1	
Treefish	2	56		Group small rockfish	0		
Aurora rockfish	2	2145	781	Yelloweye rockfish	0		
China rockfish	2	18		Group nearshore rockfish	0		
Yellowtail rockfish	1	74	29	Squarespot rockfish	0	1	
Group red rockfish	1			Chameleon rockfish	0		
Widow rockfish	1	49		Blackspotted rockfish	--	17	24
Greenspotted rockfish	1	208		Freckled rockfish	--	1	
Kelp rockfish	1	26		Rosy rockfish	--	3	
Quillback rockfish	1	7	1	Rougheye rockfish	--	64	81
Olive rockfish	1	9		Shortraker rockfish	--	2	
Group shelf rockfish	1			Silvergray rockfish	--	1	1
Unspecified rockfish	0			Stripetail rockfish	--	1	1
Shortbelly rockfish	0						
Skates:				Skates:			
Longnose skate	195	1272		Big skate	0	2	
Unspecified skate	31			Black skate	--	7	
California skate	0			Sandpaper skate	--	7	
Round fish:				Round fish:			
Sablefish	2735	4875		California scorpionfish	5		

Common name	Metric tons	Len	Oto	Common name	Metric tons	Len	Oto
Shortspine thornyhead	557	5712		Pacific whiting	5	43	
Roundfish:				Roundfish:			
Longspine thornyhead	541	4857	2	Cabezon	37	148	
California halibut	258	8		Lingcod	34	225	
Unspecified grenadier[2]	107			Kelp greenling	3	52	
Giant grenadier[2]	--	8		Unspecified thornyhead	1		
Pacific grenadier[2]	--	103		Spotted ratfish	0		
California sheephead	39	7		Rock greenling	0	1	
Sharks:				Sharks:			
Lepoard shark	3			Spiny dogfish	1	1	
Soupfin shark	2						

Notes:

1. Landings for 2011 are preliminary.
2. CDFG landing receipts only have a species code for grenadiers, unspecified, and may include giant and pacific grenadier.

Source: Commercial Fisheries Information System (landings) and California Cooperative Groundfish Survey (sample data).

b. Recreational Fishery Monitoring

The California Recreational Fisheries Survey (CRFS) began in January 2004 to provide catch and effort estimates for marine recreational finfish fisheries. The CRFS generates monthly estimates of total recreational catch for four modes of fishing [beach/bank, man-made structures, commercial passenger fishing vessels (CPFVs), and private and rental boats] for six geographic districts along California's 1000 plus miles of coast. The data are used by state and federal regulators to craft regulations to protect fish stocks and provide recreational fishing opportunities. The sampling data and estimates are available on the Recreational Fisheries Information Network (http://www.recfin.org).

The CRFS is a multi-part survey which uses field sampling, a telephone survey of licensed anglers, and CPFV logs (activity records for each trip). In 2011, approximately 55 CRFS samplers gathered recreational fishing effort and catch data statewide. The CRFS samplers interviewed almost 46,000 anglers at more than 400 sites, and examined more than 174,000 fish. The contractor for the licensed angler telephone survey completed 26,000 interviews, and CDFG received, processed and used more than 25,000 CPFV logs. The high sampling levels have contributed to greater accuracy and precision in estimating catch and effort, especially for overfished species such as yelloweye rockfish.

As a condition of their fishing permit, operators of CPFVs are required to submit a record of their fishing activities on a log provided by the CDFG. The operators must complete and submit a log of each fishing trip. Each log documents the target species, the fishing method, the type of bait, the number and type of fish landed or released, the number of anglers and hours fished, and the location where most of the fish were caught. In 2011, CRFS began using the mandatory CPFV logs along with a field validation survey to estimate CPFV effort. A voluntary telephone survey of CPFV operators was used to estimate CPFV effort prior to 2011. Catch rates are based on a field survey which consists of onboard and dockside sampling of CPFV trips.

For additional information, go to http://www.dfg.ca.gov/marine/crfs.asp.

Contributed by Connie Ryan (cryan@dfg.ca.gov)

c. Inseason Monitoring

Commercial fishery

The CFGC has authority under state law to manage nearshore species (as defined by the state's Marine Life Management Act and the Nearshore Fisheries Management Act). The CFGC has given CDFG the authority to take action as a routine management measure to close the recreational and/or commercial sectors of the cabezon, California sheephead, and greenling fisheries upon projected attainment of their respective established optimum yields and fishery allocations. The CDFG also has authority to make inseason trip limit adjustments to the commercial fisheries for cabezon, California sheephead and greenlings.

Inseason monitoring is used to track landings against statewide total allowable catches, statewide and/or regional allocations and trip limits. Inseason monitoring of California commercial nearshore species landings is now conducted by CDFG biologists in the areas north and south of 40°10' North Latitude near Cape Mendocino. This work is done in conjunction with inseason monitoring, management and regulatory tasks conducted by the Council. Weekly tallies of landing receipts are used for inseason monitoring. At present, inseason monitoring focuses on overfished species such as cowcod, canary and yelloweye rockfish.

In 2011, no inseason changes were made for cabezon, California sheephead and greenlings. The last time the CFGC had to take inseason action was in 2008. Fewer participants and increased trip limits for some species has allowed the fishery to continue unchanged.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

Recreational fishery

The CFGC has given the CDFG additional authority to take inseason action to modify management measures or close the recreational fishery for groundfish if harvests are projected to exceed or be well below federally-established harvest guidelines. Inseason monitoring of California recreational groundfish species catch is conducted by CDFG biologists utilizing a mathematical model that includes projected catch based on previous years' data as well as current catch rates obtained weekly from CRFS staff. In July 2009, the inseason monitoring of yelloweye rockfish, a species that significantly constrains the recreational catch of all rockfish, became available online to the public at http://www.dfg.ca.gov/marine/groundfishcentral/tracking.asp.

In 2011, no inseason management actions were taken. The CFGC has not had to take inseason action for the recreational fishery since 2008, due in part to modifying management areas and seasonal closures to better reduce the take of yelloweye rockfish.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

2. Management

a. 2011 State Management Measures Affecting Groundfish

Commercial fishery

Commercial fishery management has remained unchanged between 2007 and 2010; however, in 2011, the CFGC took action to increase the total allowable catch (TAC) and bimonthly trip limits for cabezon based on an increase in the cabezon allowable catch limit (ACL) adopted by the Council, roughly double the previous year's ACL (69 and 148 metric tons, 2010 and 2011, respectively). Based on the increased ACL, the CFGC adopted regulations increasing the state's total allowable catch (TAC) and the commercial and recreational allocations to 199,000 and 127,200 pounds, respectively (previously 92,800 and 59,300 pounds, respectively). Along with the increased TAC, the CFGC increased the commercial cabezon trip limits (Table 2).

Table 2. Cabezon commercial trip limit changes in 2011, effective June 9, 2011.

	Old trip limits (pounds)	New trip limits (pounds)
January-February	300	300
March-April	100	100
May-June	250	500
July-August	150	500
September-October	900	500
November-December	100	300

Recreational fishery

In June 2010, the Council increased California's recreational harvest guideline for lingcod from 422 metric tons in 2010 to 1151 metric tons in 2011 and 2012. In order to maximize opportunity for lingcod while continuing to avoid overfished species, the Council chose to remove the lingcod spawning closure for all modes of recreational fishing in California. To allow for additional retention of lingcod, the Council adopted a new recreational size limit of 22 inches, previously 24 inches, in an effort to maximize fishing opportunity and to make regulations consistent among California, Oregon and Washington.

In June 2011, the CFGC adopted regulations for the 2011-2012 recreational groundfish fishery to make them consistent with proposed federal regulations. Delays in adopting the federal regulations caused a subsequent delay in adopting state regulations, which were effective June 9, 2011. The changes included:

- Renaming the recreational groundfish management areas for simplicity (Figure 1)
- Combining two areas (Monterey South-Central and Morro Bay South-Central) into one (Central) because there were no longer any differences in the regulations
- Allowing year-round take of lingcod from beach, banks and man-made structures connected to shore

- Removing lingcod spawning closure (October through March) to align with the rockfish, cabezon and greenling (RCG) seasons in each management area
- Reducing the lingcod size limit to 22 inches, previously 24 inches
- Reducing the lingcod fillet limit to 14 inches, previously 16 inches
- Increasing the cabezon bag limit (from 2 to 3 fish) within the RCG complex 10-fish bag limit
- Restricting the take of cabezon, kelp and rock greenling to not more than two hooks on one line to be consisted with rockfish and lingcod
- Increasing the depth from 40 to 60 fm in January and February for the take of California scorpionfish to be consisted with RCG depth restrictions
- Clarifying that rockfish can be taken by hand or while diving or spearfishing

Figure 1. Recreational groundfish management areas for 2011.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

b. Nearshore Management

In 2002, the CFGC adopted California's Nearshore Fishery Management Plan (FMP) for 19 species (black, black-and-yellow, blue, brown, calico, China, copper, gopher, grass, kelp, olive, quillback, and treefish rockfishes; cabezon; kelp and rock greenlings; California scorpionfish;

California sheephead; and monkeyface prickleback). All but California sheephead, rock greenling and monkeyface prickleback are also included in the Council's federal Groundfish FMP. The Nearshore FMP is based on a framework management approach that gives the CFGC a comprehensive management strategy to prevent overfishing, rebuild depressed stocks, ensure conservation, promote habitat protection and provide for non-consumptive uses.

The CFGC adopted seasonal closures, total allowable catch, and trip limits for cabezon, kelp greenling, and California sheephead. Additionally, the CFGC provided CDFG with authority to close any of these fisheries upon attainment of the total allowable catch. Seasonal closures coincide with federal groundfish closures in waters off the state of California. In 2011, the only management changes to nearshore species are discussed above.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

c. Restricted Access for Nearshore Fisheries

The State of California began a restricted access program for the commercial nearshore fishery in 2003. The Nearshore Fishery Permit is required to take 10 shallow nearshore species: black-and-yellow, China, gopher, grass and kelp rockfishes, kelp and rock greenlings, California scorpionfish, California sheephead, and cabezon. These species can be taken with hook-and-line gear only; trap gear can be used with a trap endorsement. The Nearshore Fishery Permit program was set up on a regional basis with four regions: North Coast Region (Oregon border to 40°10' North Latitude near Cape Mendocino), North-Central Coast Region (40°10' North Latitude to Point Año Nuevo), South-Central Coast Region (Point Año Nuevo to Point Conception), and South Coast Region (Point Conception to the U.S./Mexico border). Nearshore Fishery Permit holders may only take these nearshore species within the region for which the permit is issued. Both transferable and non-transferable Nearshore Fishery Permits are issued.

A permit capacity goal was set for each nearshore region: 14 for the North Coast Region, 9 for the North-Central Coast Region, 20 for the South-Central Coast Region, and 18 for the South Coast Region. Until a region reaches its capacity goal, transferability is on a two-for-one basis, whereby two permits are purchased, one is retired and the other is used to fish. When the program began in 2003, a total of 224 permits were issued. In 2011, the number of permit had decreased to 164; however the number of permits in each region remains above its respective capacity goal.

The Nearshore Fishery Bycatch Permit program, which was started in 2003, authorized the take, possession, and landing of shallow nearshore species by vessels using only trawl or entangling nets (gill and trammel nets). Fifteen Nearshore Fishery Bycatch Permits were issued in 2011.

A Deeper Nearshore Species Fishery Permit program was also implemented in 2003. This permit allows the take of the following eight species of deeper nearshore rockfishes: black, blue, brown, calico, copper, olive, quillback and treefish. The permit is non-transferable, because there is no capacity goal for the fishery. Permit holders are not restricted by gear and may catch and land these species anywhere in the state where fishing is allowed. A total of 294 permits were issued in 2003; the number of permits issued decreased to 199 in 2011.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

C. BY SPECIES

1. Pacific Whiting

a. Primary Whiting Season

There were no directed whiting trips during the 2011 primary Pacific whiting (*Merluccius productus*) season. The primary whiting season off California started April 1, 2011 between 40° 30' North Latitude and 42° 00' North Latitude and on April 15, 2011 south of 40° 30' North Latitude.

Pacific whiting quota share holders that fished in 2010 did not participate in the 2011 early primary season off California, and either waited for the season north of 42° 00' North Latitude to open June 15, 2011, or fished for other groundfish. Prior to the inception of Individual Fishing Quotas (IFQ) in 2011, local and out of state vessels that participated in the early primary season off California landed whiting under a common harvest cap set at 5 percent of the annual allocation for the coast wide shore-based whiting fishery. Personal communication with individuals involved in the whiting fishery indicated the potential risk of encountering high operating costs, scattered schools, and small fish in the shore-based IFQ whiting fishery off California overshadowed the potential benefit of harvesting whiting earlier in the year. Pacific whiting quota share was better applied to the main fishery in the north where there are larger fish, higher volumes, and greater processing capacity.

b. Trawl Individual Fishing Quota Program (IFQ)

California shore-based landings of trawl caught Pacific whiting totaled 4.5 metric tons in 2011 and represented a 99 percent reduction from 2010 landings. Two first receivers documented whiting on 18 fish landing receipts. The ex-vessel price for whiting was $0.00/lb. The mean weight of whiting per landing was 547 pounds. Whiting landing pounds constituted .01 percent of all federally managed groundfish landed by vessels using limited entry trawl gear in 2011. The zero value and low poundage indicate that Pacific whiting was taken as bycatch with targeted groundfish species. Six vessels used large or small footrope trawl gear to take whiting. No vessels used midwater trawl to take whiting, another indicator that Pacific whiting were bycatch.

Contributed by Mike Fukushima (mfukushima@dfg.ca.gov)

2. Chilipepper Rockfish

Exempted fishing permits have been granted in recent years to study the use of different gears, commercial and recreational, to target chilipepper rockfish () *Sebastes goodei*) inside RCAs currently closed to groundfish fishing. The RCAs were implemented to protect overfished rockfish species such as yelloweye and canary rockfish. This has resulted in underutilization of other healthy rockfish stocks (e.g., chilipepper rockfish). The goal of these studies is to determine if alternate fishing strategies can provide additional fishing opportunities for both recreational and commercial fisheries while protecting overfished stocks. At this time, no fish were caught using EFPs, and no EFPs for chilipepper rockfish were renewed.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

3. Kelp Greenling

The kelp greenling (*Hexagrammos decagrammus*) is one of the19 nearshore finfish species in California's Nearshore FMP. It inhabits nearshore kelp beds and rocky reefs to a depth of 150 feet, and is harvested by recreational and commercial fisheries from Point Conception to the Oregon border. Prior to 2011, very little was known about kelp greenling population dynamics, and kelp greenling was listed as having a "data-poor" status in a 2005 stock assessment review. Specifically, there was lack of sound scientific data pertaining to age and growth, maturity, abundance, distribution, and size class structure. The CDFG's Fisheries Independent Scuba Assessment Project completed an age, growth and maturity study in November 2011.

The specific objectives of the study were to: 1) determine age and growth parameters of kelp greenling using otoliths from all size classes and sexes; 2) validate periodicity of growth band formation by marking captive fish with oxytetracycline; 3) estimate length/age at maturity by visual and histological inspection of reproductive tracts; and 4) determine spawning season by comparing monthly gonadosomatic and hepatosomatic indices.

A total of 385 kelp greenling were collected through a monthly sampling program. Females ranged from 126 to 411 mm total length (n = 162). Males ranged from 116 to 391 mm total length (n = 223).

Length-at-age data was used to generate growth curves for male and female kelp greenling using von Bertalanffy, Gompertz, and logistic growth functions. Growth model parameters were estimated using a non-linear least-squares regression and SigmaPlot graphical software program (Systat Software, 2006). From the growth curves, we compared coefficient of determination, significance level, and residual mean square error and determined that the von Bertalanffy Growth Function (VBGF) model best fit the data (Figure 2).

Female $L\infty = 386$ mm, $R^2 = 0.76$, $p < 0.0001$, $K = 0.35$
Male $L\infty = 356$ mm, $R^2 = 0.83$, $p < 0.0001$, $K = 0.49$

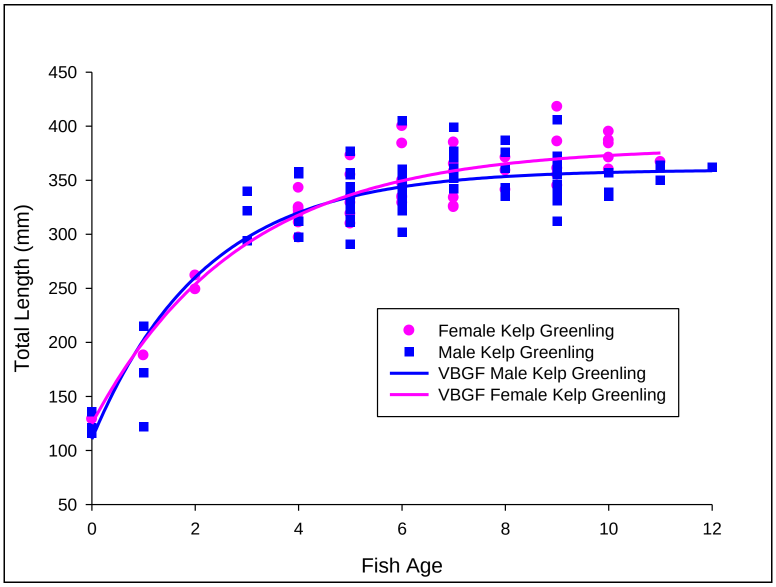

Figure 2. VBGF model showing growth curves for female (n=82) and male (n=101) kelp greenling.

Otoliths were examined and there was no significant difference between left and right otolith length. Periodicity of growth band formation in kelp greenling was validated by treating captive fish with oxytetracycline, an antibiotic readily incorporated into calcified tissues during osteogenesis. The resulting formation of a permanent mark at time of tagging and subsequent formation of a single pair of growth bands (comprised of one opaque and one translucent band), formed after the addition of the mark, validated this ageing method for kelp greenling (Figure 3).

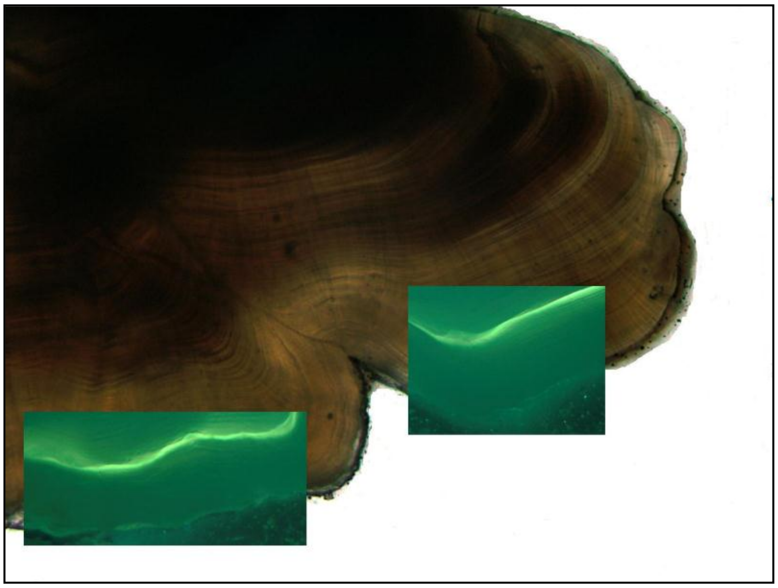
Figure 3. Sectioned kelp greenling otolith viewed under reflected light, with inset of otolith under epifluorescent light showing oxytetracycline mark and subsequent growth.

Estimates of size at 50 percent maturity were 275 mm and 215 mm total length for females and males, respectively. Seasonal maturity data indicated that kelp greenling spawn from September to January.

Contributed by Sean M. Hoobler (shoobler@dfg.ca.gov)

4. Cabezon

The cabezon (*Scorpaenichthys marmoratus*) is one of the 19 nearshore finfish species in California's Nearshore FMP. Successful implementation of the Nearshore FMP requires generating essential fishery information lacking for the species. For cabezon, there is limited information available on population abundance, natural mortality and changes in biomass. In addition, previous age estimates for cabezon have not been validated. The CDFG's Fisheries Independent Scuba Assessment Project has initiated two studies. The first is a multiple mark-recapture survey to collect information on catch, size, abundance and movement of cabezon and associated nearshore fishes in Carmel Bay, from Cypress Point to Yankee Point. The study area encompassed two marine protected areas (MPAs), allowing reserve effects to be investigated.

A total of 1673 fishes comprised of 16 species were caught in the Carmel Bay study areas during 2008-2010. Cabezon were the fourth most common species caught, composing 6 percent of the catch (107 fish). Catch-per-unit-effort (CPUE) was greater for cabezon outside MPAs than inside MPAs each year. Lengths were not significantly different between MPA and non-MPA sites or among years.

The recapture rate for all fishes in the study was low (46 fish or 3 percent), but comparable to other studies that have been conducted in the area. Cabezon comprised 8 percent of recaptured fish. Reports of tag recaptures have continued to arrive in the Department's Monterey field office since the end of field sampling in 2010 and further returns could lead to abundance estimates over the next few years that would be of great value to management.

The second study for age validation was undertaken because previous otolith edge analysis methods were unsuccessful for validating cabezon ages greater than 6 years. In 2010, five adult cabezon were collected and injected with oxytetracycline. Due to complications, these fish were sacrificed from 8 to 11 months after injection. Despite this, OTC marks were visible in all fish, and growth increment widths increased with time after injection. In those fish that survived to 11 months, one opaque and one translucent band formed after the OTC mark. This validates the periodicity of annual growth band formation in cabezon.

Contributed by Diane Haas (dhaas@dfg.ca.gov)

5. Copper rockfish

Copper rockfish (*Sebastes caurinus*) is one of the 19 nearshore finfish species in California's Nearshore Fishery Management Plan (FMP). Successful implementation of the Nearshore FMP requires generating essential fishery information lacking for the species. For copper rockfish, there is limited information available on age and growth in California waters. The CDFG's

Groundfish Project initiated a study to estimate age and growth parameters of copper rockfish in California for use in future stock assessments.

Biological sample data (i.e., otoliths) from commercial, recreational and research sectors collected during the 1970s to present have been compiled. To date, approximately 1238 otoliths have been matched with data, with the majority of them from the 1970-1980 time period. A random sub-sample of 465 otoliths representing all available size classes and sexes was selected for ageing purposes. Within the sub-set, females (n = 181) ranged from 150 mm to 565 mm total length. Males (n = 140) ranged from 168 mm to 554 mm total length. Samples where sex was unavailable (n = 144) ranged from 79 mm to 542 mm total length. Otoliths were weighed to determine whether there was a significant difference between left and right otolith; none was found.

This study is still in progress and projected to be completed by late 2012. Although ages have been estimated for some samples, estimates of growth parameters have not been completed. Once ages have been estimated for the initial 476 otoliths, additional samples can be added if necessary to reduce uncertainty in growth parameters.

Contributed by Caroline Mcknight (cmcknight@dfg.ca.gov)

D. OTHER RELATED ACTIVITIES AND STUDIES

1. Implementation of the Marine Life Protection Act

***Overview*:** The Marine Life Protection Act (MLPA), passed by California State Legislature in 1999, requires the CDFG to redesign its system of marine protected areas (MPAs) to increase its coherence and its effectiveness at protecting the state's marine life, habitat, and ecosystems. Significant advances have been made towards the successful implementation of the MLPA on a regional basis, and the development of a cohesive statewide network of MPAs. Previous attempts to implement the MLPA on a statewide level through a single action were unsuccessful. As a result, a Memorandum of Understanding established in 2004 created a public-private partnership commonly referred to as the MLPA Initiative, which split the state into five separate regional MPA planning processes (Figure 4). Four of five regional MPA planning processes have been completed thus far; and MPAs in three regions have been adopted by the CFGC and are currently in effect. The fourth region (north coast region) is pending CFGC adoption and the fifth (San Francisco Bay region) has yet to undergo a planning process. This section includes:

a) description of the MPA classification system used in California,
b) update regarding the status of each region and an overview of its MPAs,
c) description of current MPA research and monitoring efforts, and
d) other information related to adopted MPAs in California.

a. Classifications:

There are different classifications used in California's MPA network. This includes three MPA designations, one additional marine managed area designation, and special closures:

- State Marine Reserve (SMR): Prohibits all take and consumptive use (commercial and recreational, living or geologic). Permitted research, and non-consumptive uses may be allowed.
- State Marine Park (SMP): Prohibits commercial take but may allow select recreational harvest to continue. Access for research and non-consumptive use is encouraged[6].
- State Marine Conservation Area (SMCA): May allow select recreational and commercial harvest to continue. Access for research and non-consumptive uses is encouraged.
- State Marine Recreational Management Area (SMRMA): Provides subtidal protection equivalent to an SMR, while still allowing legal waterfowl hunting to continue.
- Special Closures: A geographically specific area that prohibits human entry. Special closures are generally smaller in size than MPAs and are designed to seasonally protect breeding seabird and marine mammal populations from human disturbance.

[6] In the MLPA planning process SMPs are designated as SMCAs that are designed with the intent to match an SMP in allowed regulations, goals and objectives. They can only be formally adopted as an SMP by the State Parks Commission in a separate action which takes the MPA designation intent into account. After the State Parks Commission adopts the SMP, then the area will have dual designation in statute as both an SMCA and SMP.

Figure 4. Marine Life Protection Act Study Regions.

b. Chronological overview of regional Marine Protected Area planning:

Central Coast Region: This region extends from Pigeon Point (San Mateo County) south to Point Conception (Santa Barbara County) (Figure 4). A network of 29 MPAs covering approximately 204 square miles of state waters or about 18 percent of the study region has been in place since September 2007 (Table 3; Figure 5).

Table 3. Central coast region marine protected areas.

Type of Marine Protected Area (number)	Area (square miles)	Region (Percentage)
State Marine Reserve (13)	84	7
State Marine Conservation Area (15)	117	10
State Marine Park (0)	N/A	N/A
State Marine Recreational Managed Area (1)	3	< 1
Total (29)	**204**	**18**

North Central Coast Region: This region extends from Alder Creek near Point Arena (Mendocino County) south to Pigeon Point (San Mateo County) (Figure 4). A network of 25 MPAs and six special closures covering approximately 152 square miles of state waters and representing approximately 20 percent of the study region has been in effect since May 2010 (Table 4; Figure 5).

Table 4. North central coast region marine protected areas.

Type of Marine Protected Area (number)	Area (square miles)	Region (Percentage)
State Marine Reserve (10)	84	11
State Marine Conservation Area (12)	68	9
State Marine Park (0)	N/A	N/A
State Marine Recreational Managed Area (3)	<1	< 1
Special Closures (6)[7]	1	<1
Total (25)	**152**	**20**

South Coast Region: This region extends from Point Conception (Santa Barbara County) south to the U.S. /Mexico border, including state waters around the Channel Islands (Figure 4). A network of 50 MPAs and two special closures (including 13 MPAs and two special closures previously established at the northern Channel Islands) covering approximately 355 square miles of state waters and representing approximately 15 percent of the study region has been in effect since January 1, 2012 (Table 5; Figure 5).

[7] Totals do not include special closures

Table 5. South coast region marine protected areas.

Type of Marine Protected Area (number)	Area (square miles)	Region (Percentage)
State Marine Reserve (19)	242	10
State Marine Conservation Area (21)	80	3
No-take State Marine Conservation Area (10)	33	1
State Marine Park (0)	N/A	N/A
State Marine Recreational Managed Area (0)	N/A	N/A
Special Closures (2)[2]	2	< 1
Total (50)	**355**	**15**

North Coast Region: This region extends from the California/Oregon border south to Alder Creek near Point Arena (Mendocino County) (Figure 4). The CFGC selected a preferred MPA alternative for the regulatory process in June 2011. The preferred alternative includes 19 MPAs, one SMRMA and seven special closures covering approximately 137 square miles of state waters or about 13 percent of the north coast region (Table 6, Figure 5). The preferred alternative includes regulatory text for take of living marine resources from an area with area-specific take restrictions by federally recognized tribes consistent with existing regulations.

Table 6. Proposed north coast region marine protected areas, pending final adoption by the CFGC.

Type of Marine Protected Area (number)	Area (square miles)	Region (Percentage)
State Marine Reserve (6)	51	5
State Marine Conservation Area (13)	85	8
No-take State Marine Conservation Area (0)	N/A	N/A
State Marine Park (0)	N/A	N/A
State Marine Recreational Managed Area (1)	< 1	< 1
Special Closures (7)[2]	< 1	< 1
Total (20)	**137**	**13**

San Francisco Bay Study Region: The San Francisco Bay Study Region (waters within San Francisco Bay, from the Golden Gate Bridge northeast to the Carquinez Bridge; Figure 4) is the fifth and final study region for consideration under the MLPA. The MLPA Initiative is currently developing a feasibility report for how a MPA planning process might be approached in the San Francisco Bay Study Region. This report will also consider other planning processes that have taken place within the study region, as well as lessons learned from previous regional MLPA Initiative planning processes.

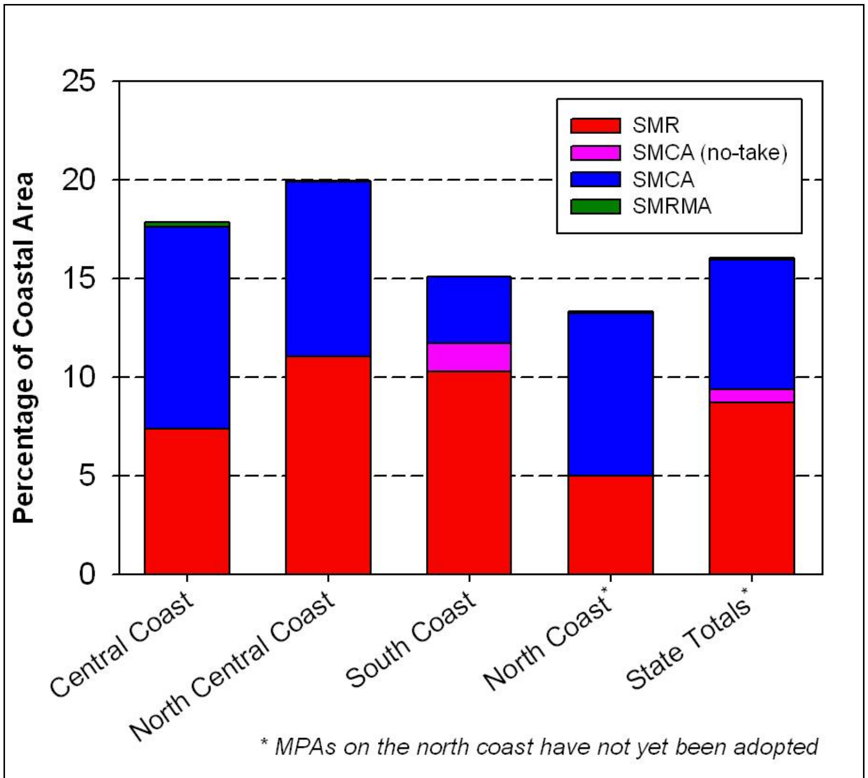

Figure 5. Marine protected area designation percentage by coastal region[8].

Linking to the National System of MPAs: After regional implementation, CDFG nominated MPAs developed under the MLPA Initiative planning process to the National MPA Center. Created by Executive Order, the National MPA Center is a division of NOAA that receives nominations by other federal, state, tribal and local governments for inclusion into a comprehensive nationwide listing of MPAs. Nominated MPAs must meet federal requirements for inclusion in the national network and database of information maintained by the National MPA Center. To date, a total of 54 MPAs (29 in the central coast, 25 in the north central coast), and all six north central coast special closures have been nominated to the national system of MPAs. All nominations have been accepted and are now officially listed as part of the national system of MPAs. South coast MPAs will be nominated during the next call for nominations in fall 2012.

2. Marine Protected Areas Monitoring and Research Efforts

Overview*:* The planning and design process for the MPA network along the entire coastline (excluding San Francisco Bay) has been completed, and the CDFG is now focusing on MPA implementation, monitoring, research, and long-term management. In addition, one of the primary requirements of the MLPA is adaptive management. To facilitate adaptive management, a comprehensive monitoring program to measure performance of MPAs relative to stated

[8] Found in the central coast, Cambria SMCA is currently the only MPA designed in the MLPA process that has also been designated as an SMP by the State Parks Commission. For purposes of reporting it is shown in this document as an SMCA only.

regional objectives and MLPA goals is being developed through collaboration between the MPA Monitoring Enterprise and the CDFG. The MPA Monitoring Enterprise (ME) was created through the State's Ocean Protection Council and the Ocean Science Trust to coordinate the development of the MPA monitoring program, to house and analyze monitoring data, and synthesize results in a manner that assists managers and policy makers in adaptive management decisions. The ME is currently in the process of developing monitoring priorities and a monitoring framework for the regional and the statewide networks of MPAs.

- *Central Coast MPA Monitoring Program:* The ME, CDFG and collaborators are preparing for the release of baseline monitoring results for the MPAs established in this region, and an update on these efforts to the CFGC is anticipated in 2013. The baseline monitoring report will rely on information collected from baseline monitoring studies conducted since 2007. For additional information, go to: http://www.dfg.ca.gov/mlpa/monitoring_phase1.asp.

- *North Central Coast MPA Monitoring Program:* A comprehensive monitoring plan for MPAs in this region was developed through the ME in partnership with the CDFG, and baseline monitoring projects for this region are currently completing their second field season. For additional information, go to: http://monitoringenterprise.org/where/northcentralcoast.php.

- *South Coast MPA Monitoring Program*: A comprehensive monitoring plan for MPAs in this region was developed through the ME in partnership with the CDFG, and 10 baseline monitoring projects for this region are currently underway in their first field season. For more information, go to: http://monitoringenterprise.org/where/southcoast.php.

- *Channel Islands MPA Monitoring Program:* In 1998, prior to enactment of the MLPA, a group of concerned citizens requested the CFGC establish a series of MPAs in the Channel Islands. Following a multi-year planning process, the Channel Islands MPAs were implemented in 2003. Though not created under the MLPA, the CFGC chose to include the Channel Islands MPAs in the MLPA Initiative process along with the rest of the MPAs adopted in the South Coast Region. A special session dedicated to the five-year evaluation of Channel Islands MPAs monitoring was held at the California Islands Symposium in February 2008. Monitoring projects included biophysical and socioeconomic-human use investigations. For more information, go to: http://www.dfg.ca.gov/marine/channel percent5Fislands/.

- *Remotely Operated Vehicle (ROV) MPA Monitoring:* Since 2003, the CDFG and its partners have performed visual surveys of fish populations and habitat in California's MPAs. The objective of these surveys is to establish baseline conditions inside and outside MPAs and to examine initial changes in fish size and density after MPA implementation. The CDFG program works closely with the ME to coordinate surveys with studies funded through the baseline monitoring programs. To date, extensive surveys have been completed in the Channel Islands (2003 – 2009), Central Coast Region (2007 – 2009), and North Central Coast Region (2009 – 2011). The CDFG plans to continue ROV surveys in MPAs in the North Central Coast and South Coast regions in 2012 and 2013.

3. Other Information Related to Marine Protected Areas Adopted in California

MPA Mobile Website: In September 2011, the CDFG unveiled a MPA mobile website allowing anglers, divers and other ocean users to look up current information about restricted areas and boundaries from land-based computers, smartphones, tablets and other portable Internet-enabled devices. This mobile website allows the public to:

- Search for any current MPA by name, county or general area to find information about the MPA's boundaries and regulations (the site will be updated as new MPAs go into effect, with no effect on the end user).
- Use an interactive map to locate any MPA and learn about its boundaries and regulations.
- Find and track the user's current location using the GPS on a mobile device, locate the closest MPA(s) and determine whether or not the user is currently located within an MPA.
- Read a summary of regulations or complete regulations for any MPA.

To access the mobile MPA website, go to: www.dfg.ca.gov/m/MPA

Marine Protected Areas and Fisheries Integration: It is expected that the statewide MPA network will result in various biological, ecological, and socioeconomic effects that may have broad implications for fisheries. Consequently, it is important to understand how this network of MPAs affects California's fishery resources, and how this information can then be used to inform fisheries management. The CDFG convened a workshop in March 2011 titled "Marine Protected Areas and Fisheries Integration Workshop". The purpose of this workshop was to elicit input from scientists representing a wide range of disciplines on the utility and practicality of using a redesigned statewide network of MPAs to inform fisheries management. Discussions focused on three main topics: possible effects of the MPA network on California's marine fisheries; potential management changes in response to the network of MPAs; and the potential for incorporating the presence of an MPA network into processes that define fishery yields. The Department expects these workshop results will serve to catalyze further discussion on the subject of MPAs and fisheries integration, and welcomes additional input including ideas not expressed within last year's workshop. To access the entire workshop proceedings, including outcomes and next steps, please go to http://www.dfg.ca.gov/mlpa/mfig.asp.

For more information on California's MPAs, visit the MLPA website: http://www.dfg.ca.gov/mlpa.

Contributed by Adam Frimodig (AFrimodig@dfg.ca.gov) and Elizabeth Pope (EPope@dfg.ca.gov)

4. Baseline Population Study of nearshore species in Carmel Pinnacles State Marine Reserve, Carmel Bay

Carmel Pinnacles State Marine Reserve (Pinnacles) was established in September 2007 as one of 29 newly designated MPAs along the central coast of California. Prior to its implementation as an MPA, there was limited data on fish populations at this site. Over a three year period from 2008 through 2010, information on nearshore groundfish abundance, size, catch rates, and movements inside this MPA and in a nearby reference site at Carmel Point were collected. Fish were caught using hook-and-line and trap gear aboard chartered CPFVs, commercial fishing vessels and CDFG vessels. Sampling was conducted during summer through early fall each year; typically July through September. Species of interest included lingcod, cabezon, kelp greenling and rockfish. Following capture, fish were measured, tagged and released. Fish exhibiting excessive trauma or fish that were less than 20 cm total length were released without tagging.

Over three sampling years, 87 volunteer anglers using hook-and-line gear caught 3449 fish of 18 species, 2878 of which were tagged and released. Overall, more fish were caught outside the MPA than were caught inside, although fish were typically larger inside the MPA. Black, blue, canary, copper, olive, vermilion and yellowtail rockfish were caught most frequently at Carmel Point, while gopher, China and kelp rockfish were most common at Pinnacles. Blue, gopher and olive rockfish were the most common fishes caught both inside and outside of the MPA.

To complement hook-and-line sampling, a total of 745 traps were deployed over the three year period yielding 1237 fish of 12 species, 1156 of which were tagged and released. Gopher rockfish, China rockfish, and cabezon were the most common species trapped at Pinnacles, while gopher rockfish, black-and-yellow rockfish and kelp greenling were the most common fish trapped at Carmel Point. Gopher rockfish was the dominant fish caught at both sites making up 74 percent of the catch at Carmel Point and 80 percent at Pinnacles. More fish were trapped inside the MPA than outside, and fish inside the MPA were typically larger.

To date, 59 tagged fish were recaptured and re-released during CDFG sampling days; and 22 tagged fish have been recaptured by the public (recreational anglers and divers, and commercial fishermen), yielding a 2 percent overall recapture rate. To date, all fish have been recaptured in the same general area where originally released.

We compared the lengths of the 13 most commonly caught species to known lengths at 50 percent maturity. For most species the 75th percentile length was above the reported length at 50 percent maturity; however black rockfish and yellowtail rockfish lengths were below their 50 percent maturity lengths at both sites. At the non-MPA site, blue rockfish and olive rockfish 75th percentile lengths were also less than the length at 50 percent maturity.

These baseline data on fish communities at Carmel Pinnacles State Marine Reserve provide an important metric for future comparison of population dynamics and MPA effectiveness. Data collected may also provide useful information for stock assessments for some “data-poor” species. This work complements similar studies being undertaken along California’s central coast by researchers at Moss Landing Marine Laboratories and Cal Poly San Luis Obispo.

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APPENDIX 1:

2011 CALIFORNIA GROUNDFISH COMMERCIAL FISHERY REVIEW

The 2011 California commercial groundfish harvest (Table 7) was approximately 8253 metric tons, with an ex-vessel value of $28.1 million. Total harvest was 18 percent lower in 2011 compared to 2010; however, that was mostly due to a sharp decline in Pacific whiting landings, a high volume fishery. This decline was a result of the advent of the trawl individual quota program where fishermen were given individual quotas for some groundfish species, including Pacific whiting. California fishermen leased their Pacific whiting quota shares to out-of-state fishermen in exchange for sablefish quota shares. This turned out to be a smart move because an earthquake-driven tsunami hit Crescent City in March 2011, destroying much of the harbor and docks used for offloading and processing Pacific whiting. Groundfish revenue increased 37 percent in 2011, compared to 2010, due primarily to the higher price per pound paid for sablefish compared to Pacific whiting. In 2010, the average price per pound for Pacific whiting and sablefish was $0.08 and $2.13 per pound, respectively.

In 2011, 63 percent of the groundfish landed were taken by bottom and mid-water trawl gear, a decrease from the 76 percent observed in 2010. Line and trap gears were the second and third most common gear types in 2011 at 26 and 10 percent, respectively; both gears saw increased use compared to 2010 (19 and 4 percent, respectively). Gill and trammel net landings were minimal, accounting for less that 0.2 percent of the groundfish catch. Since 2001, there has been a 49 percent decrease in trawl landings due to increased restrictions and a vessel buyback program. Gill and trammel net gear decreased 87 percent due in large part to increased state and federal regulations. On the other hand, trap landings and hook-and-line gear landings increased 275 and 70 percent, respectively, between 2001 and 2011 as fishermen sought alternate ways to catch groundfish.

Dover sole, sablefish, and thornyheads dominated California's 2011 groundfish harvest, making up approximately 80 percent of the state's landings (83 percent of groundfish revenue). Landings of Dover sole increased slightly (6.6 percent) in 2011. Sablefish landings increased by 12 percent while thornyheads declined 22 percent compared to 2010. Rockfish landings decreased 7 percent between 2010 and 2011. The major decrease (50 percent) in rockfish landings occurred between 2001 and 2011, due to increased restrictions aimed at protecting overfished rockfish species (e.g., canary and yelloweye rockfish) resulting in low trip limits coastwide.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

Table 7. California commercial groundfish landings (metric tons) for 2009-2011.

		2009	2010	2011[1]	2001	Percent change between 2001 and 2011
ROUNDFISH	Cabezon	18	23	37	72	-49.0
	Kelp greenling	1	2	3	11	-76.6
	Lingcod	57	47	34	62	-44.7
	Grenadiers	71	95	107	212	-49.7
	Longnose skate[2]	78	142	195	--[3]	--
	Pacific whiting	1792	2427	5	2306	-99.8
	Sablefish	2249	2450	2735	1508	81.4
	Spiny dogfish	45	6	1	3	-71.9
	Other fish	72	31	37	673	-94.5
FLATFISH	Arrowtooth flounder	45	68	105	9	1023.7
	Dover sole	3167	2622	2797	2407	16.2
	English sole	73	24	19	421	-95.4
	Pacific sanddab	11	0[3]	4	8	-53.6
	Petrale sole	532	213	193	560	-65.5
	Sanddabs	96	56	45	777	-94.2
	Starry flounder	17	13	10	42	-76.8
	Other flatfish	114	66	97	326	-70.4
ROCKFISH	Bocaccio	6	4	8	22	-63.3
	Bronzespotted	0	0	0	0	-100.0
	Canary	1	0	0	14	-97.7
	Chilipepper	241	342	293	346	-15.2
	Darkblotched	46	17	4	17	-78.9
	Pacific ocean perch	1	0	0	1	-92.2
	Shortbelly	0	0	0	5	-91.7
	Widow	4	10	1	332	-99.6
	Yellowtail	2	1	1	42	-96.7
	Minor shelf	22	18	25	138	-81.9
	Minor slope	278	246	242	333	-27.3
	Black (North of 40° 10')	90	50	25	93	-73.1
	Minor nearshore (north of 40° 10')	5	3	10	28	-64.3
	Shallow nearshore (south of 40° 10')	52	55	66	82	-19.5
	Deeper nearshore (south of 40° 10')	39	36	49	71	-31.0
	Unspecified rockfish[4]	1	0	0	15	-97.1
	California scorpionfish	3	3	5	20	-74.5
	Longspine thornyhead	540	552	541	596	-9.2
	Shortspine thornyhead	485	462	557	204	173.4
	Unspecified thornyhead[4]	2	13	1	48	-97.3
TOTAL		**10,256**	**10,098**	**8,253**	**11,805**	**-30.1**

Notes:
1. Landings data for 2011 are preliminary.
2. Longnose skate market category was added in 2009. Prior to that, longnose skates were included in the unspecified skate category.
3. Zero (0) indicates that less than 1 metric ton was landed; -- indicates no landings occurred.
4. Unspecified rockfish and unspecified thornyhead market categories were discontinued in 2001.

Source: California Fisheries Information System.

APPENDIX 2:

2011 CALIFORNIA GROUNDFISH RECREATIONAL FISHERY REVIEW

The 2011 California recreational fishery caught approximately 1666 metric tons of groundfish and nearshore species (Table 8), according to estimates generated by the Recreational Fisheries Information Network (RecFIN) that are based on data collected by California Recreational Fisheries Survey (CRFS) samplers using both sampler examined catch and fish observed discarded dead. Recreational groundfish catch in 2011 was approximately 37 percent higher than in 2010 and was due to increased catch of lingcod and rockfishes. Lingcod catch doubled in 2011 due to longer fishing seasons in most regions and a smaller size limit. Rockfish catch increased 28 percent in 2011 due to longer fishing seasons in most regions. Changes to the sampling protocol instituted in 2004 prevent a direct comparison between 2001 and 2011 recreational catch. However, given that the recreational fishery has seen increased restrictions since 2001, much like the commercial fishery, the overall catch is likely lower.

Rockfishes made up 72 percent of the recreational groundfish and state nearshore species catch in 2011, down slightly from 2009 and 2010 (77 percent both years). The slight decline can be attributed to the large increase in lingcod catch in 2011. That rockfish make up the majority of the recreational groundfish catch is not surprising given that anglers most commonly reported bottomfish as the target species when asked by CRFS samplers. Of the rockfish, vermilion, black and bocaccio were the most frequently caught rockfish in 2011, followed by brown, gopher and copper rockfishes. California scorpionfish, a closely related species in southern California, accounted for 6 percent of the rockfish catch in 2011. Of the non-rockfish groundfish, lingcod was most frequently caught (14 percent) in 2011. Lingcod was followed by sanddabs, California sheephead (not a groundfish species, but a state nearshore species), cabezon and leopard shark. While the ranking of the non-rockfish species changed slightly between 2010 and 2011, these same species continue to be popular with recreational anglers and account for the majority of the groundfish catch.

Contributed by Traci Larinto (tlarinto@dfg.ca.gov)

Table 8. California recreational groundfish catch[1] (metric tons) for 2010-2011.

	2010	2011[2]		2010	2011[2]
Flatfish					
Butter sole	0.0[3]	0.0	Rock sole	0.4	1.3
Dover sole	--[3]	0.0	Sand sole	0.5	1.1
English sole	0.0	0.0	Starry Flounder	0.6	1.2
Pacific sanddab	42.6	81.1	Unspecified sanddabs	0.9	8.0
Petrale sole	0.4	0.6	**Flatfish total**	**45.0**	**92.9**
Rockfish					
Bank rockfish	0.1	0.2	Honeycomb rockfish	4.8	9.5
Black and Yellow rockfish	20.3	14.1	Kelp rockfish	6.4	17.6
Black rockfish	218.6	178.1	Mexican rockfish	0.0	--
Blue rockfish	52.3	61.4	Olive rockfish	12.1	23.5
Bocaccio	56.6	103.3	Pinkrose rockfish	--	0.0
Brown rockfish	72.9	86.2	Quillback rockfish	2.9	4.3
Calico rockfish	0.3	1.9	Rosethorn rockfish	0.1	--
California scorpionfish	63.1	99.7	Rosy rockfish	6.0	6.8
Canary rockfish	12.9	15.7	Speckled rockfish	7.1	8.1
Chilipepper	2.8	5.3	Squarespot rockfish	1.9	5.7
China rockfish	18.0	15.3	Starry rockfish	19.3	24.4
Copper rockfish	48.5	66.9	Stripetail rockfish	0.0	0.0
Cowcod	0.2	0.8	Swordspine rockfish	--	0.0
Flag rockfish	5.1	9.0	Tiger rockfish	0.1	0.4
Freckled rockfish	0.1	0.1	Treefish	5.3	11.7
Gopher rockfish	91.1	72.2	Unspecified rockfish	24.0	82.5
Grass rockfish	5.7	10.5	Vermilion rockfish	140.7	195.2
Greenblotched rockfish	0.2	1.3	Widow rockfish	0.7	1.4
Greenspotted rockfish	11.4	17.9	Yelloweye rockfish	1.4	1.9
Greenstriped rockfish	0.8	1.1	Yellowtail rockfish	24.4	45.9
Halfbanded rockfish	0.6	1.6	**Rockfish total**	**938.8**	**1201.7**
Roundfish					
Cabezon	28.4	40.1	Pacific whiting	0.0	--
California sheephead	35.7	46.2	Rock greenling	1.6	0.7
Kelp greenling	15.8	22.6	Sablefish	--	0.0
Lingcod	106.3	226.0	Unspecified greenling	--	0.0
Monkeyface prickleback	4.3	1.1	**Roundfish total**	**192.1**	**336.8**
Sharks and skates					
Big skate	0.0	0.1	Soupfin shark	1.2	0.1
California skate	0.0	0.0	Spiny dogfish	1.5	9.7
Leopard shark	34.7	24.6	**Sharks and skates total**	**37.4**	**34.5**
			GRAND TOTAL	**1213**	**1666**

Notes:

1. Recreational catch includes sampler examined catch and observed discarded dead catch.
2. Catch data for 2011 are preliminary.
3. Zero (0) indicates that less than 1 metric ton was caught; -- indicates no catch was recorded.

Source: The Pacific Recreational Fisheries Information Network (RecFIN).

OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2011

OREGON DEPARTMENT OF FISH AND WILDLIFE

2012 AGENCY REPORT

PREPARED FOR THE 1-2 MAY MEETING
OF THE TECHNICAL SUB-COMMITTEE
OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE

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April 2012
OREGON DEPARTMENT OF FISH AND WILDLIFE

A. Agency Overview – Marine Resources Program

MRP Program Manager:	Dr. Caren Braby
Resource Management and Assessment:	Dave Fox
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The Marine Resources Program (MRP) is within the Oregon Department of Fish and Wildlife (ODFW) and has the jurisdiction over marine fish, wildlife, and habitat issues coastwide. MRP is headquartered at Newport in the Hatfield Marine Science Center, with field stations at the coastal cities of Astoria, Tillamook, Charleston, Gold Beach, Brookings, and Corvallis. MRP is tasked with the responsibility for assessment, management, and sustainability of Oregon's marine habitat, biological resources and fisheries. In addition to direct responsibilities in state waters (from shore to three miles seaward), MRP provides technical support and policy recommendations to state, federal, regional, and international decision-makers who develop management strategies that affect Oregon fish and shellfish stocks, fisheries, and coastal communities. Staffing consists of approximately 60 permanent and more than 70 seasonal or temporary positions. The current annual program budget is approximately $8 million, with about 70% coming from state funds including sport license fees, commercial fish license and landing fees, and a small amount of state general fund. Grants from federal agencies and non-profit organizations account for the remaining 30%.

B. Multispecies Studies

1. Sport Fisheries Project

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2011. Starting in November 2005, major ports were sampled year-round. We continue to estimate catch during unsampled periods in minor ports based on the relationship of effort and catch in minor ports relative to major ports observed during summer-fall periods when all ports are sampled. Samplers were stationed in all ports during the winter of 2011-2012, to attempt to ground truth estimates for unsampled periods. This was the result of a review of the ORBS program by and funded through the National Marine Recreational Information Program (MRIP). Black rockfish (*Sebastes melanops*) remains the dominant species caught in the ocean boat fishery. Lingcod (*Ophiodon elongatus)*, several other rockfish species, cabezon (*Scorpaenichthys marmoratus)* and kelp greenling (*Hexagrammos decagrammus)* are also commonly landed. Oregon's fishery for Pacific halibut (*Hippoglossus stenolepis)* continues to be a popular, high profile fishery requiring International Pacific Halibut Commission (IPHC), federal, and state technical and management considerations.

The ORBS program continued species composition, length and weight sampling of groundfish species at Oregon coastal ports during 2011. Since 2003, as part of a related marine fish ageing research project, lingcod fin rays and otoliths from several species of nearshore groundfish including rockfish species, kelp greenling and cabezon were gathered. Starting in 2001, from April through October, a portion of sport charter vessels were sampled at sea for species composition, discard rates and sizes, location, depth and catch per angler (CPUE) using ride-along samplers.

Starting in 2003, the recreational harvest of several groundfish species is monitored in-season for catch limit tracking purposes. In-season action was taken in 2011 to prohibit retention of cabezon by anglers fishing from boats. The shore fishery remained open. As in recent years, the retention of canary rockfish (*S. pinniger)* and yelloweye rockfish (*S. ruberrimus)* was prohibited year round. In order to remain within the yelloweye rockfish impact cap (via discard mortality), the recreational bottomfish fishery was restricted to inside of 20 fathoms from July 21 to September 30. Landings in the sport Pacific halibut fisheries were monitored weekly for tracking the status of catch limits. The majority of halibut continue to be landed in the central coast sub-area, with the greatest landings in Newport. Other ODFW management activities included participation in the U.S. West Coast Recreational Fish International Network (RecFIN) process, data analysis, and public hearings to discuss changes to the management of Pacific halibut and groundfish fisheries for 2012.

Starting in July 2005, sampling of the shore and estuary fishery was discontinued due to a lack of funding. Black rockfish make up the largest component of the estuary boat groundfish taken and surfperch made up the majority of shore-based catch by weight. Salmon dominate estuary boat landings by weight. Pacific herring historically have comprised the majority of both shore- and estuary-based boat landings by number of fish, but have not dominated catch in recent years. ODFW continues to pursue funding opportunities to reinstate the shore and estuary sampling program.

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2. Yellowtail Rockfish Exempted Fishing Permit

In 2009 and 2010, the Oregon Chapter of the Recreational Fishing Alliance (RFA-OR) in conjunction with ODFW received an exempted fishing permit (EFP) from the National Marine Fisheries Service (NMFS) to test experimental recreational fishing gear to target under-utilized yellowtail rockfish (*S. flavidus)* while avoiding the overfished yelloweye rockfish on select charter fishing trips. The experimental terminal tackle gear has a long leader (30-60 feet) between the weight and hooks, with a float to keep the line vertical in the water column. Ten charter vessels from three sections of the Oregon coast were to conduct three trips each over the course of the fishing season, to distribute trips spatially and temporally. ODFW supplied onboard samplers for each trip to gather information on total catch, gear set up, location, and to collect biological information from retained fish and provided some introductory data analysis.

Due to a delay in issuance of the permit by NMFS, no trips under this EFP were conducted in 2010. NMFS issued the permit for 12 months from the data of issue (late August 2010), rather than 12 calendar months. In 2011, 22 trips occurred out the ports of Garibaldi, Depoe Bay and Newport. The applicant did not apply for an EFP for 2012; therefore no further trips are anticipated. Data analysis will continue into 2012.

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3. Commercial Fisheries Monitoring and Sampling

Data from commercial groundfish landings are collected throughout the year and routinely analyzed by ODFW to provide current information on groundfish fisheries and the status of the stocks. This information is used in management, including inseason adjustments of the commercial nearshore fishery, which is conducted in state waters. Species composition sampling of rockfish continued in 2011 for commercial trawl, fixed gear, and hook and line landings. Biological data including length, age, sex, and maturity status continued to be collected from landings of major commercial groundfish species.

Contact: Carla Sowell (541) 867-0300 ext. 222 (Carla.Sowell@state.or.us)

4. Maturity Studies

We continued research begun several years ago to produce histologically verified female maturity data for a variety of species for which maturity data is unavailable or outdated. A report detailing age and length at maturity data for female quillback and china rockfish (length only) was completed, available at:
http://www.dfw.state.or.us/MRP/publications/#Research

Contact: Bob Hannah (541) 867-0300 ext. 231 (bob.w.hannah@state.or.us)

5. Movement of Rockfishes Using Acoustic Telemetry

Analysis of data continued from a 4-month 2010 study of the movements of quillback, copper and brown rockfish at Cape Perpetua, an area of low-relief emergent structure subject to frequent seasonal hypoxia. The data from this study, which utilized Vemco's VPS acoustic telemetry technology, has produced home range estimates for these species as well as very detailed information on movements and movement responses to a moderate hypoxic event.

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6. Development and Testing of a Video Lander for Studying Demersal Fishes on Nearshore Rocky Reefs

We completed several field projects designed to determine the utility of using a video lander to study the abundance and distribution of demersal fish living on high relief rocky reefs. Work in 2011 included a large-scale gridded survey to evaluate the suitability of the western boundary of the Yelloweye Rockfish Conservation Area (YRCA) at Stonewall Bank. The data showed that for the northern portion of the YRCA, the area just to the outside (west) of the closure boundary enclosed similar numbers of yelloweye rockfish and preferred habitat to the area inside the YRCA, suggesting that an expansion of the YRCA to the west would significantly improve the level of protection for yelloweye rockfish provided by this marine protected area. Analysis of relative abundance data for all of the common demersal species observed indicated that a video lander deployed in the manner used in this study could detect statistically significant differences in relative abundance of about ±50%. The write-up of this project continues.

Contact: Bob Hannah (541) 867-0300 ext. 231 (bob.w.hannah@state.or.us), Matthew Blume (541) 867-0300 ext. 286 (matthew.blume@state.or.us)

7. Reducing Eulachon Entrainment at the Footrope of a Shrimp Trawl

We continued field studies in 2011 examining how footrope changes can be used to reduce entrainment and subsequent bycatch of eulachon and other small demersal fish in a shrimp trawl. In 2010, an experimental footrope, modified by removing the central one third of the trawl groundline was shown to reduce eulachon bycatch by 33.9%, ($P < 0.001$). However, it also reduced the catch of ocean shrimp (weight) by 22.2%. As a follow-up experiment in 2011, we fished the same experimental footrope design against the same control footrope, but reduced fishing line height in the experimental trawl to reduce shrimp loss. Shrimp loss dropped to just 14% with this change, however, eulachon bycatch reduction was also reduced to just 14%, relative to the control net. Our conclusion is that eulachon bycatch can be reduced by eliminating a large section of groundline. However, significant shrimp loss will result, which could result in more hours of towing, possibly negating benefits to eulachon populations.

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8. Evaluation of Eulachon and Other Species Behavior When Exiting a Shrimp Trawl

We conducted a study in 2011 that used high-definition stop-motion video to view the condition of eulachon and other fishes as they exited the escape opening of a bycatch reduction device in a shrimp trawl. Observed behaviors were quantified in relation to a proposed model of an ideal trawl escapement based on an actively swimming fish avoiding contact with the grid. This model of avoidance-based escapement assumed that a roundfish in excellent condition would, 1) maintain distance from the grid, 2) avoid physical contact with the grid, 3) maintain a forward swimming orientation, and 4) maintain an upright vertical orientation. Of the species and size classes of fish encountered, large eulachon (approximately 170-240 mm total length), came closest to the proposed model of avoidance-based escapement, indicating less behavioral impairment than other species. Almost 80% of the large eulachon maintained an upright vertical orientation throughout their escape and exited the trawl in a forward-swimming orientation. Large eulachon maintained distance from the deflecting grid better than the other species encountered ($P < 0.001$) and typically showed no contact or only minimal contact with it (63%). Only about 20-30% of the large eulachon showed behaviors indicating fatigue, such as laying on or sliding along the grid. In contrast, both adult and juvenile Pacific hake (*Merluccius* *productus*) frequently showed signs of fatigue, including sliding along or laying on the grid, exiting the trawl in physical contact with the grid or failing to maintain an upright vertical orientation throughout their escape. Lingcod (*Ophiodon elongatus*) and juvenile rockfish (*Sebastes* spp.) were intermediate in their escape behavior between Pacific hake and large eulachon.

A manuscript summarizing this work is in review at Fisheries Research.

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9. Marine Reserves in Oregon

Status of sites
Harvest prohibitions took effect on January 1, 2012 for Oregon's first two established marine reserve sites. Three new marine reserve sites have been identified and are to be established, as mandated by Senate Bill 1510 passed by the 2012 Oregon Legislature. Harvest prohibitions are not to take effect until two years of baseline data collection are completed.

Monitoring
For the two established marine reserve sites, ecological and human dimensions (social and economic) baseline data collection was completed in 2011. Data collection was conducted by ODFW staff and external scientific research partners. Local fishing vessels were utilized when and where feasible. Baseline monitoring reports are to be completed in the spring of 2012. Monitoring will continue at these two sites.

In February 2012, ODFW hosted a marine reserves ecological monitoring workshop with 31 invited west coast scientists. The purpose of the meeting was to seek expert feedback on current and future ecological monitoring activities conducted by ODFW.

ODFW is to begin baseline data collection at two of the three new marine reserve sites in 2012.

Management plans
ODFW staff worked with local community teams, for the two established sites, to develop site management plans. The management plans outline strategies for ecological and human dimensions monitoring, reporting, and evaluation; outreach; compliance and enforcement; and community and public engagement. The plans also highlight priorities and implementation efforts of the local community that complement that of the state. Management plans for the two sites are to be completed in the spring of 2012.

Contact: Cristen Don (541) 867-7701 ext. 228 (Cristen.Don@state.or.us)

10. Hypoxia Effects on Seafloor Communities

As part of an Oregon Sea Grant research grant, personnel from ODFW's Marine Habitat Project partnered with the Partnership for Interdisciplinary Study of Coastal Oceans (PISCO) to continue and expand documentation of the ecological effects, including disturbance and recovery, of recently discovered hypoxia events on seafloor communities. We conducted a survey of seafloor biota at three sites offshore of central Oregon (Cape Perpetua, Yaquina Head, and Siletz Reef) with a Remotely Operated Vehicle (ROV) during May, June, August, and December of 2011. In concert with PISCO's efforts to collect oceanographic data (e.g., temperature, salinity, dissolved oxygen content), which documented the spatial extent and degree of hypoxia in the study area over a seasonal time scale, we collected video footage of organisms occurring on the seafloor along a previously-established (i.e. "fixed") transect line. Our objective was to continue the nearly-annual time series of ROV video data along a fixed transect line. We have monitored the Cape Perpetua reef complex regularly since 2000. Hypoxic events occurred on the inner continental shelf during September 2011, but the oceanographic extent and duration of these events were not as extreme as in prior years (e.g., 2002 and 2006). Due to vessel scheduling conflicts, we were not able to document immediate post-hypoxic conditions, but our site visit during December did not yield any significant qualitative differences in fish community structure or abundance. This was the second and final field season for this Sea Grant project, and data analysis and report writing will be performed in 2012.

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C. By Species

1. Black Rockfish PIT Tagging

Black rockfish comprise approximately 50% of the catch in Oregon's primary recreational groundfish fishery, making this species an important component of managing the fishery. Historically, assessments of black rockfish have relied on CPUE data from recreational fisheries to estimate the trend of relative population abundance. However, these data are not robust to problems of sampling bias, or to changes in fishing distribution, bag limits, or fishing power. The need to independently estimate exploitation rates and population abundances for black rockfish off Oregon prompted us to investigate the use of passive integrated transponder (PIT) tags for a mark-recapture program. Since PIT tags are invisible to anglers, there is no tag non-reporting problem, and tag detection rates can be estimated directly. Tags are injected in the hypaxial musculature below the gill arches, determined to be the best site by a previous PIT tag retention study. At tagging, categorical barotrauma symptoms were noted and fish with significant barotrauma symptoms were recompressed by immediate submersion in a cage and released at depth. PIT tags (12mm x 2mm) were inserted in 4,188 black rockfish in 2011 during 20 days of fishing near Newport. The total number of black rockfish tagged since the project began in 2002 is now 32,759. Carcasses of black rockfish are counted and electronically scanned for tags year-round upon being landed by recreational and charter fishers. In 2011, 75% of the black rockfish landed in Newport and 37% of those landed in Depoe Bay were scanned for tags. We recovered 309 tags, all in Newport. All ten tag cohort years were recovered. We have had consistent recovery rates each year. Estimates of annual exploitation rate derived from this project vary from 3.2% to 4.9% and are less than expected assessment values of approximately 5%. Survival rate estimates remain imprecise, likely due to problems with non-mixing. As the number of fish tagged has increased, there has been a corresponding decrease in variation of parameter estimates. Black rockfish populations off Oregon and California underwent a full assessment in 2007. Results from this study were included in the 2007 assessment as an index of abundance for the assessed population. Based on the input of the assessment author and reviewers, this index will likely be incorporated in future assessments. Tagging and recovery efforts will continue in 2012.

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2. Photograph-based Length Estimation of Recreational Yelloweye Rockfish Discards

In 2011, we continued a portion of a 2010 pilot project designed to collect data on the length distribution of yelloweye rockfish discarded in the recreational bottomfish and halibut fisheries off Oregon. Due to the prohibition on retention in most U.S. West Coast fisheries, data of this type has become extremely limited in recent years. Anglers were asked to photograph any yelloweye encountered with a known-size reference object in the photograph frame. The relationship between the length of the fish and the size of the reference object in the photograph can then be used to estimate the length of fish using computer software. We provided digital cameras to crewmembers of 20 participating charter vessels, and asked that they photograph all yelloweye rockfish they encountered over the course of the season. We suspended work with private vessels in 2011 due to the high effort required and low number of photos obtained until a more efficient method can be developed. Data on the number of useable photographs from 2011 was not available at the time of this report writing but work will continue into 2012.

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3. Morphological differences between “Blotched” and “Solid” Blue Rockfish Morphotypes

Blue rockfish (*S. mystinus*) are a major component of the nearshore fishery landings along the U.S. west coast. Field identification of blue rockfish relies on several characteristics; dark bars across the head, maxilla extends anterior of mid-orbit, blue coloration on the pelvic fins, spots absent on the dorsal membrane. By using these characters, we found two distinctly different fish were being grouped together that can be distinguished as two morphotypes with careful observation. We have designated the terms ‘blotched’ and ‘solid’ to differentiate these two blue rockfish.

Recent genetic studies on blue rockfish have found population differences north and south of Cape Mendocino (Cope 2004). Burford and Bernardi (2008) confirmed the presence of two reproductively isolated sympatric lineages. Peterson (in review) confirmed two unique lineages and has assigned large genetic distances between these morphotypes. Burford (2009) has identified 30 private alleles in solid blue rockfish and 45 private alleles in blotched blue rockfish. These studies confirm major genetic isolation between these two morphotyes although there is confirmed habitat overlap.

We conducted a pilot study investigating morphological difference between the two blue rockfish morphotypes. Our research found three gross anatomical characters to distinguish between these morphotypes. Body shape and color and patterning were different between morphs. The blotched morph has a deeper body and head and green background coloration with small distinct dark patches of black color along the sides. The solid morph is more streamlined and has a uniform dark brown coloration with a speckled appearance. The second feature is the extension of the lower jaw. Solid blue rockfish morphs have an approximately 0.5 cm "overhang" of the lower maxillary while the blotched morph has little if no overhang. Ovary coloration is also different between morphs. Blotched morphs have a yellow/orange colored ovary while the solid morph has a slightly pink or cream colored ovary. Five morphometric characters also distinguish between these different blue rockfish morphotypes. Head depth at the posterior end of the maxilla, distance between the dorsal fin origin to the anal fin origin, distance between the dorsal fin insertion to the anal fin insertion, distance from the first dorsal spine to the anal fin origin and the depth of the caudal peduncle were all found to be significantly different between morphotypes. In 2012, we will examine specimens from the original description of *S. mystinus* to determine the morphotype of blue rockfish. These characteristics will be used to identify landed blue rockfish more accurately and enable fisheries managers to better set harvest levels at sustainable levels in the future.

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D. Publications

Dauble, A.D., S.A. Heppell, and M.L. Johansson. 2012. Settlement patterns of young-of-the-year rockfish among six Oregon estuaries experiencing different levels of human development. Marine Ecology Progress Series 448: 143-154.

Hannah, R. W., P. S. Rankin and M. T. O. Blume. 2012. Use of a novel cage system to measure post-recompression survival of Northeast Pacific rockfish. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science 4:46-56.

Hannah, R. W., S. A. Jones, M. J. M. Lomelli and W. W. Wakefield. 2011. Trawl net modifications to reduce the bycatch of eulachon (*Thaleichthys pacificus*) in the ocean shrimp (*Pandalus jordani*) fishery. Fisheries Research 110:277-282.

Hannah, R. W. and P. S. Rankin. 2011. Site fidelity and movement of eight species of Pacific rockfish at a high-relief rocky reef on the Oregon coast. N. Amer. J. of Fish. Mgt. 31:483-494.

Hannah, R. W. 2011 Variation in the distribution of ocean shrimp (*Pandalus jordani*) recruits: links with coastal upwelling and climate change. Fisheries Oceanography 20(4):305-313.

Hannah, R. W. 2011. Maturity of female quillback (*Sebastes maliger*) and china rockfish (*S. nebulosus*) from Oregon waters based on histological evaluation of ovaries. Oregon Dept. Fish Wildl., Information Rept. Ser., Fish. No. 2011-01. 27 p.

E. Projects Planned for Year 2012

1. Maturity studies

Work will continue to summarize maturity data for copper rockfish.

Contact: Bob Hannah (541) 867-0300 ext. 231 (bob.w.hannah@state.or.us)

2. Rockfish Movement

A study using VPS acoustic telemetry technology aimed at evaluating movement tendencies of yelloweye rockfish at Stonewall Bank is planned in 2012.

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3. Testing a Video Lander for Surveying Rocky Reefs

Work planned for 2012 includes evaluating a high definition and possibly a stereo-video version of our video lander.

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4. Reducing eulachon entrainment at the footrope of a shrimp trawl

We plan to conduct a follow-up experiment to our 2011 footrope work to determine if using a five to six foot ”window” (a gap) in the groundline (with normal fishing line height) can reduce eulachon entrainment with acceptable shrimp loss. In theory, some eulachon should herd to the very center of the groundline and utilize this gap to escape under the trawl, while shrimp should be stimulated off bottom across most of the groundline length. A second experiment examining the effect of disk-protected groundlines under the wings of shrimp trawls is also anticipated.

Contact: Bob Hannah (541) 867-0300 ext. 231 (bob.w.hannah@state.or.us), Steve Jones (541) 867-0300 ext. 239 (steve.a.jones@state.or.us)

5. Discard Mortality of Rockfishes

In 2012, we anticipate extending 2010 studies on yelloweye and canary rockfish post-recompression survival into deeper waters, more representative of capture depths for rockfish bycatch in the Pacific halibut fishery.

Contact: Bob Hannah (541) 867-0300 ext. 231 (bob.w.hannah@state.or.us)

6. Baseline Data Collection for future Marine Protected Areas

In 2012, the Marine Habitat Project will work with the Marine Reserves Program to gather baseline ecological data for the future marine protected areas designated at Cape Perpetua and Cascade Head, as well as their respective comparison areas. Marine Habitat personnel will use a ROV to survey the habitat and biota occurring on deep (>-20 m) rocky reefs in these areas.

Contact: Mike Donnellan (541) 867-0300 ext. 279 (Michael.D.Donnellan@state.or.us)

7. Developing an improved rockfish species composition expansion model

Work was initiated in 2010 to develop a better model to apply species composition data collected by port samplers to fisheries catch data. The original framework relies on a series of borrowing rules based on temporal and spatial factors. Documentation on the original borrowing rules and rationale are no longer available. However, researchers at Oregon State University recently developed a model to estimate the existing borrowing rules. While many different fish families are affected by these rules, rockfish, due to the species diversity and nominal category designation are most in need of a better expansion model. Work will continue into 2012.

Contact: Alison Dauble (541) 867-0300 ext. 284 (Alison.D.Dauble@state.or.us)

Washington Contribution to the 52nd Annual Meeting of the Technical Sub-Committee (TSC) of the Canada-US Groundfish Committee

May 1-2, 2012
Newport Beach, California

Report from the
Washington Department of Fish and Wildlife
to be submitted
at a later date

Committee of Age-Reading Experts

2011 Committee Report

Prepared for the Fifty-third Annual Meeting of the Technical Subcommittee of the Canada-USA Groundfish Committee

12 May 2012

Prepared by
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CARE 2012 Report to the Technical Subcommittee of the Canada-USA Groundfish Committee

A. CARE Overview

History
The Committee of Age-Reading Experts, CARE, is a subcommittee of the Canada-USA Groundfish Committee's Technical Subcommittee. Members are charged with the task of developing and applying standardized age determination criteria and techniques. CARE members operate within the Terms of Reference approved by the TSC in 1986 and the CARE Charter developed in 2000, and approved by CARE in 2004.

CARE Workshop
CARE meets biennially for a three-day workshop. Workshops typically consist of one "business" day and one and a half days of hands-on calibration at microscopes to review and standardize age reading criteria. The next CARE workshop in 2013 will focus on the readability of archived otolith samples stored in alcohol versus those stored in glycerin.

Report Period
This report covers the work period of January1, 2011 through December 31, 2011. The most recent biennial CARE Workshop was held April 11 through April 15, 2011. It was attended by 38 agency members from Washington, Oregon, Alaska, California and British Columbia. This reporting period included information from the Executive Summary (prepared by past Chair MacLellan) dated May 3 through May 5, 2011. *For meeting details see the 2011 workshop minutes posted on the CARE website at www.psmfc.org/care/.*

B. CARE Subcommittee (Working Group) Reports

1. **CARE Manual/Glossary Committee** – The committee consists of Kamikawa, Goetz, Forsberg, and three incoming members in 2011 (Russ, B. Campbell, and Failor).

The Manual/Glossary Committee working group members develop age-reading charter sections or definitions for age-reading terms suggested by CARE members. These charters sections and definitions are subsequently approved by CARE members and added to the CARE Manual/Glossary.

During the 2011 CARE meeting, the rockfish section was reviewed and updated. Revisions were identified and Goetz agreed to update the section as necessary. The committee is currently reviewing two new drafts for the manual: the QA/QC techniques by B. Campbell and age determination of halibut by Forsberg.

These agencies plan to work on the following new species: a hake section by NWFSC and CDFO members, a lingcod otolith section by ADFG members and a skate section by AFSC. Minor revisions and updates to the age validation section will be done by AFSC.

Goetz offered to draft a section on ergonomics. The committee generated a CARE to CARE recommendation for 2011 to present the latest ergonomic information at the next CARE meeting.

2. CARE Website Committee – Short, Atkins

The appearance and operation of the CARE website is maintained with the cooperation of the PSMFC.

In 2011, the structure exchanges were updated to include aged PDFs of completed historical case invoices (1998-2009) linked to the table on the CARE website. The CARE charter, the citation, and the disclaimer were added to the footer. The 2011 minutes were also posted.

Atkins recommended the CARE Forum continue for one more rotation and asked that the members post general communications and check for new information on a regular basis.

The committee will continue to add the following information to the website: the 2011 photos, the 2010 production numbers, the 2010 structure exchanges, and the completed case inventory samples Russ (Vice-chair) recovers from the 1998-2005 historical case inventories. The committee is also looking into the feasibility of preparing an on-line summary of the material that is archived by each of the West Coast groundfish agencies in reply to TSC to CARE 2010.

Short recommended updating the version of JOOMLA to 1.5 for security reasons and submitted a CARE to CARE recommendation to that effect.

3. Charter Committee – Munk, Goetz

The Charter, initiated in 2000, provides a framework in which the original intent of CARE may continue. It also hastens familiarization of new CARE members to the function of CARE and the responsibilities of its officers and members. The committee is responsible for facilitating changes and updates to the Charter.

There was little activity to report in 2011. MacLellan stepped down from the committee in April. There was a call for new members and none stepped forward.

The committee recommends adding a working group section to highlight the purpose of the group and current activities with a link to past achievements.

4. Sablefish ad hoc Working Group- MacLellan, Neil, B. Campbell, Anderl, Helser, Kautzi, McDonald, Cavanagh, Hilwig, McNeel

The group reviewed the **WebEx** meeting and identified issues with examples of the known-age imaged sablefish otolith. The group outlined items for documentation to be developed into a scientific manuscript. The group discussed many ageing issues: burning techniques, breaking strategies, storage strategies, and identifying annuli versus checks. They generally agreed upon criteria documenting patterns and where they were unable to agree suggestions of possible interpretations were noted.

The group plans to develop a technical document and to update the CARE manual. They continue to work identifying the 1st annulus size range, discuss the pros and cons of each agency's storage methods, and each agency's protocols of Q/C.

C. Age Structure Exchanges

Age structure exchanges periodically occur to assess calibration among CARE age-reading agencies. Depending on results, specimens of interest (e.g. demonstrated biases) are then reviewed and discussed. Exchanges are tracked by the CARE Vice-chair. Data from exchanges are available on the CARE website.

Seven age structure exchanges initiated in 2010 are now complete. The species were Pacific whiting (CDFO, NWFSC), Pacific ocean perch for training (WDFW, CDFO) and lingcod for training (ADFG, ODFW), Pacific hake (NWFSC, CDFO), big skate (AFSC, CDFO), Longnose skate (AFSC, CDFO) and Longnose skate (ADF&G between the labs in Homer and Juneau).

Four exchanges initiated in 2011 are not yet completed. These exchanges are Big skate stained thin sections (AFSC, ADFG, ODFW), Longnose skate stained thin sections (AFSC, ADFG, ODFW) Longnose skate stained thin sections (AFSC, ODFW) and Longnose skate unstained thin sections (AFSC, ODFW) (Table 3).

D. Business Session Highlights and Discussion:

Demonstrations: There were three notable demonstrations during the CARE meeting. These demonstrations included imaging, (Anderl) micro-milling, (Kastelle) and elasmobranch vertebrae staining (Matta, Gburski). Anderl demonstrated AFSC's imaging system and the associate hardware and software. The demonstrations included information on Photoshop (image manipulation, hot keys, macros, annotation, layers, stitching, scale bars) and Portfolio image storage. Gburski and Matta demonstrated their staining technique for vertebrae. In their demonstration, the thin sections were decalcified, stained, restained, soaked in glycerin, and slide mounted. Kastelle demonstrated AFSC's new micro-mill instrumentation.

Scientific presentations: Six PowerPoint presentations were given: (1) CDFO's new groundfish age data sheet (MacLellan), (2) Preliminary age validation of Pacific cod using stable oxygen isotopes (Kastelle), (3) AFSC imaging system and its uses (Andler), (4) digital reference collections via Photoshop (Wischniowski), (5) management of AFSC images (Short) and (6) digital camera and AFSC new micromill (Kastelle).

Discussion: There were three noteworthy topics of discussion. First, concern was expressed that CARE was not following its mandate. Members conferred and concluded the concern to be unfounded. Second, the CARE forum's usefulness was discussed. The members agreed to continue supporting the forum and evaluate its usefulness again at the next CARE meeting in 2013. The last topic - imaging - was the main focus for the 2011 CARE meeting. Discussions about software (image editing, tagging metadata, archiving), hardware, and image-taking protocols were facilitated through the PowerPoints presented. Imaging was recognized as a powerful tool for exchanges and documentation but members clearly stated that imaging could not be substituted for actual scope work.

Workshop: Twenty-seven CARE members utilized the hands-on session to review sablefish, skate, Pacific ocean perch, dogfish, and geoduck, Albacore tuna, Pacific cod, yelloweye rockfish, shortraker rockfish, and salmon shark. (Table 2)

Recommendations C.A.R.E. ~TSC

In 2011, recommendations were made by CARE to CARE, TSC to CARE, and CARE to TSC. Some recommendations may take more than one cycle to complete.

2009 CARE to CARE

1. Charter Working Group: No advancement has been made to add a working group section to the charter to highlight their purpose or current activities with a link to past achievements ("archive") on the website. Charter members present at the 2011 meeting discussed this and suggested this information might be better located somewhere else on the website other than the charter. The committee needs to discuss this further and make a recommendation at the next CARE meeting in 2013.

2011 CARE to CARE

1. Forum Working Group: We recommend that the Forum continue for one more rotation.
2. Website Committee: We recommend updating the CARE website content management system from JOOMLA version 1.12 to version 1.5 to remain current with technology for security and bug fixes.
3. Manual Working Group: We recommend that CARE continue revision and expansion of the CARE manual to include sections on hake, lingcod otoliths, skates, age validation, and updated rockfish ageing information. In addition, we recommend that a section on ergonomics be added. These additions or revisions should be submitted to the CARE Manual Committee (led by Kamikawa) by April 2012 for committee review. The Manual Committee will submit all changes and updates to CARE for consideration at the 2013 CARE workshop. The CARE Manual Committee will review the halibut and QA/QC sections that were submitted at the 2011 CARE meeting and distribute final drafts to the CARE membership for review.
4. CARE recommends all members review the method and validation species information on the Species Information webpage to confirm the data is current. Updates or changes should be forwarded to Short. This table will be reintroduced into the biennial meeting agenda for agency updates.

5. CARE recommends that the 2013 agenda address the effects of long-term storage of otoliths.

Original 2010 TSC to CARE recommendation:

Recognizing the value of carbon dating and other potential uses of archived ageing material, TSC recommends that CARE examine the feasibility of preparing an on-line summary of the material that is archived by each of the West Coast groundfish research agencies.

2011 CARE to TSC response:

Initial CARE Reply to TSC to CARE 2010 Recommendation: With regards to "…*examining the feasibility of preparing an on-line summary of the material that is archived by each of the west coast groundfish research agencies*": most agencies do not have publicly accessible age data sample inventories now, except AFSC. CARE recognizes that there are advantages and disadvantages associated with making inventories public. A CARE portal, (using the CARE website), may be a possible platform to identify inventories. CARE requests clarification on what data the TSC envisions would be made available on said inventory. Then CARE members will consult their agencies regarding the TSC recommendation and formulate a reply.

2011 TSC to CARE Recommendations:

TSC would like to fully endorse the activities of CARE and acknowledge their great contribution to groundfish research and stock assessment.

TSC thanks CARE for their discussions and consideration of the 2010 request to examine the feasibility of preparing an on-line summary of archived ageing material from their member agencies. Since most agencies do not currently maintain publicly accessible on-line inventories, TSC appreciates that this task will be laborious.

To clarify for CARE, TSC's 2010 information request includes the following by species:

1. Number of ageing structures collected by
   a. structure type
   b. agency
   c. year
2. Number of structures aged by year (already on the website)
3. A link to a contact person at each agency

CARE Chair query regarding 2011 archive recommendation:

"Am I correct in assuming that the TSC is looking for numbers of fish age structures (#1) collected for all groundfish species going back as far as each agency has records for?"

The TSC reply was:

This is something that we would like CARE to work toward beginning with the most recent years and progressing back in time if resources permit. This needn't be a scrupulously thorough and exhausting exhumation of numbers of structures and could be an effort that begins with the easiest information and gets added to as they can. But the more information, the better, eventually.

2011 CARE reply to TSC:

Three CARE member agencies are willing to compile and forward "an on-line summary of archived ageing material". This could increase as two more member agencies are willing pending approval. Each member agency has selected a contact person for the website link.

Three CARE member agencies chose not to participate. Some will link the CARE website to their agency website and provide a contact name.

The CARE executive committee is considering how to include the summary of archived ageing material on to the website. In 2012, changes will be made to the CARE website to record the summary of archived ageing material and be ready to implement after the 2013 CARE meeting, pending membership approval.

Table 1. Attendees of the 2011 CARE Workshop, 11-14 April 2011, Seattle, WA.

Last Name	First Name	Agency	Location
Anderl	Delsa	AFSC	Seattle
Atkins	Nikki	NWFSC	Newport
Benson	Irina	AFSC	Seattle
Blood	Cal	Retired	Seattle
Brogan	John	AFSC	Seattle
Campbell	Barb	CDFO	Nanaimo
Campbell	Lance	WDFW	Olympia
Cavanagh	Meredith	NWFSC	Newport
El Mejjati	Sonya	ADFG	Kodiak
Failor	Barbi	ADFG	Homer
Forsberg	Joan	IPHC	Seattle
Gburski	Chris	AFSC	Seattle
Gibbs	Linda	IPHC	Seattle
Goetz	Betty	AFSC	Seattle
Helser	Tom	AFSC	Seattle
Hiller	Lisa	WDFW	Olympia
Hilwig	Kara	ADFG	Juneau
Hutchinson	Charles	AFSC	Seattle

Johnston	Chris	AFSC	Seattle
Kastelle	Craig	AFSC	Seattle
Kautzi	Lisa	AFSC	Seattle
MacLellan	Shayne	CDFO	Nanaimo
Matta	Beth	AFSC	Seattle
McDonald	Patrick	NWFSC	Newport
McNeel	Kevin	ADFG	Juneau
Neil	Jodi	ADFG	Juneau
Piston	Charlie	AFSC	Seattle
Pollak	Andrew	ADFG	Homer
Rodriguez	Omar	NWFSC	Newport
Rosenfield	Sandy	WDFW	Olympia
Russ	Elisa	ADFG	Homer
Short	Jon	AFSC	Seattle
Sizemore	Bob	WDFW	Olympia
Thompson	Josie	ODFW	Newport
Tobin	Robert	IPHC	Seattle
Topping	Jenny	WDFW	Olympia
Wells	David	AFSC	Seattle
Wischniowski	Steve	IPHC	Seattle

Table 2. 2011 CARE Scope Time

Species	Participants	Agencies	Comments
Pacific cod etc	Lance Campbell	WDFW	Prep of otolith samples for LA-ICPMS
"	Craig Kastell	AFSC	"
Geoduck ageing	Craig Kastell	AFSC	Preparation & ageing methods, cross-dating
"	Lisa Hillier	WDFW	"
"	Bob Sizemore	WDFW	"
"	Shayne MacLellan	CDFO	"
Big/Longnose/skates	Elisa Russ	ADFG-Homer	Age calibration
"	Josie Thompson	ODFW	"
"	Chris Gburski	AFSC	"
"	Andrew Pollak	ADFG-Homer	"
"	Barbi Failor	ADFG-Homer	"
Albacore tuna	Barb Campbell	CDFO	Age calibration
"	David Wells	SWFSC	"
Pacific ocean perch	Sandy Rosenfield	WDFW	Age calibration
"	Jennifer Topping	WDFW	"
Pacific ocean perch	Sandy Rosenfield	WDFW	Comparing methods otolith preparation
"	Jennifer Topping	WDFW	"
"	Charlie Piston	AFSC	"

Pacific ocean perch	Sandy Rosenfield	WDFW	Alaska vs west coast growth patterns
"	Jennifer Topping	WDFW	"
"	Betty Goetz	AFSC	"
Dogfish	Sandy Rosenfield	WDFW	New WDFW training method for ageing
"	Jennifer Topping	WDFW	"
"	Lance Campbell	WDFW	"
"	Patrick McDonald	NWFSC	"
"	Omar Rodriguez	NWFSC	"
Dogfish	Chris Gburski	AFSC	Evaluate staining method, compare dorsal spine to vertebrae age
"	Omar Rodriguez	NWFSC	"
"	Patrick McDonald	NWFSC	"
Pacific cod	Sonya El Mejjati	ADFG-Kodiak	Age calibration
"	Chris Johnston	AFSC	"
Greenland halibut	John Brogan	AFSC	Age calibration
Sablefish	Kara Hilwig	ADFG-Juneau	Age calibration - known age otoliths X 3 occasions
"	Jodi Niel	ADFG-Juneau	"
Sablefish	Patrick McDonald	NWFSC	Age calibration
"	Meredith Cavanagh	NWFSC	"
"	Delsa Anderl	AFSC	"
"	Lisa Kautzi	AFSC	"
"	Kevin McNeel	ADFG-Juneau	"
Sablefish	Kara Hilwig	ADFG-Juneau	Sablefish working group - known age otoliths, calibration, documentation
"	Jodi Niel	ADFG-Juneau	"
"	Kevin McNeel	ADFG-Juneau	"
"	Shayne MacLellan	CDFO	"
"	Barb Campbell	CDFO	"
"	Delsa Anderl	AFSC	"
"	John Brogan	AFSC	"
"	Lisa Kautzi	AFSC	"
"	Patrick McDonald	NWFSC	"
"	Meredith Cavanagh	NWFSC	"
Skate/shark	Chris Gburski	AFSC	"
"	Sonya El Mejjati	ADFG-Kodiak	"
"	Elisa Russ	ADFG-Homer	Age calibration
Pacific cod	Delsa Anderl	AFSC	"
"	Barbi Failor	ADFG-Homer	"
"	Chris Johnston	AFSC	"
"	Andrew Pollak	ADFG-Homer	"
Yelloweye rockfish	Kara Hilwig	ADFG-	Age calibration

		Juneau	
"	Kevin McNeel	ADFG-Juneau	"
"	Barb Campbell	CDFO	"
Yelloweye rockfish	Kara Hilwig	ADFG-Juneau	Age calibration
"	Jodi Niel	ADFG-Juneau	"
Yelloweye rockfish	Kara Hilwig	ADFG-Juneau	Age calibration
"	Kevin McNeel	ADFG-Juneau	"
"	Elisa Russ	ADFG-Homer	"
"	Andrew Pollak	ADFG-Homer	"
"	Kevin McNeel	ADFG-Juneau	"
Shortraker rockfish	Jodi Niel	ADFG-Juneau	Age calibration
"	Charles Hutchenson	AFSC	"
Salmon shark	Barbi Failor	ADFG-Homer	Age calibration
	Chris Gburski	AFSC	"

Table 3. CARE age structure exchanges initiated/completed from 2010-2011

Exchange ID No.	Exchange Year	Species	Stock	Originating Agency	Coordinator	Cooperator(s)
11-004	2011	Longnose Skate	US West Coast	ODFW	J. Thompson	AFSC
11-003	2011	Longnose Skate	US West Coast	ODFW	J. Thompson	AFSC
11-002	2011	Longnose Skate	Gulf of Alaska	AFSC	C. Gburski	ADFG, ODFW
11-001	2011	Big Skate	Gulf of Alaska	AFSC	C. Gburski	ADFG, ODFW
10-006	2010	Longnose Skate	Gulf of Alaska	AFSC	C. Gburski	CDFO
10-005	2010	Big Skate	Gulf of Alaska	AFSC	C. Gburski	CDFO
10-004	2010	Pacific whiting	US West Coast	CAP/PSMFC	O. Rodriguez	CDFO
10-003	2010	Pacific Ocean Perch	Pacific Northwest Coast	WDFW	S. Rosenfield	CDFO
10-002	2010	Lingcod	Gulf of Alaska	ADFG	K. Munk	ODFW
10-001	2010	Pacific whiting	Pacific Northwest Coast	CDFO	J. Groot	NWFSC